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# Proceedings

# What will the Agri-Food Industry Look Like in 2015?

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## 1. Introduction

**In addressing the question posed in the title of this presentation – *What will the agri-food industry look like in 2015?* – it is proposed to start with a brief profile of the industry, followed by an outline of the major international developments that are likely to impact on it in the early decades of the new millennium.**

**A scenario of the industry in 2015 will be presented, describing the economic environment in which it will be operating, the expected structure of the sector and how the conflicts between biotechnology and consumer demands may be shaping its future direction.**

**Given the period of reduced uncertainty following the Berlin Agreement, the opportunity must be taken to develop the technological competencies and human resources necessary to ensure the international competitiveness of Ireland's agri-food industry in the 21st century.**

## 2. Profile of the Agri-Food Industry in Ireland

Among the important features of the industry are:

- Two-thirds of the total land area is farmed, amounting to 4.43 million hectares in 1997.
- The percentage of the work force accounted for by agriculture (12%) is more than twice the European average (5.1%). Total employment in the sector is 130,000, with a further 45,000 engaged in food processing (1996).
- Agricultural incomes amounted to IR£2.1 billion in 1998, which is 5% of National Income. The food industry accounted for a further IR£1.7 billion
- Agri-food exports account for 32% of the net inflow of funds from international trade (1995).

## 3. Drivers of Change to 2015

- The predominant developments that will determine the future of the Irish agri-food industry are:
  - The further reform of the EU Common Agricultural Policy (CAP) leading to reduced price supports for agricultural products.

- The outcome of negotiations (starting this year) under the World Trade Organisation (WTO) expected to result in more liberal world trade and much greater globalisation of markets.

The main strategic challenges facing the agri-food industry derive from these inter-related international developments. Other important drivers of change are outlined below.

### 3.1 World developments to 2015

- World population will grow from 5.3 billion in 1990 to 7.0 billion in 2010 and possibly to 7.5 billion by 2015. This will be attended by a corresponding increase in the demand for food products.
- The growth of world agricultural production (1.8% per annum) will be slower than in the recent past but, will still exceed the projected rise in the world population.
- World free trade in agricultural products could be substantially achieved by 2015.
- The consumption of livestock products will continue to grow, particularly in developing countries.
- The production of cereals for use as animal feed will increase.
- Food sales in developed countries will grow in value but not appreciably in volume.
- More developing countries may evolve from being net agricultural exporters to becoming net importers of agricultural products.
- In predicting continuing long-term economic growth, particularly in Asia and Latin America, cognisance must be taken of the likelihood of regional and short-term fluctuations.

### 3.2 European developments to 2015

- Consumer demands for assured food safety, protection of the environment and animal welfare will be increasingly enshrined in legislation and will pose growing constraints on food producers and processors.
- A related issue of central importance is the extent to which the EU accepts biotechnology, including genetically modified crops and animals.
- Incomes will grow to a greater extent than the demand for food and will be attended by increased demands for environmental goods.
- With an ageing population, together with an increasing interest in the health attributes of food, there will be a growing market for functional foods.
- Changing family, and other circumstances, will have a significant impact on farming practices and systems.
- Consumer preferences, habits and lifestyles will lead to a much more dynamic consumer market for convenience foods and niche products.
- Fresh produce will be available from worldwide sources.
- Through the more widespread use of information technology, the market intelligence available to food companies and retailers will enable them to target individual consumers. Also, a substantial proportion of consumers will shop for food and other products on the Internet, leading to the creation of a global market.

## 4. Scenario for the Agri-Food Industry in 2015

Having outlined the major drivers of change that will impact on the sector, attention will now be given to responding to the question posed in the title to the presentation – **What will the agri-food industry look like in 2015?** The economic environment in which the industry will be operating is clearly of paramount importance in determining the future size and structure of Ireland's agriculture and food processing sectors. However, a more intractable determinant, namely the conflict between technological developments, notably biotechnology, and consumer concerns, is also shaping the future direction of the industry not just in Ireland but throughout Europe and elsewhere.

### 4.1 Economic environment

The agri-food industry will be operating in an environment characterised by:

- A sustained focus on international competitiveness.
- More liberal world trade, with much reduced protection from global competition.
- Reduced price supports for agricultural products.
- Substantially greater requirements in relation to assured food safety and quality, protection of the environment and animal welfare.
- Ubiquitous application of information technology and probably also biotechnology.

### 4.2 Structure of the agri-food industry in 2015

In response to the pressures highlighted above, the pace of structural changes in the sector will be accelerated. While the number of farms and food processors will be significantly reduced, the scale of individuals operating units will be substantially expanded.

In the 1998 Labour Force Survey, 100,000 people are enumerated as farmers. Further escalation of the ongoing downward trend would reduce the number of commercial full-time farmers, together with those making a significant proportion of their income from farming, to something in the region of 50,000 – 60,000 by 2015. As discussed in Section 6.1, this sharp drop in farmer numbers is already being reflected in the dramatic decline in recent years in the number of young people participating in agricultural education and training and entering the industry.

**It is envisaged that in 2015 the agri-food sector in Ireland will comprise:**

- Some 20,000 commercial full-time farmers, predominantly dairy producers, (up to 13,000 each producing on average 100,000 gallons of milk per annum) together with about 4,000 beef/drystock farmers, possibly 2,000 arable/horticultural producers, 1,000 sheep farmers and less than 500 pig producers
- Some 30,000-40,000 part-time livestock producers deriving a significant portion of their income from farming – many will have farm-forestry and/or other enterprises.

From the viewpoint of having an internationally competitive agriculture in the next millennium, the above two categories of farmers are of paramount importance. Together, they will make up the bulk of the competitive farming sector. Also, they will be the main users of the advisory and research services. Accordingly, it is essential that potential entrants to both categories are made the primary targets of the restructured education and training programmes, outlined in Section 6.1.

There will also be some 20,000-30,000 farmers with jobs, deriving a smaller proportion of their total income from farming, as well as 20,000 farmers exiting the sector.

- A small number of Irish-based multinational food companies. There may be no more than two major dairy companies, each processing in excess of 0.5 billion gallons of milk annually. The beef processing sector will undergo even greater rationalisation, resulting in less than four or five beef slaughtering companies handling at least 80 per cent of exports.
- Some 100 small and medium-scale food companies (each employing 50 to 250 people) supplying niche markets for prepared and semi-prepared consumer foods.
- Expanded markets for organic foods and horticultural products, in particular nursery stock and mushrooms.
- The market place will be dominated by the globalisation, or at least the Europeanisation, of the food retail sector.

### 4.3 Biotechnology and consumer concerns

In response to the growing conflicts between advocates of biotechnology and consumer concerns, it is possible to envisage the emergence of two agricultures in Europe during the early decades of the next millennium.

Firstly, Europe may develop a high-tech-biotech agriculture supplying consistent quality raw materials to those very large sections of society that need to have affordable food products. While this will continue to be the largest segment of agriculture, Europe may also develop a sizeable organic-ecological agriculture, supplying a growing number of discerning consumers who are more concerned with healthy eating. This does not imply that organic foods are inherently better than conventional foods in terms of nutritional composition or microbiological quality. However, organic livestock products in particular may have a higher purity status because of the lower use of agro-chemicals in their production. Whether, however, the same assurance can be given in relation to the possible microbiological contamination of organic foods, for instance vegetables, is less certain.

As the high-tech-biotech agriculture becomes more widespread, the greater is likely to be the consequential growth of organic-ecological agriculture. The emergence of the two agricultures may help to alleviate European consumer concerns over the more widespread use of biotechnology in food production. It may also provide a resolution to the damaging conflict that may arise in the upcoming World Trade Organisation (WTO) negotiations between the US and Europe in relation to the more universal application of biotechnology in food production. Such a dispute would further erode consumer confidence in biotechnology and could prove detrimental to its further development and application.

To ensure the balanced development of both agricultures, it must be recognised that competitive production in organic-ecological agriculture is more difficult to achieve than with high-tech-biotech agriculture. Thus, success in organic-ecological agriculture requires comprehensive research and training support. In addition, organic-ecological agriculture should focus on food purity and wholesomeness. Bringing in animal welfare concerns would increase livestock production costs. This could prove detrimental to the development of an internationally competitive organic-ecological agriculture.

In relation to the high-tech-biotech agriculture, the central question is – **How can consumer confidence in biotechnology be established?** This is absolutely critical in Europe, and is becoming more important in the US and elsewhere. If this is not done, and done rapidly, the fate that has befallen food irradiation may be repeated with biotechnology.

To secure consumer confidence, a number of issues need to be addressed with urgency. To begin with, one statement that should be precluded from all reasoned debate on biotechnology is that "genetic modification of crops is just a *continuum* of conventional breeding". Having said that it is just a "*continuum*", advocates of genetic modification of crops frequently go on to say that it is a "*technological revolution*". They cannot have it both ways. Genetic modification of crops is a *quantum change in technology* that brings with it huge potential benefits but possibly also unintended consequences.

Secondly, the reported benefits that biotechnology brings to consumers need to be scientifically documented. It is widely accepted that biotechnology has immense benefits in the medical and pharmaceutical fields. Thus, society is not against biotechnology *per se.* Rather, consumers perceive that the benefits of agri-food biotechnology are largely captured by multi-national companies and, to a lesser degree, by farmers. They are very sceptical about the tangible benefits to consumers.

The third area is the urgent need for a credible, regulatory framework in Europe for biotechnology. The Food and Drug Administration (FDA), together with other organisations, has done an excellent job in developing a rational and balanced public attitude to biotechnology in the US. It is becoming more widely accepted that Europe needs a similar organisation.

Fourthly, there is a growing need for public research and development institutions to become more centrally involved in agri-food biotechnology. The immediate priority is to evaluate, *in tandem*, genetically modified crops, both in terms of their agronomic performance and environmental risks. In many European countries, the public institutions that over past decades undertook comprehensive research on agricultural technologies have been significantly eroded. These institutions carried out credible impartial research, which gave consumers the confidence in new and emerging technologies that are now commonplace in food production. Further to this, a recent development which must be questioned is the growing preoccupation of researchers in universities and other public institutions with taking out patents to protect the intellectual property rights of their own biotechnology developments. Who is minding the house?

Society must have trustworthy, credible and impartial quantification of the environmental risks that are perceived to be associated with genetically modified crops. Otherwise, biotechnology, as already mentioned, may suffer the same fate as food irradiation. How can we ensure that this does not happen? There would be great merit in having a science-based audit undertaken of the reported benefits and potential risks that are associated with the application of biotechnology. To be credible, the audit must not understate the risks. Such an audit might help to alleviate the damaging international conflict between the US and Europe which, as previously mentioned, could arise in the upcoming WTO negotiations. Such a development could be detrimental to the further development and application of biotechnology.

## 5. Strategic Core Technologies and Related Competencies

The pace of structural change in agriculture and food processing is accelerating. However, with effective strategic management, combined with the necessary scientific, technological and innovative competencies, the value of Ireland's agri-food industry can be maintained and possibly expanded. This raises the central question addressed in the Technology Foresight Report on Natural Resources published by the Irish Council for Science, Technology and Innovation (ICSTI) in conjunction with Forfas, earlier this year, namely – **What core technologies and other related competencies need to be built up to optimise the position of the agri-food industry in 2015?**

The opportunity provided by the period of reduced uncertainty following the Berlin Agreement must be used to re-tool and re-direct the scientific and training support services for the agri-food industry. To ensure the future competitiveness of the industry, urgent priority needs to be given to building up strategic scientific and technological competencies detailed below:

### 5.1 Strategic research and development competencies

**a. The capacity to monitor, evaluate and harness appropriate developments in biotechnology,** with particular regard to:

- Assessing, *in tandem*, both the agronomic performance and environmental risks of transgenic crops under Irish conditions.
- Applying gene mapping in conjunction with *in vitro* culture methods to improve the efficiency of plant breeding and propagation.
- Developing DNA based diagnostic tests for plant and animal diseases and pathogens in food production and processing.
- Establishing a better understanding of animal reproduction mechanisms, in particular ovulation, oestrus detection and embryo survival.
- Identifying genetic markers to improve animal growth efficiency together with meat and milk quality.
- Developing improved food cultures and novel enzymes to enhance the quality, safety, functional and nutritional attributes of food products and ingredients.

As outlined in Section 5.2, a properly resourced national agri-food biotechnology research and development programme is essential if Ireland is to have an internationally competitive agri-food sector in the next millennium.

b. **Production and processing technologies and systems (combined with the necessary training programmes) that meet consumer demands for guaranteed food safety and assured freshness and consistent quality**, with particular regard to:

- Developing preventative measures at both farm and processing levels to ensure the microbiological and chemical safety of Irish food products and updating the National Food Purity Database.
- Developing strategies to maximise grass production and utilisation, together with nutritional and management regimes, designed to produce milk, beef, sheep and pig meats of consistent quality at minimum costs.
- Assessing the suitability of different dairy, beef and sheep breeds in grass-based production systems.
- Improving tillage and horticultural crop production, with particular regard to increasing production efficiencies while raising product quality and safety and minimising environmental impacts.
- Developing improved systems for the production and management of farm forestry and organic produce.

c. **Economically competitive and environmentally sustainable farm production and food processing technologies and systems,** with particular regard to:

- Quantifying and minimising the environmental implications of a range of farming systems, with particular attention to modelling the environmental risks of production systems and practices, in different geographical locations.
- Quantifying gaseous emissions from farming systems and developing strategies to reduce them.

d. **Provide the analytical capability to support policy developments for the agri-food sector and rural areas** with particular regard to:

- The further development of quantitative sectoral and farm models to project the impact on the agri-food industry of reduced price supports (CAP reform) and liberalisation of trade and globalisation of markets (WTO outcome) as well as environmental constraints and assessing their impact on rural areas.
- Developing models of consumer preferences to predict future demand in consumer markets for Irish food products and to guide product development and innovation.
- Developing information systems to support the strategic development of the agri-food industry and rural areas.

### 5.2 National Agri-Food Biotechnology Research and Development Programme

The Report of the National Consultation Debate on Genetically Modified Organisms and the Environment states that “70% of the forecasted growth in biotechnology will be in the agri-food sector”. The report goes on to point out that “in view of the importance of the agriculture and agri-food sector to the Irish economy…. (the) potential benefits of adopting biotechnology could not be ignored”.

Further to this, the aforementioned Foresight Technology Report states that biotechnology will be ubiquitous in the agri-food industry in the early decades of the next millennium. To have an internationally competitive industry in the immediate years ahead, Ireland must build, as a matter of urgency, a **World Class Capability in Agri-Food Biotechnology**.

As further detailed in Section 5.1, the main thrust of Ireland's research and development programme in agri-food biotechnology should be directed towards the evaluation, adaption and application of emerging biotechnologies, the bulk of which will have been developed elsewhere.

To put in place this vital strategic capability as rapidly as possible and without unnecessary expenditure on "bricks and mortar", immediate priority needs to be given to developing three applied Biotechnology Centres in Crops, Livestock and Food by upgrading existing research facilities. The investment necessary would be of the order of £50-£100 million over 5 to 7 years. To be successful, it is essential that each of the centres has the critical mass of scientists and technologists with a firsthand knowledge of ongoing advances in biotechnology.

## 6. Training

### 6.1 Mainstreaming agricultural education and training programmes

Notwithstanding the absolute need to put in place, as a matter of urgency, strategic scientific and technological competencies outlined in Section 5, there is little point in doing so unless the end users are effective receptors of emerging technologies. In particular, farmers and food processors must have the education and training necessary to harness the technologies. It is no exaggeration to state that the most serious threat to the future welfare of Ireland's agricultural industry is the aforementioned dramatic decline in the number of young people participating in agricultural education and training programmes and entering the industry.

Since 1994, the number of school leavers enrolling in Teagasc's programmes has fallen by almost half (1,800 to under 1,000). By 2010 the number of potential young farmers will have halved again, resulting in a continued decline over the coming decades in the number of young people participating in agricultural education and training. Many crises have hit the agricultural sector in recent decades. However, few are more serious than the durable impact that the cascading decline in the number of young people availing of agricultural education and training, and entering farming, foreshadows for the international competitiveness of the agri-food industry in the next century. It is somewhat ironical to record that as Ireland entered this century, proper education and training was one of the main pillars of Horace Plunkett's resolute campaign for "*Better Farming, Better Business, Better Living*". We will, of course, be celebrating the extraordinary achievements of Horace Plunkett in the Centenary Conference being organised by the Department of Agriculture, Food and Rural Development early next year.

While the number of farmers will be reduced by half or more over the coming decades, the scale of individual farms will, as already indicated, be substantially increased. The larger enterprises will require higher levels of technological and business skills for their profitable operation. To ensure the continued competitiveness of Ireland's agricultural industry, it is essential that the progress made in the past decade in raising the educational attainment of young farmers is maintained and, where possible, accelerated.

With the objective of raising participation rates in education and training for agriculture and attracting more able school leavers, plans are well advanced to have Teagasc's training programmes maintreamed by incorporation into the CAO Application System. The accreditation of the courses by the National Council for Educational Awards and the National Council for Vocational Awards (both councils are being incorporated into the National Qualifications Authority) will allow those students who reach the necessary standards to progress to third level diploma and degree qualifications in agriculture, horticulture and other enterprises.

### 6.2 Nationally accredited food industry training system

The grave prospects arising for the agri-food industry from the severe downturn in the demand for education and training of future farmers (Section 6.1) is further exacerbated by the longstanding, and well-documented, low level of training undertaken by a substantial proportion of those employed in the food processing sector.

The level of training undertaken by Irish food companies is less than half that of their international competitors. The critical need for a concerted systematic approach to properly accredited food industry training is repeatedly highlighted in a number of recent reports, including:

- The Food, Drink & Tobacco Industry Sectoral Study 1998-2003 (Submitted to FAS and the Food, Drink & Tobacco Industry Training Committee by Goodbody Economic Consultants, 1991).
- The Report of the Food Industry Development Group (1998).
- The Report of The Task Force on the Beef Industry entitled Preparing the Irish Beef Sector for the 21st century (1998).

To underline the vital strategic importance of addressing this need, it may be noted than an industry-led, structured national food training programme would do more to raise the long-term competitiveness of the sector than increased expenditure on research and development. Food training is a vital conduit for the transfer of research to food processors, as well as to farmers.

The new science-based food safety systems, now becoming mandatory throughout the entire food chain from farming to retailing, will greatly increase the demand for properly designed technical training courses for food operatives, regulators and managers. The provision of such courses is a prerequisite to inculcating a food safety culture at all levels within the industry. Other key industry areas where there is a growing training demand include advances in processing practices and technologies, innovative technical management and information technology.

To meet these needs a **Nationally Accredited Food Industry Training System,** benchmarked to the best international practice, must be developed as a matter of urgency. To achieve this, priority needs to be given to investment in the:

- development of nationally accredited courses
- provision of training facilities linked to research
- training of in-company trainers.

In parallel with the mainstreaming of agricultural education and training (Section 6.1) food industry training should be incorporated into the general training provision currently accredited by the NCEA and NCVA.

Human capital is a vital resource in an increasingly "knowledge based" economy. To prosper, the agri-food industry must have a properly trained workforce in farming and food.

## 7. Conclusion

A quantum mindset change is required in the way we look at the competitiveness of the agri-food industry. In particular, it must be recognised that competitiveness is becoming:

- Multi-dimensional, and
- Knowledge driven.

Although perhaps an over-simplification, the single most fundamental change already underway is the shift in competitiveness away from being largely a single dimensional requirement to becoming a multi-factoral prerequisite. Throughout the 1970s and most of the '80s, competitiveness was largely seen as a single dimensional requirement, namely cost of production. There are now at least five dimensions to food competitiveness. Cost of production may still be the most important component of competitiveness. However, food safety has assumed central importance; and, together with consistent quality, wholesomeness and animal welfare, are rapidly gaining in importance on the cost of production. It would be most informative and beneficial to the industry to quantify and track the relative importance of the five dimensions of competitiveness in different countries and trading blocks.

As we enter the next millennium, competitiveness is becoming increasingly dependent on goods and services which have a high knowledge content. The Technology Foresight Ireland Report entitled *An ICSTI Overview*, stressed the strategic importance of Ireland developing a *Fourth Level* Science and Technology capability in addition to the further development of the Primary, Secondary and Third-Level education systems. The Fourth Level Capability (Appendix, Figure 1) would comprise "world class research activities including training in selected areas", aimed at putting in place "multidisciplinary and commercial skills in partnership with industry, in the context of industry development priorities".

To prosper in the knowledge-based economy, the agri-food industry in Ireland must give immediate priority to:

- building up the necessary core technological and related competencies, in conjunction with
- developing the human resources in farming and food.

## Acknowledgements

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## References

This paper draws extensively from the following reports:

Technology Foresight Ireland – An ICSTI Overview (ICSTI and Forfas, April 1999).

Technology Foresight Ireland – Report from the Natural Resources Panel (ICSTI and Forfas, April 1999).

Towards a Resolution of the Biotechnology Conflict – Summary Address by the Author at the World Agricultural Forum (Missouri, May 1999).

Agri-Food 2010 Committee – Submissions by Teagasc – The Agricultural & Food Development Authority (September 1999).

National Consultation Debate on Genetically Modified Organisms and the Environment – Report of the Chairing Panel (July 1991).

# *Beyond Agenda 2000:* What will be the effects of drastic farm policy liberalisation?

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**Last week, the ministerial conference of the World Trade Organisation (WTO) started a new round of negotiations on international agricultural trade. The European Union is ready to negotiate the level of export subsidisation and other forms of price support in order to retain the direct allowances initiated by the MacSharry reform in 1993. These are needed, it maintains, to defend the 'multifunctional role' of its agriculture. This position is criticised by the Cairns Group, which demands complete liberalisation of agricultural trade, and by the US, which pretends to support this goal. At the end of my paper I will briefly go into the more down-to-earth motives behind the lofty principles of the main players. However, let us first look at the possible consequences of the full liberalisation that the US and the Cairns Group profess to pursue.**

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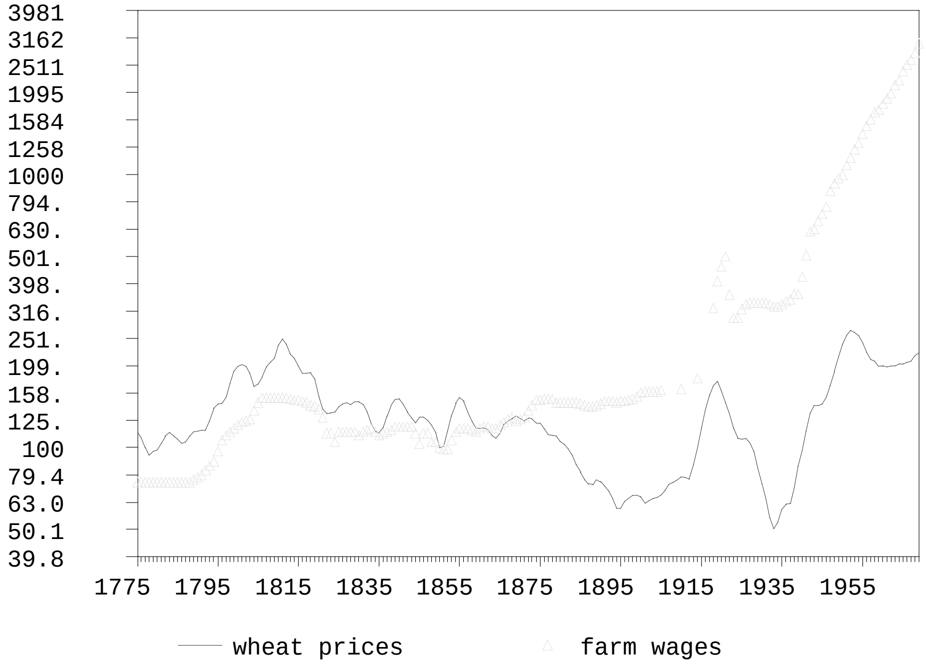
According to a standard view, protection is merely caused by political factors. It is unnecessary for agricultural development, and leads to distortions. Renouncing protection should lead to welfare gains. Agriculture may go through some difficult years of adjustment, but afterwards farm profits and productivity growth should recover. This is a hypothesis. One way to test it is to look at the historical record, so let me recapitulate the history of agricultural protection. Modern agricultural protection started in the late 19th century as a reaction to the evolution of agricultural prices. From about 1875, agricultural prices became much more volatile and fell to a lower average level than they had been since the mid-18th century. At the same time, farm wages became more inflexible and consistently higher. (See the evolution of wheat prices and farm wages in Figures 1(a), (b). N.B.: the post-World War II rise in wheat prices was not real because of inflation.) As a result, most countries in Western Europe resorted to protection. By the 1930s, all developed countries had begun protecting their farm sectors.

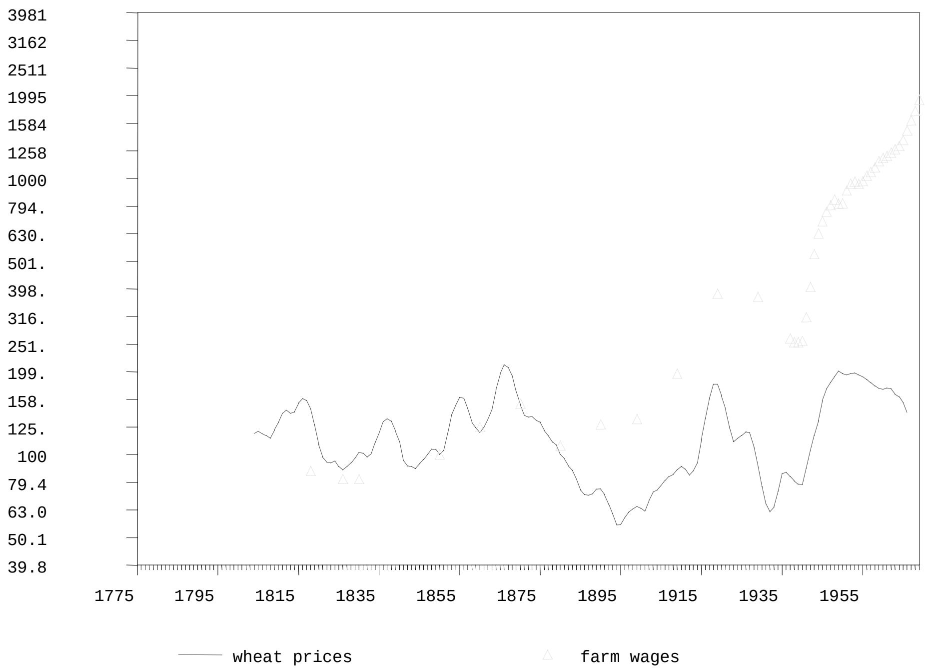
What happened in the developed countries that had initially resisted or eventually abandoned agricultural protection? Between 1875-1930, Denmark, the Netherlands, and the white settler countries across the ocean still stuck to free trade. These countries had special advantages in agriculture. They adjusted more or less to conform to the standard view, but real recovery had to wait until world market prices temporarily rallied at the beginning of the 20th century. The UK also stuck to free trade. It had the most technically advanced agriculture in the world, but industrial competition for labour had raised farm wages and it no longer had a comparative advantage in agriculture. According to the standard view, adjustment would have involved a reduction in the share of agriculture in the economy, but should still have led to a recovery of profits and productivity growth in the farm sector. In reality, farm profits remained low, and

**Figure 1: Nominal wheat prices (5-year moving average) and farm wages (1850 = 100)**

**(a) England and Wales**




**(b) United States**

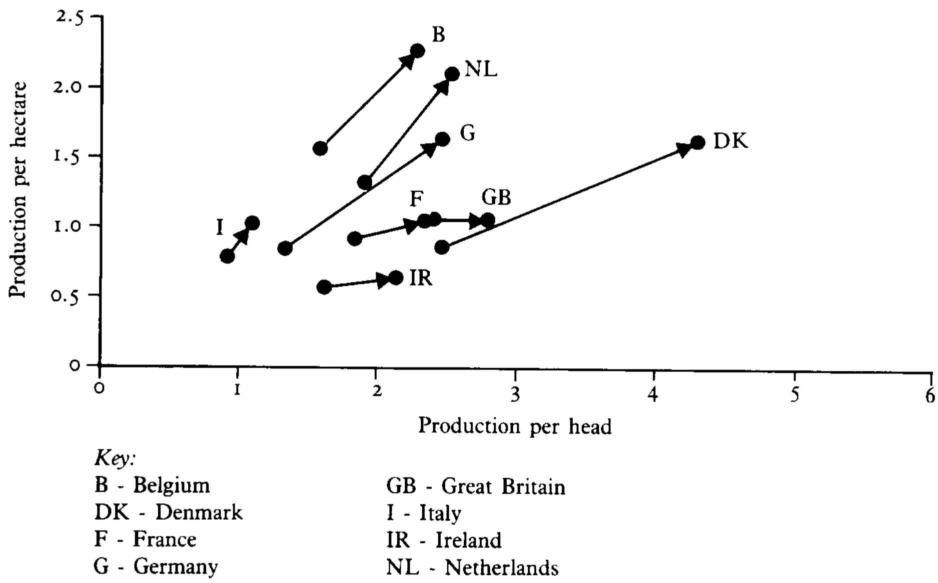



Sources: See Koning (1994).

productivity stagnated throughout this period (see Koning 1994 and literature there referred to). Already by the eve of World War I, Britain had fallen far behind the European productivity frontier (see Figure 2). Conversely, Germany, the textbook case of agricultural protection, rapidly increased its farm productivity and took Britain's place at the frontier.

After World War II, the record becomes scantier, because most countries stuck to protection. In the 1950s, the US and Denmark tried to return to free market policies. However, these cases are inconclusive, because political reactions to falling farm incomes led to a return to protection after a few years. In Denmark there were signs that productivity growth was being affected, and model studies suggested that the same would have happened in the US had the experiment been continued (Cochrane and Ryan, 1976; Koning, 1986). After 1984, New Zealand abandoned protection. This country has a clear competitive advantage in livestock and horticulture. The impact on farm incomes was alleviated by massive debt remission and a simultaneous liberalisation of labour markets and industrial trade, but monetary reform increased the problems for farmers, because exports were hampered by revaluations. If you speak with representatives of the New Zealand Ministry of Agriculture they will probably tell you that the adjustment was a success; but in fact, it had a mixed outcome. Agricultural area decreased by 20%. The output of horticulture and milk increased, but that of beef and sheep declined. The labour volume remained stable, but family workers were substituted for hired workers (Johnston and Frengley, 1992). In horticulture, productivity growth increased, but this was probably due to investments made before 1984. Meanwhile, in the livestock sector, which makes up two-thirds of New Zealand's marginal lands and other production factors (Philpott, 1994). In fact, this means that

**Figure 2: The growth of agricultural productivity per head and per hectare in eight countries of Western Europe, 1870-1910 (in wheat units and prices of 1870)**




Source: Van Zanden (1991).

productivity growth decreased. Finally, investments in agriculture have considerably decreased (Cloke, 1996; Gibson *et al.*, 1992), but the long-term effects on innovation and productivity are still unknown. One might suggest that, to some extent, agricultural adjustment in New Zealand was saved by the lucky coincidence of an economic boom in land-lacking East Asia, which stimulated the demand for New Zealand's livestock products.

New Zealand is the only case of real farm policy liberalisation in developed countries after World War II. Aside from this case, we have only indirect evidence. For example, we can compare the rates of productivity growth in agriculture in countries with different levels of agricultural protection. Countries with moderate protection appear to have higher productivity growth than countries with high protection. But it also turns out that countries with low protection have less productivity growth than those with moderate protection (Van der Meer, 1989).

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So the empirical record does not unambiguously support the standard view on agricultural liberalisation. Another question is that of its theoretical status. The standard view is often associated with modern micro-economic theory, but the relation is tenuous. Micro-economic theory is better in predicting the short-term effects of policy reform than the long-term dynamic effects. Moreover, the standard view is based on a simplistic version of economic theory, in which a smooth reallocation of labour is ensured by perfect information, fixed preferences, and well-functioning labour markets. More advanced micro-economic theory points to mechanisms that can hamper the flow of labour out of a depressed sector. For example, information problems of non-farm employers may make it rational for them to pay higher than market-clearing wages, which can cause unemployment, age discrimination and other obstacles for farm workers who want to change jobs (e.g., Akerlof and Yellen, 1986). Also, instead of leaving a depressed sector, people may react by psychological and cultural adaptation. A colleague and I have made a theoretical model, which illustrates how adverse economic conditions may induce the formation of social norms that reduce the mobility of people, which leads to continued crowding and low earnings (Haagsma and Koning, 1999). Such mechanisms can slow down the outflow of labour, especially in a sector like agriculture, which is spatially separated from other sectors and in which many workers are self-employed.

If reallocation is slow, the profitability of a sector becomes sensitive to forces that influence the growth rates of the supply and demand for its products. Between about 1750-1875, demand for farm products was stimulated by a demographic upswing and an industrialisation that made extensive use of farm-based materials and energy sources. Conversely, lack of fertiliser and high international transport cost made it difficult for the supply to keep up with the increase in demand. As a consequence, agricultural prices, profits and land rents were quite high in this period. From the late 19th century, however, the acceleration of population growth levelled off, while the rise of electricity, internal combustion and industrial chemistry entailed a massive substitution of minerals for farm products. At the same time, the chemical industry provided fertilisers that boosted yields, while steamships and railways induced a rapid expansion of an export-oriented commercial agriculture outside Europe. The farm depression in the late 19th century was not only caused by a shift in comparative advantage, as the standard view would have it, but also because these new forces boosted the supply of farm products ahead of demand. To defend their incomes, however, farmers only more eagerly seized the new possibilities to raise their production, helped by government-sponsored research and extension. In this way, technical change became a treadmill that generated overproduction. Because reallocation was slow, a balance between supply and demand growth was achieved, not by the outflow of farm labour, but by a chronic profit squeeze which reduced investment and innovation. One could say, the treadmill only stopped accelerating when its speed squeezed its own fuel supply. This is the pattern that is suggested by Britain in 1880-1930, and which is not clearly contradicted by New Zealand today.

Of course, the EU is different from the UK around 1900. Farm and non-farm labour markets have become more integrated. In many regions in North-western Europe, with suburbanised rural areas, it is hard to imagine that farmers would adjust to price reductions by withdrawing into an isolationist agrarian culture and voluntarily accepting earnings far below those in other sectors. On the other hand, the inflexibility of non-farm wages has increased, and new skill requirements may also hamper a rapid outflow of farm labour. Moreover, there are large differences within the EU. In some member countries, agriculture's share in employment is not unlike that in Britain around 1900.

