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EAST MALLING RESEARCH ASSOCIATION
Securing a safe and sustainable UK food supply

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Food security: food production and climate change

Dr Chris Atkinson
East Malling Research

Food security is a complex global issue that has come to the top of many national and international agendas as the reality of an ever-expanding world population demand on food production becomes apparent. Food security is also a national issue because only a proportion of the food consumed within the UK is produced within the UK. The advantages, as well as the disadvantages, in integrated global food markets means that we, as consumers, have access to high quality, nutritious, varied diets but these have to be sourced from around the world. Table 1 defines what the food security issues are based on suggestions published earlier by Defra. Current expectations suggest that the global population will rise from the current six billion to nine billion by 2050, with 40% of this in the two largest populations (① India 1.75 billion, ② China 1.43 billion and ③ USA 0.42 billion). Concerns over population growth are not, however, in themselves novel. The Reverend Dr Thomas Robert Malthus (1766-1834) has become extremely well-known for his analysis (the first) of the impacts of social improvement on population growth (An Essay on the Principle of Population). Within the six additions of this treatise (1798-1826) he expressed his concerns about population growth (at the beginning of the industrial revolution) preceding the expansion of the population's resources, particularly with respect to food supply.

Reverend Dr. Thomas Robert Malthus (1766-1834)

The United Nations now estimates that if we are to deal with the predicted increase in world population, food production will have to double. Despite agricultural production keeping pace with population growth over the last 40 years, it will have to sustain increased production rates along with changes in the type of food we produce. The doubling of world food production over the last 40 years has, however, only been achieved via a seven-fold increase in nitrogen fertilisation, along with a doubling of land under irrigation and an 18% increase in the area of cropped land.

Added to this is the rise of the 'middle classes'; as consumers become more affluent, GDP per capita increases and diets move away from vegetable consumption to that of meat. Populations within China and India are already showing shifting consumer preferences with increased consumption of meat (particularly chicken) and dairy products compared to more traditional plant-based food sources. The latter require less energy and emit less greenhouse gas during production. These changes will all have to be achieved against a background of climate change, which will itself have a large impact on potential food production. This in turn will influence factors such as energy demand and use, further greenhouse gas emissions, environmental pollution, land use and water availability. Four billion of the 2050 population will be living in countries where there are likely to be problems linked to water, a vital resource for food production. Clearly, we must also develop approaches that are sustainable and reduce the need for chemicals to control ever-demanding outbreaks of novel and old pests and diseases. This issue is particularly relevant when we consider that, despite current levels of pesticide use, some 25% of total global food production is still lost to pests and diseases.

To be successful, we will have to make food production more efficient and use less of our dwindling resources. For example, on average the cultivatable land available per capita for food production in 1970 was 0.38 ha; this had declined to 0.23 ha by year 2000 and by 2050 it is predicted to have fallen to 0.15 ha

per individual. Can the required increase in agricultural efficiency (a third agricultural revolution) be achieved when there has been a 20-year world-wide decline in investment in agricultural/horticultural research?

Table 1. What is Food Security?

Food security* - key points to be addressed

Availability/stability	How much (volume) food is available and how reliable (provenance) is supply. This would also include the potential risk of losing access to supply chains as might happen in response to climate change
Access	The transport and distribution of food and the legal, political, economic and social aspects of its distribution
Affordability	Food will need to be available at prices that the public can afford irrespective of social (poverty), political (insecurity) or economic background
Quality/Safety	Food must be of a nutritional quality (nutritional insecurity) to match dietary requirements and the promotion of healthy lifestyles

*Adapted from Defra 'Ensuring the UK's Food Security in a Changing World' – July 2008.

Food security now has the potential to become a problem which is not restricted to the all familiar recurrent issues of the third world. It will impact, albeit differentially, at the global level both climatically and with respect to food trade and transport. Scientific solutions, through R&D, cannot answer all the questions raised by this issue. Many of these require political resolution and moral judgements and potential behavioural changes from us all. It is a subject that we all need to understand and engage with in the debate.

Research at EMR has particular interests in the issue of water and its capacity to limit food production along with its increasing scarcity, as the climate changes. How the UK uses water for food production is important not only nationally but also world-wide. A significant proportion of UK food (average 40% over all sectors, but 90% with respect to fruit) is sourced from parts of the world where the impacts of climate change could be more dramatic and sources of water under greater threats of running out, e.g. Southern Europe. Because efficient agricultural production cannot be achieved in the absence of water, the sourcing of UK food supplies from regions where water is limited, will initiate a 'water footprint'.

