Challenges in the control of food quality and safety

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Food hazards, mortality, health benefits, risk-benefit balance

Summary

For historical reasons our control of food quality and safety focuses on contaminants including pathogens and toxins with well-known detrimental effects on human health, as well as reductions of nutrient contents compared with standard for the type of food. This has been very successful, so today most traditional serious safety risks are almost eliminated, the risk of introducing new hazards is rigorously controlled and nutrient deficiencies are very rare.

However, even though uncontaminated and plentiful food is now available to almost everyone in our society, food quality still affects our health, but in ways that are more subtle and complex than the old views based on pathogens, toxins and nutrients. The old picture of the effect of food on health is not just inaccurate; the benefits or risks to health we observe in modern populations from diets with different balances of food types are very often directly at odds with what we would predict from our traditional understanding of the quality and safety of these foods. So it is becoming increasingly clear that some of the fundamental principles and assumptions behind our management of food quality and safety are likely to be revised during the next few years. This may lead to substantial changes in concepts and procedures throughout the food chain, however, it is certain to result in better food for the consumers.

Introduction
Since food laws were first introduced many hundreds of years ago, the public control of food quality and safety has traditionally been focused on the prevention of well-understood risks caused by careless or even wilful contamination or substitution of proper food with contaminated or adulterated material. With the discovery of vitamins and minerals this was extended to also safeguard the provision of nutrients by monitoring and if necessary fortifying key nutrients.

Food poisoning (pathogens, allergens and clearly attributed toxins) now contributes with only around 0.1% to mortality in the UK (< 600 deaths per year). Together with fortification programmes, the increase in income relative to the cost of food has virtually eliminated the traditional malnutrition syndromes. This has not reduced the interest in food safety nor the expenses spent on ensuring it. Paradoxically, whenever the food safety control successfully discovers and minimises a food hazard, whether BSE, dioxin, pesticide residues or Salmonella, it seems to generate a surge of concern and distrust regarding food safety and force the food producers into ever more expensive safety assurance schemes.

**Food safety is not the same to everyone**

One way of understanding the situation is by describing the different definitions and perceptions of food safety among different groups in society. A bit schematically they can be listed as:

Legal definition:

- Food is safe if it is produced in accordance with the applicable regulations, including observation of due diligence.
Public health definition:

- Food is safe if its consumption does not increase the risk of any disease compared with other similar foods.

Consumer definition:

- Food is safe if I trust the source of it, if I believe that the producer did his/her best according to his/her own standards.

For those types of risk where we completely understand the link between food production method, food composition, and disease risk, and have adapted the regulations to reflect this, the three definitions coalesce. There is little difference in the perception of food safety when it regards classical food safety issues such as trichinosis or adulteration of wine with ethylene glycol, except in terms of what level of risk is acceptable. Normally the legal definition and consumer perception of a hazard that can be defined as an avoidable contamination will be concerned with much smaller risks than are relevant from a public health perspective, in contrast to risks that relate to the consumer’s own choices and actions. However, the greatest discrepancies relate to issues where we do not understand the relation between food composition and the effect on human health, in particular if risks must be balanced against benefits.

**Risks versus benefits**

Traditionally the view has been that protection against risks is a more important aspect of food safety control than exploitation of benefits (Essers et al. 1998), in particular because of the legal implications of being responsible for someone’s
disease or death. Due to this the public investment in both research and applications on the prevention of risks (from both contamination and malnutrition) tends to be much larger than what is spent on potential benefits of certain foods. Much of the research and development of foods with health benefits have been justified by the commercial interests of marketing foods with health claims, rather than the benefit for public health of promoting optimal diets. This situation is justifiable if the benefits appear to be smaller than the risks or of similar magnitude. However, we are now in a situation where we can estimate with some certainly that the likely, but largely unexplored, benefits of the foods that benefit our health are vastly greater than risk of hazards traditionally seen as relevant for food safety. While much of the reason for this situation is the success with elimination of traditional risks, it also means that substantial improvements in public health will require better understanding of balances between risks and benefits.