What could be the effects of a far-reaching liberalisation if reallocation is still slow, so that agricultural response still resembles that in Britain in the early 20th century? Like in Britain at the time, not all of agriculture would become stagnant. However, the dynamic would withdraw to the most favoured regions and sectors. For example, arable farming in Northern France or Eastern England, livestock in Denmark, or horticulture in the Netherlands. Outside these pockets of continued dynamism, however, agricultural progress will slacken. Some relief may be found in the partial transformation of farming into a green services sector. This is central in the EU's rural development policy, but the economic possibilities of this approach should not be exaggerated. Markets for farm tourism or organic foods are limited even if they are growing. A niche market strategy for selling high value-added artisanal foods will not compensate for a sector-wide decrease in protection. There are some successful cases, but their results cannot be generalised: the margins earned by some early adopters of this approach will be eroded by competitive niche formation among those who try to emulate the success.

How would a far-reaching farm policy liberalisation affect rural society? The common wisdom is that the effect will be limited because the share of agriculture in rural economies has strongly decreased. I wonder whether this is entirely realistic. For example, can the contribution of farm incomes to regional demand be equated to agriculture's share in regional production? A larger share of farm incomes may be spent locally than the shares of incomes earned in the tourist industry. And what about the linkages between farming and other rural activities, or the importance of farming for social and economic continuity? A deserted region where farmers have left will not easily become an attractive location for other enterprises or even tourism. Of course, in urbanised rural areas, like the Netherlands, the impact of a decrease in farm incomes will be slight. Whether this is also true for other regions is a moot question.

Another question concerns the effect of liberalisation on long-term global availability of food. At first glance, it seems somewhat outdated to raise this question. Food availability is no longer on the farm policy agenda. In a world plagued by farm surpluses, it is not seen as a serious concern. However, the global food situation in the next century may differ from that in the past. Scarcity gave way to abundance after the late 19th century because new developments in industry and transport boosted farm production. However, this was based on the tapping of easily exploitable reserves, which are now becoming scarcer. To be sure, the world's biophysical carrying capacity for farm production is still sufficient. Table 1 shows recent estimates of this capacity by Wageningen agronomists. The bottom line indicates that the capacity is large enough to feed the world population at its probable peak in the mid-21st century – even if the population increase would conform to the highest projections, everyone

**Table 1. Ratio of potential food supply and projected food demand in 2040, for selected regions. (For demand, two extreme combinations of population and diet and an average combination are used. Potential food supply is shown for high external input (HEI) and low external input (LEI) farming systems)**

| | HEI system | | | LEI system | | |
|---|---|---|---|---|---|---|
| Region | Vegetarian diet, low population | Moderate diet, medium population | Affluent diet, high population | Vegetarian diet, low population | Moderate diet, medium population | Affluent diet, high population |
| South America | 89.2 | 41.7 | 20.0 | 30.1 | 14.1 | 6.8 |
| Central America | 15.6 | 7.2 | 3.5 | 6.8 | 3.1 | 1.5 |
| North America | 49.3 | 22.3 | 10.5 | 25.0 | 11.3 | 5.3 |
| West Africa | 16.0 | 6.4 | 2.9 | 6.8 | 2.7 | 1.2 |
| Southern Africa | 31.0 | 14.8 | 6.9 | 14.6 | 7.0 | 3.3 |
| South-East Asia | 11.8 | 5.1 | 2.4 | 3.8 | 1.7 | 0.8 |
| South Asia | 3.7 | 1.6 | 0.8 | 2.0 | 0.9 | 0.4 |
| Europe | 13.5 | 6.4 | 6.4 | 6.5 | 3.1 | 1.6 |
| World Total | 19.7 | 8.8 | 4.2 | 8.4 | 3.7 | 1.8 |

Source: Penning de Vries *et al.* (1995)

on earth would have affluent diets, and agriculture would generally be on a low external inputs base (see bottom right of the table). However, in this case, the margin is not very wide: the global maximum is less than twice the projected demand. Also, over three-quarters of the biophysical reserves are in regions like Latin-America, Sub-Saharan Africa and ex-USSR countries, where institutional problems will complicate their exploitation. Moreover, vast investments and innovations will be needed to reclaim the potentials indicated by these estimates. It is quite possible, therefore, that the supply of food will have more difficulty keeping up with demand in the next century than it did in the past. The World Bank and the International Food Policy Research Institute are still predicting further decreases in international farm prices in the next decades (Mitchell *et al.*, 1997; Rosegrant *et al.*, 1995), but their projections are based on heroic assumptions and filled with uncertainty. Other economists think that farm prices will have to rise to balance supply and demand. If they are right, timely investments in research, soil improvement, infrastructure and human capital are needed to avoid unnecessary scarcity in the future. This is especially important because these investments involve long gestation periods. However, a world-wide liberalisation of farm policies in the final phase of an outgoing age of overproduction would cause farm prices to fall, especially in the countries that have the most means for such investments. It would give an entirely wrong signal as to future needs, and might induce an undershooting of investment levels that are needed to ensure sufficient availability of food in the long term. After some time, this could lead to soaring agricultural prices in world markets, which would not hurt rich countries very much, but would cause havoc in net food-importing poor countries.

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These assumptions are based on a world-wide dismantling of farm income supports. However, how plausible is it that such a dismantling will occur? The Cairns Group demands world-wide liberalisation, but there are signs of dissension. Farmers' organisations demand a guarantee of support if global liberalisation is not achieved; richer Cairns Group countries are supporting their farmers by 'non-distorting' measures; and in East-Asian Cairns Group countries, small rice and maize farmers are contesting the liberalisation campaign that is supported by the lobbies of Malaysian palm oil plantations, Philippine coconut oil exporters
and Bangkok-based rice middlemen. In any case, the Cairns Group cannot sway the GATT/WTO negotiations, and it looks to the US for support. The US talks about liberalisation, but the dynamics in its farm politics work toward offensive protectionism. Its 1996 farm act uses 'de-coupled' allowances to abandon acreage reduction programmes and expand farm exports against prices that are below the country's own costs of production. This is not liberalisation, but a form of disguised dumping – an option that is only open for rich countries. Countries with more farmers and smaller treasuries have more difficulty supporting their farmers by direct allowances.

So the liberal block in the GATT/WTO is not quite as liberal as it seems and it suffers from internal division. This block is resisted by the EU and agricultural importing countries like Norway, Switzerland, South Korea and Japan. They want to protect their agri-sectors and less favoured rural regions, and therefore talk about the blessings of multi-functional agriculture that deserve continued support. Can we therefore conclude that a far-reaching liberalisation of farm policies will not be realised, and that the negative effects that I have indicated will not occur? Yes and no. Full-fledged liberalisation is improbable, but the struggle for market shares between the big powers might still drive farm income supports down to a level that could cause problems now and in the future. To force up its share in world markets, the US tries to outlaw tariffs and other support instruments that are within reach of other countries. In turn, the EU is ready to negotiate its level of price supports to keep room for MacSharry-type allowances, which it wants to use in a similar way as the US uses its decoupled allowances: to expand farm exports at prices below the costs of production. So the main powers would engage in disguised dumping practices that would push world market prices under the already low levels that would result from a free market, while the rest of the world is stripped of possibilities to shield its farmers from these low prices in the world markets. The EU also has an interest in maintaining low prices in the Central and Eastern European grain belt. It wants to reduce its farm prices and compensate current EU farmers by direct allowances before the accession of new member states. These allowances can then be denied to farmers in the new member states because they never had the higher prices. In this way, the EU hopes to avoid a hard choice between restricting its own production to create room for new member states in its own markets, and confronting the US with a demand to re-negotiate the trading rights of these countries. The effect is not hard to imagine. Just think of how Irish agriculture would have developed had this strategy been applied in 1973.

So, although a wholesale liberalisation is not forthcoming, the struggle for market shares may lead both to continued dumping and to a restriction of possibilities to support farm incomes. It is questionable whether this will merely have positive effects, as the standard view would have us believe. More attention has to be paid to the dynamic problems of agri-food in a global economy, which evolves in a more complex way than this view assumes.

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# How has the 'Freedom To Farm' Legislation Impacted on the US Agri-Food Industry?

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**The United States went through a major policy debate in 1995 and 1996 on the road to passing the latest round of omnibus farm legislation. Officially titled the 'Federal Agriculture Improvement and Reform Act' or the FAIR Act, it is usually know in the vernacular as the 'Freedom to Farm' bill. The legislation was a major change in the approach to government involvement in agriculture in the United States. It has also engendered a wide range of responses since its passage, some positive, some not so.**

**This recent round of low commodity prices has certainly focused attention on the legislation and has produced a number of individuals and some trade organizations to call for a change in the underlying policy, including a reversion to earlier agricultural laws. Others suggest that the current market conditions are temporary and that the current policies will be very appropriate after the world economy recovers and begins to display the kind of growth observed in the early 1990's. Another camp suggests that what farmers are faced with are problems of risk management and indicate various strategies for dealing with risk, either as an insurance scheme or through some other management approaches that would deal with the short-run problem. And still others indicate that the problem is one of simply not enough cash. They would deal with the issue by simply providing our producers with additional funding in the form of exactly that, write a cheque.**

**It is informative to return to some of the history behind some of the reforms that have occurred in United States agricultural policy over the last couple decades in order to understand the driving forces behind those reforms as well as to understand the watershed events that have taken place over the last 2 years. The paper will also touch on where the policy debate in the United States sits at the end of the millennium, including the types of options being debated by the various trade associations and farmer organizations as well as indicating where the discussion may head over the coming few months. The paper will close with a discussion on how this policy debate may affect the United States position in the coming trade round.**

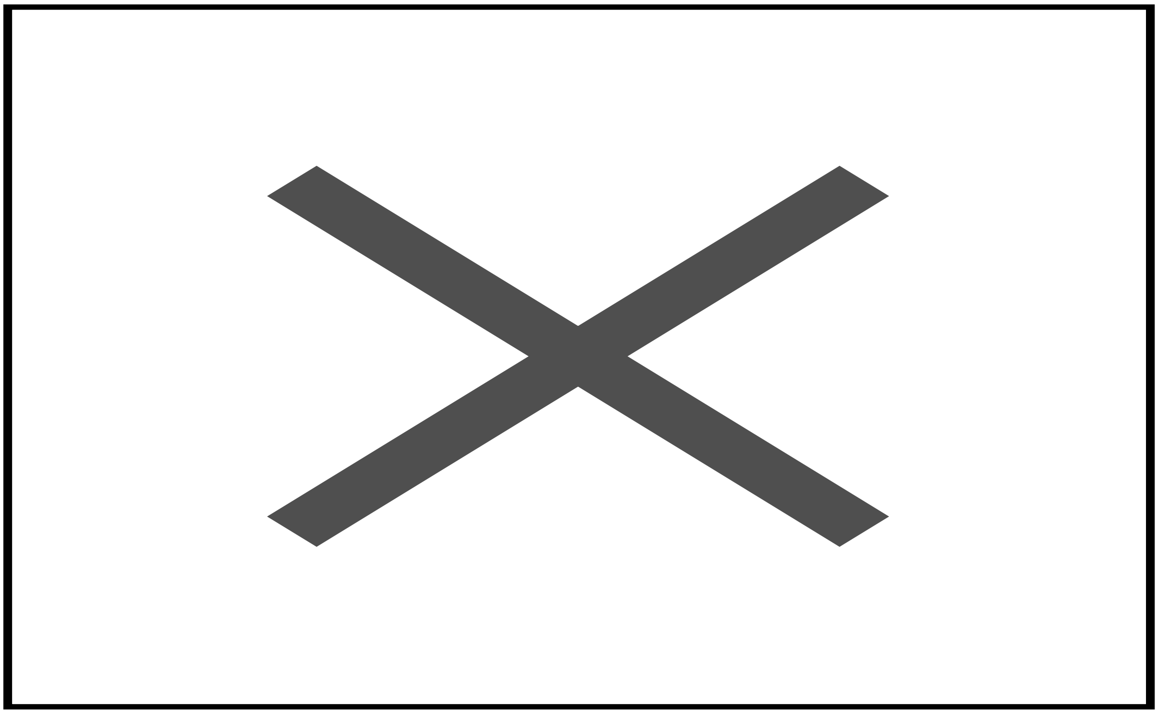
## Freedom to Farm's Historical Setting

The FAIR Act or Freedom to Farm (FTF) legislation was a major change in policy for the United States. It reflected a turn away from extensive government involvement in producer planting decisions. It removed the government from providing a price support floor to producers. It took away the government's role in providing a buffering stock response to high or low prices. It also took away any counter-cyclical payment program to help offset some of the fluctuations in market prices. In short, it provided producers with the freedom of the marketplace, with what were envisioned as some form of transition payments in order to give producers some guarantee of income as they learned lessons under the new rules.

One may well ask why producers were willing to give up the kinds of programs that had provided them with a well understood set of playing rules for so long. Essentially, the programs had come into being, and were essentially unchanged, in 1981. The government – read that as Congress – established a target price for the commodities, and provided a floor on most program commodity prices, in exchange for which producers agreed to limit their plantings within some historical base. Further, when supplies became large, producers were also required to take land out of production in order to get the price and income protection. Without a doubt, the willingness to give up the supports was not universal. When first suggested, many of the trade associations objected strenuously. The authors of the bill, however, recognized the long history of Congressional action, literally from 1982 on, to reduce the level of support. In short, they made the fundamental change in policy in order to have a known pattern of payments to producers from 1996 through the 2002 crop without fear of further budget reductions. It was a budget deal.

A quick examination of the history of support provided to agriculture in the United States through the regular programs probably makes this point best. Figure 1 gives the potential gross returns to wheat production per acre for a farmer who would have voluntarily entered the farm program. These are potential returns, because they remove the effects of the set-aside programs operated in a number of years covered by the graph. Two features added to the increase from the 1982/1983-crop year through the 1985/1986 period. The 1981 farm legislation incorporated an increasing target price (the price used to calculate payments) for producers, but also allowed producers to increase the yield on which they claimed payments every year. The 1985 legislation, on the other hand, fixed the target price. It also fixed the yields used to calculate the payments, thus the flattening of the potential revenues. The commitments made in the 1985 legislation however did not last long. In 1987, Congress faced large budget deficits and moved to reduce overall spending. Agriculture was viewed as being particularly vulnerable and was faced with reductions in the target price in one form or another due to Congressional action in 1988, 1989 and 1990.

**Figure 1: Potential gross returns to United States wheat producers under various farm programs**



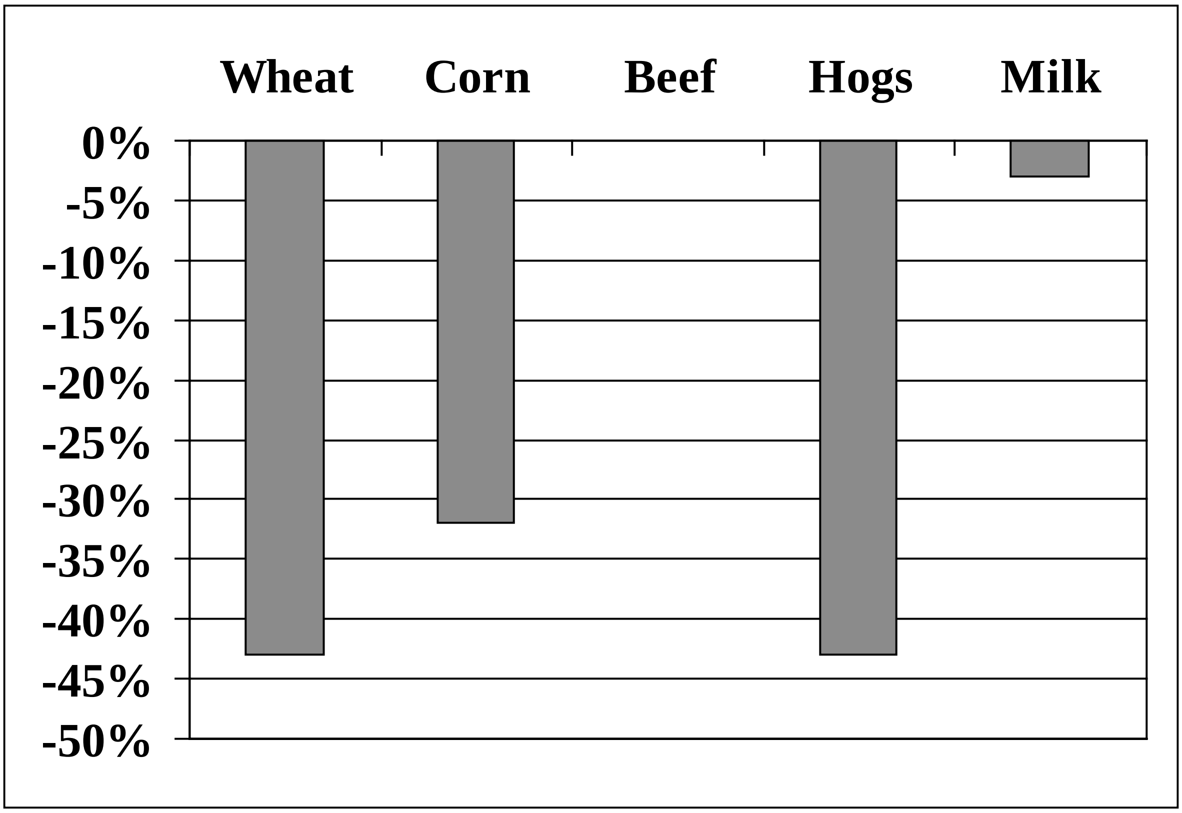
The 1990 farm bill, which was to govern the commodity programs for the 1991/1992 through 1995/1996 crops was also written in a budget deficit reduction climate. Rather than continue to reduce the level of support on a per acre basis, however, it was recognized that producers were locked into production of specific crops by the policies basic structure. In generating savings in the 1990 legislation then, the program simply stopped payments on 15% of the producer’s eligible base and freed the producer to plant essentially any crop desired. This was an early taste of planting flexibility some producers seemed to enjoy. The increases in potential revenue for the wheat producer after the 1991/1992 crop comes entirely from the improved yields and market revenues on that 15%.

The budget directive to the legislators when the 1996 act, the FAIR Act, was being developed was a savings goal of over $10 billion over the upcoming 7 years. The FAIR Act structured the payments in such a way that the producer signed a 7-year contract. The key here being a contract. Past long-term federal farm programs, such as the Conservation Reserve Program, had been held exempt from budget reductions due specifically to the long-term nature of the contract signed between the producer and the government. The 7-year FAIR Act contracts were structured to fit into the same mold. Taking such an action then locked in fixed government payments for the 7 years. This was viewed as a clever move in a budget deficit setting. Now that the United States is running budget surpluses, the view may have changed.

## The Current Situation

Market conditions at the time Freedom to Farm came into existence were very strong. Producers faced prices that in some cases set historical highs, while at the same time,

**Figure 2: Change in prices: 1999 relative to 1996**




many had record or near record yields. The livestock markets were also in fairly reasonable shape. The hog sector in the United States, for example, was going through the benefits of swine disease problems in Taiwan as well as in Europe, and had its' numbers well in line with overall demand. Even though feed costs were somewhat high, the overall returns to hogs were sufficient to generate considerable growth. The cattle sector was under some pressure, due mainly to cyclical oversupply. Dairying was going through a series of 'boom or bust' periods, but overall was also in reasonable shape as the bill was debated.

Understand as well what the FAIR Act offered producers in the first few years. Under the previous legislation, known as the Food, Agriculture, Conservation and Trade Act (FACT), most of the effects of a change in market price for a program crop were offset by a counter movement in deficiency payments. At least most of a producer's production was covered. As discussed earlier, not all, as the producer's actual yields were usually well above the yields used to calculate payments. Further, the budget savings effort under the 1990 Act combined with the fixed yield so that on average the producer was not receiving counter-cyclical payments on up to 25% of expected production.

Subsequently, market prices have come under extreme pressure. Dairy prices continue to fluctuate. Hog prices dipped to Depression levels (actually below in real terms) due to oversupply conditions. The cattle sector continues in it's cyclical path and is now showing some small signs of recovery.

The grains and oilseed sector has also undergone one of the worst reversal of fortunes since the early 1970's. Maize prices that went as high as $5.00 per bushel in 1996 are likely to average just $2.00 per bushel for the 1998 crop. Soybean prices, after averaging $7.35 per bushel in 1996, averaged less than $5.00 per bushel for much of the last year. Wheat has undergone similar conditions.

Three causes have contributed to the dip in the grains and oilseed sectors. A more complete description is available in Westhoff (1999). The three main factors are:

- increased production in exporting countries, caused by acreage boosts due to high commodity prices in the mid-1990s, four consecutive years of average-to-favorable growing conditions, and policy changes,
- a slow-down in world demand growth, caused in part by the world financial problems of the past 2 years, and
- Chinese decisions to build grain stocks when world prices were high, and reduce stocks when world grain prices were falling.

## The Policy Debate Today

These last 2 years have prompted debate from many fronts for reform of the current system of providing support to producers. Given that FTF fixed payments, when prices collapsed, there was no mechanism in place to offset the drop in producer income. This led in 1998 to an *ad hoc* provision from Congress to provide what was to be a one-time set of payments to compensate producers somewhat for the drop in commodity prices. Then came 1999. As prices remained low, Congress again determined it appropriate to provide additional funds to the agricultural sector. In fact, the payments provided in 1999 are well in excess of those given in 1998. This has prompted several to suggest that the current set of agricultural policies are not serving the sector well and that some reform is required.

In many respects those involved in the agricultural policy process in the United States seem to be falling into one of three camps:

- Improve the risk management provisions through insurance or other management schemes,
- Fundamentally reform the underlying commodity policies in the FTF legislation, or,
- Continue to just give money.

## Improve risk management

Early in 1999, much of the debate on agricultural policy in the United States revolved around insurance schemes. The United States has a long history of crop insurance. It moved from the coverage of losses from specific causes, such as hail or flood damage, to what is known as multi-peril coverage several years ago. Over the last few years, numerous innovations have been developed in the industry. Producers have recently been offered such products as fertilizer insurance. This program provides producers with insurance against being prevented from applying fertilizer in the spring. With this program, producers taking the policy are willing to forgo putting down fertilizer in the fall and thus preventing the runoff of fertilizers over the winter and early spring. Producers know that they will be at least as well off financially, even if weather precludes them from getting fertilizer in the ground in the spring. Other recent innovations also include insuring not just the producer's yields, but the revenue as well.

For the most part, insurance programs are provided to farmers through private insurance companies. The government plays an extensive role in the program however, providing subsidies for the insurance premiums, as well as providing a reinsurance service to the private companies. The reinsurance role is critical. Unlike automobile insurance where on any given day, some small percentage of the policy holders may have an accident, in crop insurance, when any one individual is filing a claim due to drought or flooding, the odds are that a large percentage of the policy holders in a given geographic area will also be filing. Consequently companies are not able to spread the risk across an area that disperses the risk. When they must make payments, they will quite likely need to make many payments. This is when the government steps in and provides the capital needed in such high outlay years.

Officially, the program is to operate at a point where the revenue from the premiums – those coming directly from the producer and the government subsidy – exactly offset the losses, without government reinsurance. The program has a mixed history of achieving this objective. Further, many who view insurance options as a way to provide a safety net to producer income, fail to grasp the concept that to face a loss ratio of one, the program can only provide payments of a particular level. In short, it is difficult to develop a program that can meet the dual objectives of providing an actuarially sound program, while at the same time, support producer incomes in low price years.

As part of the overall budget process this year, Congress provided $6 billion to the agricultural sector, targeted in theory toward an improved crop insurance/risk management program. The House Agriculture Committee developed its own version of a crop insurance reform package earlier this year. It continues, and in some cases enhances, subsidies for insurance premiums. It even goes so far as to suggest the development of livestock insurance programs. Senators Roberts (R-KS) and Kerrey (D-NE) have developed a bipartisan bill in the Senate, also targeted to improve the delivery and product provided through crop insurance.

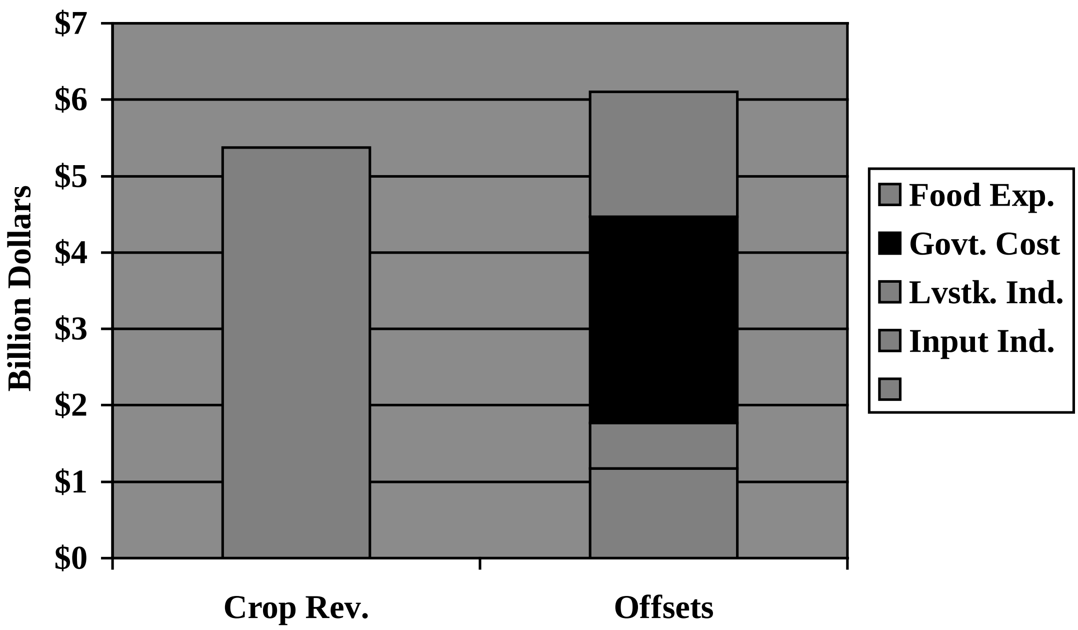
As discussed, the insurance program is delivered through private companies. These companies are in business to earn a profit. They face a variety of administrative costs associated with delivering the insurance product. Roughly one quarter of the government premium subsidies are captured by the companies to pay these administrative costs, and to provide the companies with a return on their investment. Consequently, spending a fixed amount of money on the program will inevitably lead to less than the full amount making its way to producer income.

Recognizing this fact, Senator Lugar (Chairman of the United States Senate Committee on Agriculture, Nutrition and Forestry R-Ind.) has proposed a program that would spend the same amount of funds by providing producers with an additional payment if they agreed to participate in self-selected options to manage risk. Among these would be the development of a plan to market their crops, advance pricing of their crops, taking marketing courses, even purchasing crop insurance. While support for Senator Lugar's position has not been as extensive as that behind crop insurance reform, given Senator Lugar's position on the Committee, essentially no legislation has passed out of the Senate this year on either risk management or crop insurance reform. What may happen in 2000 remains to be seen.

**Fundamental commodity reform**

First and foremost, the majority of producers seem to appreciate the planting and production flexibility they are afforded under the FAIR Act. They seem to prefer to make their own decisions regarding which crops are planted where and for the most part, in reaction to their own perceptions of market signals. Nearly all of the policy options suggested so far in this debate have been as 'additions to' rather than 'replacements for' the FAIR Act. The buzzwords of this debate will typically have the phrases 'safety net' or 'counter-cyclical' featured prominently in their descriptions.

**Figure 3: Crop revenue and offsets under flexible fallow program**



Also, for the most part, producers do not seem to be pushing a return to requiring all producers to take land out of production to receive program benefits, nor are they suggesting that the government return to holding large quantities of stocks.

Early in the year there were several producers and trade associations that suggested much of the decline in the markets could be laid at the feet of the FAIR Act. Clearly, however, there were much larger forces at work in the world markets than just a change in United States policies. The earlier policies would have mitigated some of the price reductions by requiring producers to idle land. Further, the policy would have shifted some grain out of the market and into government stocks. As FAPRI has analyzed the policy, whether producers would have been better off under the earlier policy or the current one, depend very much on when one asks the question. With the market conditions of 1996 and 1997, producers' incomes were higher under the FAIR Act than under the previous bill. From 1997 onward however, the reverse is true. On average, however, over the entire 7-year life of the bill, the difference in income levels between the two policies is negligible.

A relatively limited number of individuals are suggesting a full-fledged return to legislation similar to the 1990 provisions. Instead, most of the alternatives again, attach themselves to the current planting flexibility and fixed payment scheme.

One that has attracted some interest is known as the 'flexible fallow' option. It allows a producer to receive a higher government price guarantee in direct proportion to the amount of land the producer takes out of production. Based on the payment schedule suggested by the proponents, a wheat producer for example would be willing to idle 30% of his land and receive the higher government guarantee unless market prices were above $3.53 per bushel (current market prices are around $2.45 per bushel for milling grade wheat in Kansas City).

Crop producer incomes increase under such a plan ($5.4 billion on average over 2000-2008). Conversely, livestock producer incomes would decline ($0.60 billion) and government costs would rise significantly ($2.70 billion). The input industry would see its income decline ($1.17 billion) and naturally, consumer food expenditures also rise ($1.63 billion).

At the same time, the volume and value of agricultural exports would decline, which is a lesson to which many of our producers are paying particular attention. One of the main reasons export values decline in the face of higher prices are the changes in policies that have taken place outside of the United States, particularly in the European Union. With the adoption and subsequent implementation of the Berlin Accord, European cereal producers are going to significantly improve their likelihood of being able to export (wheat in particular) without the use of export subsidies. This will free the same European producers from the export constraints imposed by the Uruguay round, as those constraints only applied to exports using subsides.

The arithmetic will vary with exchange rates, but with the intervention price dropping to something in the $3.00 per bushel range, any action on the part of the United States to push prices on a sustained basis to levels higher than $3.25-$3.30 will likely elicit a significant response on Europe's part. This story does not apply only to wheat. The reforms will also likely make European beef much more competitive on world markets, even to the stage that movements in cattle prices in the United States may have some effect on European cattle prices. Further, cheese exports are also expected to be more competitive subsequent to the adjustment in intervention prices.

### Just give cash

There are two schools of thought to the 'just give cash' camp. One recognizes that Congress has taken action in the last 2 years to provide direct cash payments to producers when prices have been low. This same camp takes the idea that producers are better off taking their chances in the political process and accepting whatever form of additional cash Congress is willing to provide. This camp contends that given the political scene, Congress will always provide more money in an *ad hoc* program, such as in 1998 or 1999, than would ever be obtained through some systematic policy.

The other camp suggests that the political scene may well change. The tight position of the two parties in the House of Representatives has probably contributed at least somewhat to the size of the funding pot in the last 2 years. It may also argue for additional funds next year. But subsequently, the political landscape may be very different. Thus this second camp suggests that some counter-cyclical/safety net program be developed and implemented in the coming calendar year, before the 2000 elections, in order to provide some future support system, independent of the political process.

The most well known of these fundamental commodity reform options is called the Supplemental Income Payment Program or SIP. Again, it would be offered in addition to the FAIR Act and would NOT be a replacement. It provides a floor level of income under the various commodities based at some percentage of historical average gross revenues for the commodity in question. On average, even if it provided the protection at 95% of the historical average, the program would pay out relatively little. Averaged over 2000-2008, the program would give average government costs of only $780 million. Shifting the period from 2001-2008 drops the average to only $500 million.

But the story of SIP is not captured just in the averages. Given the usual variability in crop yields, prices and export markets, it is possible to discuss some of the probabilities of higher – and lower – expenditures under SIP. Based on some of this kind of probabilistic analysis at FAPRI, there will definitely be years when no expenditures would occur, even if the coverage were extended to 97.5% of the historical average. Conversely, the cost to the government could be very high should the export markets, prices and yields move in the wrong direction. The average maximum cost under the program at the same 95% base would run into the multiple billions of dollars.

## The Policy Debate and the Next Trade Round

From a European perspective one would likely say all of this debate is well and good, but what does it mean to me? Some strains are probably already coming through. For one, the

United States has not remained as pure to a zero-for-zero option as was indicated by the initial FAIR Act discussions. While the original FAIR Act was very decoupled, the actions by Congress to make payments due to low market prices, clearly couples the *ad hoc* programs of the last 2 years to price movements. The programs are still separated from production decisions. But would the payments have been made without the drop in prices, not likely.
The policy debate indicates the commitment by the United States for a strong decoupled component to any program. Again, nearly all of the policy debate has been focused on additions to, not replacements for, the FAIR Act. The United States has also – with the exception of an occasional dairy market – refrained from the use of direct export subsidies. Expect that discussion to continue in this round. But there is growing realization by a number of those in the agricultural sector that simply eliminating export subsidies by countries willing to spend a great deal to subsidize production does not move the sector very far down the road toward a free market

This is the challenge many of our policy decision-makers are wrestling with. A strong desire to keep the program as market oriented as possible, while at the same time providing producers with some protection from the kind of market collapse observed in the last 36 months. This is not just a debate among politicians, but one that has permeated many of the trade associations and commodity groups as well. There seems to be a growing consensus to develop policies that are WTO legal, that maintain a flexible farm program that sends most – but not all – of the market signals through to producers.

The United States will likely continue to push for a reduction in tariff levels, including some review of how those tariffs are applied. The push to open markets will not be limited to simple tariff barriers, but will also likely continue in the sanitary/phytosanitary arena as well. The experience in the United Kingdom to barriers based on something other than scientific data may give an example of how producers in the United States have felt for some time.

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# What Policy Options Need to be Evaluated in Relation to Freer Trade?

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**"There are more questions than answers" (Johnny Nash)**

**The principal objective of my paper is to pose a series of questions about the implications of freer trade. Policymakers in Government, business strategists and representatives of farming interests all have a need for answers to a series of questions which are posed by the prospect of freer trade.**

**In my paper I will**

a) **Paint a scenario of the possible marketing environment in which the food and agricultural industries could operate about 2010. Freer trade will be a major influence in this scenario;**

b) **Summarise the capacity which has been built up in Ireland to analyse the effects of policy changes;**

c) **Consider some of the questions for public and business policy which are posed by freer trade and comment on the capacity of economic and other models to provide answers to these questions.**

**The paper itself will not provide answers, since its principal objective is to ensure that we are asking the right questions.**

### A Scenario for the Agri-Food Industry after 2010

We have no insights or methodologies, which enable us to accurately foretell the future. Painting a scenario is as much a work of creation as of science. Nevertheless we are forced (as are the strategic planners in all major companies and in government departments) to forsake our scientific caution and undertake the exercise.

The marketing environment in 2010 is likely to be substantially different from that of today. The following developments will have an impact on consumer attitudes, on retail structures, and on the prices obtainable in the marketplace

(a) trade will be substantially freer in agricultural and food products by that date
(b) there will be a substantial increase in membership of the European Union
(c) there will be further changes in consumer habits and expectations
(d) current changes in retailing will accelerate.