All food production has its definable quantity of 'embedded water'. The 'embedded water' or 'virtual water' content of a product is the volume of freshwater used to produce the product, measured at the location where the product was actually produced. Despite the importance of global trade and the economic benefits to all, water supply issues within crop production regions can be damaged and there may be limitations in a regions ability to use its own water to feed its own population. Intensification of agriculture in southern Europe is already impacting on water supplies for agriculture and will continue to do so. At some point over the next 50 to 100 years food production, export and trade from countries such as Spain, Greece and Italy will likely decline. The world's demand for water doubles every 21 years and currently agriculture uses 70% of the world's fresh water supply.

To offset such impacts, expectations are that the UK should and could do more farming. Is that possible? Any such approach will be required to be environmentally sustainable, optimising usage limitations in available land. It will undoubtedly require increased efficiency of crop production systems and use of resources, such as water and fertilisers. There is however some evidence, from the make-up of UK

agriculture and horticulture when looking at changes in cropping patterns (land area use) and total production, that increases in production efficiency have been achieved (see Defra statistics). Interestingly, in some cases, production area has actually declined, but total production (yield multiplied by land area) has increased. These examples are important because they indicate where and how food production efficiency has increased. A key aim to developing UK-based sustainable food production must be an increase in production efficiency, whether this is achieved by increasing crop per unit land area, or more food per unit of nitrogen fertiliser or water used in its growing. This approach may also inform the research community where best to direct limited R&D budgets to enhance crop production efficiency. We need of course to factor in the impacts that climate change will have on what we can grow and we will have to adapt by seeking alternatives or substitute crops, particularly where it may no longer be possible to grow an existing favourite due to environmental change.

Consumers have an important role in understanding and developing the appropriate solutions to the process of delivering change, particularly, for example, those which might be based on acceptance of alteration in 'apparent food quality'. For example, the use of irrigation water to prevent initial development of potato scab is excessive and has no impact on yield, as scab generally only causes cosmetic losses of tuber quality. Consumers will also need to be engaged in debate related to UK sourcing of food supplies from around the world and their environmental, social and political impacts. The impact of failing to secure food of an appropriate nutritional quality also provides an important challenge. Many links are now being established between poor diets and health, i.e. increases in coronary heart disease, strokes, obesity, diabetes and several types of cancer. The urgent need to improve the diets of school children has received considerable attention. Another consumer behavioural change being suggested, is a move towards reducing meat consumption. This potentially benefits human health in some cases, but more importantly can reduce greenhouse gas emissions, while increasing crop production efficiency with respect to land (or resources, energy use) availability, etc. Similar consideration should also be applied to the suggested benefits from low input production systems and their yields, particularly with respect to the scale of population costs and benefits. There is no single solution, nor any easy solutions; all approaches will need to be considered fully, giving equal and appropriate consideration to novel crops, new technology and biotechnological crop improvements.

Suggested further reading

- Food Matters. Towards a Strategy for the 21st Century Cabinet Office, 2008
- 'Rethinking Britain's Food Security'. Barling *et al.*, 2008
- IAASTD - International assessment of agricultural science and technology for development. *Web site*
- 'Food Futures: Rethinking UK Strategy'. A Chatham House Report. Ambler-Edwards *et al.*, 2009.
- 'Feeding Britain'. The Smith Institute. Bridge & Johnson, 2009
- Agricultural sustainability and intensive production practices. Tilman *et al. Nature* (2002) 418, 671-677
- Testing the assertion that 'local food is best': the challenges of an evidence-based approach. Edwards-Jones *et al. Trends in Food Science* (2009) 19, 265-274
- Do increases in agricultural yield spare land for nature? Ewers et al. *Global Change Biology* (2009) 15, 1716-1726
- Global environmental impacts of agricultural expansion: the need for sustainable and efficient practices. Tilman. *Proceedings of the National Academy of Sciences* (2009) 96, 5995-6000
- House of Commons Environment, Food and Rural Affairs Committee (EFRA) - Chairman Michael Jack *'Securing food supplies up to 2050; the challenges faced by the UK' (HC 213-1) July 2009*
- 'Development of Indicators for a Sustainable Food System'. Defra, August 2009
- First Report from the Council of Food Policy Advisor. Defra, September 2009
- Comparison of putative health effects of organically and conventionally produced foodstuffs: a systematic review. Report of FSA, Nutrition and Public Health Intervention Research Unit, LSHTM, Dangour *et al.* 2009

Breeding strawberries for improved quality and reduced waste

Adam Whitehouse, Dr David Simpson, Abi Johnson, Kirsty Hammond and Andy Passey
East Malling Research

Strawberry breeding has been carried out at East Malling Research (EMR) since 1983 with 28 cultivars being released since 1988. Over 230 million plants of these cultivars have been sold worldwide, with the majority supplying the UK/Northern European market but others being sold as far as the USA and South Korea. Since June 2008 the breeding programme has been jointly funded by the EMR Strawberry Breeding Club composed of seven companies (CPM, East Malling Ltd, European Strawberry Nurseries Association, Horticultural Development Company, KG Growers, Mack Multiples and Meiosis Ltd.) and the Department for Environment Food and Rural Affairs (Defra).