**Food components that affect human health**

Below is a schematic overview of our present level of knowledge about a range of risks and benefits for different groups of compounds present in food. As a gross simplification, it includes estimates of the number of deaths from each cause, as one of several relevant measures of the effect of the control of food safety and quality on our health.

*Hazards traditionally considered serious food safety issues responsible for food poisonings and with no indication of benefits:*

Pathogens including prions (BSE)
• Cause characteristic disease
• Most people are not affected by low-dose exposure
• Many cases are not diet-related
• Official estimate of total deaths per year in the UK:
  o Bacteria and vira: 500 (down from at least 2,600 between 1912 and 1937)
  o Prions: 3-5 (projected for future years, reached a high of 28 in 2000).

Allergens
• Relatively easy to link with specific patients, but still some under-reporting
• Most people not at risk, since they have no allergy or succeed to avoid the allergen
• Official estimate of total deaths per year in the UK:
  o 5-10

Mycotoxins, dioxins etc.
• Almost impossible to link with specific patients
• Risk depends crucially on assumptions about dose-response relations
• Official estimate of total deaths per year in the UK:
  o No quantitative estimates, aflatoxins linked to increased risk of liver cancer in some developing countries
Food components traditionally considered moderately serious hazards, but accepted in foods at certain levels due to recognised benefits for producers or consumers, or due to disproportionally high cost of further reductions:

GMOs, pesticide residues, growth hormones etc.

- No known direct effects on health (prerequisite for approval for use in food)
- Theoretical health benefits (e.g. general reduction in mycotoxins content from using pesticides) not confirmed by the available data and may be mistaken.
- Risk depends crucially on assumptions about dose-response relations
- Official estimate of total deaths per year in the UK (from food consumption):
  - Nil

Food additives: colorants, preservatives, flavours, process aids etc.

- No known direct effects on health (prerequisite for approval for use in food).
- Occur mainly in foods made from sugar, starch and fat, with low content of bioactive substances, vitamins or minerals
- Preservatives may reduce health risks from pathogens and mycotoxins, although normally their main purpose is to prevent spoilage, and spoiled food is normally not consumed
- Official estimate of total deaths per year in the UK:
  - Deaths caused by the additives: Nil
  - Deaths caused by excessive intake of sugar and fat: 7,000

Nitrite added to processed meat
• Epidemiological support for link with cancer, in particular colorectal (bowel) cancer
• Nitrite + protein may react to form nitrosamines that are known as mutagens (can convert cells into cancer cells)
• Risk confounded with risk from salt and the mutagen PhIP, which often occur in the same food
• Benefit by reducing risk of pathogens
• Official estimate of total deaths per year in the UK:
  o No separate estimate, included in (increased) risk of cancer and (decreased) risk of pathogens

Nitrate in vegetables
• Epidemiological and mechanistic support for inverse links with cancer, cardiovascular disease and caries
• Nitrate $\rightarrow$ nitrite, + acid $\rightarrow$ nitric acid
• Absorbed in the gut and recycled through saliva; nitric acid kills bacteria, nitrate in the body may form NO, which reduces inflammation and blood pressure
• There are concerns about potential risks associated with formation of nitrite and subsequently nitrosamines in re-heated spinach or in stored fresh lettuce if bacteria convert the nitrate into nitrite.
• Official estimate of total deaths per year in the UK:
  o No separate estimate, included in (reduced) risk of cancer

Nitrate in water
• Epidemiological support for link with methaemoglobinaemia, which can affect infants < 3 months of age fed powder-based formula

• These data are confounded with cases of pathogen infections, where we now know that infected infants secrete nitrate as a reaction to the presence of bacteria

• Official estimate of total deaths per year in the UK:
  o No estimate, no recent cases (>10 years)

Natural non-nutrient organic compounds (plant secondary metabolites, animal conjugated linoleic acids etc.)