Each of these developments is now considered in turn.

**Freer Trade**: The World Trade Organisation (WTO) negotiations began in November 1999. There will be considerable pressure on all parties to reach agreement for a further period, because of the nature of the current agreement. Article 20 of the current agreement commits members to a “continuation of the reform process”. A continuation of the terms of the Uruguay Round agreement indefinitely into the future is not seen as a realistic proposition.

We must presume that substantial further "progress" in the direction of free trade will be achieved by 2010, even if completely free trade is not achieved by then. I am not advocating freer trade. I am merely suggesting that freer trade is likely and that it is therefore necessary to examine its consequences. I am making no value judgements as to whether these developments should take place: I am just indicating a high probability that they will.

What precisely do we mean by freer trade? The main elements are
(a) a likely reduction or probable elimination of the practice of subsidising exports from the European Union;
(b) increased access to European markets for agriculture and food products from outside the Union in the form of duty-free access and reduced levels of protection;
(c) the extent to which trade may be restricted in pursuance of aims of protection of human or animal health, animal welfare or the environment will be increasingly questioned.

The policy of using export subsidies to assist in maintaining competitiveness in export markets and export levels is particularly under threat in the WTO negotiations. The practice is used predominantly by European countries, including the EU, Norway and Switzerland, and also by the USA. Most other WTO members want as a minimum a deadline set for ending the practice.

The ending of export subsidies could have particularly severe effects on the beef and dairy sectors of the Irish food processing industry, particularly in those sections of both industries which are producing undifferentiated commodity products, which compete almost exclusively on price.

**Enlargement:** In most discussions of the future market environment the WTO negotiations receive substantially more attention than does EU enlargement. EU enlargement has been seen as something that will take a long time and as a result was not of immediate relevance. There are some reasons to believe this view is erroneous.

The political thrust to admit new members sooner rather than later appears to be growing and has been assisted by factors such as the collapse of the Russian economy and the war in Kosovo. Applicant countries, which assisted in the latter effort expect to be rewarded by fast tracking their applications. A two-tier approach to the original list of applicants has already been replaced by a single track.

Commentators now suggest that some applicant countries including Poland and Hungary could join as early as 2003, and that overall membership could be as large as

27 by 2010, incorporating all 12 of the current short-listed applicants (e.g. Economist, 1999a).

In trying to paint a scenario for 2010, we must assume that, by then there will be at least six new members of the Union and probably many more. The community will include Poland, a country with immense potential in areas where we are competitive.

**Consumer habits**: There is some evidence of common forces impacting on the food market. These include:
- an ageing population
- an increase in the number of single person households
- rising health concerns
- changing employment structures
- rapid technological developments
- increased international travel
- media proliferation and fragmentation

These developments and trends will impact on consumers in the following ways:
- consumers are becoming more demanding in terms of quality, variety and value for money;
- consumers will have less time for food preparation and will turn to foods which offer higher levels of convenience;
- people will reassess their diet in light of rising health concerns;
- consumer tastes will become more sophisticated and individual;
- consumers will become more inclined to experiment with new tastes and eating habits as they adopt a more cosmopolitan outlook;
- consumers will become more concerned with the production methods used in the supply chain.

The outcome of these forces will be five significant trends that will impact on consumer preferences over the next ten years. These are:
*(a) Increased demand for healthy and functional food products.*
*(b) Increased demand for convenience foods.*
*(c) Increased meal consumption outside the home.*
*(d) Internationalisation of consumer tastes and habits.*
*(e) Consumers will continue to expect value for money.*

**Retailing:** Five drivers of change are foreseen:
(i) retail concentration and internationalisation;
(ii) private label growth;
(iii) centralised distribution;
(iv) food-service growth;
(v) increased use of marketing information and IT.

The number of retail companies will decline and the power and negotiating strength of those who remain will increase. There will be increasing pressure by retailers on their suppliers to reduce prices, as well as to provide a range of additional services.

I have described one possible scenario in a little detail, concentrating in particular on the free trade aspects. One could paint several. Each scenario raises questions about the likely impact. In the next part of the paper, I will try to sketch the kinds of questions to which partial answers could be given by the use of the econometric or other models at our disposal. The models do not help us to define the questions. If we have chosen the right questions, they can provide us with an indication of the direction and magnitude of impacts.

## Role of Economic Research

Economic and social research can only suggest answers to these questions. However the future is uncertain: markets are affected by weather, by political events, and by shocks such as BSE, as well as by the kinds of factors which lend themselves to econometric or other modelling.

We, in the Rural Economy Research Centre, now have a capacity (in collaboration with FAPRI in Missouri and colleagues in Irish Universities in the FAPRI Ireland Partnership) to model the Irish agricultural economy.

## Results of our Modelling to Date

To date the FAPRI Ireland Partnership has

(a) projected what agricultural production, output and incomes would have been if there were no CAP reform
(b) projected what the specific impacts of the agenda 2000 proposals as they were a year ago would have been (four papers in Pitts, 1998)
(c) projected the impact of the specific policies agreed in Berlin (Donnellan *et al.*, 1999)
(d) projected the impact of alternative scenarios in relation to milk quota abolition (Rural Economy Research Centre, 1999).

Work is currently at an advanced stage in (a) modelling the impact <u>at farm level</u> of the Berlin agreement (b) modelling the impact of changes in farming on the food processing and input sectors.

## Projections to 2007

The projections for Irish agricultural output in 2007 as a result of the Berlin agreement are now summarised. (Donnellan, Binfield and McQuinn, 1999).

**Beef:** The Irish beef reference price in Ireland falls by 13% compared with 1998 to £77 per 100 kg. Beef cow numbers fall by 5%: total cow numbers by 9%: carcass weights fall by 8%, live exports are at 223,000 head (an increase of 26% on 1998), while slaughterings fall by 7%. The value of output from the cattle sector declines by 26% as a result of these changes. However, increases in direct payments of 28% offset the impact of these losses on the incomes of cattle farmers.

**Dairy:** Milk prices decline from £1.04p per gallon in 1998 to 94p in 2007. Milk volumes increase by the increase in quota of 2.86%. The resultant decline in milk sector revenue is compensated by a new direct payment so that the nominal income of the dairy sector is hardly changed.

**Sheep:** The volume and value of output from the sheep sector is set to decline substantially for reasons not related to the Berlin agreement. Ewe numbers are projected to fall by 20%, and the volume of sheep output by 13%. Prices may show a slight increase on 1998 levels.

**Pigs:** Pig prices in Ireland in 2007 are projected to be similar to those of 1998 with output volume down by 5%.

**Crops:** Wheat area up by 9,000 hectares by 2007, barley down by 21,000 hectares; cereal prices down by 7%; receipts by cereal sector down 2%: increases in subsidies compensate in part for the decline in prices.

All projections of prices and receipts are nominal and therefore take no account of inflation. Receipts refer to income of the sector: other projections suggest that farmer numbers sharing in this revenue will decline by at least 10%, even without further policy change.

These projections are now the baseline against which we will project the impact of other scenarios. They are our best estimates of what the sector will look like 7 years into the new century –

*if* there were no further changes in policy

*if* the assumptions regarding the global economy, exchange rates etc. are fulfilled, and

*if* there were no shocks, pleasant or unpleasant

However, we have considerable reason to believe there will be further policy changes. A number of key issues are facing the European Union including (a) the Millennium round of talks on freer trade (b) enlargement of the Union (c) reviews of the agreements made in Berlin, particularly related to milk but possibly occasioned by pressures on the Community budget.

The issues of freer trade, enlargement and the Community budget are inherently linked but also in time as there seems likely to be a period about the years 2002/3 when key decisions on all three issues may have to be made.

## Questions on Effects of Freer Trade Scenario

We have already projected the potential impacts of the Berlin Agreement on agricultural output and incomes. The first question for policymakers in relation to freer trade is – can we do the same for a freer trade scenario?

***Q 1:*** *What will be the impact of freer trade for Irish agricultural production in Ireland, agricultural incomes, the level of exports?*
Can economic or other research provide answers to this kind of question. The answer is yes, but ... There are a great many unknowns. How free? What level of export subsidisation, if any, is permitted? What level of import access is guaranteed? What level of import protection will remain? Some of the more crucial questions relate to how the farming sector would respond to substantially changed market conditions.

How much would milk production increase if quotas were abolished? How much would beef production decline if direct payments were decoupled from animals?

Until we get much closer to the negotiations and have a feel for what may be on offer, some assumptions may have to be made, which will subsequently emerge as incorrect. The difference in outcomes from the Agenda 2000 proposals as they were in December last year (a projected decline of 10% in agricultural incomes – see McQuinn and Riordan in Pitts, 1998) and the current projected out-turn (stability in agricultural incomes – Donnellan *et al.*, 1999) illustrates this very well. The difference in outcomes can largely be ascribed to differences in the policies originally prepared and those agreed.

***Q 2****: What will be the separate impacts on Ireland of (a) removal or restriction of export subsidies, (b) increasing minimum access to the European market, and (c) reducing tariff protection of the European market?*

It would be possible to estimate these separate effects in good time i.e. well before negotiations are concluded. We note that an American study (Cox *et al.*, 1999) has already made estimates of this kind, in relation to dairy products, for the main trading blocks worldwide. It would be necessary, as with all our existing work, for our American colleagues to first estimate, using their world and European models, the impact on European prices and production. We would then use our models of the Irish agricultural sector to estimate the impact, given the EU price and production levels.

***Q 3:*** *What will the effects be on Irish agriculture of increasing the size of the European Union to 27 members*

While this issue fundamentally is also one of freer trade, it may differ in its detailed implications. The nature of the agreements reached in the negotiations could have major implications for our competitiveness, within the European Union. For example the maize silage subsidy has had significant effects in maintaining the competitiveness of cattle and dairy enterprises in parts of Continental Europe.

Again estimations of this kind are possible but will depend on the assumptions made. We do not know anything of the terms on which these countries will join the Union. We do not know if there will be a transition period, during which prices and subsidies are gradually aligned, as was the case when Ireland joined. While we can assume a single market, without barriers and with a tendency towards a common price, we do not know whether there will be access to the direct payments system and if so, to what degree.

Policymakers will require estimates of the impact on Irish agriculture of enlargement well before negotiations have concluded.

***Q 4:*** *What are the implications for competitiveness of the food processing industry of freer trade?*

Some of the key policymakers are those on the boards of agribusiness companies. If much freer trade is expected within a decade, this will alter the rules of the competitiveness game for their companies. Boards of directors and senior management will need to consider what investments in plant, new technology or markets they should make in order to cope with the new circumstances.

Let us consider the implications of freer trade for the dairy processing industry. Freer trade could imply the end of quotas, lower milk prices and competition on world markets without subsidies. But this begs a whole series of other questions. At what price will world markets for butter and milk powders settle? Will lower prices in Europe for the "intervention" dairy products induce a similar reduction in prices for cheese, liquid milk and fresh dairy products? If not, how large will the premium be for these products in pence per gallon terms and would it justify a change in product mix in Ireland? How large an investment would be necessary in plant and marketing? If in any market, we are competing predominantly on price, what scale of production is necessary to maximise economies of scale or minimise processing costs?

A study is already being carried out, with support from the Irish Dairy Board, the Irish Farmers' Association and the Irish Dairy Processors to examine some of these questions.

The study is not yet complete and in fact is raising a series of further questions. Historical experience has indicated that commodity cheeses have not performed better in general in price terms than butter and powder. However the price trends for specialist cheeses have been better. The problem with specialist cheeses is that, by definition, the market is small.

In a free market the Irish dairy industry will be competing with those of the Southern Hemisphere, where there are substantial economies of scale, substantial unexploited production potential and lower production costs both in farming and processing. Nearer home we will be competing with Poland, which has some of these advantages. In the period up to quota abolition in the EU, the dairy industries in these countries will be free to expand their production, and will invest in the latest technologies for processing commodity products. Already in Argentina, Australia and New Zealand, the basic technology in powder plants is more modern than in Ireland, where there has been little investment for the last 15 years.

***Q 5:*** *What is the appropriate strategy for the Irish dairy industry to compete in this free trade world?*
It would seem (but the work is not complete) that an appropriate strategy for the Irish industry would be one based on characteristics and qualities of our industry, which are not easily imitated and are therefore more defensible. These could arise where, because of our superior technology or knowledge or quality, we can compete in premium markets which countries such as Poland or Argentina cannot in the short term.

We have described the likely scenario where there will be substantially greater markets for prepared and partly prepared consumer foods for the retail and food service industries. Implicitly this means reduced markets for staple food products but increased markets for food ingredients.

The market for ingredients will be divided in two (a) a market for basic ingredients which can be supplied by firms with low costs and modest technological capacities from Eastern Europe or Latin America; (b) a market for sophisticated products from multinational food companies. Here the key buying characteristic is the service, technology and functionality of the ingredient on offer. These multinationals may only have a limited number of worldwide suppliers, who will be expected to work with the company to provide solutions to its technological problems and collaborate with it in providing the next range of new functional and prepared consumer foods.

Ireland has at least one indigenous firm with these characteristics, while several others are developing in that direction. In an era of freer trade, involvement in “knowledge-based” products, such as sophisticated ingredients, provides some protection from the cut-throat competition and fluctuating returns of commodity markets. While most of the opportunities to date have been in the dairy powders area, there have also been opportunities in cheese and the growth of the Mozzarella market in Europe has primarily been through supply to world-class catering and food manufacturing companies.

Perhaps the original question about the right product mix is not the most appropriate. The more important question may be in which segment of each product market are we competing. Can we move into segments which are more easily defensible? *or* which take account of the sources of our competitive advantage in the new free trade world? While within the current EU15 lower production costs are an important source of competitive advantage (which we cannot fully exploit because of the quota system), it is doubtful that this can be our main source of competitive advantage in 10 years time. We need to build an industry around those sources of advantage, which will distinguish us from suppliers such as Poland and Argentina, viz. a higher level of technological and marketing expertise and a capacity to collaborate with multinational catering and food companies and retailers.

The same sort of strategic questions as those discussed here also face firms involved in the meat and other sectors of the food industry.

Other policy issues which may require analysis in the coming years include

***Q 6****: What would be the effects on production, incomes etc. of policies to limit nitrate and phosphate use and release into ground water?*

***Q 7****: What would be the effects on production, incomes etc. and at individual farm level, of policies to ensure national compliance with limits on greenhouse gas emissions?*

***Q 8****: What will the effects on production, incomes etc and at individual farm level of policies involving a switch in basis for calculating entitlements to direct payments from numbers of livestock to land areas?*

***Q 9****: What will the effects on production, incomes etc. and at individual farm level of policies limiting the levels of direct payments to be made to individual farmers set either as a ’cap’ (invariable ceiling) or as a modulation of rates of payment at higher levels of entitlement?*

***Q 10:*** *What will be the relative competitiveness of forestry and beef production in Ireland if subsidies are decoupled as part of a WTO deal?*

***Q 11:*** *What will the impact of any or all of these policy changes be on the rural economy?*

Not all of these issues are directly related to free trade but many are related indirectly. Any policy change in the CAP must have regard to its acceptability in a WTO context. Many of the proposals to change the CAP would involve decoupling of direct payments which is the preferred option under WTO rules and qualifies payments for inclusion in the "blue box".

A new form of trade which is likely to arise in the next decade is trade in emissions. The world wide concern over the greenhouse effect has led to the Kyoto Agreement, in which countries accepted caps (a new CAP!) on their national emissions of greenhouse gases. The Kyoto Agreement provided for emissions trading at an international and national level. This is of interest to the agricultural community for two reasons: (a) agriculture, particularly cattle and sheep, are significant sources of methane, one of the major greenhouse gases; (b) the number of cattle and sheep is projected to decline in Ireland over the next decade, thus creating a potentially tradeable asset in "reduced emissions".

The mechanics of including agriculture in an emissions trading system are considerable and tend to be ruled out on administrative grounds (Environmental Law Institute, 1997). However, in recent weeks, the Economist has reported a deal between a coalition of Canadian energy companies and a group of Iowa farmers to buy up to 3.3 million tonnes of carbon dioxide credits (Economist, 1999b).

Could farmers in a decade or so be as concerned with the market price of "emissions" as they are today with mutton or beef?

## Conclusions

In this paper I have raised a series of questions which may exercise the minds of policymakers in the first decade of the new millennium as a result of the trend towards freer trade. I have provided few answers. As the old song says "there are more questions than answers". Providing answers to these questions can keep many of us busy for a long time.

I have indicated that economic and social research may assist policy makers, whether in business or Government, in trying to steer a correct course. There will be many uncertainties which cannot be included in economic models, and many assumptions will have to be made in advance which may not coincide with future reality. Nevertheless, Governments, Boards of Directors and Farming Organisations want some guidance to help them in negotiations and in advance planning. Our models and analysis will hopefully assist them in making the correct strategic decisions.

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# A perspective for the dairy industry 2010

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**The dairy industry is one of the most important sectors of Irish agriculture and accounts for 33% of agricultural output with the production of 1.1 billion gallons of milk per annum. The dairy industry also makes a significant contribution to sustaining rural communities. Milk producers in Ireland have received a relatively high milk price in recent years. However, the application of a milk quota regime within the EU as well as other measures such as tariffs on imports, export refunds etc. were necessary to support milk price. European Community membership in 1973 provided Ireland with a good degree of policy stability as the wider international political and market situation was reasonably predictable in the 1970's and 80's. Now, however, the political changes in Central and Eastern Europe, the completion of the Single Market and policy changes in the CAP (Common Agricultural Policy) and world trade agreements (WTO), all suggest a more unstable and unpredictable time ahead. The purpose of this paper is to develop a vision of the dairy industry at the end of the next decade and describe some of the changes, opportunities and challenges that are likely to confront the industry in a different policy environment.**

## Future policy environment and industry structure

The current policy environment for the dairy industry is the Agenda 2000 agreement on CAP reform. This provides a stable outlook until 2008 subject to review in 2003. A perspective on the outlook beyond 2008 is critical for strategic planning in the immediate years ahead. Eventual movement to the free market seems inevitable and the only question is how rapidly this will occur. For the purposes of developing a 2010 scenario, we have assumed a relatively rapid time-table leading to many of the elements of the free market being in place by 2010 or shortly afterwards. While this timing is undoubtedly debatable, it does provide a clearer focus for strategic analysis than exists in much current discussion.

The free market elements which we assume for 2010 or thereabouts include the following: abolition of quotas, elimination of export refunds and other forms of support, absence of an intervention system other than aids to private storage and tariff reductions of 10 to 15%. In relation to industry structure, it is assumed that considerable consolidation will have taken place by 2010 and that something close to the following picture will exist. The processing sector will have consolidated into 2/3 major processing sites and 2/3 smaller sites; the number of milk producers will have declined to at most 20,000. In reaching these assumptions, we have taken into consideration the conclusions in Technology Foresight Ireland, ICOS recommendations for industry restructuring and current trends in producer numbers. A final assumption is that milk output will expand post-quota and will have increased by 30% in or about 2010. The potential for increased output is discussed later in this paper.

## Dairy Production 2010

It is envisaged that the dairy production sector will be very different in 2010 than it is today as we move towards freer trade.

A national milk pool of ~1.45 billion gallons is a realistic target. Up to 20,000 dairy farmers each on average producing ~70,000 gallons of milk per annum, with much larger herd sizes (~60 cows). The likely distribution of dairy farms by milk pool size is shown in Table 1.

**Table 1. The structure of dairy farms by milk pool size now and the envisaged structure by milk volume sales in 2010**

| | 1997/98 | | 2010 | |
|---|---|---|---|---|
| | Number ('000) | % | Number ('000) | % |
| < 20,000 gallons | 11 | 34 | 0 | 0 |
| 20,000 – 55,000 gallons | 16 | 52 | 8.0 | 40 |
| 55,000 – 100,000 gallons | 3 | 11 | 9.0 | 45 |
| > 100,000 gallons | 1 | 3 | 3.0 | 15 |
| Total | 31 | 100 | 20.0 | 100 |

Source: (current structure) Dept. of Agriculture: 2010 data based on authors' estimate.

### Competitiveness of the dairy industry

Competitiveness is a complex term given it's multi-dimensional aspects (Boyle, 1998). It is, however, central to all agricultural and rural development policies. Competitiveness in the past generally referred to cost competitiveness. It now has to be considered in broader terms. Issues such as type of technology used to produce food, the environment, animal welfare, scale of enterprise, Government regulatory policies as well as development and taxation policies, education level of farm work force, rate of adoption of new technologies, milk processing sector structure etc also need to be considered. Production systems will need to incorporate many of these issues as well as being cost competitive.

### Cost competitiveness in milk production

Cost competitiveness at farm level is an important determinant of the success of the dairy industry. It also has an important bearing on what policy strategies might best suit the future development of the industry. Fingleton (1998) reviewed recent trends in relation to the cost competitiveness of milk production in Ireland (Table 2).

**Table 2. Itemised costs of milk production for specialised creamery herds (1990-1998)**

| Year | Direct | Overhead | Total | Net receipts | Margin | Cost/receipt ratio |
|---|---|---|---|---|---|---|
| 1990 | 30.0 | 29.0 | 59.0 | - | - | - |
| 1991 | 29.0 | 28.0 | 57.0 | - | - | - |
| 1992 | 30.0 | 28.0 | 58.0 | - | - | - |
| 1993 | 31.8 | 29.5 | 61.3 | - | - | - |
| 1994 | 33.6 | 28.1 | 61.7 | 106.4 | 44.7 | 0.58 |
| 1995 | 35.4 | 30.4 | 65.8 | 111.2 | 45.4 | 0.59 |
| 1996 | 35.3 | 31.0 | 66.2 | 107.5 | 41.3 | 0.62 |
| 1997 | 30.9 | 29.5 | 60.4 | 102.1 | 41.7 | 0.59 |
| 1998 | 33.0 | 30.0 | 63.0 | 105.4 | 42.4 | 0.60 |

Source: Fingleton, 1999 and NFS data

The total input cost in 1991 was 57.0 p/gallon compared with 66.2 p/gallon in 1996. The average total cost of production in 1998 was 63 p/gallon. The direct costs were higher than the overhead costs. Family labour is not included in these costs. The margin per gallon of milk in 1998 was 42 p/gallon. The ratio of total costs to value of output was generally around 0.6. The overall costs (1998) ranged from 45.2p/gallon for the lowest cost group of farms (lowest 20% of farms) to 80.4 p/gallon for the highest cost farms (highest 20 % of farms). This data shows that there is great scope for reducing costs on many farms, nationally (Table 3).

**Table 3. Cost variation by quintile in 1998 for specialised dairy farms (p/gallon)**

| | **Q1** | **Q2** | **Q3** | **Q4** | **Q5** |
|---|---|---|---|---|---|
| Total | 45.2 | 55.2 | 62.1 | 68.5 | 80.4 |
| Direct costs | 24.5 | 28.3 | 32.2 | 36.1 | 41.6 |
| Overhead costs | 20.7 | 26.9 | 29.9 | 32.4 | 38.8 |
| Q1 = Lowest cost 20% of farms. Q5 = highest costs 20 % of farms | | | | | |

Costs of milk production expressed on a per gallon basis do not reflect the scale of operation at farm level. Many farmers are now leasing quota. The average costs associated with quota leasing in 1998 was 4 p/gallon.

## Cost comparison with other countries

Economic costs are often used in assessing the competitiveness of milk production. "Cash Costs" refer to the actual cost outlays by producers. Total economic costs include as well estimated resource costs to cover family labour etc… Ideally economic costs should be considered as well as cash costs when assessing the competitive strength of the dairy industry. Table 4 shows measures from the 1992 AIB/Farmers Journal study.

Ireland generally emerges as competitive in terms of "cash costs" but much less so in respect of "economic costs". This is probably because of the large number of small farms in Ireland, which cannot support a full time labour unit. The analysis in Table 4 is now relatively out of date and is in need of updating.

**Table 4. Competitiveness of Irish agriculture production costs £/100 kg (1997*)**

| | **Production costs £ /100 kg (1997)** | | **Production costs as % output values** | |
|---|---|---|---|---|
| | "Cash costs" | "Economic Costs" | "Cash costs" | "Economic costs" |
| Germany | 20 | 31 | 60 | 119 |
| France | 15 | 25 | 60 | 112 |
| Italy | 21 | 52 | 52 | 128 |
| Netherlands | 18 | 28 | 57 | 114 |
| Denmark | 24 | 33 | 74 | 130 |
| Ireland | 13 | 29 | 52 | 130 |
| UK | 18 | 27 | 64 | 117 |
| US | 22 | 26 | 77 | 92 |
| Australia | 8 | NA | 64 | NA |
| Canada | 15 | 30 | 52 | 100 |
| New Zealand | 6 | NA | 68 | NA |

* Update of AIB / Farmers Journal 1992 study (Source: Boyle, 1998)

More recent information (EDF, 1999) although on a more limited data set is likely to be more representative of dairy farming in 2010 (Table 5).

**Table 5. Costs, returns and result of the dairy enterprise**

| Country | Euro/100 kg milk (FCM) | | | |
|---|---|---|---|---|
| | Total receipts | Total costs | Net margin | Costs/receipt ratio |
| Belgium | 35.8 | 32.5 | 8.5 | 0.91 |
| Germany | 35.2 | 32.7 | 5.1 | 0.93 |
| Ireland | 34.3 | 25.0 | 13.9 | 0.73 |
| Holland | 37.1 | 36.6 | 6.4 | 0.99 |
| Sweden | 36.0 | 32.0 | 7.4 | 0.89 |
| UK | 33.5 | 28.5 | 11.1 | 0.85 |

Source: EDF analysis 1999; FCM – Fat corrected milk

Family labour is included in these costs. The results show that Ireland and the UK have the lowest receipts /100 kg milk (FCM). There is a large difference in cost of production between countries. The costs of production in Ireland are significantly lower than the other countries. The margin/100 kg milk (FCM) for Ireland is much better than the other countries mainly as a result of the low production cost structure. This supports the previous analysis in that Ireland is cost competitive in term of cash costs. There is no obvious reason why Ireland should loose its comparative advantage in terms of production costs in the foreseeable future.

**Can Ireland compete after 2006**

The structure of the milk production sector of the industry is poor. It is likely that considerable change will occur over the next decade. It is important that innovative strategies are put in place to facilitate an increase in the scale of the farm business while maintaining the maximum number of farm families in rural areas. These might include, milk quota policy changes, taxation policy, strategies to facilitate entry of young farmers to the industry, development plans, education etc… Farm partnership is also an attractive option for future development. It is however, likely that the number of farmers will continue to decline and the relative size of farm will continue to increase.

Milk producers in Ireland will be increasingly dependent on subsidies after 2006 if income is to be maintained in a scenario where milk quotas are removed. While the farm margins may seem relatively good in nominal terms now, the real value of the returns on dairy farms will be much reduced. The question arises as to what extent Irish dairy farmers can adjust to these changes. It is argued that for a net exporting country like Ireland, two key parameters matter in addressing the impact of price reductions on any sector (Boyle, 1998 and Sheehy, 1996). The first is the supply elasticity or the responsiveness of production to price changes and the second is the underlying rate of technological change within the sector. Faced with price reductions, a sector with relatively low supply elasticity would experience a relatively lower income loss than a sector with a relatively high elasticity. Similarly, a sector with an inherently faster rate of technological progress could expand production to a greater extent at all price levels. It is argued that a sector, which is favourably endowed with these two parameters, has the potential to enhance market share in a scenario of price cuts.

Boyle (1998) suggest that “cash costs” expressed as a ratio of the value of output gives a proxy of supply elasticity. The smaller the ratio the smaller the supply elasticity. Ireland has a favourable cost/receipt ratio relative to other countries and consequently Ireland should suffer less severe production and profit effects in the face of price reductions than most other countries (Boyle 1998; EDF, 1999; Fingleton, 1996). Ireland also has the capacity to reduce costs faster than other European countries. The cost of labour may be an exception to this.

The underlying rate of technological progress for different countries is more difficult to define. Little comparative data for European countries is available. Continued technical innovation is very important for competitiveness long term. Dillon (1998) evaluated the change in milk production technology at Moorepark over a period since quotas were introduced 1984 up to 1996. These results are summarised in a systems context in Table 6.

**Table 6. Change in herd productivity at Moorepark**

| | Moorepark1983 | Moorepark 1996 | |
|---|---|---|---|
| | Pre-quota | MGI* | HGI** |
| Milk yield (gal/cow) | 1,084 | 1,407 | 1,632 |
| Stocking rate (cows /Ac) | 1.17 | 1.05 | 1.00 |
| Grass (t/cow) | 3.30 | 3.69 | 3.88 |
| Silage (t/cow) | 1.40 | 1.56 | 1.65 |
| Concentrate/cow) | 0.63 | 0.63 | 0.63 |
| Total intake (t DM/cow) | 5.33 | 5.88 | 6.16 |

*MGI – Medium Genetic Index Cows; ** HGI – High Genetic Index Cows

Considerable progress was made in milk production technology over the years and this progress is likely to continue into the future. Productivity at farm level is influenced to a large extent by the level of animal performance from a forage-based diet. The costs associated with the cow can be diluted when a higher level of animal performance is achieved. It is important that the relatively stable economic environment ahead is used to apply the best technology on dairy farms. Continued innovation in milk production technology is necessary to maintain competitive advantage.

**Moving toward an increase of 30% in milk output by 2010**

The policy environment for milk production at the end of the Berlin Agreement will depend on many factors. A detailed discussion of these is outside the scope of this paper. It is assumed here that milk quotas will be abolished from 2008. An assessment of the potential to increase milk output from farms to compensate for a likely drop in milk price is assessed. Competition in the form of cow premiums etc. is not considered.

**Latent milk output increase in the national herd**

There is considerable scope within the national herd to increase milk output/cow. The potential productivity improvement at farm level has not reached full potential over the years. Milk yield per cow is an indicator of productivity at farm level. Data from specialised herds (NFS, 1997) shows that the average milk yield per cow is 960 gallons per cow. Milk quota per cow is 880 gallons. This would suggest that milk deliveries to dairies per cow are low. A significant amount of milk is fed to calves. Table 7 shows the distribution of farms by level of milk yield per cow and by level of milk quota per cow.

The data in Table 7 show that an alarming number of farms have low herd productivity as measured by milk yield per cow. This is mirrored to a large extent by the low level of milk quota per cow, available on these farms. This would suggest that a high proportion of farms have too many cows on their farms for the quota available. DairyMis data and data from milk recorded herds shows clearly that lactation length is declining over the years. This trend is associated with a drop in milk yield per cow.

**Table 7. Distribution of farms (%) by level of milk yield/cow and milk quota/cow**

| | Milk yield/cow | Quota available/cow |
|---|---|---|
| <700 gallons/cow | 9 | 17 |
| 700-800 gallons/cow | 11 | 13 |
| 800-900 gallons/cow | 13 | 18 |
| 900-1,000 gallons/cow | 23 | 24 |
| 1,000-1,100 gallons/cow | 25 | 20 |
| 1,100-1,200 gallons/cow | 12 | 5 |
| >1,200 gallons /cow | 7 | 3 |
| Total | 100 | 100 |

Source: NFS

The milk production of the national herd should be ~1,100 gallons/cow taking cognisance of the national breeding programme over the last 20 years. It is argued that low herd productivity is due to milk quotas and the administration of milk quotas in Ireland rather than a failure in technology transfer. Farmers are keeping too many cows for the quota available. This is done in anticipation of obtaining additional quota. There are significant costs associated with this strategy. Using data from DairyMis herds, it is estimated that restricted performance due to quota, costs a minimum of 5p/gallon. This additional cost is likely to be much larger on dairy farms generally. It should also be noted that some farmers have made significant amounts of money in some years by gambling on additional quota being available. A significant number of farmers are also loosing potential income by not filling the quota available. These tend to be smaller farms who are generally more risk adverse.

It is likely that rapid adjustments can be made in herd productivity if milk quotas were removed. A realistic expectation is that an immediate increase in volume of milk sales per cow, of 150 to 200 gallons per cow is achievable. This assumes that milk feeding to calves would discontinue. The additional on-farm cost associated with delivering this additional milk to dairies is minimal. The costs would mainly relate to additional milk storage on farm, some additional feed for cows and also costs associated with calf rearing.

## Farmers currently leasing milk quota

Currently, a significant proportion of dairy farmers are leasing milk quota with a view to growing the dairy business. Data from the National Farm Survey (NFS) shows that costs associated with quota are now 4 p/gallon. Data from DairyMis farms show that quota lease charges amount to 11 p/gallon (range 0 to 30 p). Quota lease charges will increase significantly in the immediate future, as the proportion of milk available for leasing is likely to increase and many dairy farmers will be farming with a net milk price of 70 to 80 p/gallon prior to the abolition of milk quotas. Their milk pool will be large and they will be well placed to expand further when quotas are finally abolished. These farmers are unlikely to experience a major shift in actual net milk price, as milk quota lease charges would cease and they will have the necessary farm structure to grow rapidly post milk quota.

**Modelling change in farming system if milk quotas are removed**

The economics of milk production in a situation where no milk quotas apply is very different to a milk quota scenario. In order to maximise income in a milk quota situation; the average production costs on the farm should be reduced to a minimum. Cow numbers should then be reduced until the milk output equals the quota available. In a non-quota environment, production should increase until the value of the marginal output equals the marginal revenue (~milk price).

Farm systems analysis was carried out to investigate the potential for increasing milk output if quotas were removed. It should be noted that many dairy farmers might not react in a similar way to milk price change for a variety of reasons. A model farm was used for this analysis. This farm represents many dairy farms where quota is limiting before land. A two-year-old beef system was used as the companion enterprise to dairying. Table 8 gives a brief description of the model farm. Changes were modelled using resources within the farm.

**Table 8. Model farm for farm systems analysis**

| | |
|---|---|
| Enterprises | Dairying and beef |
| Farm size<br>Quota size( year 0) | 80 acres<br>40,000 gallons |
| Number of cows in year 0 | 38 |
| Other livestock units in year 0 (beef cattle and replacement heifers) | 42 |
| | |
| **Other assumptions**: | |
| Milk yield per cow – 1,100 gallons of which 50 gal./cow was fed to calves | |
| Optimum quota management (year 0) | |
| Inputs, outputs and costs based on current information | |
| Capital infrastructure and labour available for this scale of enterprise | |

In this analysis, the base year (year 0) refers to the period when milk quotas apply (year 2007/8). The farming system was allowed to change from year one. Cow numbers increased rapidly until the land area became a constraint to further expansion. Replacement heifers were always reared within the system.

The effect of removing quota constraints (year 1) on cow numbers and milk volume sales for the model farm is shown in Table 9.

