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FORECASTING AND ASSESSMENT IN SCIENCE AND TECHNOLOGY

OCCASIONAL PAPERS

No. 206 July 1987

FOOD AND HEALTH IN THE YEAR 2010

R.R. Gormley, G. Downey, D. O'Beirne
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FOOD AND HEALTH IN THE YEAR 2010

PROJECT TEAM

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SUMMARY

Using a previous report for the FAST ALIM 2 programme as a springboard, projections are made of future (to the year 2010) developments in Europe in the understanding of the relationship between food and health. Implicit in these projections is the assumption that no cataclysmic economic event(s) occurs in the interim period but rather that an evolution of current economic and political trends continues without significant medium to long-term disruption. Should this assumption prove false, major changes in national and international priorities may alter the relative importance of the topics highlighted.

It appears likely that current lifestyle trends will continue with a heightened demand for convenience foods that have a positive nutritional image. Increased attention to individual nutritional needs is a likely development leading to a demand for personalised diets for the attainment of optimum nutrition. In relation to diet-related disease, it is likely that better understanding of the major risk factors should result in a greater focus on metabolic and physiological features now only beginning to emerge as relevant. Coupled with a greater desire to prevent disease onset, a probable development is the identification of foods which offer some protection against certain types of illness and also those responsible for sub-clinical conditions in certain individuals. The importance of natural complexity in foods will be increasingly realised and there will be major developments in the
nutrition of the aged. The role of preventive medicine will expand and the benefits of alternative medicine will also become more obvious.

Consumer unease with science and technology will remain an important social feature in 2010. Demand for greater information on the nutrient content of food will have stabilised at a level slightly below that currently found although it seems likely that nutritional concerns will have dictated changes in the food offered in a wide range of away-from-home outlets. However, greater government involvement in relation to food and nutrition policies will be restricted to the provision of information and encouragement to change; no significant formal intervention (for reasons of human nutrition as distinct from economic considerations) in food production, processing or retailing seems likely in the Europe of 2010. Segmentation in the market will see the emergence of specialist food stores with a defined, up-market niche while greater use of home computers will lead to increased monitoring of personal nutrient intakes. Home-shopping is unlikely to affect food purchase patterns but home delivery of ready-to-eat foods is expected to increase; this will extend from the present ethnic and hamburger types of operation to all food types. Paradoxically, the consumption of 'reward' foods seems set to expand in parallel with a continued swing to fresher foods.

Agricultural production systems will have changed in the direction of giving an improved nutritional profile in many foods; this includes changes to reduce or eliminate the use of chemicals
(hormones, antibiotics and pesticides). A number of the sensory problems which militate against the production of formulated foods of better nutritional quality will have been overcome while the current movement towards use of natural colours and flavours will be sustained. Due to continued concern over food freshness and nutrient content, the application of food chilling is set to expand while traditional preservation technologies will have been considerably refined to minimise nutrient loss. Much greater use of modified atmosphere packaging is probable; however it is difficult to predict the extent of the use of irradiation by the food industry of the 21st century. Significant progress in hazard identification and quantification will lead to a better understanding of potential risks arising from natural toxicants and also from new and modified food processing technologies.
A major project entitled "Technological change in agriculture and the food industry, and public policy in relation to food production, nutrition and consumer safety", carried out in 1985/86 by Gormley, Downey and O'Beirne (1-5) of AFT as part of the FAST ALIM 2 programme, provided a thorough review and assessment of the latest scientific evidence on links between nutrition and health and between various agricultural and food processing practices and food quality. The outcome of the project was a list of 45 conclusions and recommendations. Some of these have, and are, being implemented by the Commission of the European Communities (CEC) and presumably more will be implemented in the future; the report (1) is a useful baseline document and is being used by expert EEC groups planning future programmes and strategies in the food, health and consumer areas.

The 1985/86 study showed that while there was a good measure of consensus on many of the issues in the diet/health/food production/food processing/consumer matrix there was considerable disagreement on a number of fundamental issues. The purpose of the present study, therefore, is to re-examine the possible outcome of some of these issues in the long term, i.e. in about 20 years time (up to the year 2010), and to pin-point some new ones, which may be clarified by new research techniques and technologies coming on-stream in the next two decades. Such an exercise will be useful to the longer term "forecasting" elements of the FAST ALIM 2 studies. However, the authors hasten to stress the difficulty in forecasting so far ahead and alert the reader to the fact that the
The study is divided in three parts: Part 1 deals with diet/health issues, part 2 with food purchasing, nutrition policies and consumer education, while part 3 addresses some issues in production agriculture and in food science and technology in the European food system of the future.
1.1 Food in the future