• Most bioactive compounds are known to be toxic in high amounts

• Most of them have low bioavailability and/or are efficiently excreted or degraded, so do not accumulate in the human body

• Many of these compounds have positive effects on food quality, e.g. taste

• Most have not been tested for beneficial effects in the concentrations and intake levels they occur in food

• The foods with the highest concentrations of non-nutrients tend to be associated with reduced risk of cancer and cardiovascular disease

• Official estimate of total deaths per year in the UK:
  o Direct toxicity from natural toxicants in food: no recent cases (>10 years)
  o High caffeine consumption during early pregnancy significantly increases the risk of miscarriage, but it is difficult to make an official estimate, since many women reduce caffeine consumption when pregnant, or underestimate their own consumption when asked.
- No official estimates of reductions in disease risks for any one compound or combinations of them
- Overall diet-related, preventable mortality from cancer: 52,000
- Overall diet-related, preventable mortality from CVD: 68,000

Salt, added sugar and saturated fat

- Very important for taste of many foods as we know them
- Clearly associated with increased disease risk: High salt intake with elevated blood pressure, high sugar and fat concentrations in food with obesity and associated diseases
- Actual mechanisms of risk not well understood
- Official estimate of total excess deaths per year in the UK:
  - Salt: 20,200
  - Saturated fat: 3,500
  - Added sugar: 3,500

Food components generally considered beneficial, but where some risks of excess consumption are still recognised:

Vitamins & minerals, including antioxidants

- Deficiencies or oversupply cause diseases, including cancer and CVD
- >95% have neither deficiency nor oversupply as presently defined
- Iron, selenium, calcium, vitamin A, vitamin E, vitamin D and beta-carotene have all shown significant health risks in controlled supplementation studies
- For other nutrients there is little knowledge about what constitutes oversupply
• What is beneficial intake for one group can be harmful oversupply for another
• Official estimate of total deaths per year in the UK:
  o No estimates available for mortality, neither for deficiency nor for oversupply

**Food and health is not just food safety**

As it is clear from the above, the deaths caused by food poisoning comprise only a very small proportion of diet-related mortality. This is well known to have been the case ever since legislation for food safety was first introduced, although it is not always the impression given in the media when food safety is discussed. The low risk of food poisoning can to a large extent be attributed to our success in controlling the relevant recognised hazards. In particular when considering that other aspects of food production, such as large-scale production and distribution of ready-to-eat foods would have let to increased food poisoning risks if the control had not been improved in parallel. During recent years, after BSE came under control, the confidence in food safety has been slowly increasing, although in 2006 still more than a third of consumers were less than “fairly confident” in the institutions protecting health in relation to food safety (down from more than half in 2000).

**We have little knowledge of the relations between food and health**

This distribution tends to surprise both food experts and consumers of food.

One key aspect is that most of the non-poisoning diet-related deaths cannot be attributed to any well-understood deficiency or oversupply of any nutrients. While a substantial proportion are estimated to be due to over-supply of salt, fat and sugar,
more than half of the diet-related mortality cannot be explained directly by too much or too little of any food component with well-known effect on human health.

The other new aspect is that for many types of food components, recent research results tend to contradict our traditional classifications as desirable or undesirable. Many compounds until now classified as harmful toxicants, such as nitrate and plant secondary metabolites, appear to have beneficial effects on human health (Brandt et al. 2004), while many nutrients and antioxidants are more harmful than previously expected when supplied in amounts exceeding our needs (as provided by a recommended basic diet of unfortified foods).

These two aspects reflect that there are substantial shortcomings in our present knowledge about the relation between food composition and health of consumers of generally safe and nutritious diets. We may be able to sequence the entire genome of the rice plant, but we do not know if rice is better for our health than potatoes, despite the vast difference in composition of these two foods. We do know that for most of us our health would benefit from increasing our intake of fruits and vegetables, but we don’t know if oranges or cauliflower work best, or if it is best to have some of each.