The results show that an increase of ~30% in milk output is a realistic target over a 3-year period. The rate of increase in the first 2 years is lower than later years as it takes time to replace the beef enterprise with dairy cows. This time lag could be reduced if farmers had advance notice of when quotas were likely to be removed.

**Table 9. Change in cow numbers and milk volume sales over time**

| | Cow numbers | Milk sales (gals) | Change in milk sales* |
|---|---|---|---|
| Year 0 | 38 | 40,000 | 100 |
| Year 1 | 42 | 45,676 | 114 |
| Year 2 | 45 | 49,070 | 122 |
| Year 3 | 60 | 65,860 | 164 |
| Year 4 | 69 | 77,378 | 193 |
| Year 5 | 70 | 79,800 | 200 |
| *Year 0 (Base year = 100) | | | |

The effect of milk quota removal on farm cash income is shown in Figure 1.

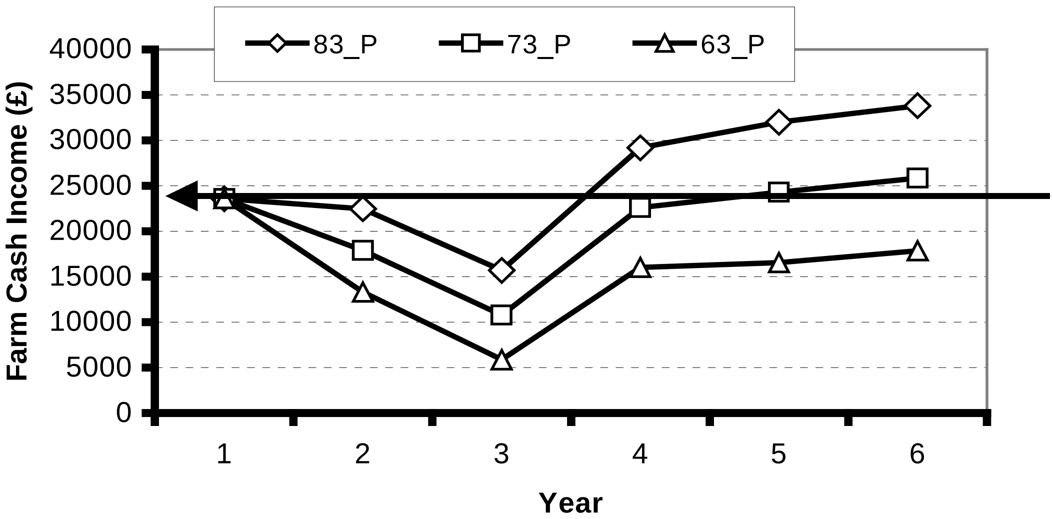
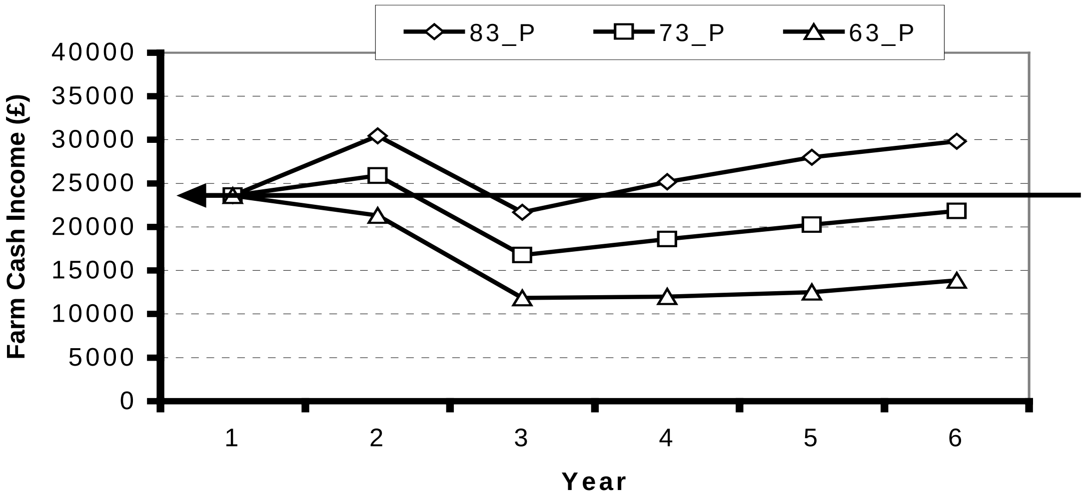



**Figure 1. Change in farm cash income if quotas are removed from year 1.**

The horizontal line represents farm cash at a milk price of 93 p/gallon (likely milk price at the end of Berlin Agreement period). Various levels of milk price below 93 p/gallon were also assessed. A milk price of 83 p/gallon post quota would be dependent on a good product portfolio. Milk price has a large influence on farm cash income. Cash income drops significantly in year 2 because of changes in the structure of the herd (i.e. drop in calf and cattle sales). The data shows that income could be recovered by year 4, if milk price dropped to 73 p/gallon. This analysis takes no account of a possible drop in input costs. While short-term borrowing would facilitate the transition over the first 3 years post quota, it is preferable if compensation mechanisms could be geared towards addressing this issue. Methods of compensation which are likely to be discussed if quotas are to be abolished are not considered here. The main issue here is to deal with cash flow problems. If no compensation mechanism is available then short-term borrowing is needed. Studies of farm structures (Clare UCD/Teagasc study) indicate that cattle facilities could be modified at low cost for dairy cattle.

The data shown in Figure 2 allows for some short term borrowing of capital (£10,000 in year 1 and £10,000 in year 2) to finance some capital development and to deal with cash flow problems in the transition period.

The data in Figure 2 shows that farmers should prepare for cash flow problems in the




early years after quota removal. Investment in facilities should be kept to a minimum during this period and the priority for investment should be for milking and milk storage facilities.

## Production Technology

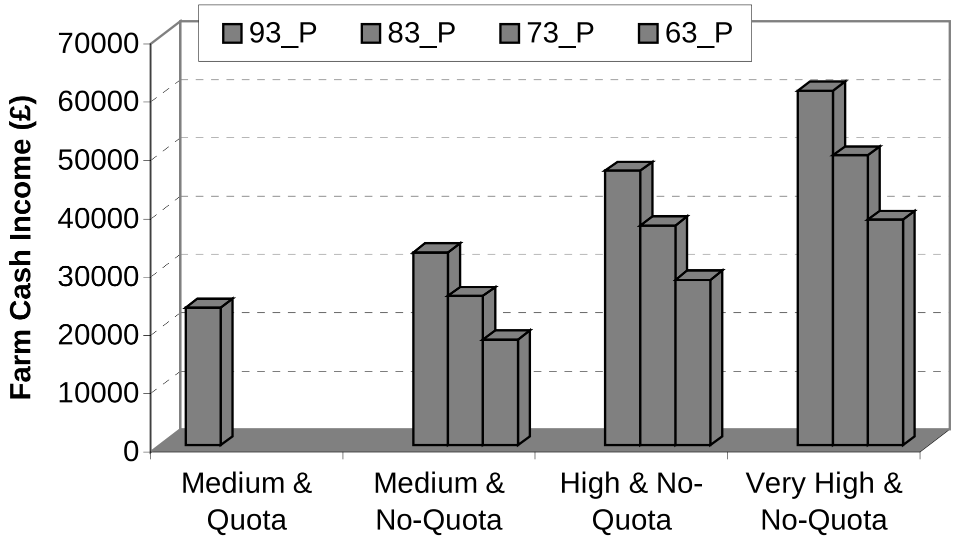
Production technology has a large influence on the ability of the farm business to recover from a low price scenario. The data in Table 10 show the effect of production technology and removal of milk quota on farm milk sales (Model farm).

**Table 10. Changes in cow numbers and volume of milk sales (year 5)**

| | Cow numbers | Milk sales (gallons) | % change in milk sales (Base = 100) |
|---|---|---|---|
| Medium technology – milk quota (1,100 gallon herd) | 38 | 40,000 | 100 |
| Medium technology – no milk quota (1,100 gallon herd) | 68 | 74,000 | 185 |
| High technology – no milk quota (1,400 gallon herd) | 67 | 93,000 | 233 |
| Very high technology – no milk quota (1,700 gallon herd) | 65 | 110,000 | 276 |

The results show the enormous potential to increase milk output if quota constraints are removed and high levels of technology are applied. The combination of high milk output per cow and increased cow numbers has a large effect on milk sales. The effect of production technology on farm cash income is shown in Figure 3.

**Figure 3: Effect of production system on farm cash income at various levels of milk price in a no-quota situation.**




It is evident that high levels of herd productivity can compensate for a drop in milk price.

**Summary on moving towards an increase of 30% in milk output**
It is likely that in practice, increases in milk output will come from improved output per cow as well as from an increase in cow numbers. The actual drop in milk price post quota for many farmers may not be that significant since they are likely to be paying high lease charges towards the end of the Berlin Agreement period. An increase of 30% in milk output is a realistic target by 2010.

**Margin from milk production 2010**
The data in Tables 2 and 3 give the current margins in milk production. There is great variation in margins which cannot be explained by soil type, weather etc. Targets for direct costs, common costs and total costs in 2010 are 25-30, 35-40 and 50-55 p/gallon, respectively. Assuming milk receipts of 80 p/gallon (milk and livestock sales), the contribution margin is 25 to 30 p/gallon. This is equivalent to £25,000 to £30,000 for 100,000 gallons of milk quota.

**Dairy farming systems 2010**
Dairy farming system in 2010 will evolve to incorporate the following:

- Consumer demands for a wider range of quality products, which are assured for safety, protection of the environment and animal welfare will increasingly be enshrined in legislation. These developments may provide market opportunities for the Irish dairy industry because of the potential in Ireland to meet consumer demands at least cost.

- There will be very few part-time dairy farmers but household income will not be dependent on farming alone (spouse working off farm). Smaller farms with surplus labour may supply some farm services, which are not time critical (e.g. spreading fertiliser) to larger farmers.

- Family labour (spouse and children) will be less involved in dairy farming in future. Partnerships tailored to Irish conditions will assume greater importance. Hired labour will demand a share of the equity of the business. Contractors will carry out more farm operations in addition to silage harvesting and slurry spreading.

- Ecological and organic farming will assume much more importance. Ecological farming will be science based.

- The feed resource will be predominantly based on grazed grass especially for spring-calving herds. Grass silage will assume less importance especially if concentrate prices continue to fall and if progress continues in relation to maize production (improved varieties etc). Concentrate feeding levels will increase.

- Milk production systems will be more technologically driven and will increasingly use the products of production technology, biotechnology and information technology.

- The skill level of dairy farmers will incorporate more business skills, computer skills as well as a high level of dairy production skills. Continuous updating of skills will be the norm as part of the annual work programme. Dairy farmers will also be far more aware of consumer requirements.

- Future farming systems will have to conform to regulations in relation to the environment; food safety and animal health and these regulations will be enshrined in legislation. It is probable that farming systems will fall into one or more of the following categories:

  - **Large high-tech farms:**
    - ⇒ Economies of scale.
    - ⇒ Units of ~200-500 cows or greater.
    - ⇒ High merit dairy cows (predominantly Holstein-Friesian).
    - ⇒ Very high output per cow.
    - ⇒ 40-50% of calves will be beef/dairy crossbreeds.
    - ⇒ Spring and autumn-calving systems and some combination of both.
    - ⇒ Large capital input and multiple ownership.
    - ⇒ Managed by salaried professionals.
    - ⇒ Uses all products of production technology and biotechnology.
    - ⇒ Intensive information systems and high output milk harvesting systems including some automated systems.
    - ⇒ Very high skills used sourced through specialist consultants.

- **Ecological milk farms:**
  - ⇒ Similar to current evolving Moorepark Blueprint for dairy production.
  - ⇒ Science-based production system.
  - ⇒ Predominantly based on spring-calving herds.
  - ⇒ Works in harmony with the ecosystem and evolves to improve ecosystem.
  - ⇒ Nutrient management plans.
  - ⇒ Dairy cattle breeds selected for medium to high yields of milk solids and high fertility indices.
  - ⇒ 40 to 50% of calves will be beef/dairy crossbreeds.
  - ⇒ Some premium on milk price.
  - ⇒ Some level of monitoring for compliance.
  - ⇒ High level of animal health and welfare.
  - ⇒ Farm labour mainly supplied by farm owner.

- **Specialist winter milk farms:**
  - ⇒ Herds based on autumn calving.
  - ⇒ Milk produced on contract.
  - ⇒ Large premium on milk price.
  - ⇒ Herds clustered together to facilitate milk assembly.
  - ⇒ Dairy cattle breeds selected for medium to high level of milk solids and for high fertility indices.
  - ⇒ Feed source will be maize silage; some grass silage and a high level of concentrate feeding.
  - ⇒ Herds may fall into one or more of the other systems listed above.

- **Farming to consumer rules:**
  - ⇒ Farms accredited to meet “clean, green, natural, healthy, fashionable” standards.
  - ⇒ Premium on milk price.
  - ⇒ High quality backed by ethical integrity.
  - ⇒ Dual-purpose cows.
  - ⇒ Very high levels of animal health and welfare.
  - ⇒ Environmental resource management.
  - ⇒ Traceability.
  - ⇒ Absence of ‘contaminants’.

## Some Issues in Relation to the Debate on the Future Development of the Industry

### Comparative advantage

The issue in relation to comparative advantage of dairy farming needs to be addressed. Dairying is the most profitable livestock farm enterprise. This is likely to continue to be the most profitable enterprise even if milk price is reduced. The question arises as to whether such a large land resource in Ireland should be devoted to other livestock enterprises, which return such, low profit margins. This question can only arise if no milk quotas apply. This means replacing other enterprises with dairy farms. Farmers who currently have no milk quota will be interested in milk production in future. The enormous benefit from scale of operation needs to be considered. There is no merit in thinking that we can get a good farm income from small farms always.

**Seasonality**
The present milk supply profile is likely to be a constraint to product development. The national strategy should be to have a portion of the national herd calving in the autumn. This is best achieved by having specialist autumn calving herds. The cost of this strategy is minimal in relation to the potential of adding value to milk and to better plant utilisation in the industry. Farmers have to be compensated for the extra costs involved as well as getting an additional margin over spring-calving production systems.

**Labour**
The cost, availability and skill level of farm labour is now becoming a critical issue for dairy farmers. It is likely that highly skilled farm labour will insist on getting equity in the farm business in future. This practice is widespread in New Zealand. New strategies are required to deal with this issue. Farm partnerships offer good opportunities. Access of young people into farming needs to be facilitated.

**Land use**
It is likely that land purchase price will continue to be high. It is important that land use policies facilitate the availability of land for dairying. Land rental charges in future will depend on government strategy and subsidies for non-dairy farm use of land. The method of decoupling subsidies can influence the availability and cost of land for dairying in future. Many farmers are constrained by farm size and farm fragmentation. Herd size can increase if access to land is available at a reasonable cost.

**Environment and animal welfare**
Farming systems need to be sustainable in terms of the environment and animal welfare. Ireland has a good track record in this regard. We need to build on this strength. There need be no conflict between profitable dairy farming and ecological sustainability.

## Dairy Processing

The dairy processing industry faces major strategic questions when confronted with the challenges of the free market. With a current product mix dominated by subsidised commodities, the direction for milk price is towards world market prices. Our relatively poor penetration of non-commodity markets leaves limited options for diversification in the short-term. On the other hand, we do not have the economies of scale to be cost leaders in bulk product manufacture. In the remainder of this presentation we focus on some of the factors which we believe are central to the development of a product strategy for the free market.

There are many who would argue that the best strategy for the future is to continue and consolidate our current emphasis on butter and milk powders based on seasonally produced milk from grass. In 1998, the proportion of milk converted into butter/butteroil was still close to 70% with cheese representing less than 20% of milk utilisation and only about 17% if one looks at the overall pattern over the past 10 years (Table 11).

**Table 11. Irish whole milk utilisation – cheese**

| *Year* | *%* |
|---|---|
| | |
| 1988 | 17.4 |
| 1989 | 16.2 |
| 1990 | 14.9 |
| 1991 | 15.6 |
| 1992 | 18.4 |
| 1993 | 18.7 |
| 1994 | 17.6 |
| 1995 | 15.1 |
| 1996 | 17.8 |
| 1997 | 17.1 |
| 1998 | 19.1 |

In spite of successive attempts through national strategic planning to promote diversification away from butter powder our traditional products have remained very resilient over many years. In a free market, we can be sure that our bulk commodities will return close to world market prices, which will be considerably below current prices, and therefore, if we maintain our current commodity mix, we will have to pursue a cost leadership approach in product manufacture in order to survive and be competitive. This is analogous to the strategy of New Zealand which many would see as our role model. However, there are others who would not find such a strategy acceptable on the basis that it minimises the value of our industry, leaves us exposed to the uncertainties of international bulk prices and underestimates our ability to achieve much greater product differentiation and to penetrate in a more substantial way premium consumer and industrial markets. From the perspective of the state, whose main concern is employment and wealth creation there is not much attraction about the prospect of a dairy industry producing only basic products and it is likely that grant supports, insofar as they will exist, will continue to favour added value projects.

### Scale economies in milk powder production

In a commodity strategy our competitive position in powder production will be of critical importance in light of trade liberalisation and greater market dominance by non-EU countries. Australia and New Zealand have seen almost unlimited expansion in recent years and their plans for further expansion are even more impressive. Australia is pursuing a plan to almost double milk powder output and New Zealand aims to expand its dairy industry more than 3-fold in output value. These developments have been accompanied by significant technological investment in large-scale powder plants with accompanying economies of scale. In the meantime, EU quota restrictions have indirectly led to a slowing of technological investment, particularly in milk drying, in Ireland.

How competitive can Ireland be in milk powder production? We have put together a cost model for milk drying taking into consideration the most important cost elements in a typical powder plant i.e. capital contribution and milk assembly (Table 12).

**Table 12. Typical costs of milk powder production**

| ***Cost element*** | ***p/gal*** |
|---|---|
| | |
| Packaging | 1.6 |
| Fuel and power | 1.3 |
| Direct labour | 1.2 |
| Direct expenses | 0.2 |
| Interest | 0.5 |
| Collection* | 4 |
| | |
| Total variable cost | 8.8 |
| | |
| Contribution to fixed costs | 5-10 |
| | |
| Milk | 100 |
| | |
| Total | 113.8-118.8 |

*O'Callaghan *et al.* private communication

We estimate that there are potential scale economies of 1-1.5 p/gal in going from present dryer capacities of around 5 t/h to capacities of 10-20 t/h. However, these can be eroded by an increase in milk assembly costs if scale consolidation requires a large extension in the milk catchment area. Economies of scale therefore might only be realised when there is an increased intensity in milk production in a confined catchment area or where expansion improves the shape of the catchment area such that the processing plant is more ideally located at its centre. In a milk quota situation the latter condition would be essential to the achievement of scale economies through amalgamation.

If a processing site, in allocating its milk pool to different product streams, gives priority to the powder plant such that its operating season can be extended, a gross capital cost saving of 2 p/gal, attributable to increased throughput, is possible. Such a strategy would marginalise other products, such as cheese, into the peak milk flow season, but would be consistent with the more capital intensive nature of powder production. In New Zealand where large multi-functional processing sites exist or are planned, this most cost efficient approach to powder production can be pursued. In the context of our 2010 scenario, we could envisage three major processing sites for milk powder, each with a 30 t/h drying capacity. If these were to operate at a maximum throughput of 75%, from a seasonal milk supply, each plant would require a milk pool of 450 m gals and would have a powder output of 160,000 tonnes (whole milk powder equivalent). Milk utilisation into powder would be 66% leaving 150 m gals for diversion to other products such as cheese or casein. Processing costs would come close to those in New Zealand, perhaps within 1p/gal. However, a disadvantage of about 1-2 p/gal in milk assembly costs relative to New Zealand would still exist. The capital investment required for a complete renewal and expansion of production facilities to match the above output is in the order of £300 m.

The differential in milk processing costs relative to New Zealand is considerably less than differences in milk production costs. Currently, as shown earlier in this paper, there is a differential in cash costs of milk production of over 30 p per gallon. Even assuming that this differential can be halved by improved technology and farm structure, it is obvious that we cannot be cost-competitive with New Zealand, and the main cost-disadvantage by far, is associated with milk production.

The foregoing shows that the pursuit of scale efficiency as the central focus of industry strategy can improve our cost base somewhat in powder production. In some other respects, however, the consequences may be negative. Large dryers are inflexible and make it difficult to supply a diverse range of powder products for different markets and different customer specifications. The very short manufacturing season for other products, necessitated by a milk powder focus, would militate against the development of value-added markets. Hence, the product range could be even less diverse than today. A shortening of the production season for non-powder products has its own implications for the processing costs of these products which can diminish the benefit of maximising throughput in the powder plant. Achieving market share for our powder output might not be simple because of a residual cost disadvantage relative to our competitors and in view of the massive expansion in output which they are aiming for. In Australia, where a rapid expansion of milk powder production is anticipated, the emphasis has been placed more on flexibility than scale and, in one example, a decision was made to build two driers of 7.5 t/h capacity rather than one of 15 t capacity.

Many of the efficiencies of a mega processing site can be achieved by a smaller site if operation through the winter was possible. Our model shows that year-round operation of a 5 t/h drier can be as efficient in capital costs as a larger drier operating at lower capacity. Scope for near-continuous operation of smaller dryers does exist by co-operation between companies in the pooling of winter milk into a single site, and, where this can be achieved, there is no scale disadvantage. However, it is difficult to envisage such a strategy accounting for more than a small proportion of powder output in an expanded milk pool.

Our conclusion is that Ireland's future investment in milk powder production should be based on driers of capacity of no more than 7.5 to 10.0 tonnes/h. The benefits of having these located in a small number of 'mega' processing sites, rather than a larger number of medium output sites, will depend on a number of factors. One of these is location relative to the milk catchment area and if this is not optimal the benefits of scale consolidation can be neutralised by additional milk transport costs.

**Specialised commodities**
The wisdom of consolidating our industry into bulk products, largely undifferentiated, for disposal at world market prices, would be questioned by many. Indeed many Irish companies already try to specialise and differentiate their commodity business and thereby increase the degree of customer focus in their operation. This imposes a need for flexibility in product manufacture which can act counter to the relentless pursuit of

scale as a central strategy for competitiveness. However, specialisation in powder commodities in itself would be an inadequate platform for future growth and development. Current markets are finite and relatively easy for competitors to access. Development prospects for butter are equally constrained and while steady progress is being made in premium butter exports, the additional milk volume represented by the growth will be modest. Opportunities to develop our other major product, Cheddar, are also limited. While there is growth in the premium mature end of the market, which Irish companies are well aware of, competition is stiff in this market segment and it does not necessarily reflect a growth in Cheddar consumption overall. In general, we must conclude that, with our present product mix, opportunities for adding further value may be limited and, in the case of cheddar, growth opportunities will be difficult to find. The implication of this is that any expansion of milk output in the future will be channelled into basic powder products unless a clear strategy is pursued to diversify our present product range.

### Prospects for cheese

Any search for an alternative to basic powder products inevitably leads to an examination of prospects for cheese. There are good reasons for this. Internationally, and in particular, in advanced consumer markets, cheese consumption is growing. The OECD forecast that cheese consumption in OECD countries will grow by 6.3% between 1996 and 2001. In the EU increase in cheese consumption is expected to be 1.1%/annum until 2000 and around 1% up to 2005 (Table 13). Growth is related to increasing affluence and to the high nutritional value and continuing product innovation associated with cheese. These factors should continue to sustain growth in consumption into the future.

**Table 13. Forecast European cheese consumption**

| | **000 t** | **2002 *v.* 1997** | **Self-sufficiency** |
|---|---|---|---|
| Germany | 1,771 | 3% | 94% |
| France | 1,444 | 2% | 111% |
| Italy | 1,234 | 5% | 77% |
| Netherlands | 335 | 6% | 216% |
| UK | 652 | 6% | 56% |
| Denmark | 101 | NC | 254% |
| Spain | 262 | 36% | 71% |
| Greece | 238 | 7% | 78% |
| Sweden | 166 | 6% | 69% |
| Austria | 143 | 6% | 68% |
| Finland | 93 | 9% | 94% |
| Ireland | 29 | 12% | 297% |
| Belgium | 192 | 3% | 38% |
| Portugal | 84 | 9% | 80% |
| EU-15 | 6,743 | 4% | 95% |

Source: Dairy Industry Newsletter

Today, the prevailing view is that there may have been relatively little advantage in producing commodity cheese instead of butter/SMP over the past 10 years. Statistics on price variations for cheeses sold in the EU show that among the main commodity cheeses, Gouda, Edam, Cheddar, Emmental and Camembert, only Emmental substantially outperformed butter/SMP while Dutch Gouda was a significant under-performer (Table 14). Some lower volume cheeses (Brie, Danablu, Havarti), however, performed much better. The conclusion might be that, in order to gain market premium, the best products are specialised cheese varieties of intermediate volume where growth potential can be realised. This has been the strategy of the Danish dairy industry in recent years. Their main processor, MD Foods has consistently pursued an aggressive development strategy, based on cheese, which overall, represents almost 60% of export value of the Danish dairy industry. Five years ago there was a dramatic loss of markets for Danish produced feta cheese but a successful marketing and product development strategy since then has seen that loss recovered through increased cheese sales in the EU, in particular in the German market. The main focus of their strategy was to move away from bulk type cheeses, such as feta, towards more value-added products that would be less affected by support policy reforms. This move from volume to value was primarily based on building greater market share through brands and own label, in a range of cheese varieties, many of which they were already producers of. Today the profitability of cheese is substantially greater than butter/SMP.

**Table 14. Increase/decrease in selected wholesale dairy prices 1989* to 1997***

| **Product** | **Country** | **ECU - increase/decrease %** |
|---|---|---|
| | | |
| SMP | Europe | 2% |
| WMP | Europe | -2% |
| Butter | Europe | 1% |
| | | |
| ***Cheese types:*** | | |
| | | |
| Brie Laiter | France | 22% |
| Danablu | Denmark | 16% |
| Havarti | Denmark | 14% |
| Havarti | Germany | 13% |
| Emmental | France | 8% |
| Tilsiter | Germany | 6% |
| Cheshire | UK | 6% |
| Cheddar | UK | 4% |
| Edam | Netherlands | 4% |
| Provolone | Italy | 3% |
| Grana | Italy | 2% |
| Cheddar | Netherlands | 1% |
| Camembert | France | 1% |
| Edam | Germany | -1% |
| Gouda | Germany | -1% |
| Gouda | Netherlands | -6% |

**Refers to three year averages centred on the year named*

The Danish model is a difficult one for Ireland since Irish companies have a much smaller range of cheese products and a much lower market penetration to build from than MD Foods. Nonetheless there are many reasons why greater emphasis on cheese would be to our advantage in the future. Firstly, cheese as a commodity product for consumer markets should offer greater price stability in a free market than butter and milk powders. Secondly, cheese is a growth product both in advanced western society and in the world overall. Thirdly, the opportunities for product differentiation and hence for adding value above basic commodity value, are more diverse for cheese than for butter or milk powders. A unique feature of cheese is its versatility as a food. Three distinct market channels have developed i.e. food retailers, the food service sector and food processors. In the food retail sector, developing major new volume brands is extremely difficult and there are relatively few examples on a European scale over recent years. Differentiation within existing brands offers continuing opportunities (examples would be bio-cheese, low-fat, 'territory and taste') but may have a modest impact on volume. The best example of a new variety from Ireland is Dubliner cheese which, in its original concept, was an attempt to modify some of the sharp taste features of cheddar to suit a continental palate. Dubliner, and similar concept cheeses for table consumption, can be an important part of future milk utilisation, but they do rely on the taste preferences of individual consumers and, as such, face a most difficult marketing challenge. Nonetheless, there are many possibilities for modifying both the flavour and texture of cheddar to suit entirely new markets, with the advantage that existing cheddar plant can be used, without the need for substantial capital investment. Indeed, if we moved to year-round production, there is the capacity in existing plant to increase output of cheddar and related cheeses to 150,000 t. Current research at Moorepark is aimed at exploring the potential of this 'hybrid' cheddar concept, and the facilities of Moorepark Technology can ease the way into markets by providing a pre-industrial scale contract manufacturing service.

In the food services and food processing sectors the buyer of cheese is an industrial customer. These companies have different expectation in terms of packaging, customer care, logistics and product specifications. Varying requirements for taste and functionality provide unlimited opportunities for product differentiation. Consumer trends suggest that growth in the food service and food processing sectors will continue to be strong. Currently, the breakdown of cheese consumption in volume terms in the EU between retail, food service and food processing is 70:20:10, compared with an even split (1/3:1/3:1/3) in the US. The trend throughout Europe is in the direction of the US split. In recent years the success of Mozzarella is noteworthy and, while that market is increasingly competitive, differentiated cheese products for catering and food processing would appear to offer the best option for Irish companies for value added and growth.

In the EU, there is a steady if modest growth in cheese retail sales and *per capita* consumption. Much of this increase in consumption is in fresh cheese which, is not a major product category for Irish companies. Certain technological and logistical barriers exist to entry by Irish companies into mainstream fresh cheese markets of the EU where the preference is for fromage frais type products. A more accessible market for Irish companies may be S.E. Asia where the market is still immature and where the main opportunities may be for cream cheese which technologically is a more suitable product for Ireland. While Oceanic countries will be stiff competitors, nonetheless, S.E. Asia is a significant area of growth potential for the future and should be included in strategic planning for 2010.

A significant contributor to returns from cheese is the value of the whey products. Irish companies are to the fore in whey processing technologies and, through continued innovation, can channel greater volumes of whey into differentiated ingredients in the future. Casein manufacture, which is an alternative source of whey, may be a less attractive option than cheese in a free market, and hence our ability to continue to expand in whey technology may be directly linked to cheese output.

**Functional foods**

In Europe the market for functional foods is still very much in its embryonic stages as consumers are becoming more aware of the health associations of these products. As this link becomes more evident the market for these products will develop at a significant rate. It is forecast that product developments in functional foods will surpass developments in diet and low calorie foods and that the functional foods share of the total food market could ultimately reach 5% over the next 15 years although this will probably be higher for dairy foods. The functional food market offers special opportunities for the dairy industry since dairy products have already strong health associations and can provide a natural medium as fermented products for probiotic cultures. Opportunities will exist for joint ventures with non-dairy companies such as pharmaceutical and health companies that have developed consumer confidence and integrity in their brands as healthy and functional products. It is expected that innovative manufacturers can benefit greatly from the functional food market.

**The challenge for the future**

The growth in consumption of dairy products is driven by consumer trends which arise from increased affluence, demand for greater variety and greater health awareness. It is not the purpose of this paper to analyse these trends, which are already well documented. What is clear is that exploitation of the opportunities presented by consumer trends will only be possible for companies with a clear commitment and strategy for innovative product development, backed-up by appropriate investment in technology, R&D and marketing. It is this challenge that provides one of the most cogent reasons for rationalisation of the dairy industry into larger units.

The future direction of Ireland's dairy industry will be set by actions taken over the next few years. If we do nothing, we will face the world commodity markets with an uncompetitive cost base. Scale consolidation can improve our competitiveness, but if pursued with the single objective of cost reduction, will drive our industry into an inflexible commodity corner with little potential to generate a margin above basic bulk value. Scale consolidation, accompanied by a strategy for product diversification, will bring cost economies for bulk products, but its most important consequence would be to provide the resources and marketing power to achieve greater product differentiation and value added. Whichever course of action is pursued, the industry faces major capital investment in advance of the free market. The producer, who has the greatest vested interest in the industry and in decisions taken about its future direction, should consider how he might participate in financing future change and thereby influence the direction of change to suit the best interests of the next generation of dairy farmers.

## Summary

1. A national milk pool of ~1.45 billion gallons is a realistic target in 2010. Up to 20,000 dairy farmers each on average producing ~70,000 gallons of milk per annum with much larger herd sizes (~60 cows). There will be no farmer producing less than 20,000 gallons.

2. Ireland is cost competitive relative to our competitors in Europe. The dairy industry will have to incorporate other issues in relation to competitiveness such as technologies used to produce food, food safety, animal welfare and the environment.
3. Ireland can compete in 2010, because of our cost competitiveness and the great potential for technological change. The structure of dairy farms should be much improved in 2010.
4. An increase in milk output by up to 30% in 2010 is achievable. The productivity of the national herd is low currently. An increase of 150 to 200 gallons per cow is achievable if milk quotas are removed. A large proportion of dairy farmers will be leasing milk quota or paying off milk quota purchase loans (short-term loans) in the short- to medium-term. They will be well placed to expand when lease charges etc. are removed. It is technically possible to increase farm milk sales by 60% within a 4-year period on farms where the dairy herd accounts for less than 50% of all livestock units on the farm (increase in cow numbers mainly). Cash flow problems will arise in years 2 and 3. The application of improved technology has the capacity to increase milk output significantly. A combination of some or all of these strategies makes an increase in national milk output a realistic target by 2010.
5. Targets for direct costs, common costs, total costs in 2010 are 25-30, 35-40 and total costs of 50-55 p/gallon, respectively. Assuming milk receipts of 80 p/gallon (milk and livestock sales), the contribution margin is 25-30 p/gallon. This is equivalent to £25,000 to £30,000 for 100,000 of milk quota.
6. Systems of production will evolve to incorporate consumer concerns, many of which will be enshrined in legislation.
7. Ireland's cost base for dairy commodity manufacture is considerably higher than New Zealand's. Most of the cost differential is on-farm. In pursuing scale economies in milk processing there is a trade-off between cost reductions on the one hand, and product flexibility and milk assembly costs on the other hand. There will be a need for massive re-investment in milk dryers in preparation for the free market. A maximum dryer capacity of 7.5-10 t/hr is more appropriate than the jumbo dryers of New Zealand.

8. With our current product mix, Ireland's milk price in a free market will be close to world market prices and the expanded milk output after quota abolition will be channelled into milk powder for the world market. Opportunities for commodity specialisation will continue to exist but will not provide an adequate platform for future development.

9. Opportunities exist for the Irish dairy industry to achieve growth in value-added markets and thereby to do better than basic commodity returns. The key to value-added is product differentiation. The main volume opportunities for value-added are in cheese. Cheese markets which should be targeted are medium volume

speciality cheeses for the EU, the food service and food processing sectors and cream cheese for the Asian market.

10. Ireland can be a leader in ingredient product differentiation mainly through exploitation of whey technology. Opportunities will also exist for added value in the growing functional foods market.

11. The most important benefit of consolidation of the Irish dairy industry into bigger processing units may be the ability to finance product differentiation rather than the improvement of costs.

12. The producer can best influence the future direction of the Irish dairy industry by investing in its development programme.