In terms of quality the strawberry market has exacting requirements, and the major effort of the breeding programme has been directed to the production of cultivars that fulfil these specifications. Retailers, responding to both EU regulations and consumers' demands, have quality benchmarks that need to be achieved before fruit can enter the market. The EU has recently (July 2009) relaxed some of its regulations regarding the fruit size and uniformity of 26 fruit and vegetables, but strawberries were not included on this list. The mainstream market still requires only Class 1 fruit, which is classified differently between retailers but usually requires the diameter of fruit to be >2 mm. The fruit should also be free from blemishes and rots, uniform in colour and shape within the punnet, and of course have an acceptable flavour and texture.

With such a precise remit, there will inevitably be fruit that fails to make the grade and without an alternative outlet, most of this will become waste. Waste is generated at all stages of the supply chain; by growers, retailers and consumers. Growers are likely to discard fruit that fails to meet size requirements or is misshapen or spoiled by rots or blemishes; retailers are likely to dispose of fruit due to oversupply, poor shelf-life or damage during handling and packaging; consumers will discard fruit that has a short product life or because they are disappointed with quality. It is only from the last of these that we have estimated figures relating to the amount of waste generated. The Waste and Resources Action Programme (WRAP) produced a report in 2008 (WRAP, 2008) which estimated that 43% of avoidable food waste was fresh fruit, amounting to >200,000 tonnes or £400 m per annum. The largest proportion (61%) of discarded fresh fruit was disposed of because it was either 'mouldy' or 'looked bad'. Strawberries were included in the table of 100 most discarded food items, with an estimate of 16,000 t or £63 M of avoidable strawberry waste being generated, per annum.

How can this waste be reduced? A number of opportunities exist and are being improved, including husbandry, handling/packaging and storage. However, breeding offers the opportunity to produce durable cultivars that meet the expectations of growers, retailers and consumers, from the very first stage of the fruit supply chain. The primary objectives of the EMR Strawberry Breeding Club address the need for improved quality and reduced waste and these are assessed at each stage of the breeding process, from the choice of parents for crosses, through the selection of seedlings to the final testing, assessing and trialling of potential cultivars. In total this process takes approximately 8 years from initial cross to release and involves the assessment of up to 13,000 seedlings.

One approach adopted by the EMR breeding programme to reduce waste is to produce seedlings that have improved fruit size and are less prone to misshapes and rots. Fruit size can be improved by selecting plants that have simple trusses, i.e. a low number of flowers/fruit per truss. There is a decline in fruit size from the primary flower/fruit to the inferior positions on the truss, so it is desirable to select plants with 5-6 flowers per truss. However, a reduction in flower number will affect yield, as less fruit is produced, so it is important to ensure that there are sufficient trusses produced by the plant to maintain a high yield.

Unmarketable fruit, mostly caused by rots or misshapes can be tackled in a number of ways. Rots are predominantly caused by fungal diseases, and the fruit can be prone to infection if berries are damaged due to a fragile skin or if grown in unfavourable conditions. Grey mould (*Botrytis cinerea*) and black spot (*Colletotrichum acutatum*) can be particularly problematic but the incidence of both diseases has decreased with the introduction of protected cropping under tunnels. However, problems with powdery mildew (*Podosphaera aphanis*) have increased in recent years, exacerbated by production from everbearing cultivars later in the season and the increasing use of tunnels. It primarily affects the leaves of the plant but can spread quickly to fruit, and although not strictly a rot, it still renders the fruit unmarketable because of its appearance. In the 2009 EMR everbearer trial some entries exhibited >35% waste due to mildew on the fruit (including the industry standard), while others had >90% Class 1. The genetics of resistance to powdery mildew are complicated and it is often unstable, eventually breaking down. The EMR programme does have cultivars and selections that have stable and durable resistance, e.g. 'Emily' and seedlings and selections are routinely screened in the field for resistance. The shelf-life of each advanced selection is also assessed post-harvest and involves storing fruit after harvesting at +2°C for 24 hours and then at 18°C for 48 hours, after which the fruit is scored and compared to the trial standard.