In 2010 European consumers will eat for the same reasons as they do today but the emphasis will change somewhat. There will be a much greater understanding of the subtleties of food composition and of the interactions between nutrients and of the relation between food/food constituents and disease and so prudent diets will be more easily planned. Consumers will eat for good health - coupled wherever possible with sensoric enjoyment and current trends for more "healthy" foods which are fresh and "natural" and free from artificial additives seem set to continue; therefore the science fiction concept of getting all nutrients from pills will find little application except in specific cases. The requirement for top quality convenience foods (as the pace and patterns of life quicken/change) on the one hand and for high quality "natural" fresh foods for the main evening meal at home or at weekends will cause an increasing polarity in requirements. There will also be a massive increase in the sale of "tailor made" readily available foods for the very young and the very old and also for consumers with specific diseases or metabolic disorders e.g. as is the case at present with gluten-free products for coeliacs. Some of these aspects are discussed further in Parts 2 and 3.
1.2 Individualised diets

Nutritional profiling at individual level will become standard practice long before 2010. This will involve individuals visiting a clinic for a series of tests which will identify intermediate metabolites associated with a range of diet related disorders, and/or allergic reactions to foods - many of them marginal or sub-clinical. Some aspects of food intolerance are already well understood (6) and are classed as enzyme defects, pharmacological, irritant and toxic, allergic, and the fermentation of food residues. These developments will be aided by new advances in biochemistry and biotechnology and the final outcome will be individualised diets and/or the inclusion of agents (e.g. an enzyme or a trace element) in the normal diet of the person concerned. These developments are, or course, in addition to the individualised diets which are presently common practice for some of the more major disorders such as coronary heart disease (CHD), diabetes and coeliac disease. The spin-off from these developments will be a multiplicity of "modified" foods which have already been alluded to above (section 1.1) and will provide great opportunity for sections of the food industry (see Part 3).

1.3. Diet and disease

Dramatic advances in overcoming diet-related diseases will have been made by 2010 but presumably some questions will still be unanswered. In addition, by that time, new diet-related diseases may have arisen. There will be a considerable concentration of
research in the next 20 years on metabolic diseases/conditions both inherited and acquired. These will include genetic hypercholesterolaemia (high cholesterol), specific amino acid deficiency and inherited aspects of energy metabolism, just to mention a few, and identification and treatment of these together with the aspects outlined in 1.2 above will be classed as the "high tech" end of nutrition.

1.3.1. Coronary heart disease and stroke: The area of CHD will be much more controlled by 2010 and hopefully its incidence in developed countries greatly reduced. The key to this will be the capacity to postpone the onset of atherosclerosis by a combination of improved diet, lifestyle and environmental factors. At present only about 60% of CHD can be attributed to known causes; the remainder is largely unexplained and may be due to stress, psychological and other factors which are extremely difficult to quantify. However, developments in a whole range of sciences coupled with more powerful statistical and mathematical techniques will help to isolate the individual contributions of different causal components in diseases such as CHD. In the dietary control aspects of CHD it is likely that the current concept of a balanced diet of relatively unrefined foods which is rich in plant and marine foods and contains a calories from fat (CF) figure of not more than 35% will prevail; with a greater understanding of CHD it is possible that the % CF figure may be further revised downwards. If this happens it will exert further pressure on the dairy and
meat industries to produce low fat products (see Part 3). The routes through which food intake might operate ultimately on the heart are several and include obesity, serum lipids, blood pressure, platelet aggregation, coagulation profiles, coronary vascular reactivity, cardiac membrane stability and cardiac substrate metabolism (7). To date most attention has been on cholesterol and blood pressure but greater attention to these other routes in the next 10-20 years may yield great benefit.

Presumably hypertension (HT) which is a significant causal factor in CHD and stroke, will also be well understood by 2010; not so at the moment with controversy (1) over the role of salt and the important possible synergistic effect of sodium and calcium in HT (1).

1.3.2 Cancer: There will be a major reduction in the frequency and severity of some cancers, especially those of the mucous membranes, by 2010. Cancer can be considered as a two-stage process (8). The first stage, i.e. initiation occurs rapidly as a result of interaction with a carcinogenic agent and is thought to be essentially irreversible. The promotional, or second stage, occupies a much longer time span and is greatly influenced in a positive or negative way by environmental factors; it is considered to be potentially reversible - particularly in the early stages after initiation. There is evidence accumulating that nutritional factors, particularly fat, fibre, retinoids (vit A) and salt may
play an especially important role during the promotional phase of carcinogenesis and it is in this area that most progress will be made. Presumably the possible role of mutagens (9) formed in food during cooking will also be better understood. It is likely, therefore, that by 2010 advice will be available to consumers as to what foods are likely to promote cancer and what ones prevent or delay it; with present knowledge it is likely that foods containing carotenoids will be in the latter category.