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# Foresight for the beef industry 2010

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**Irish cattle farmers and the entire beef sector have a long history of functioning and surviving in a very uncertain market and policy environment. Cattle supplies in Ireland are at present primarily driven by the direct payment system.**

**This paper forecasts that the direct payments will be decoupled by 2010 and replaced by a new and innovative income support system. The number of cattle farmers will continue to decline but there will be no mass exodus from the sector.**

**The direct payment system will be re-oriented to achieve a better supply-demand balance for beef and to incorporate a number of "public good" values such as rewarding environmental protection, food safety and animal welfare.**

**The direct payments may be operated using a schedule similar to the Farm Retirement Scheme but with REPS type requirements.**

**The re-orientation of the payments will be conducive to the production of "consumer oriented beef" requiring new technological inputs on cattle farms and at processing factories and in marketing.**

**Future competitiveness at farming and processing levels will depend on a number of key factors. These include clear identification of markets and market requirements and their transmission along the beef chain. Financial rewards for quality, an objective carcass classification system and cattle breeding, nutrition and rearing systems to deliver cattle to required specifications.**

## Introduction

About 120,000 farmers are engaged in cattle production in Ireland. Using about 2.5 million hectares of grassland they rear and fatten the progeny of approximately 1.2 million dairy and 1.1 million beef cows to produce about 2 million animals per year for slaughter or for export as live animals. Almost 90% of the production is exported to markets both inside and outside the EU.

The value of cattle slaughtered and live exports is approximately £1,100 million per year. In addition over half this amount is also derived from the EU direct payments. Despite these large sources of revenue the Irish cattle sector is characterised by persistently low incomes. With the expansion of the economy and the resulting increase in off-farm employment opportunities, cattle production is fast becoming a part-time occupation capable of producing a reasonable return to the labour input.

## Operating Conditions 2010

Given the increasing likelihood of direct payments being completely decoupled from production the fundamental question is what type of income support mechanism will be used in the EU for cattle farmers in a decade from now. Four main factors will determine this mechanism. These are:

- EU farm budget costs including enlargement effects
- EU commodity market balances as influenced by WTO and enlargement
- EU vision of acceptable farm structure
- External market environment as influenced by WTO and enlargement.

Five main options could be used as income support mechanisms. These are:

1. High Product Prices as used by the EU pre MacSharry reform.

2. Lower Product Prices with Animal Based Direct Payments with stocking density constraints as prevailed in the EU post MacSharry and again under the Agenda 2000 agreement for beef cattle.

3. Area Based Payments which is the current system for crops in the EU post MacSharry and under Agenda 2000.

4. Farmer Based Payments, farmers who may or may not continue producing as in the current system for crops in the US.

5. Farm Process Based Payments, or methods based payment incorporating consumer and public good values.

A summary of the type of farmer's response and the market consequences for each of these income support options is presented in Table 1. The first three options have already been operated in the EU with limited success. Option 4 has been used in the US since 1995 and its limitations have become very evident in the last 2 years when world prices collapsed.

It is likely that the existing EU system for beef, probably with further modifications, will prevail for most of the next decade. A number of modifications are already being made under Agenda 2000 to stocking density specifications and this will further tighten the animal-land link. This has obvious consequences for producer's costs and increases the degree of insulation of producers from product markets.

A move towards option five has already begun under the Agenda 2000 agreement. Firstly, there is the proposed decoupling of "headage" from the animals and linking them to land management to prevent environmental degradation. Secondly, there is also an increasing pressure to link all the other direct payments to environmental compliance criteria. In the future the direct payments could be made conditional on a range of compliance criteria for the entire farm and would most likely include minimum and maximum stocking density limits. Other compliance criteria could incorporate public good and consumer values in relation to food safety, landscape, environment, animal welfare and production technology and possibly even a "homestead" maintenance requirement. This change will have cost of production implications but it does incorporate a number of "Public Good" values which are product attributes of increasing value as affluence increases. These public good values are a marketable entity in an increasingly affluent society like the EU.

Even if the exact format of the income support system for cattle farmers for the years post 2010 are not clear, the general direction is now beginning to emerge. The basic strategic assumption must be that the incomes of cattle farmers be maintained at least in nominal terms. Therefore, the pool of revenue from cattle sales and direct payments will be largely maintained but the number of farmers will continue to decline.

**Scenario for 2010**

With this outline of the policy and market conditions that are likely to prevail it is possible to chart a scenario for the beef sector for 2010, or soon thereafter. The scenario is based on the following assumptions:

- income earned by beef farmers will be maintained, through increased levels of direct payments
- these payments will most likely be tied to the provision of public goods like environmental, animal welfare and food safety criteria
- a lower internal market price for beef will prevail, but
- a freer trade with Third Countries will operate.

Under the assumptions outlined above, it is envisaged that there will be three broad categories of beef farmers in Ireland. These are:

1. 2,000 to 3,000 large-scale full-time commercial farmers, specialising in providing finished animals under "contract" to beef processors.

2. 30,000 to 50,000 part-time farmers who are earning a significant portion of their income from cattle farming. These will be primarily engaged in producing calves, weanlings and young animals from both dairy and suckler cow farms and supplying stores or feeder cattle to specialist finishers and for the live export trade.

3. 30,000 to 40,000 other farmers who would be primarily engaged in producing weanings from the suckler cow herd. Most of these will be earning less than a third of the average industrial wage from farming. This group will be supplying weanlings to other farmers or for the live export trade.

In addition the beef industry would have output of calves and younger cattle from commercial dairy herds.

**Table 1. Farm income support options**

| Income support options | Farmers response | Market consequences |
|---|---|---|
| 1. High product price | • increased supply and reduced demand | • market imbalance |
| 2. Payment per animal | • animal numbers maintained to collect payments<br>• production responds to compliance criteria for the payment | • poducers become progressively isolated from the market |
| 3. Payment by land area | • animal numbers decline<br>• farmers will comply with payment conditions<br>• income related to scale of existing land resource base | • supply will decline and respond to market needs<br>• the consumer and taxpayer get a poor return on payment |
| 4. Payment to "existing" farmers<br>(US solution) | • existing farmers OK for income<br>• all production and supply subject "world prices" and their vagaries<br>• income for active producers low and volatile<br>• land could be abandoned unless market based margins were maintained | • existing farmers may or may not participate in production<br>• new farmers have no income support<br>• market balance unlikely as supply highly volatile and consumer prices very variable |
| 5. Payment for the "process of farming" to specified criteria<br><br>(Actual payments structured like the existing early retirement scheme but the farming process operated like REPS) | • reduce intensification and supply<br>• optimum animal numbers maintained within upper and lower stocking density limits<br>• production process to comply with:<br>  • environmental values<br>  • food safety specifications<br>  • animal welfare standards | • better market balance<br>• EU can differentiate its internal market for products on the basis of the "public good" content<br>• EU Budget costs can now be related to: both consumer and taxpayers valuation of "public goods"<br>• producer payments more easily justified to WTO |

Category 1 will depend mainly on the marketplace for their income and if they did not exist beef processors would have to become involved in finishing in order to guarantee a supply of slaughter cattle.

Categories 2 and 3 above will be substantially dependent, as at present, on direct payments for most of their farm income.

In the absence of payments that would be tied directly to animals, cattle prices all along the chain will decline. The live export trade for calves and weanlings to the Continent and the store trade to Third Countries will provide competition and ensure reasonable prices for calves and weanlings and finished animals. This trade for calves and weanlings could be affected by the elimination of the calf processing scheme and the consequential realignment of the calf and weanling trade within the EU and by increased supplies from new member states in the longer term.

Decoupling of the direct payments from the animals and the incorporation of public good values into the direct payments system will allow cattle prices along the chain to reflect more clearly than at present the final market value of the beef.

The beef processing sector already has a problem of surplus capacity, which has been documented by the McKinsey report. Reduced supplies are expected as a result of the Agenda 2000 CAP reform changes already agreed and further reductions in supply are likely to occur if direct payments are decoupled from production, as outlined above. In these circumstances we would envisage that the total number of plants involved in slaughtering would be significantly reduced, probably to a level of four or five. The beef processing sector, already has a problem of surplus capacity, which has been documented by the McKinsey Report.

Consumption of beef within the EU is likely at best to remain static, despite the reductions in wholesale prices. Prices in the EU are, however, in a free trade scenario, likely to remain above world market prices. An increase in volume of Irish exports sold on European markets could be expected.

The extent of the reduction of the beef price differential between Ireland and the EU will depend on the combined effect of:

- the increased market opportunities provided by the decline in supplies in mainland Europe which could arise as a result of the lower prices and decoupled payments

- the extent to which the production and marketing of Irish beef can be refocused on the demands of the EU marketplace.

**Core Technologies Required**

A series of core technologies and related competencies will be needed in both the beef production and processing sectors to adequately prepare us for 2010. At a macro level these can be considered as follows:

- Payment for quality
- Consumer safety

- Consistent quality
- Welfare and environmentally compatible production systems

**Payment for quality**

Accurate objective carcass grading systems will be required to facilitate the payment of animals on a quality basis. This technology will permit the clear and unambiguous transfer to the producer of accurate information on the relative merits of different categories of carcasses. This in turn will encourage producers to pursue particular animal breeding, nutrition and management strategies to meet the more rewarding specifications.

**Consumer safety**

HACCP (hazard analysis critical control points) systems will be required both on-farm and in-factory to ensure the supply of guaranteed safe beef to consumers. These will involve:

- Identification and detection methods for the control of pathogens, pollutants, toxins etc., and
- Systems to prevent the introduction of undesirable materials into beef at any stage along the production chain.

This technology will require that appropriate recording, monitoring and verification procedures relating to issues such as dietary and veterinary inputs, hygiene practices etc. This will ensure that specifications are adhered to throughout the beef production chain. A foolproof system for identification and traceability of individual cattle and cuts of beef will be needed to underpin this.

**Consistent quality**

Production systems will need to be devised to consistently and efficiently meet pre-defined quality specifications. This will require:

- Selection procedures to identify optimal animal genetics
- Models of production factors controlling meat quality
- Methods to prevent cattle diseases compromising meat quality
- Labour and technical efficient beef production methods which are economically sustainable.

These new and improved technologies will support knowledge-based beef production systems. They will integrate a comprehensive range of practices designed to consistently and efficiently produce beef carcasses of pre-defined specifications.

Innovative technologies will be required to improve process efficiency and meat quality and to increase the range of consumer products. This will involve new:

- On-line measurements of indices for meat quality.
- Early post-mortem carcass manipulation technologies.
- Expanded range of value-added consumer products.

These technologies will provide consumers with beef-based foods of consistent quality, and will significantly widen the range of products available from which to choose.

**Welfare and environmental compatibility**

Indices will be required to objectively define:

- acceptable animal welfare
- satisfactory environmental conditions
- production systems compatible with these.

These technologies will indicate the animal welfare and environment management codes that should be conformed with, and facilitate the marketing of a distinctly Irish, wholesome product to consumers.

## Technological Support

To achieve rapid and effective uptake of these appropriate technologies it will be necessary to have:

- A market surveillance system allied to the identification and interpretation of important signals, and the transfer of the latter back to beef processors and producers.

- Financial rewards for producers and processors who use the improved technologies to meet the market requirements.

- A marketing and advertising strategy to exploit the unique characteristics of Irish beef in particular, and the beneficial attributes of beef in general.

- Science-based research which is dynamically guided to push forward the frontiers of technology, particularly in areas where Ireland may have unique competitive advantages

- Training courses and advisory services for those in the agri-food sector to facilitate the uptake of the appropriate technologies.

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# Technological and economic benefits of biotechnology

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**Innovation is essential for sustaining and enhancing agricultural productivity. Agricultural innovation has always involved new, science-based products and processes that have contributed reliable methods for increasing productivity and environmental sustainability. The set of techniques commonly referred to as biotechnology has introduced a new dimension to such innovation.**

**In the simplest and broadest sense, biotechnology is a series of enabling technologies, which involve the manipulation of living organisms or their sub-cellular components to develop useful products, processes or services. In essence, this definition illustrates the breadth and implies the positive potential of biotechnology. Biotechnology encompasses a wide range of fields, including the life sciences, chemistry, agriculture, environmental science, medicine, veterinary medicine, engineering and computer science.**

**The manipulation of living organisms is one of the principal tools of modern biotechnology. Although biotechnology in the broadest sense is not new, what is new, however, is the level of complexity and precision involved in scientists' current ability to manipulate living things, making such manipulation predictable, precise and controlled. This level of control is a tremendous asset in the quest to improve the quality of life.**

**Although the umbrella of biotechnology encompasses a broad array of technologies, including recombinant DNA technology, embryo manipulation and transfer, monoclonal antibody production, and bioprocess engineering, the principle technology associated with the term is recombinant DNA technology or genetic engineering. This technique can be used to enhance the ability of an organism to produce a particular product (starch in potatoes), to prevent it producing a product (ethylene in plant cells) or to enable an organism to produce an entirely new product (insulin in microbes).**

**To date the greatest and most notable impact of biotechnology has been in the medical and pharmaceutical arena. Over 200 million people worldwide have benefited from the hundreds of diagnostics, therapeutics and vaccines produced by the $13 (£9.6) billion biomedical biotechnology industry. The use of biotechnology to produce molecules of therapeutic value constitutes an important advancement in medical science. Medications developed through biotechnology techniques have earned the approval of the US Food and Drug Administration for use in patients who have cancer, diabetes, cystic fibrosis, hemophilia, multiple sclerosis, hepatitis B, and Karposi's sarcoma. Biotechnology drugs are used to treat invasive fungal infections,**

**pulmonary embolisms, ischemic strokes, kidney transplant rejection, infertility, growth hormone deficiency, and other serious disorders. Medications have also been developed to improve the health of animals including diagnostics, recombinant vaccines and therapeutics. Scientists are currently investigating applications of advanced gene therapy, a technology that among other things can be used to pinpoint and rectify hereditary disorders, battle cancer and recalcitrant infectious diseases such as AIDS.**

**Many of the products we eat, wear, and use are made using the tools of biotechnology. Using genetic engineering, scientists are able to enhance agronomical characteristics such as biotic and abiotic stress resistance, yield and growing season, and quality traits such the nutritional content, antioxidants, vitamins, minerals, texture, color, flavor, shelf life and other properties of production crops. Plants can be used to produce completely novel products such as vaccines, therapeutic proteins and even plastics. Transgenic techniques are applied to farmed animals to improve the growth, fitness, and other qualities of agriculturally important mammals, poultry, and fish.**

**Enzymes produced using recombinant DNA methods are used to make cheese, keep bread fresh, produce fruit juices, wines, treat fabric for blue jeans and other denim clothing. We can engineer enzymes to produce sweeteners, flavors, vitamins, amino acids, antibiotics, lipases for fat metabolism, proteases for protein digestion, cellulases to prevent pilling of clothes, and de-inking newsprint for recycling. Eighty per cent of cheese is made using a genetically engineered enzyme called chymosin produced by microbes. This enzyme is chemically identical to the enzyme rennet which is isolated from the contents of the forestomach of an unweaned calf. It is easier to purify, more active (95% as compared to 5%) and less expensive to produce (microbes are more prolific, more productive and cheaper to keep than calves).**

**We can also engineer microorganisms to improve the quality of our environment. In addition to the opportunities for a variety of new products, including biodegradable products, bioprocessing using engineered microbes offers new ways to treat and use wastes and to use renewable resources for materials and fuel. Instead of depending on non-renewable fossil fuels we can engineer organisms to convert maize and cereal straw, forest products and municipal waste and other biomass to produce fuel, plastics and other useful commodities. Naturally occurring microorganisms are being used to treat organic and inorganic contaminants in soil, groundwater, and air. This application of biotechnology has created an environmental biotechnology industry important in water treatment, municipal waste management, hazardous waste treatment, bioremediation, and other areas.**

**DNA fingerprinting, a biotech process, has dramatically improved marker assisted selection in plant and animal breeding, disease diagnostics, cultivar and pedigree identification, criminal investigation and forensic medicine, as well as afforded significant advances in anthropology and wildlife management.**

**Used effectively, biotechnology has enormous potential to improve the quality of our life and our environment.**

**The primary objective of this paper is to deal with the technical and economic aspects of biotechnology, and while consumers concerns will not be dealt with in detail they are addressed briefly in the section entitled "Addressing Concerns".**

## Public-Private Research Focus

Public federally funded institutions provide the foundation for and wellspring of the major proportion of innovative research in biotechnology. In addition, these highly respected institutions provide the catalysts and intellectual breeding ground for the creation of innovative partnerships with industry. Indeed the rapid growth of the biotech industry in the US can be traced to highly nodal pockets at the epicenter of which are located major universities. This is why, for example, the San Francisco Bay area is home to the greatest concentration of biotech companies in the world. For example 1 in 3 US biotech companies is less than 35 miles from a UC campus, 1 in 5 California Biotech companies was founded by UC scientists 6 of the 10 best selling biotech drugs stem from UC research and 85% of California biotech companies employ UC researchers.

The Donald Danforth Plant Science Center in St. Louis is another example of innovation interactions between public and private enterprises. The Center is the product of a unique and innovative partnership joining the Missouri Botanical Garden, Purdue University, the University of Illinois at Urbana-Champaign, the University of Missouri-Columbia, Washington University in St. Louis and the Monsanto Company, with additional support from the St. Louis-based Danforth Foundation and the State of Missouri. The not-for-profit Danforth Center is a fully independent resource for all who are devoted to discovery and all who are committed to making available the critically needed knowledge of plant science that will sustain our planet for generations to come. It's mission is to increase understanding of basic plant biology, apply new knowledge to help sustain productivity in agriculture, forestry and allied fields, facilitate the rapid development and commercialization of promising technologies and products, (for examples, see Table 1) and contribute to the education and training of graduate and postdoctoral students, scientists and technicians from around the world.

**Table 1. Main technologies and their application in biotechnology research**

| Technologies | Application |
|---|---|
| | |
| **GENERAL** | |
| | |
| Antisense, ribozymes, co-supression | To turn off or down undesirable traits such as ripening, senescence, anti-nutritionals, |
| Genomics, proteomics, bioinformatics | To study global level gene expression<br>To select and/or modify gene coding for valuable traits |
| Directed evolution | To rapidly develop novel traits from existing genetic information for example 53 new varieties of Bt created this way |
| Combinatorial -Chemistry, -Biology | To rapidly create new drug, environmental or agricultural products |

## Genomics, Proteomics and Bioinformatics

Leroy Hood has noted that “Biology in the 21st century will increasingly become an information science” and the many programs and initiatives underway at major research institutions and leading companies are already giving shape to this assertion. The guru of information technology, Bill Gates, has commented that the two technologies that will shape the next century are biotechnology and information technology. It is to be assumed that a certain level of credibility can be attributed to the prescience of an individual who is playing a major part in the latter process and who has amassed a personal fortune to date in this endeavor. Another prescient individual Max Delbruck observed, in 1949, that any cell has in it a billion years of experimentation by its ancestors. Taking Hood’s and Delbruck’s comments into consideration, Gates observation could be further expanded to state that the two technologies that will have the greatest impact on each other in the new millennium are biotechnology and information technology. In fact it could be argued that all biological systems from the subcellular, to the organismal and even to the ecological level, owe their existence to information technology. By extrapolation it could be said that the future of biological research will be shaped in part by using silicon-based systems to find ever more effective methods to elucidate and modify these mechanisms of information flow. The corollary of this will be that silicon-based systems will more and more look to biology for methods to overcome the limitations of integrated circuits and to elucidate mechanisms that will allow the development of massive parallel processing and networking capabilities, and ultimately the simulation of higher functions and artificial intelligence. This is an area in which Ireland could shine because of its existing internationally recognized presence in information technology.

The complexity of biological systems, coupled with the explosion in gene sequence information mandates the need for multidimensional methods for gene expression analysis. High capacity methods for analysis of gene expression are key to generalizing approaches to “functional genomics”, an area in which Irish research institutions must have strong capabilities to be competitive in the next 10 to 20 years. Large-scale gene expression analysis technology provides a systematic infrastructure and throughput capabilities consistent with the need for the study of one organism or groups of organisms in the environment. The new method of analysis constitutes a paradigm shift in the biological sciences, and it will change the way many aspects of medical, agricultural and biological research are carried out, including the discovery of physiologically active compounds and drugs and disease diagnostics.

Although applications in medicine have been the main thrust of this development, this technology is now having a major impact in agriculture biotech and most specifically plant biotechnology research. Plant biology is in the midst of a move towards a more interactive approach to research similar to those undertaken in physics. Plant genome scientists will increasingly employ DNA chips in their research, and functional analysis of the genome through such approaches as gene knockout will be employed. These high-powered tools being developed to analyze the human genome are making inroads into agricultural biotechnology. Such tools are essential for genome researchers to move beyond sequencing and into the next phase of research where they conduct enormously large-scale gene discovery surveys and gene expression analyses.

## Crop Agriculture

Agricultural biotechnology offers efficient and cost-effective means to produce a diverse array of novel, value-added products and tools. It has the potential to increase food production, reduce the dependency of agriculture on chemicals, and lower the cost of raw materials, all in an environmentally friendly manner.

The initial phase of a revolution in agriculture has already occurred. Large areas of genetically modified (GM) crops of soybeans, maize, cotton, and canola have been successfully grown in the Western Hemisphere. In the United States in 1999, of the total of 72 million acres (29 million hectares) planted with soybeans, half were planted with GM herbicide-resistant seeds. When herbicide-resistant seeds were used, weeds were easily controlled, less tillage was needed, and soil erosion was minimized. Worldwide in 1999, about 28 million hectares of transgenic plants are being grown. Some experts predict that this area will be tripled in the next 5 years.

Between 1996 and 1999, eight countries, five industrial and three developing, have contributed to more than a 15-fold increase in the global area of transgenic crops. Adoption rates for transgenic crops are some of the highest for new technologies by agricultural industry standards. High adoption rates reflect grower satisfaction with the products that offer significant benefits ranging from more flexible crop management, higher productivity and a safer environment through decreased use of conventional pesticides, which collectively contribute to a more sustainable agriculture. Although the final figures are not available for 1999 it is estimated that the increase in acreage is not as dramatic as that between 1997 and 1998, when the global area of transgenic crops increased by 16.8 million hectares to 27.8 million hectares, up from 11.0 million hectares in 1997. Five principal transgenic crops were grown in eight countries in 1998, three of which, Spain, France and South Africa, grew transgenic crops for the first time in 1998. It is noteworthy that 1998 was the first year for a commercialized transgenic crop to be grown in the countries of the European Union. Estimates suggest that introductory quantities of insect resistant maize were grown primarily in Spain (20,000 hectares) and France (2,000 hectares); this is judged to be potentially a very significant development because it could have important implications for the further adoption of transgenics in countries of the European Union.

**The Technology Timeline graph**

| | |
|---|---|
| **2,000 BC** | **Cultivation** |
| **19thC** | **Selective Cross breeding** |
| **Early 20th C** | **Mutagensis and selection** |
| **Mid 20th C** | **Cell culture** |
| **1930s** | **Somaclonal variation,** |
| **1940s** | **Embryo rescue,** |
| **1950s** | **Polyembryogenesis,** |
| **1970s** | **Anther culture,** |
| **1980** | **Recombinant DNA** |
| **1980s** | **Marker assisted selection** |
| **1990s** | **Genomics** |
| **2000** | **Bioinformatics** |

| **Examples of recent plant technologies** | **Application** |
|---|---|
| | |
| Chloroplast transformation | To increase transformation efficiency and to control gene flow |
| Cobombardment | Using the gene gun to add multiple genes simultaneously |
| Transposon Tagging | Effective alternative to antibiotic selection |
| Targeted site-specific Recombination | To target gene inserts to specific sites in plant tissue |
| | |
| Chimeraplasty | To create subtle alterations in the plants own genes for example to produce herbicide tolerance without introducing novel genes |

| **Examples of crop trait** | **Source** |
|---|---|
| Resistance to Biotic Stress: Insect | *Bacillus thuringensis* insecticidal protein, DNA shuffling to create diversity, *Streptomyces,*Photorhabdus luminescens*: toxins, antibiotics, antifungal compounds, lipases, proteases*<br>Viral insecticide e.g. bacullovirus |
| Resistance to Biotic Stress: Viruses | Viral Coat protein protection, Protease inhibitors, Satellite RNA, artificial Resistance genes |
| Resistance to Biotic Stress: Bacteria | Natural and synthetic Resistance (R) genes e.g. XA21 from rice |
| Resistance to Biotic Stress: Fungal | Resistance genes, apoptosis (programmed cell death) genes, chitinases, ribosome-inactivating proteins |
| Resistance to Biotic Stress: Nematodes | Resistance genes e.g. *Mi* from tomato against rootknot nematodes; Giant feeding cell destruction |
| Resistance to Biotic Stress: Weeds | Glyphosate tolerance Enolpyruvylshikimate -3-phosphatesynthase gene from *Agrobacterium*<br>Engineered resistance to parasitic weeds |
| Resistance to Abiotic Stress: Drought | Dehydration Response Element (DRE) |
| Resistance to Abiotic Stress: Salt | Glycinebetaine insulates plant cells against the ravages of salt by preserving the osmotic balance, by stabilizing the structure of proteins such as RuBisCo and by protecting the photosynthetic apparatus. The enzyme choline oxidase helps in the production of betaine from choline. |
| Resistance to Abiotic Stress: Cold | Engineering with COR15a transcription factor, which is speculated to have a role in freezing tolerance. Plants engineered with Choline oxidase (codA) from a soil bacterium tolerated saline and cold conditions. |
| Abiotic Stress: Heat | Choline oxidase (codA) gene from *Arthrobacter globiformis* |

| **Examples of crop trait** | **Source** |
|---|---|
| | |
| Yield | *Rhizobia* Engineering to improve colonization, nodulation, nitrogen fixation, host range |
| Yield | Metabolic pathway engineering to improve nitrogen assimilation, sucrose hydrolysis, starch biosynthesis, 30% increase achieved |
| Yield | Increasing $O_2$ availability through stomata modification, bacterial hemoglobin genes, Modifying photosynthesis: RuBisCo engineering |
| Shelf life | Spoilage reduction through ethylene inhibition, polygalacturanase inhibition |
| Processing characteristics | Increase soluble solids through engineering expansions, Sucrose to Hexose conversion inhibition |
| Nutrition: Macro components | Metabolic Pathway engineering for better amino acid ratio, increased starch<br><br>Carbohydrate modification: Starch and fructans are both polymeric carbohydrates in plants, for which the biosynthesis is sufficiently understood to allow the bioengineering of their properties, or to engineer crops to produce polysaccharides not normally present. e.g. The expression of a Jerusalem artichoke gene encoding 1-sucrose:sucrose fructosyl transferase (1-ISST) in sugar-beet plants enabled the conversion of sucrose, which is normally present abundantly in beet vacuoles, into simple fructan sugars |
| Nutrition: Micro components | Metabolic Pathway engineering with genes for antioxidants, beta carotene, alpha tycopherol., isoflavonoids, phytoestrogens, ferritin, lignins, condensed tannins |
| Nutrition: Anti-nutritionals | Phytase to metabolise phytate, reduce phosphorous supplements and make chelated minerals bioavailable, removal of cyanogenic glycosidases, phytohemaglutenins, glycoalkaloids |

| **Examples of crop trait** | **Source** |
|---|---|
| | |
| Novel oils | ACP Thioesterase to alter fatty acid metabolism in rape seed to produce Laurical as an alternate to palm oil in confectionaries, detergents, etc. |
| | Sterate desaturase inhibition to get a solid spread at room temp with out chemical hydrogenation<br>Genes from jojoba to give long chain fatty waxes for cosmetics and cleaning and high temperature lubricants |
| Novel polymers | Polyhydroxyalkonates – natural biodegradable, thermostable plastics using genes from *Alcaligenes eutrophus* |
| | |
| Novel proteins | Therapeutics, alpha 1 anti trypsin for emphysema, hemoglobin<br><br>Antibodies against cancer, tooth decay |
| | Vaccine antigens against cancer, Type II diabetes, viral and bacterial diseases |

Tremendous progress in plant molecular biology over the past two decades has opened ample opportunities to improve crop plants in a way not feasible a few years ago. Among other compounds, the production of foreign proteins in plants has become an attractive alternative to conventional production systems (i.e. microbial and yeast production systems). The use of plants as bioreactors is of special interest as they allow production of recombinant proteins in large quantities and at relatively low costs. In addition, formulated in seeds, plant-made enzymes have been found to be extremely stable, reducing storage and shipping costs. Furthermore, production size is flexible and easily adjustable to the needs of changing markets.

The main objectives of creating transgenic plants are attempts to engineer metabolic pathways for the production of tailor-made plant polymers or low molecular weight compounds, increased resistance towards pathogens and pesticides, improved food quality, and the production of polypeptides for pharmaceutical or technical use. Plant-made vaccines or antibodies (plantibodies) are especially attractive as plants are free of human diseases, reducing screening costs for viruses and bacterial toxins. Production of engineered antibodies and subunit vaccines in plants turned out to be very efficient and led to the first clinical trials with plant-produced vaccines and plantibodies.

As noted by Abelson in Science (1998) changes that will have effects comparable to those of the Industrial Revolution and the computer-based revolution are now beginning. The next great era, a genomics revolution, is in an early phase. Thus far, the pharmacological potentials of genomics have been emphasized, but the greatest ultimate global impact of genomics will result from manipulation of the DNA of plants. Ultimately, the world will obtain most of its food, fuel, fiber, chemical feedstocks, and some of its pharmaceuticals from genetically altered vegetation and trees. Until 1998, comparatively little research has been devoted to changing plant genomes. Now universities, research institutions and industries throughout the country are instituting major initiatives in this field. Companies including Dow Chemical, DuPont, Monsanto, Novartis, Pioneer Hi-Bred, and AgrEvo are spending billions of dollars annually on genetic engineering and on acquiring stakes in genome-oriented companies. For example, DuPont has taken over Pioneer Hi-Bred, the major corn breeder and distributor. Calgene is now owned by Monsanto and Mycogen is controlled by Dow.

## Animal Agriculture

In animal agriculture, biotechnology's greatest immediate potential lies in diagnostics, therapeutics and vaccines for disease control. There are currently 63 animal therapeutics on the market in the US. The first genetically engineered vaccine against a cattle virus was produced in UC Davis. Rabies is now being controlled in wild animals through genetically engineered vaccine loaded bait.

Researchers are studying reproductive biology, animal genetic engineering and embryo manipulation in order to increase fecundity and productivity and produce high value animals, including leaner animals with meat lower in calories and cholesterol and cows that will produce more nutritional milk. The first goat sheep hybrid was produced in Davis as a model to study developmental biology and interspecies pregnancies.

Geneticists made major strides in developing and applying DNA finger printing techniques to pinpoint animals that are carrying genes of value, for example, genes for superior cheese-producing milk, can now be detected in bulls and cows and then using those animals in breeding programs to select for improved dairy production.

**Animal biotechnology**

- Recombinant vaccines and therapeutics, e.g. rabies, rinderpest in vaccinia delivery vectors
- Marker assisted selection
- Supplementals, recombinant Bovine Somatatropin
- Transgenics
    - - disease resistance
    - - productivity, improved milk quality, improved meat quality, reduced fat
    - - Medical applications

Transgenic animals have tremendous potential to act as valuable research tools in the agricultural and biological sciences. They can be modified specifically to address scientific questions that were previously difficult if not impossible to determine.

While the first directed "engineering" of animals was selection of desirable animals with traits for breeding purposes, there is no doubt that the first scientific contribution to reproductive physiology in animals was the successful attempt to culture and transfer embryos in 1981. The development of artificial insemination helped with the costs and control of breeding but the first technological shift came with Gurdon's 1970 transfer of a nucleus of a somatic adult frog cell into an enucleated frog ovum and the birth of viable tadpoles. This experiment was of limited success as none of the tadpoles developed into adult frogs. In 1977, Gurdon expanded the field further through the transfer of mRNA and DNA into toad (Xenopus) embryos where he observed that the transferred nucleic acids were expressed. Also in the 1970s, Ralph Brinster developed a now-common technique used to inject stem cells into embryos. When these embryos became adults, they produced offspring carrying the genes of the original cells. In 1982, Brinster with his colleagues gained further renown by transferring genes for rat growth hormone into mice under the control of a mouse liver-specific promoter and producing mice that grew into "supermice"--twice their normal size (Palmiter *et al.*, 1982).

During the two years, 1980 and 1981, there were several reported successes at gene transfer and the development of transgenic mice. Gordon and Ruddle first coined the term "transgenic" to describe animals carrying exogenous genes integrated into their genome. Since that time this definition has been extended to include animals that result from the molecular manipulation of endogenous genomic DNA, including all techniques from DNA microinjection to embryonic stem (ES) cell transfer and "knockout" mouse production.

Notwithstanding the advent of successful nuclear transfer technology with the dawn of Dolly, the most widely used technique for the production of transgenic animals including mice is by microinjection of DNA into the pronucleus of a recently fertilized egg. Using various transgenic tools such as antisense technology (putting a reverse copy to switch off expression), it is now possible to add a new gene to the genome, increase the level of expression or change the tissue specificity of expression of a gene, or decrease the level of synthesis of a specific protein (Sokol and Murray, 1996). An additional factor added by the new nuclear transfer technology is the capability of removing or altering an existing gene via homologous recombination.

The production of transgenic farm animals is costly and time consuming. In mouse experiments, less than 2 months is required from the time the construct is ready for microinjection through weaning of baby mice. In contrast, for pig experiments, 1 month to a year is required for a sufficient number of DNA injections and recipient transfers to ensure the likelihood of success. In addition, the time frame from birth of a founder transgenic animal to the establishment of lines can be 1 to 2 years for pigs, sheep, and goats to 4 to 5 years for cattle. Neal First, UW-Madison, has come up with an ingenious mechanism for testing the feasibility of developing specific transgenics before heading down the expensive road of genetically engineering an entire animal. He first does a "test-run" by using replication-defective retrovirus vectors to transiently express gene constructs in the mammary gland of animals. He has used an alpha virus containing a human growth hormone gene to produce human growth hormone in the milk of a goat. However, the transformed cells are sloughed off over time and the process needs to be repeated but it does establish whether or not the construct will work.

As we look to the future it is imperative that we continue to extend our understanding of the biochemical and molecular basis of growth and development including the structural biology of plants and animals. This requires scientists to continue mapping and sequencing plant and animal genomes in order to elucidate gene function/regulation, so as to facilitate the discovery of new genes as a prelude to gene modification.

## Environment

The immediate focus in environmental biotechnology is on bioremediation. Biomass conversion for feedstock production for biofuels, synthetics and plastics should be a long-term focus.