Misshapen fruit can also render a proportion of the strawberry crop as waste and is attributed to a number of causes; development of fruit, pollen quality, availability of pollinators, plant architecture and pests. Some of these causes are genotype specific and can therefore be addressed by breeding. The EMR breeding programme has been very successful in improving the percentage of Class 1 of strawberry fruit, demonstrated by comparing the Class 1 yields of some of the latest cultivars from the programme; 'Elegance', released in 2009, has on average 95% Class 1 fruit (EMR maincrop trials 2003-2008) compared to 84% and 78% from the industry-standard, 'Elsanta' and older UK cultivar, 'Cambridge Favourite' respectively.

Improving fruit quality also has a role to play in waste reduction, with appearance and flavour being particularly important attributes to the retailer and consumer. Along with shape, skin colour is the most visual aspect of the fruit. There is a wide variation in the intensity of skin colour of fruit from the cultivated strawberry, ranging from blush-pink, through orange, pale/mid-reds to dark red/purple. In the UK a mid-red colour is the most desirable, but glossiness and the appearance of seeds also play a role. This trait is under additive genetic control, but with a small number of genes having a large affect. The skin colour also needs to be stable; deterioration in colour over time is likely to lead to customer dissatisfaction.

Flavour and texture are of prime importance. Without a good flavour consumers are unlikely to eat the product in its raw state. Again there is huge variation in the flavours that can be expressed, from pineapple through to Stilton cheese. Evidence indicates that consumers prefer fruit that is sweet, and this has been confirmed by a recent Worshipful Company of Fruiterers' project at EMR which concluded that strawberries on sale in the UK are generally not sweet enough to be acceptable for direct consumption by children. Taste trials at EMR have also shown a positive correlation between perceived sweetness and Brix readings (measurement of soluble solids). Brix measurements form part of a retailer's requirement for fruit quality, with each retailer having a threshold Brix level that should be met before the fruit is accepted for sale. Therefore, there is a requirement for breeders to produce cultivars with enhanced sweetness and flavour. This can be achieved by careful selection of parents (sweetness is again an additive trait) and regular measurements of Brix levels throughout the season. Additionally we seek the views of consumers, either though our own taste panel, fruit walks (of which an EMRA event is held each June) or regular contact with supermarket technologists.

To conclude, breeding offers improvement in strawberry quality by addressing a wide range of traits that are important to the grower, retailer and consumer. By producing cultivars that meet the expectations of each sector of the market there should be considerable opportunities to reduce the amount of waste produced. EMR has recently released four cultivars that have improved quality over current industry standards, which should also lead to a reduction in waste:

'Sasha':
A June-bearer, with very uniform appearance and good flavour. It has a high yield relative to 'Elsanta' with high percentage Class 1 and consistent size through the season. Shelf-life is superior to 'Elsanta'. 'Sasha' is a specialist cultivar for glasshouse production.

'Elegance':
A mid to late season June-bearer, that has very uniform, bright orange/red berries. It has a higher yield than 'Elsanta', especially in the 60-day cropping system and shelf-life and Brix levels similar to 'Elsanta'. Percentage Class 1 is also higher than 'Elsanta' and retailers have scored the berries highly for appearance and firmness.

'Fenella':
A late-season June-bearer that has attractive, uniform berries, with good colour and sweet flavour. Average fruit size and percentage Class 1 is superior to 'Elsanta'. 'Fenella' has good resistance to soil borne diseases (verticillium wilt and crown rot) and is also rain tolerant.

'Finesse' (EMR346):
An everbearer with similar season and yield to 'Everest'. It has very attractive, uniform berries, a sweet flavour. 'Finesse' has shown very good all round disease resistance.

References

Hopson, C., Simpson, D.W. and Gutteridge, C.G. (2008). Understanding and improving the acceptability of strawberries for consumption by children. Report for the Worshipful Company of Fruiterers (also reported in EMRA News, issue 12, July 2008)

WRAP (2008) The Food we waste. Food Waste Reportv 2
(http://www.wrap.org.uk/downloads/The_Food_We_Waste_v2__2_.bc7f68d7.5635.pdf)

Insights to help reduce fresh produce waste in the home and supply chain

Sophie Easteal
Waste and Resources Action Programme (WRAP)

WRAP (Waste & Resources Action Programme) works with local authorities, business and households to prevent waste, increase recycling and develop markets for recycled and sustainable products. The organisation was established as a not-for-profit company in 2000 and is backed by government funding from England, Scotland, Wales and Northern Ireland.