1.3.3. Osteoporosis: This disease, which manifests itself as loss of bone tissue in the elderly, presents a major challenge for the future since people are going to live longer; one could say that "we are outliving our bones". The effect of dietary calcium in this disease is not yet fully clarified but presumably by 2010 dietary advice will be available on how to build up adequate bone tissue to ensure good bones in later life. It is likely that dairy products will play a major positive role in this context.

Obviously there are many other diseases/conditions that could be dealt with in this section but for the sake of brevity discussion is limited to three.

1.4 Interactions

Major developments in the understanding of many nutrition related "interactions" will have been made by 2010 and will lead to better control of disease and improved health; the following are
two examples of "interactive effects" that require attention both at the moment and in the future. firstly, the interaction between nutrition and infectious diseases, and especially viral diseases, both in relation to susceptibility and their invasion/severity/progression/outcome; this leads into the extremely important area of the immunological aspects of nutrition (10). Secondly the area of drug and nutrient interaction is of key importance — especially for those on long term drug therapy such as anti-epileptic (effects folate status) or hypotensive drugs. Other "interactive effects" are discussed in section 1.7 on natural complexity.

1.5. Free radicals

There is increasing evidence that free radicals (see footnote) have a number of detrimental effects in many through their role in toxicology, cancer induction and tissue ageing (11). The next 20 years will see significant strides in the understanding of the role of free radicals in these areas and also on the production of free radicals from food constituents in vivo or during food preparation (cooking). The importance of consuming foods rich in vitamin E will be increasingly recognised in view of this vitamin's potential for controlling free-radical-initiated damage.

Footnote: A free radical is a group of atoms which normally exist only in combination with other atoms and is brought into independent existence by special conditions. Free radicals contain an unpaired electron and are extremely reactive chemically.
1.6 Weight control

There is still controversy about mechanisms of weight control and why some people who eat a lot remain slim while others who eat little remain fat. By 2010 most, if not all, of the pathways of energy dissipation in humans will be understood and also their interaction with the genetic make-up of the individuals. However, one can speculate that dieting may be a thing of the past with the increased use of thermogenic drugs (12).

1.7 Natural complexity

Natural complexity in food has been referred to in recent FAST reports by Grimme (13) and Gormley et al (1). It can be argued that nature does things best and so natural complexity in food is good; however, it can be equally well argued that nature gives us many foods containing natural toxicants.

There is not much scientific evidence at present to support the desirability of natural complexity in food although it has been shown (14) that the milling of bran to reduce its particle size results in a lessening of its physiological effect in vivo. The lack of evidence is partly due to the difficulties in carrying out tests in this very complex field. However, the author speculates that the importance of natural complexity will be realised and much appreciated by 2010 especially in relation to the availability of trace elements, vitamins, polyunsaturated fatty acids and other constituents in foods; this may be due to the fact that many of
these constituents do not occur in nature as isolated entities but as subtle co-enzymes, as parts of complex molecules, as salts or esters, or as substances loosely bonded (e.g. hydrogen bonded) to other molecules which render them more available for absorption by the human. It is also important to note that we are "genetically geared" to obtaining nutrients in a food format which may be another argument in favour of natural complexity.

1.8 Nutrition of the aged

With greater control of diseases/conditions by 2010 it is anticipated that lifespan will have increased considerably which will increase the requirement for good information on nutrition of the elderly. This has been mentioned already in relation to osteoporosis (see 1.3.3 above) and there are many other examples including the effect of dietary fibre on the absorption of nutrients by the elderly.

Current thinking (15) is that there is no cut-off age at which dietary guidelines are not required. However, in the future it will be increasingly important to recognise the wide range of life experience and physical and mental capacities of the elderly population and to formulate guidelines (addressed to both the elderly and those caring for them) which are translated into terms of foods, i.e. practical, enjoyable and acceptable.
1.9 Preventive and alternative medicine

The role of preventive medicine will continue to expand between now and 2010; the trend of the last decade will continue with increased consumer awareness of prevention and greater self care. This development will be enhanced by better information (some from home computers - see Part 2) systems both at household, community and national levels. The increase in prevention will be an integral part of programmes in most European countries aimed at reducing health spending.