Bioremediation involves the use of living organisms or their products to degrade wastes into less toxic or non-toxic products and to concentrate and immobilize toxic elements, such as heavy metals, to minimize industrial wastes and rehabilitate areas fouled by pollutants or otherwise damaged through ecosystem mismanagement. Phytoremediation is also being investigated. For example, poplar trees have been engineered to clean up mercury contamination.

Another growth area in the next century will be the development of alternatives to non-renewable resources especially fossil fuels. Biotechnology will provide answers through modified enzymes and microorgamisms that can turn abundant biomass into feedstocks for the production of synthetics, plastics, polymers and biofuel.

## Forestry

Substantial opportunities exist for genetic improvement of forest-tree species through molecular biology, with the key goal of accessing QTLs governing complex traits such as yield, quality, and stress tolerance. However, implementation of adaptive-research programs will also be required to translate knowledge thus derived into commercial application. The challenge is to match effort and investment with the diverse requirements of a highly fragmented and traditional forestry industry. Unlike major agricultural crops, tree breeding, as a 20th century phenomenon, is only in the third generation of selection. As Ron Sederoff (North Carolina State University, Raleigh, NC) has pointed out, the major genetic changes accompanying the domestication of crops and animals have not yet happened for trees. The challenge is to find the genes underpinning desirable characteristics rapidly. Some include increased disease resistance, modified lignin content, increased growth rate.

## Manufacturing/Bioprocessing

Industrial biotechnology applies the techniques of modern molecular biology to improve the efficiency and reduce the environmental impacts of processes in industries like food production, grain cleaning, textiles, paper and pulp and specialty chemicals. Just as biotechnology is transforming the pharmaceutical industry, some observers predict the same impact in the industrial sector.

Today up to 90% of the enzymes used in large scale for commercial applications result from the exploitation of rDNA methods in the manufacturing process or for the improvement of the catalysts themselves. The progress made in applying the techniques of genetic engineering in the development of industrial-scale processes that produce or utilize enzymes has been simply amazing. Both improved economics as well as the manufacture of novel products not possible or practical by traditional chemical approaches have been achieved. Even today, much of the science is focused on the development of new technological approaches that will allow the future solution of problems of fundamental understanding as well as practical application.

There are several advantages of using GMOs for the production of enzymes, including:

- It is possible to produce enzymes with a higher specificity and purity.
- It is possible to obtain enzymes which would otherwise not be available for economical, occupational health or environmental reasons.
- Due to higher production efficiency there is an additional environmental benefit through reducing energy consumption and waste from the production plants.
- For enzymes used in the food industry particular benefits are for example a better use of raw materials (juice industry), better keeping quality of a final food and thereby less wastage of food (baking industry) and a reduced use of chemicals in the production process (starch industry).
- For enzymes used in the feed industry particular benefits include a significant reduction in the amount of phosphorus released to the environment from farming.

The enzymes are produced by fermentation of the genetically modified microrganisms (the production strain), which then produces the desired enzyme. The process takes place under well-controlled conditions in closed fermentation tank installations. After fermentation the enzyme is separated from the production strain, purified and mixed with inert diluents for stabilization.

In addition to enzymes bioprocessing can provide products with unique and highly desirable characteristics and offers new production opportunities for a wide range of items.

## Economic Potential of Biotechnology

Ireland can take lessons from the growth of America's biotechnology industry which has resulted from a remarkable combination of entrepreneurship, innovative capital markets, and federal research investments (Table 2). The United States leads the world in biotechnology, which is contributing to their strong economic growth and creating substantial improvements in quality of life.

**Table 2**. **Biotechnology industry statistics**

| 1998 BIOTECHNOLOGY INDUSTRY STATISTICS | | | |
|---|---|---|---|
| ($ In Billions) | 1998 | 1997 | Percent Growth |
| Number of companies | 1,283 | 1,274 | 1% |
| Number of employees | 153,000 | 140,000 | 9% |
| R&D expenses | $9.9 | $8.5 | 16% |
| Product sales | $13.4 | $11.5 | 17% |
| Revenues | $18.6 | $16.1 | 16% |
| Market capitalization | $97 | $93 | 4% |
| Net loss | $5.1 | $5.4 | 5% |

**Biotechnology industry financing**

The US biotechnology industry had a strong year in 1998 in terms of raising revenues to fund research and product development. According to the *BioWorld Biotechnology State of the Industry Report 1998*, the industry raised a total of $5,529,500,000 in 1998.

**Biotechnology industry patents**

The PTO has responded to the growing demand for patents by the biotechnology industry by increasing the number and sophistication of biotechnology patent examiners. In FY 1988, the PTO had 67 patent examiners. By 1998, the number of biotech examiners more than doubled to 184.

| | |
|---|---|
| FY 1997 Biotechnology Patent Application Submissions | 10,500 |
| FY 1996 Biotechnology Patent Application Submissions | 8,860 |
| FY 1995 Biotechnology Patent Application Submissions | 15,652 |
| FY 1994 Biotechnology Patent Application Submissions | 13,600 |
| Average pendency time for a biotechnology patent (FY 1997) | 27.1 months |
| Average pendency time for a biotechnology patent (FY 1996) | 26.2 months |
| Average pendency time for a biotechnology patent (FY 1995) | 21.6 months |
| Average pendency time for a biotechnology patent (FY 1994) | 20.8 months |

These advances have been made possible by the twin strengths of federally-sponsored research carried out by the National Institutes of Health (NIH), National Science Foundation, US Department of Agriculture and other agencies, in association with universities, research institutes throughout the country and the entrepreneurial leadership of about 1,300 US biotech companies. In 1998, the industry generated revenues of about $19 billion, spent $10 billion on R&D, and employed about 150,000 highly-skilled workers. Most biotech companies are fairly small, with two-thirds of firms having fewer than 135 employees.

The biotech industry survives on an inflow of funds from venture capitalists and proceeds from public share issues. These investment inflows are crucial because most biotech firms do not have substantial revenues, and the industry as a whole reports a net loss. Biotech investors often wait years to receive investment returns since it typically takes over 7 years and \$200-\$350 million to bring a new biotech drug to market. Although the agriculture time line is shorter it still takes about 6 to 7 years but costs much less. Therefore, the encouragement of risky and long-term capital inflows from investors is important to the continued health of the industry.

## Addressing Concerns

Biotechnology is one of the areas receiving a great deal of attention from advocacy groups both in the Europe and the US. Most scientists working in the field are in total agreement with the stated mission of these groups that is we need to feed and clothe the world's people while minimizing the impact of agriculture on the environment. But the human population continues to grow, while arable land is a finite quantity. So unless we will accept starvation or placing parks and the Amazon Basin under the plough, there really is no alternative to applying biotechnology to agriculture.

As noted today's biotechnology differs significantly from previous agricultural technologies. Using genetic engineering, scientists can enhance the nutritional content, vitamins, minerals, antioxidants, texture, color, flavor, growing season, yield, disease resistance and other properties of production crops. Engineered microbes and enzymes produced using recombinant DNA methods are used in many aspects of food production. The cheese and bread you eat and the detergent you use to clean your clothes all have used engineered enzymes since the early part of this decade.

By reducing dependency on chemicals and tillage through the development of natural fertilizers and of pest-resistant plants, biotechnology has the potential to conserve natural resources, prevent soil erosion and improve environmental quality. Strains of microorganisms could increase the efficiency, capacity and variety of waste treatment. Bioprocessing using engineered microbes offers new ways to use renewable resources for materials and fuel.

Biotechnology is, in fact, the low-risk alternative to current practices. Take pest control. The economic and environmental costs of using existing methods are well known. But many of us are not aware of the potential costs of not controlling pests. Not controlling fungal disease in plants, for example, allows them to generate deadly toxins such as aflatoxin and fumonisin, which have been found, among other things, to cause brain tumors in horses and liver cancer in children.

The most cost-effective and environmentally sound general method for controlling pests and disease is the use of DNA. This approach already has led to a reduction in the use of sprayed chemical insecticides. According to the National Agricultural Statistics Service, 2 million fewer pounds of insecticide were used in 1998 to control bollworm and budworm than were used in 1995, before "Bt" cotton was introduced. And the Bt gene-introduced into the crop plant, not sprayed into the atmosphere, is present in minute amounts and spares beneficial insects. Recent data also shows that herbicide tolerant crops have reduced the amount of chemicals used to control weeds as they permit the use of more environmentally friendly herbicides and reduce the need for pre-emergent spraying.

There is no evidence that recombinant DNA techniques or rDNA-modified organisms pose any unique or unforeseen environmental or health hazards. In fact, a National Research Council study found that "as the molecular methods are more specific, users of these methods will be more certain about the traits they introduce into plants". Greater certainty means greater precision and safety. The subtly altered products on our plates have been put through more thorough testing than any conventional food ever has been subjected to. Many of our daily staples would be banned if subjected to the same rigorous standards. Potatoes and tomatoes contain toxic glycoalkaloids, which have been linked to spina bifida. Kidney beans contain phytohaemagglutinin and are poisonous if undercooked. Dozens of people die each year from cynaogenic glycosides from peach seeds. Yet none of those are labeled as potentially dangerous.

Millions of people have eaten the products of genetic engineering and no adverse effects have been demonstrated. The proper balance of safety testing between companies and the government is a legitimate area for further debate. So are environmental safeguards. But the purpose of such debate should be to improve biotech research and enhance its benefits to society, not stop it in its tracks.

**The costs of over-regulation**

The purpose of regulations should be to ensure safety and efficacy, to limit potential product risks while encouraging innovation and economic development. By raising the cost of biotechnology R&D over-regulation drains capital resources and slows the pace of research. This stalls innovation, which in turn, delays or blocks the entry of new products into the marketplace. This can sustain reliance on less efficient, less precise, less predictable and sometimes more hazardous alternative technologies and products. Over-regulation leads to higher operating costs and extended development times which raises investment risks and exacerbates concerns about long term prospects for company success. Less capital and higher “burn rates” jeopardize smaller firms. Over-regulation disproportionately affects the academic research community – the historical source of fundamental scientific knowledge and the highly-skilled workforce on which biotech companies depend. The transfer of the products of innovative research to the outside world is stymied and the consumer suffers.

## Research and Development

Federal research funding plays an important role but also it must be kept under consideration that the industry is very sensitive to adverse policy changes, such as prohibitive regulations. A decision-making framework applied to biotechnology involves four steps:

- identifying research priorities for which biotechnology offers a comparative advantage;

- determining relevant national policies;
- formulating an appropriate research agenda;
- providing for delivery of products to end users.

Recommendations to policymakers and managers of national agricultural research systems are the following:

- Support future policy dialogues that identify needs and mechanisms for follow-up regarding policy and managerial dimensions of biotechnology.
- Raise awareness of the potential benefits and costs of using biotechnology to achieve national goals.
- Assure relevant stakeholder and end-user participation in policy dialogues for identifying needs regarding biotechnology policy.
- Develop mechanisms that help find funding for research by addressing issues of sustainability and user orientation.
- Institute policy analysis on socioeconomic aspects of biotechnology, necessary legal reforms, and build regulatory capacity to deal with biotechnology and related agricultural policies.
- Conduct regular studies to analyze trends in public and private investments and capacity development in biotechnology.
- Initiate policies and programs to encourage partnerships with the private sector that complement investments made in the public sector.

## The Future

The practical effects of the genomics revolution will only be partially manifested during the next decade. During that time, the genomes of microbes, plants, and mammals will be sequenced, and much will be learned about the functions of genes and the means by which they are controlled. Today, humans employ the capabilities of only a few plants. A major challenge is to explore the opportunities inherent in some of the hundreds of thousands of them. In addition to the usual macro- and micronutrients, plants synthesize 80,000 other substances. Many of these phytochemicals have effects on human health. Some appear to be associated with lower morbidity in adult life. The exact chemical compounds are largely unknown, but groups of chemicals, including glucosinolates and phytoestrogens, have been identified as being helpful. As more data become available concerning desirable micronutrients, the goal of increasing their content in foods will become compelling. Genes for synthesizing these substances will be identified and incorporated in the various food crops.

As noted to date, US investment in biotechnology has been focused primarily on the health field. The results of this research are having a profound impact on medicine and health care, providing improved approaches to the diagnosis, treatment, and prevention of disease. Ireland and Europe also has potential in this area and while health-related research must remain a priority, researchers are poised to build on the common foundation in basic science to bring the power of biotechnology to bear in other fields. Modest investments now in several rapidly developing areas of biotechnology research outlined above will lead to major economic and societal benefits, including foods that are more abundant and nutritious, a cleaner environment, and non-toxic biomanufacturing. As noted, experiments are increasing rapidly on crops modified for nutritional and health advantages in the final food product, so called ‘functional foods’ and ‘nutriceuticals’, both for human consumption and animal feed. In addition, crops and animals are being modified for production of pharmaceutical benefit, so called ‘pharming’. The metaphor is used of crops becoming factories, producing: vaccines (e.g. the polio vaccine in a banana), plastics, industrial starches, and feed supplements and enzymes.

A coordinated effort to pursue these priorities can provide, over the next decade, the leverage needed to fulfill the broad promise of biotechnology, which may well play as pivotal a role in social and industrial advancement over the next 10 to 20 years as did physics and chemistry in the past century.

Biotechnology is poised to make major contributions to the economic growth of the European Union and Ireland in the 21st century. Coordinated implementation of these priorities will enable the Ireland to stake its claim in this burgeoning field.

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# Implications of biotechnology for the Irish agricultural and food industry

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**As we move towards the next millennium there are many challenges facing not only agriculture but also society in general. To-day the industrialised world is being transformed by the application of modem technology including biotechnology. This latter science is predicted to play a major role in alleviating disease, enhancing food security and in environmental protection as outlined in the previous paper entitled "Technical and economic benefits of biotechnology" by Dr. McGloughlin. In this country our target for the agricultural and food industry must be to continue to increase efficiency by both traditional and new technology. To-date plant genetic engineering has largely focused on the modification of agronomic traits that contribute to enhanced production efficiency. These traits are primarily in the areas of herbicide, insect or disease resistance and are revolutionising many crop production systems in the Americas and elsewhere. It is anticipated that a shift in focus towards the modification of traits that confer unique quality attributes to food products will make an even larger impact in the future. A strategy for modifying the quality of food products involves the redirection or modification of endogenous metabolic pathways to achieve unique endpoints.**

**New technologies have been applied in agriculture and food production as they evolved. In the latter half of the 20th century, major improvements in agricultural productivity have been largely based on selective breeding programs for plants and animals, intensive use of chemical fertilisers, pesticides and herbicides, as well as developments in mechanisation. This has been a very successful model at raising productivity, yet, these improvements have brought corresponding problems of increasing uniformity in the genetic base of crop plants and domestic animals, pests resistant against chemical pesticides, impacts on environmental quality, and capital intensive production. There is now and will be in the future increased emphasis on developing better and more sustainable ways for maximising production efficiency while at the same time reducing any environmental impact associated with agricultural practices. In this regard the tools and products of biotechnology and genetic engineering will be of major importance, and the emerging biotechnology revolution is stimulating hope that it will provide the basis for more sustainable agriculture**

**The new aspects of biotechnology differ from previous agricultural technologies in a number of ways that are likely to be of significance. Biotechnology can enhance productivity and product quality with minimal increase in production costs by providing tools to more effectively develop and incorporate desired characteristics of plants and animals. Using genetic engineering, it will be possible to enhance the nutritional content, flavour, growing season, yield,**

**disease resistance, and other properties of critical importance in the production crops. Engineered microbes and enzymes produced using recombinant DNA methods are currently used in many aspects of food production. Biotechnology has the potential to conserve natural resources and improve environmental quality by reducing the dependency of chemical inputs through the development of natural fertilisers and of pest-resistant plants and by contributing to the functioning of biocontrol systems. Biotechnology can provide modified organisms to degrade wastes and pollutants and for biomass conversion to reduce dependency on non-renewable resources.**

**The impact of biotechnology on Ireland's agricultural and food industry will most likely bring significant benefits. In this paper the areas of most relevance will be discussed under three headings: Crops, Animals, and Food.**

## Arable Crops

Most research to-date has focussed on herbicide resistance, however, other important traits are now at an advanced stage of development including insect protection, virus resistance and crops with enhanced quality parameters. There is also the possibility that in the future plants may be used as mini-factories, for the production of various pharmaceutical compounds. The first trials of genetically modified crop trials carried out in Ireland were conducted at Teagasc's Crop Research Centre at Oak Park, Carlow using herbicide tolerant sugar beets produced by Monsanto. Herbicide resistant sugar beet allowed for the use of relatively low cost herbicides on sugar beet which controls a wide range of weeds, was environmentally friendly, with significant potential savings over current weed control systems. This concept has been evaluated in eight European countries since 1990 and no problems of any type have been encountered. Other varieties of sugar beet have been engineered to another herbicide named Glufosinate. Wheat varieties have also been modified which are tolerant to the imidazolinone herbicides. These groups of herbicides provide greater flexibility, are environmentally friendly and provide superior contact and residual control of weeds. As effective weed control is of paramount importance in maximising yield potential it is essential to have available a range of weed control options so that problem weeds can be easily overcome. The most important breeding goals for cereals are disease resistance, yield, and other traits, which depend upon the crop, for example, improved brewing or baking characteristics.The possibility of growing crops for specific industrial and non-food uses should not be overlooked.

### Diseases and pests

In Ireland, disease pressure from fungal diseases is very high and resistant cultivars currently play a significant role in minimising the adverse effects of diseases and pests. Cultivar related input programmes are already practised in normal or conventional farming and with new decision support systems and molecular based diagnostic techniques this approach could be exploited further in future lower cost production systems. Disease resistance based upon the 'gene-for-gene' interaction in fungal disease (the concept that for each gene determining resistance/susceptibility in the plant, there is a corresponding gene for avirulence/virulence in the pathogen) has proved the most effective. However, disease resistance in modem cultivars is mainly monogenic, hypersensitive in character, and therefore such cultivars have a relatively short life span unless protected by increasing frequency of spraying with fungicides. This type of resistance is also often unstable, breaking down as the pathogen adapts to the change in selection pressure exerted by the introduction of a new variety. As a result, new varieties are constantly replaced due primarily to their disease resistance breakdown.

Traditional plant breeding has made a significant impact in improving resistance of many crops to important diseases. However a major limitation is the length of time required to make crosses and back-crosses, and to select the desired resistant progeny, which make it difficult to react rapidly to the evolution of new fungal races. Moreover, for many major fungal diseases these plant-breeding techniques will not provide a solution because there are simply no natural sources of resistance available to the breeder. Biotechnology research into disease resistance lags behind that for herbicide and insecticide resistance, with the first introductions expected within 3 to 7 years. The development of varieties with broadly based multigenic disease resistance (field resistance) could overcome a large part of this problem and its introduction could be helped greatly by developments in breeding and bio-technology.

The major disease targets for wheat breeding globally are Septoria leaf spots (S. *tritici)* and *Septoria nodorum* and Fusarium ear diseases, with several other diseases, for example, powdery mildew *(Erysiphe graminis)* also being important. Diseases for which there are effective seed treatments are generally not major targets, for example, smuts and bunts *(Ustilago* spp. and *Tilletia* spp.) and *Cochliobolus sativus.*

*Septoria tritici,* the causal agent of Septoria leaf blotch is estimated to cause yield and quality losses in wheat of 15% world-wide, and many Teagasc trials have shown that losses as great as 50% of the potential harvestable grain in Ireland are common where no fungicide application takes place. New research carried out in US universities has confirmed that pathogens like *S. tritici* can be blocked by transgenic expression of genes or specific peptide inhibitors. Developments in this area could lead to the creation of new disease control strategies which have a great possibility of being both sustainable and effective against a broad spectrum of bacterial as well as fungal pathogens of cereal crop plants. Such multi-genic resistance could save Irish cereal farmers some £10 million annually in fungicide costs alone. The benefits to both farmers and the environment are obvious. As the area of science known as genomics and bioinformatics gathers momentum, other means of triggering the plants defence mechanism are also being explored. One such approach is the evaluation of fungal avirulance genes, which are only brought into play if the plant produces a disease resistance protein as a result of infection. The introduction of these genes into plants would be expected to deliver enhanced resistance to fungal pathogens.

A number of field trial results have been published recently for experimental lines, including a wheat variety with *Fusarium* resistance. While the incidence of *Fusarium* is sporadic, yield losses do result even from a mild attack. In Ireland the disease can reduce yield by 25% and the contamination by mycotoxins can be significant. Only a few fungicides offer protection and consequently new wheat cultivars with built in defence mechanisms would be very useful.

Other diseases caused by virus present significant problems for tillage farmers, and once the plant is infected no pesticide is of any use in protecting the plant. Viruses have developed many novel ways of moving from one infected plant to another using vectors such as aphids, nematodes and fungi. While resistant varieties have been employed through plant breeding for crops such as potatoes and sugar beet the success with cereal varieties has been slow with the result that all cereal crops in Ireland are now treated with aphicides as the main control measure. The development of crops with virus resistance presents more of a challenge, because often the resistance genes governing resistance are not expressed in the plant parts on which they feed, i.e. phloem or xylem vessels. Since the primary reason for controlling aphids is their role in virus transmission, it is likely that virus resistance will remain the major focus for research. Cultivars with such resistance would be of great benefit to growers from a crop husbandry viewpoint but would also have significant benefits for the environment, as the need to routinely apply aphicides would be diminished.

Other possibilities of biotechnology relate to improving the quality of milling wheat. Improving wheat quality is an important research goal with the objective of better milling traits as well as producing wheat varieties with speciality starches/baking enzymes containing a higher protein content and greater yield. As Ireland has a market for approx. 250,000 tonnes of milling wheat it is possible that in the future new and improved wheat cultivars could result in a significant proportion of that requirement being supplied from Irish cereals compared to the 50,000 tonnes used today.

**Grass**

As with other crops significant progress has been achieved over the past 50 years in improving grass output through the use of new and improved grass varieties. Improvements in yield, persistence, winterhardiness and disease resistance has helped greatly. In contrast to cereals, where the harvest index can be manipulated to increase grain yield, grass is a total biomass crop hence progress is more difficult and slower.

Data from Aldrich (1987) indicates that the average annual rate of improvement for yield of grasses was 0.6% which is still continuing. In the future farmers need improved varieties that can produce higher yields of digestible dry matter both for conservation and grazing. Biotechnology is likely to help greatly as many gene sequences are common to wheat and grasses; consequently scientists can use a technique called comparative mapping to elucidate traits which require targeting and incorporation into new and improved cultivars.

Genetic mapping will have a significant impact on grass and clover breeding, however, as many of the important traits are complex and quantitative marker systems are now being developed as means of improving grass and clover varieties. For example, the functional relationship between traits such as high sugar content and the underlying metabolic pathways are being established. It is likely that such research will increase grass sugars by at least half their current concentration. This should remove the need for acid-based silage additives with annual savings of £5 million/annum. Grass intake should also be improved leading to increased milk and beef production and consequent improved efficiencies. Based on data from comparisons of animal production with currently available high and low sugar ryegrasses this could result in a net benefit of £35 million/annum.

Genetic modification of protein breakdown is now being actively researched. The influence of proteases which are up regulated in senescence and in times of stress are now well-understood and new techniques, which can alter enzyme characteristics, are possible. Modification could lead to increased nitrogen content by rendering protein losses much less significant. Post-harvest protein stability is a highly desirable forage characteristic with significant effects on animal performance.

Biotechnology has also allowed for successful alteration of biosynthetic pathways controlling tannins, lignins, and phenolics, which have a decisive influence on the nutritional quality of grasses. Increased digestibility, greater persistency and elongation of the grazing season by approx. 2 weeks could help to reduce the overall meal requirement, require less feeding indoors and a greater chance to finish 18-month-old cattle off grazed grass. Overall the net benefit could be as high as £100 million annually. Carbohydrate metabolism and leaf senescence are currently targets for transgenic manipulation.

In clover breeding, optimising growth, increased nitrogen fixation, greater disease resistance is likely to increase the potential of legumes for reducing outputs and boosting quality. Reducing the likelihood of clovers to cause bloat in grazing animals is another long-term target, which could be greatly enhanced with modem tools of biotechnology. Such techniques could greatly facilitate the development of sustainable farming systems. If such targets are realised savings of approximately 50 kg of inorganic nitrogen/ha could be realised on at least half the farm area on half the farms in the country leading to annual fertiliser cost savings of £20 million, with significant room for further savings possible.

As grass productivity is of crucial importance nationally, it is imperative that we use whatever techniques are available to maintain progress and to significantly increase the nutritive value of Irish grown grass. The potential gains of so doing are significant and it is certain that biotechnology will make a significant contribution.

## Animal Biotechnology

In the next decade there is a significant challenge for the animal based sector to maintain its position because commodity value will, in relative terms, continue to reduce while quality will have to increase, and production systems will come under continuous pressure to reduce input costs. Increasing output efficiency rather than increasing animal number is essential for the economic and physical sustainability of the livestock sector. Animal biotechnology research is becoming a fundamental part of livestock research programme worldwide with the objective of increasing production efficiency and product quality.

Biotechnology, in particular molecular biology, is now having a major impact on the medical pharmaceutical and agricultural industries. Furthermore, investment in biotechnology research is growing rapidly as it is deemed to offer the prospect of significant incremental advances in productivity arising from a wide range of potential developments. In cattle, this includes development of reproductive biotechnologies, identification of genetic markers to enable breeders to quickly produce more efficient livestock and enable conservationists to protect livestock biodiversity. The production of low-cost, efficient diagnostic tests to control livestock diseases, improvement in the quality of animal feedstuffs and beneficial changes in rumen microflora populations, facilitate enhancement of animal welfare and more efficient environmental management.

Biotechnology is predicted to be the quickest and most effective route to success in all of these areas. This presents a serious challenge for Ireland as we need to continue to develop and exploit new scientific knowledge and appropriate technological advances in this area to respond to the emerging opportunities in research and technology which are required to underpin a competitive animal industry.

The exploitation of developments in molecular genetics is likely to lead to improved animal production, animal fertility and development of breeding technologies associated with the improvement of animal health and welfare. Within this context the following four research areas will be of significance:

**Marker-assisted selection in farm animals**

Significant progress has been, and continues to be made in the area of livestock genomics. It is clear that DNA-based technologies will impact significantly on cattle breeding by enabling breeding values to be determined at younger ages and with higher precision than before. The DNA technologies will be complementary to quantitative genetics. This technology has the potential to identify the genes that affect traits such as growth rate, meat tenderness and flavour as well as traits and products, both meat and milk based that may be beneficial to human health. As well as the advances in genomics, rapid advances are also being made in the field of proteomics which will provide information on protein structure and function. It is predicted that the amount of genomic and proteomic information that will be generated in the immediate future will dwarf the information generated over the past 20 years. It is, therefore, likely that the identification of genetic markers associated with commercially important traits in beef cattle and with milk quality characteristics in dairy cow's will be of great significance.

**Farm animal reproduction**

An increased understanding of reproductive mechanisms in livestock, particularly cattle, has resulted in a number of commercial and potentially commercial products. These include methods of controlling the oestrous cycle and ovulation to allow fixed time AI, *in vivo* and *in vitro* (IVF) embryo production, and DNA-based methods of embryo sex determination, embryo cryopreservation and methods of pregnancy diagnosis. Developments in embryo technology will continue, including IVF embryo production from high genetic merit animals. Methods of separating x- and y-bearing sperm, based on their DNA content, are being developed to allow pre-determination of the sex of the progeny. Reproduction management for cow herds is labour intensive and will require development of in-line biosensors with the capability of simultaneously measuring several analytes, including reproduction hormones and health indicators in the milk line. Synchronised breeding, based on precise ovulation control, will allow greater exploitation of genetically superior dairy and beef sires through AI.

**Animal production**
As discussed earlier, advances in animal nutrition will be critical to exploit high genetic merit dairy and beef animals. Specific attention will be given to intake studies with genetically modified grasses and also rumen function, including genetic modification of rumen microflora population designed to extract more nutrients from ingested grass and forage. Biotechnology induced developments in forage preservation technology may be important to reduce storage losses and to enhance animal performance.

**Farm animal health and welfare**
Infectious disease of livestock is still a major constraint on production efficiency and also has implications for animal welfare. The normal controlling procedure is vaccination or chemotherapy. Disease will continue to be a problem not least because of increasing resistance to antibiotics and chemotherapeutics. The development of sensitive and accurate methods of disease diagnosis and better vaccination and immune control of disease is essential. DNA-based tests for infectious disease diagnosis and molecular typing of pathogens will be important areas for research. It is likely that the development of sensitive DNA-based methods of disease diagnosis and of immune approaches for the control of livestock disease will take place with significant positive effects on animal welfare.

## Food Biotechnology

It is only recently, with the advent of modern developments in plant biotechnology and cloning in higher animals, that the potential for genetic modification in food systems has truly been realised. While the efficacy and safety of many products of biotechnology are now well established in the pharmaceutical industry (e.g. recombinant drugs such as interferon and insulin), the technology as applied in food is not nearly as progressed. There are exceptions to this, however, including the widespread use of enzymes such as recombinant chymosin for milk coagulation in cheese production, for example >90% of the Cheddar cheese made in Ireland use the recombinant enzyme, which is sometimes (advantageously) marketed as "Vegetarian Cheddar". More recently, however, developments in plant biotechnology have lead to a variety of genetically modified foods on the market. The majority of these novel foods has emanated from research carried out at commercial companies and are improved in many cases with respect to their industrial traits such as selected herbicide resistance and increased shelf life.

It is undoubted that biotechnology will have a major influence on the food we eat in future years. One only has to look at the current trends in crop production to appreciate that almost all the worlds supply of soya (for example) will be the genetically engineered variety in the near future (Figure 1). The most important breeding goals for cereals are disease resistance, yield, and other traits, which depend upon the crop, for example, improved brewing or baking characteristics.

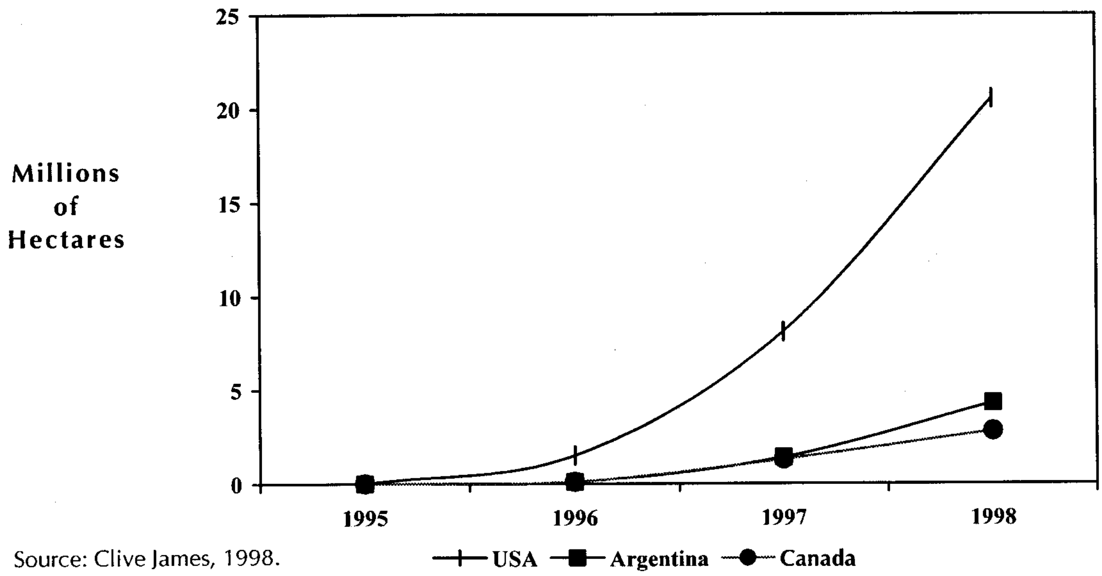


**Figure 1. Global Area of Transgenic crops: 1995 to 1998 By country**

One area where genetic engineering would be of particular benefit to the dairy industry is in the genetic modification of lactic acid bacteria (LAB) which are commonly used as starter cultures in the production of fermented dairy foods. In particular, genetic modification of LAB could have the following potential benefits:

1. They may be used to improve food safety through the increased production of antimicrobial compounds. An example of this would be the generation of genetically modified LAB which produce the broad spectrum bacteriocin lacticin 3147. This food grade bacteriocin, is composed of two post-translationally modified peptides and kills a broad spectrum of Gram positive food pathogens including *Listeria monocytogenes* and *Clostridium botulinum*. The bacteriocin has been the subject of the C-BAC group (Cork Bacteriocin Group lead by Dr. Colin Hill, University College Cork and Paul Ross, Teagasc,) for the past 5 years, over which time the bacteriocin has been shown to have proven efficacy in eliminating certain pathogens from foods such as Cottage cheese, baby formula and powdered soup. In addition, the genetic determinants responsible for production (and immunity) of the bacteriocin have been characterized and transferred to other strains. The generation of food cultures which produce this potent anti-microbial in food systems may provide an extra hurdle protection against food pathogens and could be especially important certain foods such as those manufactured with raw milk.
2. The health promoting properties of probiotic bacteria may be improved or introduced into other bacteria.
3. They may lead to the production of oral vaccines composed of LAB modified to produce surface antigens of pathogenic bacteria.
4. They may lead to the development of a new generation of starter cultures improved with regard to their processing characteristics such as being resistant to bacteriophage (bacterial viruses).

## Diagnostic Techniques

The introduction of Monoclonal Antibody technology has revolutionised the diagnosis of human diseases. To-date, the major commercial use of diagnostic techniques in agriculture has been for identification of viruses (and, to a lesser extent, fungal and bacterial pathogens) in seeds, nursery stock, and some field crops. It is unlikely that this type of technology will replace the use of fungicides; however, it will help in the development of decision-based disease control strategies. In this regard future management systems using rapid diagnostic techniques will play an important role. Diagnostic kits are available for the identification of Barley Yellow Dwarf Virus and certain potato viruses which already play an important role in reduced input chemical strategies.

In the animal area it is likely that the development of sensitive and accurate methods of disease diagnosis as well as better vaccination and immune control systems of disease control will be possible using new biotechnological based techniques. DNA-based tests for infectious disease diagnosis and molecular typing of pathogens will also be an important area in future production systems. It is also possible that such tests might play an important role in devising molecular markers for stress.

Diagnostic DNA-based techniques are going to be extremely important in the food industry where rapid and accurate assays are essential in the detection of food spoilage organisms and pathogenic bacteria in general.