**Challenges in the control of food quality and safety**

Clearly the public expects that the control of food quality and safety addresses the major food-related health risks and is not confined to only food poisoning. This challenge is being met in several ways.
Firstly, since several years the official advice about healthy food has increasingly emphasised the importance of the consumption of a healthy diet containing the foods known to be associated with good health. The notion that a daily multi-vitamin pill will insure us against all likely food-related ailments has been abandoned, instead we now recommend more of foods such as fruits, whole grains and vegetables, and less of salt and added sugar. Where breakfast cereals were previously promoted for their high contents of added vitamins, today’s emphasis is on whole grains, nuts and fruit pieces. This change is in line with the scientific evidence drawn from observational studies, which allow us to quantify the importance for health of changes in diet, and therefore are the basis of the estimates of diet-related mortality. However, observational studies are not very precise and tend to suffer from systematic drawbacks. For example, volunteers tend to report a much smaller alcohol consumption than what corresponds to the turnover in shops and pubs in the area where they live. Additionally, when we lack a mechanistic understanding of how these foods affect health, it is difficult to communicate the advice effectively, in particular when new findings require revision of previous guidelines or when the scientists disagree about the interpretation of the observations.

A good example of this new approach is calculation of the cost to childrens’ health caused by advertisements of fatty, salty and sweet foods, which formed the basis for the recent moves to restrict such advertising.

The second challenge, which it will take a longer time to meet, is to improve the research into understanding which components of foods are good or bad for our health and at which intake levels. It is not enough to understand that cauliflowers are better
for your health than shortbread, we also need to understand why and how this
difference occurs. This is a prerequisite for improving the benefits for health of both
the cauliflowers and the shortbreads. It is also, perhaps even more importantly,
necessary to prevent deterioration of our health from changes in food production
methods that inadvertently may reduce the benefits of those foods for health. One of
the reasons for the popularity of organic and other “natural” foods is a concern among
consumers about the consequences of modern production methods. In some contexts,
such as BSE, these concerns have been proven right. The only way we can safeguard
the consumer’s health without stifling innovation is to improve our knowledge of
food and health to the extent where we can convincingly estimate the effects of
relevant changes in composition. The proof that we have reached this level of
knowledge will be that we will be able to model the correlations observed in real
human populations, however, this goal is still a long way ahead.

Some scientists claim that new methodologies must be developed in order to make
progress in this area, where my personal view is that plenty of useful methods have
already been developed, but not yet systematically put to use in this regard. In some
cases it appears that the main barrier to progress is a reluctance to challenge
traditional dogmas just because they are dogmas. For example, it appears to be more
difficult to obtain funding for research on potential benefits of nitrate in vegetables
than on potential benefit of vitamin C in the same food, despite the fact that the
existing data indicate that increasing the nitrate intake will benefit our health very
much more than increasing the vitamin C intake.

Historically, adherence to dogmas has often held science back, but only temporarily,
and it will be very interesting to see how this field develops during the next 10 -20
years. Whatever happens, our views of the control of food safety and quality will change, and these changes will have to be reflected in the norms and regulations that secure safe food the consumer can trust, throughout the entire supply chain.

For example a recent discussion paper from the Cabinet Office’s Strategy Unit (2008) estimated that nearly 70,000 deaths could be prevented by increasing the intake of fruits and vegetables and reducing the intake of salt, saturated fat and added sugar. FSA’s chief scientist’s recent annual report mentioned the numbers of UK deaths associated with diet of approximately 68,000 per annum for cardiovascular disease (CVD) and 52,000 p.a. for cancer. These estimates are based on quite reliable epidemiological studies showing how diets with different compositions are associated with relative differences in disease risk and mortality. However, we have little definitive understanding of the specific reasons for these differences, and this seriously impedes our ability to obtain the benefits of the best diets for a larger part of the population.

References


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