The area of alternative medicine will increasingly formalise itself and will set its own standards (16). This will be aided by the rising cost of formal care and by greater public dissatisfaction with it. With increasing affluence people will "dabble" more in "leisure medicine", i.e. it will become a recreational thing and they will look more at nature as a resource that can be used on an individual basis. In food terms this will mean that certain foods will be eaten because of their recognised or assumed beneficial effects on health and well-being; this is nothing new and has been around for centuries - honey is a good example. However, it is likely that the future will see much more scientific evidence for the beneficial effects of certain foods on health - at present many health benefits associated with certain foods are just speculation. The collection of scientific evidence as a result of more people exploring the alternative medicine area will result in a greatly increased acceptance of its benefits by those involved in formal medicine by the year 2010.
PART 2 - NUTRITION POLICIES AND FOOD PURCHASING (G. Downey)

2.1 Social climate and background

One of the points identified in the original FAST document (1) was the effect of widespread social and political trends on the self-view of society. At its core, the crisis of confidence in the ability of society to control ever-expanding technologies and re-establish a role for the individual in local and national decision-making has led to a retreat into a defensive and individualist mentality in developed countries. How will this scenario change in the next 20 years, if at all, and what effect will such developments have on food and nutrition policies and food purchases? To attempt to answer these questions, one must examine the longer-term trends in relation to those issues which have produced the present climate of concern.

Consumer suspicion with regard to the development of new technologies, especially in the information sector, and the size, motivation and influence of the business community seems unlikely to abate significantly. The full effects of the nuclear accident at Chernobyl on the public's attitude to technology have yet to be realised and the continued activities of environmental ginger groups (e.g. Greenpeace) find increasing media exposure and show no signs of weakening in their resolve to alter fundamentally man's view of himself in the global environment from marauder to caretaker. Increasing urbanisation in Western Europe will continue
to heighten the sensitivity to ecological considerations in the general population and lead to greater pressure on the use of technologies which are seen to be environmentally damaging.

Consumer concerns in relation to the value systems of large business (especially food processing) enterprises are unlikely to decrease, especially following the exposure accorded to the recent Guinness scandal in the City of London. The purported concern of business with the well-being of its customers is increasingly less readily accepted by consumers in the wake of the apparent disdain with which at best good business practice, and at worst the law of the land may have been treated by one of the well-established industry giants.

Finally, the spectre of Acquired Immune Deficiency Syndrome (AIDS) is only beginning to loom over Western European countries. Its immediate effect in a large segment of the population may have been to increase an already obvious isolationist, self-centrist frame of mind in an attempt to minimise disease spread. Quite where this outlook will stop is impossible to predict but at the very least it seems likely to further increase the feelings of threat already identified in the general population and further entrench behaviour and eating habits motivated by self-preservational instincts. Trends previously described in purchasing patterns thus seem likely to continue if not intensify.
2.2 Dietary guidelines and government action

A radical change in dietary advice seems unlikely to occur by 2010. The trend away from specific target figures to more general exhortatory declarations is likely to continue with perhaps increased attention being paid to alcohol and tobacco abuse. It may be, however, that increased segmentation in shopping habits (see below) will produce a population sector which will demand a more explicit codification of desirable levels of nutrient intake. Such a sector will probably be able to monitor nutrient intake with ease and accuracy through the increased availability of suitable software packages for home computing systems; to cater for their needs, the approach identified in the previous report (l) of identifying a zone of risk-free intake of many or all nutrients would be required. This would have the advantage of avoiding any obsession with a specific nutrient intake quantity and permit a wide variety of food to be eaten while still avoiding excesses or deficiencies of many or all nutrients. Public discussion and interest in the guidelines and the general question of diet and health shows no sign of abating although the motivation may be increasingly cosmetic (a desire for slimness) rather than the prevention of disease. In an environment which seems set to increase the importance of image (often at the expense of substance) and which is becoming more difficult from a retailing point of view, market segmentation is one of the few methods available for growth. To this end, the choice of food available in restaurants, snack food outlets, institutions and centres may
diversify to include menus designed to appeal to the more
nutrition-conscious of the population. Such outlets will in all
probability maximise their use of dietary guidelines and Government
statements on diet and nutrition to attract customers, but any more
positive action at government level to implement food and nutrition
policies beyond that already taken seems unlikely, given the
liberal tradition in Western parliamentary democracies. Assuming
the continuation of current economic trends for the foreseeable
future, the development of individualist as opposed to cooperative
political philosophies by much of the European electorate seems
likely to be sustained and increase resistance to any attempt by
Governments to more actively intervene in food production,
processing and retailing systems. Paradoxically, action at EC level
in relation to the food production system may be increasingly
demanded by consumers with the aim of providing better food choices
and reduced prices; however, any attempt to directly influence
personal decisions in relation to food choice is unlikely to
succeed. Scope still exists for advice and encouragement to those
population groups which are receptive (see below).