## Conclusions

In the short term the survival of Irish agriculture will be greatly influenced by policy decisions (domestic, EU and world) and the ability of growers to increase production efficiency based on existing technology. New technology will, however, be directed more towards reducing the cost of inputs particularly those that are perceived to be environmentally undesirable or unacceptable to the consumer. In this category biotechnology and genetic engineering have definitely a significant role to play. There have been many concerns raised in this country and in Europe generally in relation to this new and developing science e.g. lack of product labelling, environmental effects, antibiotic markers used in the selection process, as well as ethical, moral and social aspects. These issues need debating as genetic engineering is an enormously powerful tool and consumers as is their right are naturally cautious. It must be stated, however, that this science has a very impressive record of safety stretching back many years since it’s development. It is also worth comparing the attitude of regions such as the America’s and Australia with that of Europe, where the global figures for approved biotechnology crops breaks down at approximately 60, 28 and 12%, respectively. Public opinion in regions such as the America’s and Australia has pretty well moved on to the stage of realising that genetic engineering when regulated properly has many advantages. This debate and reassurance need to take place in this country based on good scientific reasoning and scientific research results. To-date, over 25,000 field trials have been carried out in 30 different countries on 56 different crops with no adverse risk to human health or the environment noted. At present there are 60 million acres of genetically modified crops in commercial production in Asia, Argentina, Canada, Mexico and the USA.

The regulatory approvals in Europe for genetically modified experimentation and marketing are strenuous and are covered under the environment, food and feed regulations of the European Union. There is also concern in some quarters that commercial biotechnology companies can now own genes by patenting. However, while these companies have a right to benefit from a specific application of a novel and non-obvious and useful invention for a specific period of time, they do not have ownership of a gene. It is also worth remembering also that these companies have no automatic right to use their invention unless they meet all health, safety or environmental regulations including international treaties. This is only right and proper. I feel that the Heidelberg Appeal formulated at the closure of the Earth Summit held in Rio de Janeiro in 1992 is worth repeating *"The greatest evils which stalk our Earth are ignorance and oppression, not science, technology, and industry, whose instruments, when adequately managed, are indispensible tools of a future shaped by humanity, by itself and for itself, in overcoming major problems like overpopulation, starvation, and worldwide diseases".*

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# How can the Irish agri-food industry meet consumer demands for food safety?

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**Both regulatory and commercial pressures leave the Irish agri-food industry with little option but to buy into the national food safety management programme that is now materialising. In planning for the future farmers and processors would be well advised to make a virtue out of necessity and to invest in food safety and wholesomeness to the extent that is necessary for competitive market advantage. Under new EU food law, risk management will become the responsibility of food chain operators from farmers to retailers and this requires the implementation of new food safety systems. These differ fundamentally from the inspection-based controls of the past in that they must be science-based and be integrated with the day-to-day management of business enterprises. The biggest hurdle in implementing a national food safety management programme is the implementation of HACCP (hazard analysis critical control points). By far the most important action that the Irish agri-food industry can take is to implement HACCP from farm to retail, including the principle of continuous improvement that will ensure that agreed food safety objectives are always achieved in practice.**

**A high level of expertise and commitment will be needed at farm and factory to plan, implement, audit and continuously improve HACCP systems and it is Teagasc's responsibility to provide this expertise through on-site farm and factory training. Teagasc is in a position to do this by virtue of its training tools, on-site consultancy and auditing experience, and technology transfer from its own laboratories and those of its research partners.**

**Food safety is now at the top of the research agenda and is likely to remain there for the foreseeable future. Although the agri-food industry must address all issues that are perceived as hazards by consumers, it is essential to direct scarce research resources at the real hazards. Chief among these is the threat of emerging pathogens.**

## Introduction

The competitiveness of Irish food production will be determined by how well it manages the challenges confronting it. Chief among these are:

- the problem of skills shortages, staff attraction and retention;
- food safety and wholesomeness;
- retail pressures, the power of brands and growth of private labels.

While the aim of this conference is to look at the likely shape of the sector in 10 to 15 years time, a horizon of 3 to 5 years is more realistic in discussing how the sector can meet consumer demands in food safety, taking account of the higher level of uncertainty of consumer forecasting as well as the urgency of successfully dealing with this problem if the sector is to prosper.

This paper assesses to what extent food safety issues may influence the development of the industry, and what are the responsibilities of the main players in the Irish food chain. Finally, it considers what Teagasc can deliver in its training and advisory capacity, as well as the major food safety questions that require further research.

Consumer demands for food safety can usefully be considered to impact on the industry along two dimensions, on one dimension through mandatory legislation and on the other through trade specifications, especially those set by the large retail multiples. Industry has little choice but to comply with both; one is their legal responsibility and a prerequisite for market entry, the other is simply commercial reality, survival and development in ever increasing competitive markets.

There are good reasons to believe that concern about food safety will continue. Among these is the ongoing improvement in surveillance and reporting of food-borne illness, which inevitably leads to public perception that the incidence of food poisoning is on the increase. New agents and pathogens continue to emerge, bypassing existing safety controls and taking their toll on consumers. Also as lifestyles change and living standards rise, consumers will increasingly demand and expect more from the industry and likely too will be more litigious in seeking redress if food safety expectations are not satisfactorily fulfilled.

In view of the importance of the sector to the Irish economy, and the enormous penalty for failure, the industry must make a virtue out of the necessity to react to such demands and invest proactively in the safety and wholesomeness of their products and services. This should be done in such a way as to provide for and sustain competitive advantage on home and international markets. In short, the industry must seek to objectively substantiate and demonstrate the advantages of “the green image” so often subjectively claimed.

Teagasc’s top priority is to provide for the essential scientific independent knowledge and assistance on which to soundly base efforts of the industry in working towards such objectives. Through a comprehensive programme of research, technology transfer and training, Teagasc seeks to provide essential supports to the industry in its broadest sense; the farmer producers, the factory processors, the caterers and the retailers and including the regulatory and development agencies, to enable all collectively to guarantee and demonstrate the integrity of the Irish food chain, and thereby safeguard and underpin future competitiveness of this vital national industry sector.

**Anatomy of a crisis**

The public health statistics are alarming. More Britons were poisoned by their food in 1997 than since records began, with 1 m cases estimated (Coughlan, 1998). Although the USA counts itself among those nations that have very safe food supplies, the Government estimates that there are 76 m cases of food-related illness a year in the country, with 5,000 deaths (Mead *et al.*, 1999). Such an astonishing toll of consumer deaths and illness forced the Clinton administration to introduce a national early-warning system to provide earlier detection and response to outbreaks of food-borne illness through enhanced surveillance, improved risk assessment methods, new pathogen research methods, improved inspection and compliance, and better education.

The Food Safety Authority of Ireland reported a rapid increase in food poisoning notifications in Ireland in the period 1996-98. Notifications of salmonellosis in Ireland have doubled since 1996. Cases of *E. coli* O157 infection, although at a lower level, are also increasing. The detection and reporting of food-borne disease in Ireland has been poor and this makes it difficult to estimate if, and by how much, food poisoning has actually increased. The establishment of the new National Disease Surveillance Unit will give more accurate information.

The recent food scandals have forced governments to change their approach to food control. Responsibility has been shifted from government departments to legislatively independent food safety agencies in Ireland, the UK, France and at the level of the EU. These moves are intended to improve the flow of independent and verifiable information about food safety to the public.

EU product liability law now includes primary foods so that, for example, a farmer can be sued for produce found subsequently to be unsafe; farmers were not held liable in the past. This directive has to be transposed into Irish law by December 2000.

These public developments have put food safety at the top of the political agenda. EU food policy now has food safety as its prime objective (Byrne, 1999).

**Consumer responses**

Consumers attitudes determine the commercial fate of food products and their trust in food safety and its control has declined in recent years.

When consumers get to distrust the agriculture/food industry and the public agencies, the dramatic vulnerability of the whole food chain to scares and crises is profound (Prendergast, 1998). For example, the research linking BSE and vCJD triggered the sudden lack of consumer confidence in beef products and led to the dramatic fall in demand in 1996, and cattle prices plummeted to a 20-year low in Ireland by early 1998.

A survey carried out by the EU Commission showed a spectacular level of concern about food safety, which was matched only by the public's concern about the safety of medicines (Prendergast, 1998). The expectation was that medicines would stand out on top because they are considered to be unsafe in normal use, quite different from the traditional perception in relation to other products which were generally regarded as safe in normal use.

The attitude of consumers in the EU contrasts with that in the USA where consumers show a higher level of trust. The FDA is credited with this, and there is a move to establish a similar agency in Europe. While the US system has advantages in terms of transparency and consumer trust, the US statistics on food poisoning show that there is much room for improvement in the system of food control there.

EU consumers were found to be much less concerned about the top nutritional issues of fat and cholesterol compared with food safety (Cowan, 1998). In the UK market, the primary reason for the interest in organic food is put down to the impact of food scares and the concern over GM food (Cowan, 1999).

A most important element in the whole mix of actions intended to address the food safety crisis is the move towards increased transparency. By transparency is meant the public availability of results and opinions, so that consumers by being exposed to information will eventually be in a position to determine risk for themselves. Lack of transparency has contributed greatly to keeping consumers in ignorance, dependent on public authorities and the media for knowledge (Prendergast, 1998).

## A National Approach to the Management of Food Safety

The goal of a national food safety management programme is to reduce food poisoning to a minimum, to eliminate food scandals and to increase the confidence of consumers in farmers, food processors and the authorities. The need for appropriate, science-based measures to describe and control the problem of food-borne diseases has been acknowledged by the United Nations organisations FAO, WHO and Codex Alimentarius.

The food industry requires an approach that will achieve product safety in the most efficient, reliable and cost effective way. In this section the responsibility of food producers and public agencies is looked at in the context of a national food safety management programme.

A fundamental concept is that risk is an element of day-to-day living, and zero risk is not a practical option. Consumers are unlikely to be willing to pay the cost of achieving the maximum theoretical level of safety. The key issue therefore is the management of risk, and this requires the setting of food safety standards, based on risk assessment, and the implementation by industry of management systems based on HACCP (hazard analysis critical control points).

This should be underpinned by open, transparent information on risk, so that consumers are aware of the risks, understand them and make their own decisions on consumption based on this.

***The regulators' responsibility:*** In Ireland, FSAI has overall responsibility for specifications, certification and compliance with food safety requirements. Setting standards is the job of EU and national authorities, and should be based on scientific evaluation (risk assessment) and widespread consultation (risk communication). The risk assessment is done by scientists who evaluate the adverse health effects of exposure to food-borne hazards. Here, the aim is to be as quantitative as possible – risk is a function of the probability of an adverse health effect and the severity of that effect.

Risk assessment needs to be based on the best available knowledge, drawing on expert scientific advice and making appropriate allowances for the inevitable uncertainties involved. The available scientific data may be incomplete and difficult to interpret, thus making it very difficult to establish with certainty the nature and degree of risk. Where there are uncertainties about the scientific evidence, an element of political judgement is involved in reaching decisions.

In the light of the scientific results, a decision must be reached on the maximum level of each hazard that is acceptable for consumer protection. Here, risk communication is important with consumers and all interested parties including industry, so that realistic goals are set.

At this point the stage is set for the development and implementation of systems by industry to meet the agreed food safety standards.

***The agri-food industry's responsibility:*** This falls within the area of risk management and HACCP is basically a risk management tool. By far the most important action that the Irish agri-food industry can take is to implement systems based on HACCP principles from farm to point of retail sale, and to apply the principle of continuous improvement so that the agreed food safety objectives are always achieved in practice.

HACCP was developed in the chemical industry in the 1950's and was first applied in the food sector by the Pillsbury Corporation to meet NASA's requirements in the 1960's. Since then it has grown to become the universally recognised and accepted method of food safety assurance.

HACCP marries the elements of risk assessment with risk management: the hazards in an operation or process are first analysed, prioritised and resources apportioned; critical control points are identified and monitoring measures with their respective critical limits are agreed. Research support is particularly needed in the area of hazard analysis (the risk assessment element) because it lies beyond the normal expertise of food producers or processors.

HACCP can facilitate the move towards self-regulation in the industry by providing a systematic framework within which new technology can be applied at production and processing levels. Responsibility that used to rest on government inspectors to detect and correct food safety problems is now the responsibility of the management of the enterprise. The 'horizontal' hygiene directive 93/43/EEC (SI 86 of 1998) requires all food processors after primary processing to develop a system based on HACCP principles. Harvesting, slaughter and milking are currently excluded. 'Vertical' directives are in force in the veterinary sectors, including meat, fish, dairy, eggs and game. The level of HACCP differs considerably between these directives. A weakness in the hygiene directive is that there is no requirement for verification or documentation of HACCP systems, which is essential for auditing them. There is as yet no agreed standard on what constitutes a HACCP plan, though one is in preparation by the National Standards Authority of Ireland. Thus current controls still rely more on inspection (observation, removal of samples) than on audit.

The main aim of the forthcoming Commission White Paper on food law is to bring the hygiene directives together in one comprehensive piece of legislation and to reinforce controls from farm to table (Byrne, 1999).

By its very nature HACCP must be product and facility specific. HACCP may be different at different facilities, even for the same product. As more and more reliance is placed on HACCP, the task of auditing and assessing it becomes almost insurmountable. Thus far, the regulatory role has been limited to verifying that no overt food safety inadequacies exist.

The integration of HACCP into the day-to-day management of the business can be difficult. The Bord Bia Quality Assurance Schemes for beef, pigmeat and eggs seeks to address this problem by putting HACCP into the business management system, thereby making it auditable.

Research on the implementation of HACCP by Irish food processors (Doyle, 1998b) found that the majority of companies introduced HACCP to achieve either better internal control or to meet customer demands, rather than to meet legal obligations. This suggests that the mandatory aspect of HACCP is not the principal motivator, and that it is a useful business management tool in its own right.

*Farmers:* The difficulty now being experienced with the full implementation of HACCP in factories is a foretaste of the greater difficulties that will be faced at farm level. Implementation of HACCP on farms is optional now but will be necessary, and probably mandatory, in the future. Farm processing includes the sourcing of livestock and feeds, cleaning, milking, harvesting, storage, and transport. The use of feedstuffs, and in particular medicated feeds, creates potential hazards. Changes in regulations with legal and voluntary bans on particular feed ingredients increases the need to farm under a management system. Under the product liability directive producers can show due diligence by implementing HACCP.

An increasing number of intensive farm producers have implemented safety/quality management systems, showing that these systems can be successfully applied at farm level (Daly, 1998). About 500 pig producers supplying slaughter plants that are registered with Bord Bia are required to operate to the Pigmeat Code of Practice which is based on HACCP principles (Keane, 1999). Egg producers now operate under a similar scheme. Beef, grain and horticulture quality assurance schemes are in operation. Some dairy co-operatives and beef companies have developed in-house codes of practice for their milk or cattle suppliers.

*Farming under a management system*: Acceptable levels have been established for many hazards including residues of pesticides and veterinary drugs and numbers of pathogens. Codes of practice are now rapidly being produced for the various sectors, but having the code is only the start. All farmers will have to implement the codes. Implementing systems requires both education and training – education to convince farmers, and training to ensure that procedures are followed on a consistent basis.

*Retailers:* In the interests of competitiveness and brand protection, the specifications set within the trade are often higher than the legal requirements. Retailer assurance is now the key assurance in relation to safety/traceability of beef in the EU countries (Duffy, 1999). Consumers have given their trust to leading retailers to ensure that quality systems are in place which allow traceability and which guarantee all aspects of animal rearing and processing.

*Traceability:* For large animals, it is possible, through tagging, to have some degree of traceability, at least up to primary processing. But for foods such as grain and milk, traceability is less specific because there is mixing from an early stage of production. This difficulty in meeting blanket traceability for foods, as perceived by consumers and often promoted by retailers, further highlights the need for a preventive approach to controlling hazards in foods (Daly, 1998).

***Teagasc's responsibility:*** The biggest hurdle in implementing a national food safety management programme is the implementation and verification of HACCP. A high level of expertise and commitment is needed at farm and factory to plan, implement, audit and continuously improve HACCP systems, and it is Teagasc's responsibility to provide this expertise through on-site farm and factory training. Teagasc is in the position to do so by virtue of its training tools, skills in auditing and on-site consultancy, and technology transfer from its own laboratories and those of its research partners. In view of the high level of consumer concerns about food wholesomeness, and the extension of product liability back to the primary producer, it is inconceivable that farmers and processors will be able to compete in the future without these new skills.

Teagasc must also meet the needs of the public authorities for expert technical training in food safety auditing and other relevant areas.

**Teagasc food safety outputs:** In summary, recent Teagasc research developments in food safety include**:**

- development of a food purity database for Irish dairy, meat and fish products;
- development of HACCP protocols for beef, pig and lamb slaughtering (to be published early in 2000);
- development of hide and carcass decontamination methods for *E. coli* O157:H7;
- development of Lacticin 3147, a pathogen inhibitor (at the National Dairy Products Research Centre);
- development of rapid detection methods for food poisoning bacteria;
- development of rapid methods for detecting chemical residues in foods.

In addition to the above research outputs, The National Food Centre has assisted 400 Irish food companies to develop HACCP based food safety systems. It has also provided scientific support to Bord Bia for developing and implementing the beef, pigmeat and egg quality schemes. Four thousand food factory personnel have been trained in hygiene and three hundred staff in the Department of Agriculture and the Department of Health were instructed in HACCP auditing.

### What are The Major Food Safety Questions that Require Further Research?

This section attempts to prioritise the research that is needed to support the sector. Research priorities are dictated in the final analysis by supermarkets and consumers. Market signals, sometimes magnified enormously by the media are transmitted back along the food chain by the retailers, mainly the powerful multiples. The resulting search by industry for innovative solutions to market needs is the main driving force behind research.

Food safety is at the top of the research agenda, having been driven there by public developments during the 1990's. The priority now accorded to food safety is shown in the report of the Beef Task Force (June 1999) and the Food Industry Development Group (December 1998), also the National Development Plan 2000-2006.

Food safety is likely to remain at the top of the public research agenda for the foreseeable future, because, the root cause of the recent spate of food safety scares is the inexorable process of change in food production caused by competitive forces. Thus, the threat to consumers' health, whether real or perceived, from newly emerged food-borne pathogens or GM foods is simply today's manifestations of a continuing process of industrial change which conventional controls have failed to cope with.

***Real versus perceived hazards:*** Although industry must address all issues that are perceived as hazards by consumers, it is essential to direct scarce research resources at real hazards. Risk assessment enables separation of real hazards, where control is inadequate, from perceived hazards where competent technologies have been developed for control, although consumer concerns may persist. Examples of real hazards are food-borne pathogens, prion diseases and food allergens, while GM foods and chemical residues can be much more effectively controlled.

The most pressing research needs are identified below; they include the control of emerging pathogens, antibiotic resistance, BSE detection, GM foods, allergies, diet and cancer, and consumer attitudes to food safety.

***Emerging food-borne pathogens:*** Undoubtedly the major threat to food safety is the emergence of 'new' pathogens. Miller *et al.* (1998) listed only four food pathogens recognised in 1942, compared with over a dozen which were first identified in the past two decades. For example, only 20 years ago *Listeria monocytogenes, E. coli* O157:H7, *Campylobacter* and *Cyclospora*, all of which have caused recent outbreaks, were not known to cause food-borne illness.

New pathogens emerge as food is grown, processed and sold in new ways, and as microbes adapt. Foods are increasingly mass-produced and can come from almost anywhere in the world. These shifts have inadvertently created new opportunities for pathogens. *Listeria monocytogenes*, for example, grows well at refrigerator temperatures, and therefore thrives on chilled, pre-packaged foods. It is also the pathogen with the highest death rate, killing more than 500 Americans a year (Mead *et al.* 1999). Likewise, the increased presence of *E. coli* O157:H7 in food may be associated with the consolidation of beef and dairying into fewer but larger production and processing units (Miller *et al.* 1998).

By definition, HACCP systems cannot manage unknown emerging pathogens, so research-based knowledge is needed. Also, advances in biotechnology are providing opportunities for continuous improvement in the rapidity of methods for detection and quantification of microorganisms in factories. New and improved technologies may eventually provide methods with the speed and specificity to be employed for monitoring CCPs.

*Research Priority No. 1:* The top research priority is the control of emerging pathogens, by developing improved detection and identification methods and improved prevention technologies.

In Britain estimates of a 3% incidence of *E. coli* O157:H7 in cattle suggests that several hundred thousand carriers may exist in the national herd. Can these animals be identified and decontaminated before slaughter? Approaches that have potential for reducing the pathogen load in the gut of cattle are vaccination, competitive exclusion (probiotics) and better hygiene in feed and water troughs. Another question for research is whether slurry spreading on farmland can spread the infection? These questions can only be answered by farm-based investigations and these are urgently needed.

*Research Priority No. 2:* There is a need to reduce the pathogen load of animals *ex* farm.

There is a general lack of validated critical control points in meat slaughter operations. For example, none of the decontamination procedures that may be applied on the killing-line have been proven to assure complete elimination of *E. coli* O157:H7 (Doyle, 1998a). The surest approaches to ensuring inactivation of pathogens are thermal processing or irradiation treatment sufficient to kill $\log_{10}5$ (Sheridan, 1999). However, irradiation is not compatible with slaughter operations, and the research on thermal decontamination is not completed yet.

Despite these problems, abattoir owners are expected to implement HACCP systems that reflect best practice as it currently exists. Teagasc will publish HACCP procedures for beef, pig and lamb slaughter based on current state of the art best practice. These will be revised regularly to incorporate new technologies at critical control points in meat slaughter, as they become available from research. The new HACCP plans will be incorporated in training course materials for meat plant operators, starting in 2000.

*Research Priority No. 3:* Development and validation of critical control points in meat slaughter operations, and also in secondary food processing operations.

***Chemical residues in food:*** There have been relatively few incidents of residues in food causing observable toxic effects to consumers, and the results of residue monitoring indicate that, generally, chemical residues are not a significant food safety problem; however, residues may occur at levels which are considered to be undesirable, or which exceed permitted levels, and food production practices must aim to reduce or eliminate residues from food (O'Keeffe and Kennedy, 1998). Paradoxically, consumers may worry more about perceived long-term effects of chemical residues on health, than about the acute illnesses caused by food pathogens.

The COMA (1998) report concluded that there is no food contaminant that increases the risk of cancer, and there is little epidemiological evidence that chemical contamination of food and drink resulting from properly regulated use significantly affects cancer risk (i.e. excepting abuse or accidents). This conclusion is based on the 1997 reports of the World Cancer Research Fund and the American Institute of Cancer Research and covers residues from pesticides, herbicides and veterinary pharmaceuticals, food processing aids, nitrates and fertilisers, and materials migrating from packaging.

Continued vigilance is required however, to prevent abuse and to reassure consumers.

*Research Priority No. 4:* To further develop the National Food Residue Database as a service to the Irish food industry and as a source of information for consumers. An immediate priority is to increase the information on dioxins in Irish food, especially dairy products, meat, fish and shellfish.

It is estimated that 90% of human exposure to dioxins is through the food supply, consequently, protecting the food supply is critical. Contamination of food with dioxins is most likely to occur via contaminated feed and industrial pollution.

***Antibiotic Residues:*** Another real food safety hazard arises from the use of antibiotics as growth promoters in animal feeds, which is suspected of causing an increase in drug-resistant infections in humans. The rapid rise in the percentage of antibiotic-resistant pathogens (e.g. *Staphylococcus aureus* and *Salmonella typhimurium* DT104) isolated from hospital patients has led WHO to recommend that the use of any antibiotic for growth promotion should be terminated if it is used in human medicine, or is known to select for cross resistance to antibiotics used in human medicine (WHO, 1997). Sweden set the example in 1986 by banning the use of antimicrobials as growth promoters. It worked, and in 10 years the use of antibacterials in animals fell from 50 to 20 tonnes per annum by 1996. The ban led to clinical problems in pig herds, necessitating radical changes in hygiene, production and housing; production losses have now been partly corrected.

In late 1995, a report by the EU Commission estimated that if growth promoters were banned throughout the EU, reduced efficiency and higher treatment costs would increase food costs by 1 bn Euros a year. When Sweden joined the EU in 1995 it was allowed to keep its ban, but was given until the end of 1998 to either convince the rest of the EU States to join its ban, or to drop its ban and fall into line with the other members.

This year EU Farm Ministers imposed bans on four drugs, including virginiamycin and bacitracin. The USA still allows penicillin and chlortetracycline to be given as growth promoters, even though they are routinely used to treat humans.

Only a few bacteria can survive in both animal and human hosts (e.g. *Salmonella*, *Campylobacter* and *E. coli*). For the majority of strains that cannot, the key issue is whether resistant strains that are specific to animals can transfer their resistance genes to strains that infect humans. There is no clear evidence of natural transfer, but laboratory experiments show that it is feasible for resistance genes to transfer between different bacterial strains.

*Research Priority No. 5:* Identify factors that lead to the development of antibiotic resistance in pathogens carried by food animals and develop preventive measures, including the search for alternative methods of growth promotion that do not require the use of antimicrobials.

***Prion Diseases:*** In 1997 Stanley Prusiner won the Nobel Prize for his controversial proposal that prion proteins, like viruses and bacteria, can cause infectious disease. The most likely explanation for the 44 definite plus probable cases of vCJD to date remains exposure to BSE before the introduction of the ban on specified bovine offal in Britain in 1989. There was concern about the long incubation period of vCJD of up to a decade, or even longer; thus the number of cases in Britain is currently unpredictable, and this more than anything else about the disease, is responsible for the public dismay and political turmoil surrounding BSE.

Irish concern centres around the persistence of BSE in the national herd. The incidence in Britain (3,178 confirmed cases in 1998) is falling at a rate of 30 to 40% per annum, while in Ireland the incidence of BSE, although much lower, remains static at about 80 cases per annum. The hope is that the incidence in Ireland will fall as soon as tighter controls on the manufacture and sale of meat and bone meal take effect (SI No. 278 of 1996). No test yet exists for BSE in cattle at the pre-clinical stage of the disease. This is a serious obstacle in the development of a comprehensive HACCP plan for beef.

*Research Priority No. 6:* Develop a test capable of detecting BSE in live cattle at the earliest pre-clinical stages of the disease, to enable the removal of contaminated cattle from the food chain.

***GM Foods:*** There is evidence that health concerns about genetically modified organisms in food is mostly without foundation (McConnell, 1998). Likewise, the Food Safety Authority of Ireland concluded that GM foods are as safe as their conventionally grown counterparts. However, the evaluation of the safety of new GM products, including potential problems with pesticide residues in foods manufactured from pesticide resistant crops, and communication of risk to consumers will have to be done in a more transparent way in future.

*Research Priority No. 7:* Develop tests to identify GM ingredients in food products.

***Food Allergies:*** The incidence of food allergies is high, for example, in the US some 8% of children and 2% of adults exhibit allergy (Bush, 1997). These adverse reactions to foods are caused by an immune response that leads to the release of histamines.

Over 170 foods have been documented as causing allergic reactions, chief among which are the “major serious allergens” (MSA’s). These include the so-called “big eight”, namely, milk, eggs, soya, wheat, peanuts, shellfish, fruits and treenuts, which between them account for the great majority of food allergies. Current research in the UK is aimed at identifying the steps that might be taken to reduce the incidence and severity of allergic reactions. This includes attempts to identify the causative agents in different allergenic foods, although sensitised individuals generally react to only one of these foods. This work includes identifying the different proteins that elicit allergic reactions, including comparing the tertiary structures of the different proteins and looking for similar amino acid patterns. In the meantime, developments in food labelling are essential to protect consumers with food allergy.

***Diet, lifestyle and cancer****:* Recently, two influential reports (World Cancer Research Fund, 1997; COMA, 1998) fuelled new concerns by claiming an association of colorectal cancer with red meat consumption. The reports concluded that inappropriate diets cause about a third of all cancer deaths worldwide. They also concluded that lower consumption of red and processed meat would probably reduce the risk of colorectal cancer.

The British Nutrition Foundation and the European Cancer Prevention Organisation (Hill, 1997) noted that the COMA report was based on evidence from the US, while in Europe, higher consumption of fruit and vegetables, especially in Mediterranean countries, appeared to have a protective effect against cancer. Institutional research on this topic is justified in view of the importance of red meat consumption to the Irish economy.

*Research Priority No. 8:* To elucidate the "reciprocal relationship" between meat consumption and fruit and vegetable consumption, concerning the risk of colon cancer.

Any association of meat intake with cancer may be influenced by cooking methods and the meat industry might be advised to discourage people from over-cooking meat to be "very well done" (Zheng *et al.*, 1998). This problem arises in barbecuing, grilling and frying where food may be scorched on the surface. Polycyclic amines are formed by the incomplete combustion of amino acids. A number of polycyclic amines, such as benzopyrene, are carcinogenic and mutagenic, and are widely believed to make a substantial contribution to the overall burden of cancer in humans.

*Research Priority No. 9:* Development and promotion of appropriate cooking methods for meat and fish products to reduce or eliminate the formation of polycyclic amines.

***Consumer research:*** Knowledge of consumer attitudes to safety and wholesomeness in the main markets for Irish foods is needed to guide the product development activity in Irish agri-food businesses. Without this essential research information the failure rate of new products will continue to be unacceptably high.

*Research priority No. 10*: To develop consumer lifestyle models for the main markets for Irish foods, so that new product development is informed about consumer demands in safety and wholesomeness.

***Research resources:*** The above priorities, although by no means a complete listing, are the most pressing areas for research. Progress is essential to generate the information needed to underpin the Irish agri-food sector in future markets. Achievement of these research goals is far beyond the present research resources of Teagasc and Irish universities. Additional resources will be needed as well as the maximum use of links to international research organisations that are working towards the same goals.

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# Securing a balance between competitive agriculture and environmental protection

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**This conference has projected a two-tier model of farm development. Large units with land of good quality are likely to become intensive agribusinesses with the aim of achieving greater efficiency in farm production through optimising inputs and application of new technology. These units will be required to operate within the norms of environmental performance.**

**The second tier aided by CAP reform and new rural development initiatives will have both farm and land-based activities including farm forestry production and also nature conservation management. These multifunctional operations will be required to deliver multiple benefits in greater measure than in the past.**

**The common challenge for both groups in the new millennium will be to balance the priority of food production with the needs of environmental protection and enhancement. The needs will vary between the groups and indeed between farms.**

**Research is now being challenged to develop the appropriate knowledge base and know-how for both groups. This paper examines the policy background, the issues and interactions between agriculture and the environment, focusing on the main pressure points. It describes the research role in securing a balance between the respective legitimate interests.**

## The Framework for Sustainable Agricultural Development

The recent Council Regulation (EC) No. 1257/1999 on support for rural development is aimed at the achievement of an economically efficient and environmentally sustainable agriculture and the integrated development of rural areas.

At national level the Government recognises that future rural development must be considered in an integrated way embracing agricultural/employment, social and environmental dimensions with the achievement of sustainable development as a core objective. The Governments (Department of Agriculture and Food, 1999) future strategy for agriculture includes:

- Continuation of measures supporting environmental protection in recognition of the role of farms as custodians of the natural resources of the countryside; inclusion of environmental safeguard conditions in various agricultural support schemes.

- A recognition of the strong desirability to protect and preserve the natural environment aided by incentives for compensatory support for environmental purposes.

The new European agricultural model was defined by the Agricultural Ministers in their consideration of CAP reform under Agenda 2000 in Luxembourg in 1997. The model saw agriculture as an economic sector that must be versatile, sustainable and competitive. Apart from primary food production, agriculture was seen as encompassing stewardship of the landscape, and environmental protection i.e. a multifunctional agriculture.

**Defining environmental sustainability**
Under the Agenda 2000 framework (CEC, 1997), agriculture must be considered in the overall context of sustainable development which encompasses economic, social and environmental goals. Ireland's sustainable development strategy (Department of the Environment, 1997) includes an action programme for "sustainable agriculture" and places emphasis on greater adoption of the Rural Environment Protection Scheme (REPS) by farmers.

The central question surrounding environmentally sustainable agricultural development has two interrelated parts:

- What levels of environmental impacts are acceptable (i.e. sustainable)?
- Can land-based agriculture achieve production efficiencies that keep pollutant losses at or below acceptable levels?

**Legislative and regulatory measures**
Farming must conform with an increasing range of measures aimed at environmental protection. There is now considerable scope under the legislation to control nitrogen (N) and phosphorus (P) inputs to agriculture. To-date there has been only limited implementation of such controls. However, the recent setting of water quality improvement targets by the Government is likely to result in the more widespread adoption by Local Authorities of their powers to control N and P use. The recent introduction of bye-laws by one Local Authority (Cork County Council) is particularly noteworthy.

**The integration of environmental goals into the CAP**
Whilst Agenda 2000 reinforces the concept of direct payments to farmers, the intention is to make support payments conditional on the carrying out of basic good farming practice. A new Regulation No. 1259/99 establishes common rules for direct support schemes under the CAP. In effect, under this Regulation, Member States will have discretion in making payments conditional on implementation of specific environmental practices, as they consider appropriate. Allied to this, focused agri-environment payments such as REPS will be made for actions going beyond Good Farming Practice. REPS operates on the assumption that a baseline level of good farming practice is being exceeded and that additional costs are incurred in achieving this. The intention of the REPS Scheme is to provide compensation for losses incurred for farming in an extensive manner.

## The Environmental Impacts of Agriculture

Agricultural activities have both beneficial and harmful effects on the environment through changing the quality of soil, air, water, natural habitats, biodiversity and landscapes.

The major linkages between agricultural policies/activities and the environment derive from their effects on:

- Water quality
- Air quality
- Soil quality
- Stewardship of countryside/biodiversity

The potential environmental impacts of agriculture vary in character and intensity depending on farming system, land use type, soil and hydrogeological factors and other influences. There are a number of widely recognised environmental impacts in Irish agriculture:

- Damage to the quality of surface and groundwaters notably *via* pollution of watercourses from the over or inappropriate use of P and N fertilisers, animal manures and bio-solids. Eutrophication of surface water is the most widely identified problem.

- Damage to soil quality and stability, particularly erosion from over-grazing, compaction from heavy machinery and possible localised heavy metal imbalance.

- Air pollution and reductions in air quality from intensive livestock units, manure spreading and possibly crop spraying.

- Impact of agriculture on wildlife, eco-systems, biodiversity and countryside values.

Possible environmental threats to agriculture, arising from certain industrial developments including the recycling of municipal bio-solids on farmland must also be considered in the post 2000 period and in addition to possible environmental impact of Genetically Modified Organisms (GMOs).

## The Main Issues

### Water quality

There is very strong evidence (McGarrigle, 1999) to suggest, that agriculture is now the single biggest source of pollution problems in Irish rivers and lakes. The detailed surveys carried out by the Environmental Protection Agency (EPA) cover thousands of sample points at approximately 4 km intervals on over 13,000 km of major Irish rivers. These surveys are long-term and based on detailed knowledge of rivers, locations of pollution sources and changes in the catchments over a 30-year period.