2.3 Food purchasing patterns

The recent trend in European retailing for increased
domination by multiples is set to continue until the turn of the
century, with forecasts for the UK that they will account for 80%
of the retail market by the early 1990's (17). These outlets will
become increasingly automated with the widespread use of EPOS
(Electronic Point of Sale) systems coupled with scanning equipment for product bar code reading. While introduced to optimise management information and achieve efficiencies in stock control levels and costs, such systems would also lend themselves to the provision of nutrient information on shopping baskets i.e. they may render current nutritional labelling systems obsolete; note that nutritional labelling has been dealt with comprehensively in another FAST contract (18). Such a scheme (not available at point of sale) has previously been reported in the Netherlands although no information on its popularity is available. The identification of specialist, precisely targeted retail outlets is emerging as a growth mechanism for UK multiples with, for example, Marks and Spencer setting up a small number of specialist sports stores and Woolworth launching a chain of Superdrug drugstores (19). It seems logical to extend this specialisation to the food sector and the development of a chain or chains of specialist, high quality food shops under the control of a multiple and targeted at a particular market is likely to emerge. Extensive use of such shopping-basket nutrition information at point of sale would seem a useful selling point; such information is available in a restricted form in a number of multiple outlets in the UK although its use and operation does not appear to have been successful.

Penetration of the home computer market in Europe has, in the main, fallen below initial forecasts and the precise use to which those bought to date are put remains unclear. It does seem
likely, however, that, with real costs falling, domestic ownership levels will rise and the more powerful systems available may be used for home management information. Such systems seem likely to be used for nutritional monitoring of shopping-baskets or individual dietary patterns although to be effective, food labelling systems and food composition databases will require to become more complete and accessible. Even though such a development risks increasing the obsessional nature of dietary practices indulged in by certain population sub-groups, it must surely present an opportunity to highlight problem areas in an individual's diet (e.g. excess calorie intake) and present a better means of their control by identifying specific consumption patterns causing any imbalance.

Home shopping is a development which seems set to grow although predictions about its success are vague and questionable as yet. Evidence of interest by major retailers can be found in the recent entry of the UK Littlewood chain with Shop TV which uses television via British Telecom's Prestel service (20). Such a facility has been available in the UK on Prestel since 1978 although the response has been slow since most customers are business rather than households. An alternative mechanism is currently used by Space-Shopping on European satellite TV stations; direct contact with the home consumer is generally dependent on cable networks or domestic satellite dishes both of which are restricted as yet. However, access to such networks seems likely
to expand considerably thus making TV shopping a reality. It does not seem likely, though, that shopping for all commodities will be popular by this means; it is ideally suited to consumer durable and leisure items but clothes and food purchases do not seem likely to become a significant sector of such business. Evidence does exist to show that shopping may increasingly become a leisure activity and the increasing range of services available in shopping centres dominated by multiples will prevent any move to remote food purchases.

Another development which is now in its infancy but seems set to grow significantly is home delivery of ready-to-eat foods. Although restricted to certain ethnic restaurants in the UK, many hamburger outlets in the US now sell more than 50% of their food at drive-through windows and most of this is for home consumption (21). This development has implications for food processors and retailers alike since there is no reason why any type of food could not be sold in this manner.

2.4 Food choices

An interesting paradox which has become apparent in food purchasing patterns lately is the combination of "healthy" food purchases with "reward" foods. The market place is capitalising on a behavioural trait which would indicate that while many consumers are switching to foods of a nutritional profile which they perceive to be superior, they do not pursue this trend ruthlessly; instead
they indulge in confectionery products and main course foods which they enjoy, but which do not have a positive nutritional image, as a treat during leisure time. Thus, food and eating patterns have become a leisure pursuit for many and this seems set to grow. Ironically, some of this growth is likely to involve fast-food outlets (22), the produce of which is believed in many circles to be less than desirable nutritionally. Despite the popular view, consumption of fast foods would appear to be quite low by most of the population of developed countries and owners of such outlets foresee a considerable expansion of their business by the turn of the century. No significant demand has been experienced by them for any fast-food product with a more positive nutritional profile although plans by one (Wimpy) for the introduction of a vegetarian-type burger product are well-advanced (22) despite problems of flavour with this and other low-fat products. The view that such foods are not currently under threat is supported by market research carried out in the UK. Data reveal that the "reward" nature of "junk foods" ensures their place in the nation's diet while conventional foods appear to be most under threat by those with an interest in diet and health (about 50% of the group surveyed) (23). With the constant emphasis on new markets, it is often not realised that a major population sub-group (accounting for about 30% of the UK market) is either apathetic about, or hostile to, diet-related health concerns - these are mainly the poor and unemployed and represent a bigger marketing challenge with potentially greater rewards due to the lack of within-group
segmentation. Therefore, established food purchasing patterns are unlikely to change for the majority of the population while for a small sector with greater disposable income and leisure time, the pattern and method of food purchases will alter to some degree to reflect desired lifestyle images.
PART 3 - TECHNOLOGIES AND PRACTICES IN AGRICULTURE AND THE FOOD INDUSTRY (D. O'Beirne)

3.1 OVERVIEW

In the previous study for the FAST Programme (1) the major potential hazards to consumers in the nutritional and toxicological areas were assessed. Under the heading of nutrition, these related to nutrient imbalance and to excessive losses of key nutrients. Agriculture production practices and food formulation could significantly contribute to nutritional imbalance; there were losses of nutrients during food processing and during storage of fresh and processed foods. The major potential toxicological hazards related to naturally occurring chemicals, to chemicals used in agricultural production and by the food industry (fertilisers, veterinary products, pesticides, food additives), and to chemicals formed during food processing.

The main mechanisms available for reducing these risks in the future are through developments in public policy (research funding, technology regulation, consumer education, etc.) and through advances in new applications and modifications to existing technologies used by agriculture and the food industry. Major factors in shaping future developments are:

(a) improved understanding of hazards
(b) exploitation of opportunities arising from basic and applied research and development, and from
technological change

(c) the impact of consumers attitudes and requirements on market demand and on public policy

The process of identifying and quantifying hazards will continue to be refined through improved analytical methods, better design of animal and human studies and from the availability of more experimental data. Areas where the impact of this will be seen include improved safety of permitted chemicals (pesticides, additives, etc.) through exclusion of the more hazardous products; clarification of the potential hazards from natural toxicants and nitrate levels in foods; clarification of the risks from new processing technologies such as irradiation; and possible clarification of some of the current uncertainties relating to optimum nutrient intake (see Part 1).

Applications of research findings in fields such as agricultural biochemistry, plant and animal physiology, biotechnology, alternative agricultural production methods and functional properties of food ingredients, will provide major opportunities for modifying the nutrient and chemical content of food systems. Opportunities will also come from technological change in the food processing industry. Technologies forecast (24) to have a major or moderate impact by the year 2000 are:

- 25 -
<table>
<thead>
<tr>
<th>Major Impact</th>
<th>Moderate Impact</th>
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<tbody>
<tr>
<td>process design</td>
<td>biotechnology for the food industry</td>
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<tr>
<td>process automation</td>
<td>modified atmosphere packaging</td>
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<tr>
<td>microelectronics</td>
<td>aseptic processing</td>
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<tr>
<td>new packaging systems/concepts</td>
<td>microwave heating</td>
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<td></td>
<td>extrusion cooking</td>
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<td>new sensors</td>
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<td>mathematical modelling</td>
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The high level of concern among consumers about issues relating to food safety and wholesomeness is likely to continue. Efforts to meet dietary guidelines, particularly in terms of fat intake, will have significant implications for agricultural production and food formulation. Problems relating to poor information, confusion and loss of confidence among an important minority of consumers have already been outlined (1). It can be expected that public policies on consumer education will address these issues in the 1990's. However, because these efforts are likely to be at best partially successful, the agricultural and food industries can expect to have to meet both real and perceived concerns. This should lead to greater diversity in the market place (some organically produced foods, additive-free foods, etc) but also may divert some research and legislative efforts towards non-priority hazards. Specific likely developments by 2010 are considered under sections 3.2 (nutrient imbalance/losses) and 3.3.
(toxicological hazards).

3.2 Specific Developments: Nutrient Imbalance/Losses

3.2.1 Agricultural production: Agriculture is likely to play an increasing role in helping consumers meet dietary guidelines. For example in the 1990's, fat levels in meats will be reduced by modifying husbandry methods - by greater use of male animals and by slaughtering at a younger age before depot fats have accumulated. Fat levels in meat produced in Mainland Europe are already lower than the 15-20% range found in the UK or Ireland. This is due to the use of leaner breeds and also to more bull beef production. However, further fat reduction can be achieved in all countries. Greater control over levels of key nutrients will be possible in both plants and animals through advances in understanding of plant and animal biochemistry and physiology and of the mechanisms controlling nutrient accumulation (25, 26). This will facilitate some change through husbandry modification. However, more profound changes will be possible by using this information as a basis for the application of biotechnology. As a result, considerable control of fat and cholesterol levels should be possible in animal products. In muscle meats levels may approach about 5% intramuscular fat (the minimum level required for good eating quality, 27) with little or no subcutaneous fat. If adequate funding is made available for biotechnological modification of plant foods, the levels of key vitamins (ascorbic
3.2.2 Food formulation: Fat, salt, and refined ingredients play important roles in many formulated foods currently available to consumers. While the food industry has begun to introduce "healthier" formulations, reducing the levels of these components poses significant constraints related to acceptability, uniformity, processability, storability, etc. (28). For example, reducing fat levels can affect texture, mouthfeel, lubrication, juiciness, flavour, and flavour binding as well as having implications for satiety and the level of fat-soluble vitamins.