Recent trends in Irish water quality are disturbing (Lucey *et al.,* 1999). The long-term trends (1971-1997) show a continuous reduction in unpolluted river channel (84 to

51%) and increasing levels of slight and moderately polluted river channel (10 to 47%). Agriculture is implicated in almost half the cases of slightly and moderately polluted river channel. There is also concern about lake water quality, with 19% of those surveyed in less than satisfactory condition (Lucey *et al.*, 1999). Nutrient losses from agricultural point and diffuse sources, particularly P, are implicated.

To date, there is only limited evidence of nitrates in groundwater with a relatively small number of "hot spots" in the country. However, designation of nitrate vulnerable zones is expected in the near future. Unlike many of our European neighbours the emphasis of Irish policy and legislation in relation to agricultural nutrients is focusing on reducing P loss to surface water rather than nitrate to ground water. Pesticides do not appear to constitute a problem.

**Air quality**

The Kyoto Protocol (1997) set a legally binding target for the EU to reduce emissions of greenhouse gases by at least 8% below 1990 levels in the period 2008-2012. There is a requirement for inventory data on gaseous emissions for agriculture. In June 1998, Ireland agreed a national target to limit its greenhouse gas emissions to 13% above 1990 levels in the period 2008-2012. This represents Irelands contribution to the EU's overall reduction target of 8%. Carbon dioxide, methane and nitrous oxide are the greenhouse gases most commonly associated with agriculture. The agricultural contribution to total carbon dioxide emission is very low.

It is estimated that agriculture in Ireland accounts for 34% of the total emissions of greenhouse gases (McCumiskey, 1998). This compares with an average OECD agricultural contribution of 6.7% (OECD, 1997). Methane and nitrous oxide are the dominant agricultural constituents. Agriculture in Ireland accounts for over 70% of total nitrous oxide emission (Environmental Resources Management, 1998).

The largest source of methane emissions is from ruminants. Anaerobic storage of animal manures also emits methane and carbon dioxide. For most OECD countries (OECD, 1997) agriculture is the major source of total methane production varying from a low of 21% in the Czech Republic to a high of 80% in Ireland.

**Ammonia emissions**

The agricultural contribution to total ammonia emission is estimated to be >90% (Carton, 1999). The annual emission from agriculture is estimated at 130,000 t which is equivalent to about 30% of total annual fertiliser N usage (Carton, 1999). Apart from the economic losses which are calculated to be £50m per annum, the loss has serious environmental implications in terms of Ireland meeting its international obligations under the EU acidification strategy, the UNECE Convention on Long-Range Transboundary Air Pollutants as well as the EU Directive on Integrated Pollution Prevention and Control. Although not a greenhouse gas, ammonia emission is a pollutant owing to its acid deposition propensity and contribution to nitrate leaching.

**Soil quality**

Soil must be considered as a non-renewable resource and is subject to physical chemical and biological degradation with agriculture contributing to these negative effects. In this regard, information on the qualitative aspects of our soils i.e. soil heavy metal/organic micropollutant content is essential for (a) demonstration of the cleanliness of our soils, (b) counteracting existing (geochemical) pollution, (c) planning and evaluation of baseline surveys and (d) the provision of a soil quality data bank. It is envisaged that problems such as that presented at Askeaton during 1995 will surface at irregular intervals and will need to be addressed.

Since the introduction of headage payments and premia, sheep overgrazing in certain hill areas has resulted in changes in species composition and the elimination of certain species. High grazing pressure particularly on fragile soils has the capacity to cause erosion. This is a classic example of conflict between farming and the environment (EPA, 1996).

The soil quality/agronomic issues relating to usage of municipal sewage sludge in agriculture are also likely to grow in importance. This is because (a) large quantities of high grade sludge will become available from the Dublin treatment facility and (b) prohibition of wastes with high organic matter content going to land fill.

**Stewardship of countryside/biodiversity**

***Countryside management:*** Agricultural development and, in particular, intensive agriculture has led to a reduction in semi-natural habits throughout the countryside and to a loss of biological diversity. Estimates of hedgerow reduction are put at 16% (Webb, 1988). The Rural Environment Protection Scheme (REPS) now affords a high level of protection for these landscape features across 35% of the land area. Landscape protection also extends to vernacular landscape features and archaeological sites. Approximately 6% of all archaeological sites known 10 years ago have disappeared. Research shows that intensive large farms are most likely to remove archaeological features. The beneficial impact of REPS in increasing awareness of these features and in identifying previously unrecorded features has also been demonstrated. The obvious question is how REPS type protection can be extended to include intensive farms. This matter needs to be addressed.

***Protection of designated natural heritage:*** The European Union Habitats Directive came into force in 1997. This brought into the farmers’ domain concepts such as Natural Heritage Areas (NHA’s), Special Areas of Conservation (SAC’s), Special Protection Areas and Nature Reserves, etc. Areas designated by the Government and EU Directives extend over 10% of the national area. All NHA’s occurring on the farms of REPS participants are protected by management agreements and attract high payments for the farms concerned. The SAC’s and SPA’s will form part of the European Wide NATURA 2000 programme which seeks to protect the best remaining examples of National and European heritage. Extensive areas of the Burren, together with blanket peatlands, heaths and upland grasslands account for over 60% of the SAC’s and must be farmed in accordance with agreed management prescriptions. Farmers with SAC’s and SPA’s have a right to compensation for loss of income and additional costs associated with the farming restrictions, with environmental cross compliance also being applicable. In specific circumstances a certain level of destocking will be required.

In general the aims of the above are to enhance and conserve important landscapes, their aesthetic quality, wildlife habitats and heritage areas and farmers in turn are required to carry out appropriate management agreements and practice appropriate farming methods.

## Managing Phosphorus (P) for Profitable Farming and Minimal Environmental Impact

### Agronomic and environmental responses

P is considered to be the major pollutant contributing to water eutrophication. The relative contribution of the different sources of P is complex and is not known in a quantitative way at the present time. It makes sense that adequate slurry/manure storage should be available on each farm with provision for the safe disposal of soiled waters, that the rate and timing of spreading of farmyard slurries, manures and chemical fertilisers should be in accordance with Teagasc guidelines. While control of point sources of P is feasible, control of diffuse sources is more problematical. Recent research (Tunney *et al.,* 1997; 1999) is adding substantially to our understanding of the problem and indicates for the specific soil/hydrologic conditions investigated, that propensity for P loss from soil to water rises exponentially with increasing soil P levels.

This research is quantifying the trade-off between agronomic response and environmental impact. Further studies will be necessary to establish how widely, the results achieved to date apply to other soils and catchments in Ireland. P loss to water should be of the order of 0.35 kg P per ha per year, or lower, for good water quality (Tunney *et al.,* 1998). For good water quality the indications are that the soil test P (STP) should be in the lower range for optimum or near optimum agronomic production.

The current state of knowledge indicates that potential for P runoff is strongest in impeded soils which account for about one-third of agricultural land. For free-draining soils which account for 50% of the land area, the loss of P from soil to water is less likely to contribute to water eutrophication. However, confirmatory research is essential.

### Refining phosphorus advice for agriculture

The recent adjustment of P advice for grassland effectively maintains output with reduced P inputs and with significant economic savings for farmers. The investigation of trade-offs between P-use, agricultural response and environmental impact is the subject of continuing research.

The importance of determining optimal P application rates may be gauged from recent experimental findings at Johnstown Castle (Culleton *et al.,* 1999) which show that under comparable beef production levels more P is lost in water than removed in beef production at high STP levels. For dairying, preliminary research findings (Culleton, 1998) indicate no difference in performance between Soil P Index 3 (current advice for intensive dairying) and Soil P Index 2 at stocking rates of 2.5 cows/ha. These results indicate that there may be scope for modification of the current P Index System for grassland, but must be the subject of continuing research over a range of soil types (Herlihy, 1999). It is estimated that reducing the upper limit of Soil P Index 3 from 10 mg/l to 8 mg/l would achieve an economic saving of £80/ha, apart from the positive environmental effect. Recent surveys on REPS farms (McEvoy, 1999) have demonstrated improved P use efficiencies of 20% to 30% without any compromise in production when compared with comparable conventional farms. This was achieved through adoption of Nutrient Management Planning.

From the viewpoint of competitive agriculture, the indications are that possible adjustments in P usage are unlikely to impact negatively on grassland agriculture, but must be the subject of confirmatory research.

The following are priority areas for research:

- Production implications of modifying the P Index System.
- Trade-off between P use, productivity and environmental impact.
- Contribution of agricultural P to water pollution.
- Develop geographically focused environmental risk assessment models.
- Develop management protocols for more efficient P use.
- Contribution of Soil P to production.

## Managing nitrogen (N) for profitable farming and minimal environmental impact

### Nitrogen losses

The EC Drinking Water Directive imposes a limit of 50 mg/l (MAC) of nitrate in drinking water. If zones are designated farmers will be subject to mandatory uncompensated measures based on Good Agricultural Practice and Polluter Pays Principle. It is important to note that an additional Framework Directive on Water is being seriously considered by the EU that will encompass regulations on catchment management, groundwater action programmes, and other site specific controls. This Framework could have significant implications for future farm practices in any relevant areas.

An estimated 70% to 80% of N inputs is not recovered in soil or in animal production and is lost to water or to the atmosphere. Apart from obvious environmental impact, this represents a substantial economic loss to farming. For example, ammonia losses are put at £50m per annum.

Teagasc nutrient balance studies (Mounsey *et al.*, 1998) at farm level indicate N surpluses of 300 kg/ha for intensively stocked (>2 LU/ha) dairy farms resulting in ammonia volatilisation, leaching and denitrification. This surplus reflects the poor efficiency of nitrogen recovery. Teagasc research (Ryan and Fanning, 1999) has demonstrated that arable systems and, in particular, fallow have a much greater propensity for nitrate leaching than grassland. This, in turn, is associated with elevated nitrate levels in surface waters.

There is a linear relationship between N application rates and losses through leaching and denitrification (Watson *et al.*, 1998). Research (Ryan, 1999) indicates N leaching losses (nitrates) of the order of 15% to 35% under Irish conditions at high N inputs and losses to air (ammonia, nitrous oxide) of the order of 10% to 20%. There are particular difficulties in accurately measuring these losses and in accounting for all applied N.

**Securing a balance**

In nitrate vulnerable zones applications of N in excess of 300 kg/ha are likely to breach the MAC (Scholefield *et al.*, 1991; Ryan, 1999). Under the Nitrate Directive, farms in vulnerable zones would be required to reduce stocking to 2.5 cows/ha initially for 4 years and thereafter to 2 cows/ha. The losses incurred by intensive dairy farms (>2.5 cows/ha) would depend on:

(i) The proportion of the total farm business that is in dairying;
(ii) Costs associated with the dairy enterprise, in particular, quota leasing costs;
(iii) Opportunity to lease or rent land and the associated costs;
(iv) Investment in fixed costs;
(v) Capacity to increase production/cow.

It is interesting to note that the recent Bye-law introduced by Cork Co. Council would limit stocking to 2.5 cows/ha where ground water nitrate levels exceed the approximate guide level of 20 mg/l.

In order to secure a balance between competitive agriculture and environment in respect to N usage the following points are pertinent:

- There is an urgent requirement to quantify the trade-off between N usage, production response and environmental impact.

- Current Teagasc N advice for animal production does not discriminate between production systems i.e. dairying, beef production, sheep production.

- The aim is to develop a new advisory framework which will take into account livestock system, soil type, sward productivity, level of concentrate use.

- This will result in more sharply focused advice for transfer on to farms.

- The refinement will result in more efficient use of N and consequent financial savings as well as reduced environmental risk.

- Recent Teagasc studies have demonstrated improved N use efficiencies of the order of 25% on a sample of REPS farms (<2LU/ha) without any compromise in production when compared with conventional farms. This was achieved through application of Nutrient Management Planning principles.

The major challenge is to maintain agricultural output with improved N efficiencies i.e. reducing chemical N input with the following research priorities:

- Investigate protocols for improved N efficiencies.
- Investigate trade-off between N use, productivity and environmental impact.
- Quantify contribution of agricultural N to water and air pollution.
- Devise management protocols to minimise N losses.

## Reducing Greenhouse Gas Emissions

The relationship between denitrification and nitrogen input is linear (Watson *et al.*, 1998) and there is a linear relationship between methane emission and ruminant numbers. Between 1990 and 1999, the cattle population has increased by 15% with sheep showing a 5% decline. Over the same period N fertiliser consumption has increased by 7%. As a consequence of these changes, greenhouse gas emissions have also increased. The FAPRI projection is a decline of 6% and 12%, respectively, in cattle and sheep numbers between 1999 and 2008, which will reduce emission levels. However, pigs and poultry are projected to increase by 5% and 8%, respectively.

- In order to reduce nitrous oxide emission levels, major focus must be on the improved efficiency of nitrogenous fertiliser usage through the adoption of best technical advice and implementation of Nutrient Management Planning.

- The new Teagasc N advice framework which is currently being elaborated will have a significant impact.

Reducing methane emissions is problematical. The achievement of maximum efficiencies in ruminant feed and production systems will be essential.

The major sources of ammonia and odour emissions are livestock buildings, manure storage and spreading of manures and N fertilisers. The bandspreading of slurry will reduce emissions and also the covering of manure storage facilities each incurring additional cost burdens. Unless urea is used according to the Teagasc protocol, it has the capacity for significant air pollution through ammonia losses. However, there are few effective means to reduce ammonia emissions from buildings and this matter must receive research attention. Similarly, there is a requirement to develop cost-effective odour control systems particularly in buildings. In this regard, Irish research (Curran *et al.*, 1999) is demonstrating that air biofilter systems offer potential solutions.

## Managing Manures for Profitable Farming and Minimal Environmental Impact

Manure production in Ireland is estimated at 100 million tonnes. Grazing animals, pigs, poultry and horses contribute 96%, 3%, 0.4% and 0.6% of the manure load, respectively. Approximately, 31.6 million tonnes of manure is collected annually indoors and requires management. Of this cattle, sheep and horses account for 89% (28.1 million tonnes), pigs for almost 10% (3.2 million tonnes) with poultry accounting for 1% (0.3 million tonnes). Projections of changes in animal numbers by the year 2010 suggest no major changes in the quantities of manure requiring management.

Provision of adequate manure storage will increase costs. However, improved management can assist in minimising these i.e. eliminating ingress of clean water. Stored animal manure is estimated to contribute 2% to total methane production. Careful consideration must be given to the use of anaerobic digestion as a strategy to reduce emissions from this source, particularly on grassland farms. The limited availability of manure spreading dates on grassland farms is a significant challenge. Provision of adequate manure spreading equipment is also a limiting factor.

***Commercial dairy, dry stock and arable farms:*** Comparatively speaking, nutrients are in balance on these farms in contrast to Intensive Agricultural Enterprises (IAE's) (Pig and Poultry Units).

- The greatest challenge for the former is to improve basic manure management in accordance with Teagasc guidelines i.e. landspreading. This involves adequate and safe storage, spreading at the right time and at the correct rate. REPS is now achieving this objective on participating extensive farms.

- There is a need for improved educational and demonstration programmes to ensure the implementation of existing advice.

- Greater controls on storage requirements and landspreading of manure in terms of dates, rates and methods of spreading will emerge in response to the need to reduce emissions to the environment. There will be an increased cost implication, which may impact on competitiveness.

- Low emission spreading equipment such as bandspreader and shallow injection will replace the vacuum tanker.

***Intensive Agricultural Enterprises (IAE's):*** Large land areas located at increasingly longer distances from the units are required for IAE manure. Between 50 and 60 farms are being used by pig farmers applying for IPC licenses to assimilate the manure from their units. The problem of locating acceptable IAE manure spread lands is being accentuated as organic wastes from the agri-food sector and sewage biosolids are competing for the same spread lands. This is arising as a consequence of IPC licensing requirements for these industries, increasing costs for use of land fill and the ban on sea dumping of sewage sludge. Furthermore, the availability of spread lands for IAE manure is also restricted by legislative requirements, Codes of Practice, REPS, and the recently introduced Groundwater Protection Scheme. As a result costs are increasing and impacting on competitiveness.

- In order to secure a better balance between production and environment it is necessary to examine alternative manure management strategies including anaerobic digestion, manure separation for these enterprises.

- The nutrient concentration of manure particularly N in chicken litter and P in pig and poultry manure severely limits spreading rates. To address this, diet manipulation is being examined as a possible means of reducing concentrations.

- The development of reliable risk assessment strategies for manure spreadlands is under investigation as another strategy to deal with the problem.

- Greater controls on manure storage and landspreading will incur significant costs.

## The Soil Resource and Countryside Management

***The soil resource:*** Agricultural land-use plays a pivotal role in creating and maintaining biotopes particularly in areas of semi-natural vegetation in the hill land ecosystem. Grazing intensity imbalances (associated with CAP) may disturb fragile biotopes and lead to soil degradation and erosion. Part of the problem is also attributable to natural causal factors. The phenomenon is being addressed by Teagasc. This research shows (Hanrahan and O'Malley, 1999) that with appropriate grazing management techniques and grazing intensities, soil erosion not problematical on the particular shallow peat experimental site under study.

Heavy metals and persistent organic micropollutants are the main potential soil contaminants. Research to date (McGrath and McCormack, 1999) indicates little serious man-induced contamination. However, as much as 22% of soils breached the provisions of the EU Sewage Sludge Directive for Heavy Metals in Soils. Some localised geographic areas displayed a very high incidence of heavy metal imbalance (>50%) attributable to geochemical factors with some aerial deposition e.g. lead and selenium. Historic usage of DDT and y-HCH was detected in specific land-use types. In view of the impending usage of sewage sludge in agriculture, the development of necessary baseline data and also management guidelines is a matter of urgency.

The information base on soil biological degradation is inadequate, with little or no trend data on soil organic matter levels, changes in soil structure such as compaction or the general biological state of soils.

Priority research areas include:

- Developing appropriate grazing management systems for fragile upland areas.
- Quantifying extent of soil erosion.
- Developing baseline data and management guidelines for sewage sludge application to agricultural land.

***Countryside management:*** New approaches will be required to restore lost habitats and biological diversity particularly in areas of high aesthetic value and in order to equip farmers to meet the requirements of countryside management, there is a need to develop appropriate research, education and training programmes. Priority areas for investigation include:

- Monitoring impact of new management protocols on biodiversity.
- Testing and demonstrating least cost farming methods that conserve and enhance our landscapes and the biological diversity of farmland.

## Conclusions

- Farmer commitment to environmental responsibility and care must be seen as part of an overall approach to quality food production.

- Regional rural development planning will be an important component of the Agenda 2000 CAP Reform and the environment will play a significant role in these plans. Farming will be expected to respond to the environmental issues identified.

- There will be an obligation for all farms to respect good farming practice including environmental legislation.

- Agricultural practices with capacity for pollution must receive serious research attention in order to quantify the parameters of sustainable farming and also the trade-off between productivity and the environment. In this regard, the parameters of Good Farming Practice require definition.

- N and P are the major environmental pressure points and there must be a major focus on improved N and P efficiencies.

- The traditional view that conforming with environmental standards will incur additional cost is not universally true. This is illustrated by the recent adjustment of P advice for grassland which effectively maintains output with reduced P inputs.

- From the viewpoint of competitive agriculture the indications are that there may be scope for further adjustments in P usage which are unlikely to impact negatively on grassland agriculture. However, in high risk areas, there may be restrictions on farm practice in respect to control of P loss to water that may impact on competitiveness.

- For N, there is significant soil variability in loss through leaching. Application above 300kg/ha is likely to breach MAC in Nitrate Vulnerable Zones with consequential negative impact for intensive farms. Aims must be to minimise losses.

- Greater controls on storage requirements and landspreading of manure in terms of dates, rates and methods of spreading will emerge in response to the need to reduce emissions to the environment. There will be an increased cost implication, which may impact on competitiveness. The implications for intensive pig and poultry enterprises will be significant.

- Air emissions from agriculture must be quantified and minimised through the development of appropriate nutrient and animal management practices.

- For fragile upland areas, critical stocking levels must be established in order to conserve vulnerable habitats and soil resources.

- Countryside management must receive a new research focus in order to develop farm practices that conserve and enhance our landscapes and the biological diversity of farmland. Monitoring the impact of new countryside management protocols on biodiversity should be carried out.

- The extension of a REPS type scheme to the intensive farming sector in order to protect important landscape features should be considered.

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# How should consumer concerns be addressed?

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I am very happy to be given the opportunity to talk to you on behalf of the European Commission's Directorate General for Health and Consumer Protection, about how consumer concerns in the area of food safety and quality should be addressed.

Consumers' aspirations regarding food have become manifold, and sometimes contradictory. The desire for products that are affordable for everyone, which was prevalent in the years following the Second World War, is still there, but consumers also want their favourite products to be available all year round, for them to be ready after five minutes in the microwave, while after the same time tasting as if they came fresh from the farm and, of course, being healthy and safe.

In fact a Eurobarometer survey carried out in 1997 revealed that the most important issue for 68% of consumers was the safety of the food they eat. And that was after the BSE crisis, admittedly, but *before* the dioxin crisis!

Moreover, it would be extremely short-sighted to think that consumer confidence has only been shaken by these big crises, as growth promoters, antibiotics, hormones, pesticides, herbicides, listeria, salmonella, campylobacter and E. coli have also taken their toll and contributed to diminishing consumers' confidence. In addition to feeling threatened, many consumers feel betrayed. In their opinion, the intensive production methods developed over the last decades with the laudable objective of giving everybody enough to eat, have got out of hand and are no longer used for the long-term benefit of all but for the short-term profit of a few.

So what principles should we follow in order to restore that shrunken consumer confidence?

I would say that we need the following three elements: better legislation, stronger controls and full transparency.

And I would add that we need all three together and that none should take precedence over the others, since the best legislation is of no use if it is not based on authorized opinions and backed up by efficient controls, and this whole edifice collapses if consumers have a feeling that things are being hidden from them.

During the years when a major, if not sole, objective was always to produce more at lower prices, we may have lost sight of the fact that food-related public policies must have public health as the highest priority. Public authorities have a duty to ensure that consumers can make informed choices and that the agri-food industry and trade fulfil their responsibilities concerning food safety and quality. The chain by which food products reach consumers is long and complex, and clearly if one link is weak, whether it is at production, transport or distribution level, the impact on public health can be significant. This is even more true now that the Single Market is in place and that the globalization of trade is a reality.

A global food market requires a global approach to food safety. Although the EU cannot be the only body responsible for all aspects of food safety, as Member States do have an essential role to play, it is obvious that when food products cross borders freely the issues need to be addressed at EU level as well.

Similarly, an integrated food chain, where there is no close link between the farm, the slaughterhouse, the food-processing plant, the supermarket and finally the consumer's kitchen, requires an integrated approach to food safety. By this I mean that public policies concerning food safety should not be based on piecemeal legislation in separate areas – health on the one hand and consumer protection on the other – but on a coherent regulatory framework applying to all links in the food chain, i.e. primary production, processing, storage, transport and retail sale, and guaranteeing food safety from stable to table.

This framework should be built upon the following guidelines: only safe food may be placed on the market; food law must guarantee a high level of health protection; primary responsibility for the safety of food rests with producers and suppliers, and traceability should be possible all along the food chain.

This needs to be translated into concrete terms.

It is, for instance, difficult to understand why the feed manufacturing industry should be subject to fewer and less rigorous requirements and controls than the food manufacturing industry. Recent experience has confirmed that the safety of food from animal origin begins with safe animal feed. The lack of internal and external controls and of traceability mechanisms enabled the dioxin crisis to spread from one end of the food chain to the other. Although legislation cannot prevent all incidents affecting the feed and food chain, it can lay down appropriate requirements concerning the materials which may or may not be used in animal feed production, including animal by-products, chemicals and pharmaceuticals. Therefore the Commission intends to put forward legislation which will require all feed producing plants to be officially approved and controlled regularly, and to set up a rapid alert system for feed.

Animal health is also an essential precondition for food safety. The availability of a correct picture of the situation in this respect is a prerequisite for action. Therefore harmonised reporting requirements need to be introduced. The information gathered will enable the public authorities to set targets and propose more effective measures to reduce the prevalence of zoonoses.

As regards food hygiene, which is the most obvious aspect of food safety, the European Community has developed a series of requirements which differ according to whether the food is of animal or plant origin and which leave out the primary production of food of plant origin. All these requirements need to be integrated into one piece of legislation that applies to all products and all along the food chain.

When it comes to novel foods, consumers are clearly concerned. And that should not surprise us since the debate is still raging on whether these products will or will not have a negative impact on people's health or the environment over the long-term. Some are criticising the public authorities for not coming up quickly enough with clear and comprehensive legislation applying to the marketing and labelling of GMOs. But 30, 20 or even 10 years ago, who would have thought that we would ever need rules governing the sale of tomatoes with fish genes! Apart from the difficulty in assessing the possible risks involved, there is also a moral dilemma at stake.

This dilemma concerns the application of the precautionary principle. Some would like it to be enforced in the strictest possible way, while others would like it to be completely ignored. Of course the public authorities have to find a happy medium between those two extremes and say to consumers: 'We are doing our best to ensure that only safe products are put on the market, but we cannot guarantee zero risk'. Therefore sometimes the analysis of the risks leads the public authorities to ban a product – for instance in the case of the EU ban on American hormone-grown beef; sometimes it leads them to adopt a piecemeal approach – for instance in the case of GMOs, and sometimes it leads them to authorize a product – for instance in the case of the recent lifting of the embargo on exports of British beef to the rest of the EU.

But how can the public authorities perform the risk analyses upon which they will base their decisions? The answer is: with the help of *independent* and *transparent* scientific advice. This is particularly important where approvals and specific evaluations are required. When the European Commission restructured its services following the BSE crisis, it went to great lengths to separate the advice function from the regulation and control functions, to select the scientists on the basis of excellence and following a public call for expression of interest, to publicize the names of the members of each Committee and to put the agendas and the opinions on the Internet immediately after adoption.

Of course there are cases where the scientific data are inconclusive, or where two scientific bodies come up with conflicting opinions. Think of the recent conflict between France and the UK on beef exports. On the one hand the French Food Safety Agency says that it is against the precautionary principle to lift the ban because nobody can explain why the number of BSE cases in the UK is still around 2,000 per year and does not seem to go down, and that the measures put in place by the UK to guarantee the safety of their meat are insufficient. On the other hand the EU Scientific Committee says that these 2,000 cases are residual, and that the safety measures put in place by the UK are adequate. In such circumstances it is up to the public authority to make a decision which will inevitably be berated as essentially "political" by the losing side.

And after all, to put the debate in a wider perspective, is it not a good thing for the functioning of a democracy that the political authorities should sometimes have to take responsability and make a choice between conflicting scientific opinions? Personally I would fear that if this never happened we might end up with a "government for experts" instead of a "government for the people".

All this boils down to saying that even if advisory bodies do provide invaluable help in making more rational and better informed decisions, in the end it will always be up to the politicians to find the appropriate answer to consumer concerns.

Once scientifically-based measures are in place, it is necessary to control their implementation. This is perhaps the aspect of the public authorities' work in the area of food safety which is dearest to the hearts of consumers. For if consumers are unhappy when they learn that for whatever reason, good or bad, there is no legislation to protect them from some particular threat to their safety or health, they are completely *outraged* when they learn that such measures do exist but are not being applied!

Following the BSE crisis the European Commission has reorganised and strengthened its control system. Shifting the responsibility for inspections from the Directorate General responsible for Agriculture to a Food and Veterinary Office which is part of the Directorate General responsible for Health and Consumer Protection guarantees that consumers' health comes first. In addition the inspection reports are now posted on the Internet as soon as they are finalised. This makes our system one of the most, if not <u>the</u> most, transparent in the world and should help us convince both the national public authorities, the agri-food industry and consumers that it is no longer possible to hide deficiencies in the surveillance systems and non-compliance with the Community rules. In addition the number of inspectors has more than doubled over the last 3 years. The next step will be to introduce a comprehensive piece of legislation on controls, taking into account the general principle that all feed and food at all levels of the production chain must be subject to official controls, since the requirements concerning controls at both national and EU level are enshrined in various pieces of Community legislation which do not cover all aspects in a uniform way; they contain some loopholes and are sometimes outdated.

I would add that it is also up to the agri-food industry and trade to implement good practices based on the general hygiene rules and, whenever possible, on the "Hazard Analysis and Critical Control Points" approach. This approach, which associates closely the public authorities, the industry and the trade, greatly contributes to increasing food safety and therefore reassuring consumers. It implies, however, great efforts in education and training for all the actors in the food production and distribution chain.

Now I come to the fourth element we can use to address consumer concerns regarding food safety, namely information.

There are two kinds of information that should be made available to consumers.

Firstly consumers should be informed about potential risks in the area of public health. For instance, why try to suppress information about the BSE or the dioxin affair? Sooner or later the information will inevitably become known, and once it is known, the impact on consumer confidence – and therefore on the market – will be even greater than if consumers had been told from the very beginning that there was a problem, what exactly the problem was and in the same breath what measures were being taken to minimize the consequences. In other words, always tell the truth, the whole truth and nothing but the truth.

Secondly Article 153 of the Amsterdam Treaty emphasises, among other things, consumers' right to information. Here we are not talking necessarily about crisis communication on acute – but often marginal – health hazards, but about information having a long-term educational impact on issues of importance to consumers' daily lives. This gives the public authorities, both European and national, an obligation to inform consumers on the various aspects of food safety.

Consumers should be informed on how to choose the right foods (they must be made aware of the need for a balanced diet), how to handle food properly, how to cook it properly and how to preserve it properly. Consumers do bear part of the responsibility and that it is our duty to help them play their role.

Moreover better informed and educated consumers are likely to demand better and safer food products from retailers, who will in turn demand them from wholesalers, who will in turn demand them from producers. This bottom up approach may enable the public authorities responsible for food safety to tilt the balance in favour of consumers much more efficiently than a top down approach.

Finally, consumers need to know about traceability, GMOs, hormones, antibiotics, additives, etc. It is easy to see that these are still unchartered waters and that consumer concerns may no longer be limited to the freshness of food products – however important that might be – but may take on a political and even an ethical dimension. Eating a steak is no longer as easy as it used to be, now that consumers are also concerned about the threat posed by genetic engineering to the normal development of species, the potentially allergenic effect of additives or the decreasing power of antibiotics due in part to their use in some parts of the agri-food sector!

The role of the public authorities is not to downplay these concerns. It is to address them frankly by passing onto consumers all the information available, even the bits that may actually *increase* their concerns in the short run, and to help them make up their own minds.

So as not to remain too theoretical and to give you a concrete example of what a public authority can do to inform consumers about food safety, I would like to talk briefly about the two-year information campaign on food safety which the European Commission launched in 1998. This initiative is particularly dear to my heart as it has been managed by my unit. The overall objective was precisely to address the concerns consumers may have in this area by informing them on the various aspects of food safety, drawing their attention to their own responsibilities and raising a public debate on food-related issues.

The Commission decided to launch and manage this campaign on the basis of subsidiarity: it would be a campaign conducted under its auspices, but it would in fact be 15 different campaigns, devised and implemented in each Member State by a national contractor. The Commission's role was therefore to establish the main thrust of the action and to provide the contractors with the basic information they needed, in particular on the European legislation applicable to food and the European systems for checking food products. Since the contractors, chosen following a call for tender, were consumer organisations or institutes specialised in nutrition, consumers felt as though they were given independent information and advice. In some countries it was even the first time that information on food-related issues did not come from the agri-food industry or the public authorities directly. So the intention was clearly to have a campaign "by consumers for consumers". However, in order to ensure that there was no "reversed bias", the contractors were asked to co-operate with the national public authorities and the national representatives of the agri-food industry and trade.

In Ireland, for instance, the focus was on food hygiene. The objective was to teach primary and secondary school pupils how to handle, store and cook food correctly. They were asked to write an essay on the topic "A Day in the Life of a Fridge" and to compose a rap song on the multiplication of bacteria which was broadcasted by all national and local radio stations during the first three weeks of November as part of a message promoting food safety. But the campaign also gave coordinators the opportunity to go beyond food hygiene and tackle controversial topics such as GMOs, additives, hormones and beta-agonists, to name but a few. Consumers were presented the pros and cons and encouraged to reflect on the economic, health and ethical aspects. The communication strategy was designed specifically with a view to stirring up a public debate among opinion leaders and the general public. Thanks to this initiative the debate on some of the most controversial food-related issues is no longer restricted to politicians, scientific experts and industry, trade and consumer representatives, but also includes the individual consumer, who is no longer a clueless spectator but an informed actor.

I would like to conclude by saying that if the sustained development of our economies, with the combination of technological progress, globalisation and open frontiers, does offer consumers the prospect of more goods for less, experience has taught us that greater purchasing power alone is not enough to make a market flourish and to improve the quality of life of the European citizen. For this, confidence based on a strong consumer policy is required. This has been recognised in the Amsterdam Treaty which calls for a high level of consumer protection in the definition and implementation of Community policy.

The aim must be, as it has always been, to guarantee the highest possible standards of safety, to ensure quality and to provide transparent access to information and redress. These principles are the foundations upon which consumer confidence lies and will remain the key objectives of the Health and Consumer Protection Directorate General at the beginning of the new millennium.

In particular, rebuilding trust in the food sector is one of our highest priorities. Sound scientific evidence must continue to be the cornerstone of food policy-making. Independence, excellence and transparency will remain the hallmarks of the Scientific Committees. The value of their work should not be underestimated. The Committees have made a considerable contribution to decision making on important and complex issues such as BSE/TSE and antibiotic resistance.

However, we need to be aware that science may not always be able to provide all of the answers. Current scientific knowledge may be incomplete and scientists might in their risk assessment have different views on the interpretation of the data available. In circumstances where a serious risk to public health is identified but where science is incomplete, the precautionary principle should be applied. We need to make this principle operational by clarifying the criteria for its use inside the European Union and beyond.

In all cases, policy makers and politicians need to consider other aspects such as economic, social and environmental parameters alongside scientific evidence. They also have a responsibility to develop a coherent approach to decision-making, throughout the whole of the food chain. Close co-ordination between all interested parties and at all levels in the preparation of risk management measures is essential.

Risk communication is another key element. Consumer confidence even in the best system cannot be sustained if consumers themselves are left in the dark. Consumers need clear and understandable information allowing them to make a well-informed choice. Well-informed consumers are in fact the best guarantee we have that food will become safer. Our role as public authorities is therefore to make consumers aware that they too have a role to play - perhaps the major one - and that they must take the safety of their food into their own hands. The best way to achieve this is not so much to provide them with ready-made answers as to give them the elements that will enable them to ask the right questions. The new information technologies are an important tool here. They will assist us in ensuring that the consumer voice is heard and acted upon in the 21$^{st}$ century.