Formulated foods of good sensory quality, with nutrient contents in line with dietary guidelines will be available by 2010. This will be a crucial development, because the food processing industry plays an increasingly central role in determining what is available to consumers (29). These formulated foods are likely to take a number of forms: modifications of existing food products, combinations of products (e.g. meats and plant foods) to dilute fat levels (30), foods based on novel ingredients which have good functional properties [e.g. mycoprotein, (31)]. There will also be formulations "tailor-made" for sub-groups in the population with special nutritional needs (see Part 1). Developments in this area depend on the success of a number of lines of basic and applied research. These include greater understanding of functional
(physical, sensory, etc.) properties of food components and ingredients and their interactions. For example, reduction of fat levels in food systems without loss of acceptability is particularly difficult. Work with gelled proteins and some polysaccharides to simulate the textural properties of fat emulsions may become important (29). In general, research on surface properties of food components (emulsification, etc.) and on flavour manipulation and flavour binding needs development (29). Advances in control (process design and automation) of existing and new technology, and development of these new technologies (HTST, extrusion, etc) will also be essential parts of exploiting the potential of this range of optimally formulated foods.

3.2.3 **Food processing:** While significant losses of some vitamins and minerals can occur in some food processing operations (e.g. thermal processing), consumption of processed foods is not considered to constitute a nutritional hazard for most consumers (1). However, these losses are of concern to consumers and could be important for sub-groups of the population. By 2010 processing losses will be minimised by two main developments:

(a) increased use of milder processing conditions

(b) increased consumption of fresh and minimally processed chilled foods
Milder processing conditions will arise through optimum use of current and new technologies (24, 32, 33) and through the introduction of new technologies considerably milder in their effects on nutrients. In general, conditions currently used in thermal processes have been determined experimentally and are far from optimum (32). Pressures to optimise are growing for reasons of quality retention, energy saving, etc. as well as for minimising nutrient losses. There are continual efforts to close the gap between the quality attainable in frozen foods and thermally processed foods (32). The optimisation needed will be facilitated by developments in computer modelling of processes, better sensors, better microelectronic control systems, etc. Many of the new technologies in thermal processing predicted (24, 32) to have a major impact by 2000 and beyond (i.e. HTST - aseptic processing, microwave heating, multistage drying, extrusion cooking, novel packaging, etc.) will be considerably milder in their effects than those currently used, particularly when combined with advanced process optimisation. Developments in non-thermal technologies which can substitute for some thermal processing (i.e. freeze concentration, extraction technologies, ultrafiltration, reverse osmosis, etc.) also provide major opportunities for nutrient retention.

Consumption of fresh and minimally processed chilled foods is estimated to grow by 100% by 2000 A.D.; the corresponding projected changes for frozen and canned foods are respectively +25%
and -25% (24). The absence of a major processing step in producing these products will reduce nutrient losses. However, extension of shelf-life by modified atmosphere packaging, irradiation (if accepted by consumers) and other technologies may result in losses during storage which would not occur in fresh unstored foods. The likely magnitude of such losses is currently not well documented and is being assessed by a working group within the European COST 91 bis Programme. The group's findings will help to determine the nett gains or losses in nutrient retention in certain foods. However, since chilling is known to be of major benefit in retention of vitamins in stored processed foods (34) it is likely that losses will not be great and that there will be substantial nett gains from the growth in consumption of chilled foods.

3.3 Specific Developments: Toxicological Issues

3.3.1 Agricultural Production: Current concerns among consumers about the wholesomeness of food produced by modern agricultural technologies will receive increasing attention in the years ahead. This will include better communication of the role of agro-chemicals and their potential hazards, demonstrations that adequate surveillance of use and monitoring of residues is being carried out, etc. However, by 2010 there will probably be major changes in what consumers consider to be acceptable agricultural practices. For example, despite their potential technological and nutritional benefits, it is likely that veterinary chemicals which have even a remote chance of causing major biological effects in
humans (anabolic hormones, β-agonists, etc.) will not be acceptable for use in agriculture. Other chemicals - antibiotics, pesticides, fertilizers - despite being generally regarded as constituting little risk, each also present uncertainties as to their absolute safety, and research and regulations will attempt to minimise these uncertainties.

In the case of antibiotic use, improved surveillance and monitoring should eliminate hazards related to residues in food. However, the problem of development and transfer of antibiotic resistance will demand resolution. This will be heightened by emerging problems of resistance arising from antibiotic use in hospital wards. By 2010 therapeutic use of antibiotics in farm animals will probably be substantially reduced by major modifications to animal husbandry (improved practices and housing designed to minimise stress, reduced opportunities for disease transfer, etc.) and possibly through replacement of some antibiotics with vaccines.

In the case of pesticides, the possibility that hazardous chemicals might inadvertently remain on permitted lists will be reduced by advances in techniques for safety evaluation and by the availability of more data. In addition, some data will be available on the possible long-term and synergistic effects of low levels of pesticides in the diet. However, the high cost of these studies and the impracticality of covering the many possible
combinations of chemicals will mean that these issues will remain largely unresolved. As a result of this and because of environmental concerns, there will be considerable emphasis on agricultural practices which involve the use of less pesticides (integrated pest management) or no pesticides (organic farming). The nett effect will be to reduce the overall "chemical" burden on consumers by reducing the level of pesticide use.

The significance of the hazard posed by high levels of nitrates in vegetables and drinking water resulting from nitrogen fertilizer use is unclear. However, follow-up research addressing issues raised in a recent study by Forman et al. (35) should resolve the issue in the near future. Corrective steps (restriction of nitrogen fertilizer use, husbandry modifications) can be taken if necessary.

Of all the toxicological issues raised by technologies and practices used in agricultural production, the single largest change in research activity, regulatory attention and consumer concern will relate to natural toxicants (toxicant = toxic substance; toxin = a specific poison of organic origin). By 2010 there will be major advances in analytical procedures, substantial developments towards quantifying the magnitude of the hazards posed by different toxicants, and developments in breeding to minimise the levels of the more hazardous toxicants in plants. Regulators will be faced with the prospect of acknowledging the presence of
suspected and known carcinogens in the food supply and of trying to distinguish between large and small risks (36).

3.3.2 Food formulation/processing: Continuing concern about the safety of food additives will affect use patterns in the future. A Delphi study carried out for the FAST Programme (24) predicts that the use of synthetic colours and flavours and the use of preservatives will decline in the next 10-15 years with a corresponding increase in the use of natural colours and flavours. The use levels of emulsifiers, stabilisers and sweeteners are unlikely to change. Based on concerns identified in a previous FAST report (1), additives which cause allergic reactions will probably be eliminated by 2010. Where possible, additives are likely to be manufactured using biotechnology-based processes rather than by processes involving chemical synthesis. The new milder processing technologies and improved process control discussed earlier will have important roles in eliminating the need for some additives (37) and in facilitating the use of natural additives since many natural additives are heat labile.

It can be expected that by 2010 testing protocols which are acceptable to regulators and consumers for evaluating the safety of novel foods and novel food processes will have been worked out. This will be particularly important in facilitating the introduction of novel foods/processes which can improve the nutrient balance or reduce the chemical burden in foods. The
absence of protocols in which the consumer has confidence has been one factor (though not the only factor) in the current controversy over the wholesomeness of irradiated foods. Food irradiation appears to be a safe technology (38) and could play a significant role in reducing microbiological hazards in the food system (37, 39). However, the extent of uncertainty surrounding its likely acceptability by consumers is such, that by 2010 it may be either a leading novel technology or be relegated to minimal use (37). The availability of agreed protocols will help minimise such controversies in the future.
CONCLUSIONS

1. The subtleties of food composition and of the interactions between foods and certain diseases will be understood and so prudent diets will be more easily planned.

2. Nutritional profiling at individual level will be standard practice by 2010 and will result in individualised diets. Personal monitoring of nutrient intakes will be commonplace using home computing systems.

3. There will be a massive increase in the sale of "tailor made" readily available foods for the young and old and for consumers with specific diseases or metabolic disorders.

4. Advances in risk factor analysis will result in greater attention to currently emerging biochemical and physiological mechanisms of disease development.

5. The benefits from "natural complexity" in foods will be realised as will the protective effects of certain food constituents against specific diseases/disorders.

6. The role of preventive and alternative medicine in disease prevention/treatment will expand dramatically by 2010.

7. No significant formal intervention (for reasons of human
nutrition as distinct from economic considerations) by European governments or by the EEC in food production, processing or retailing seems likely up to the year 2010.

8. Home shopping for food is unlikely to be popular but home delivery of a wide range of ready-to-eat foods will be commonplace.

9. The core elements of current dietary recommendations seem set to continue unchanged well into the 21st century; however, some of the fringe elements will be subject to modification.

10. Improved agricultural production methods will result in food crops and animals with a better nutritional profile (e.g. higher vitamins, less fat) with less contamination from farm chemicals, veterinary products and (in the case of plant foods) with lower levels of natural toxicants.

11. Nutrient losses in food during storage and processing will be minimised through the greater use of chilling and modified atmosphere packaging together with optimisation of conventional preservation processes, e.g. canning.

12. Risk assessment techniques will have improved dramatically by 2010 leading to a greater acceptance by consumers of certain foods and food processes; i.e. consumers confidence will be largely restored.
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