WRAP's current business plan (2008-11) sets targets to:
- Divert 8 million tonnes of waste materials from landfill
- Save 5 million tonnes of CO_2 equivalent emissions
- Generate £1.1 billion of economic benefits to business, local authorities and consumers.

These targets are being tackled through work in the four priority areas to optimise packaging, reduce household food waste, improve local authority collection systems and the quality of material recycling.

With approximately 5.9 million tonnes of household packaging waste and an estimated 6.7 million tonnes of household food waste being generated in the UK every year, the retail sector and WRAP decided to take positive action to reduce the environmental and financial impact of this issue.

Established in 2005, the Courtauld Commitment (www.wrap.org.uk/retail/courtauld_commitment) is a voluntary agreement between WRAP and major grocery retailers and brand owners which is leading to new solutions and technologies so that less food, products and packaging end up as household waste.

The Commitment is a powerful vehicle for change and has already resulted in real reductions in packaging and food waste and realised significant commercial savings. Over 40 major retailers, brand owners, manufacturers and suppliers have signed the agreement since its launch and the signatories represent 92% of the UK's grocery supermarkets.

WRAP is in discussions with the current signatories - as well as other potential signatories – and representatives of the Governments of the UK on the Courtauld Commitment Phase 2. This may well incorporate future packaging and food waste reduction objectives and will consider alternatives to weight-based measures such as carbon or recycled content.

Household Food Waste

WRAP research (www.wrap.org.uk/retail/case_studies_research/report_household.html) estimates that 8.3 million tonnes per year of food and drink waste is generated by households in the UK. This is the equivalent to 330 kg per year for each household in the UK, or just over 6 kg per household per week. The research categorises food and drink waste by how avoidable the waste was and has further identified reasons for the disposal of the 5.3 million tonnes of avoidable waste.

The greenhouse gas emissions associated with avoidable food and drink waste is the equivalent of approximately 20 million tonnes of carbon dioxide per year. This is roughly 2.4% of greenhouse gas emissions associated with all consumption in the UK.

Fresh fruit, vegetables and salad account for 1.36 tonnes of the total avoidable, household food waste

which is why WRAP has initiated a number of projects in this area, summarised below.

Helping Consumers Reduce Fruit and Vegetable Waste – published June 2009
This project examined consumer attitudes and behaviour around storage of fresh fruit & vegetables in the home and highlighted the following opportunities for retailers to enable their customers to get more out of their fresh fruit & vegetables, by:

- Reviewing the advice currently given to customers, on-pack, in-store and on-line
- Introducing advice where it is lacking, and making all advice clear and prominent
- Complementing this basic storage advice with relevant tips and information (for example, recipes)

As a member of the project team, Sainsbury's was the first retailer to trial new storage guidance to customers both in store and on its website, but the research has since been adopted by other retailers at point of sale, on pack and online. In addition, Love Food Hate Waste (www.lovefoodhatewaste.com) provides detailed tips on storing different types of fruit and vegetables, to keep them at their freshest for longer.

Ethylene and fungal control strategies to reduce waste of fresh produce – underway
This project, currently underway, has two elements. The first aims to assess the impact of present levels of ethylene and microbial contamination at pack-houses, supermarket depots, back of store locations and in-store retail areas on the quality and rates of deterioration of fresh produce and develop guidance to manage ethylene levels to reduce waste. On completion of the project WRAP will deliver an integrated ethylene and fungal control strategy for the supply chain and support knowledge transfer.

The second element will assess the impact of a range of ethylene removal technologies and an ethylene action inhibitor on fresh produce waste in the domestic refrigerator and develop guidance for consumers to help them reduce waste of fresh produce.

Reduction of supply chain and consumer food waste of retail main crop potatoes - underway
This work has two main outputs. Firstly, an extensive consumer survey has been undertaken to understand the causes of household potato waste.This has explored purchase behaviour, in home storage and cooking/consumption behaviour and a reaction test to establish what consumers do with potatoes at different stages of deterioration (i.e. greening, sprouting and rotting). These insights into household consumer wastage of potatoes will be used to inform WRAP's Love Food Hate Waste consumer campaign and, to direct packaging trials on Kind Edward and Maris Piper varieties of potatoes.

The second aspect is an investigation into the volumes and causes of main crop potato waste in the retail supply chain including growers, packers and the retail store. A key aspect will be to identify good practice and disseminate guidelines for packing, storage and handling of potatoes to prevent waste.

Next Steps
WRAP continues to work towards a world without waste, where resources are used sustainably. However, this aim will not be achieved without collaboration across all sectors of industry and society to drive change. We welcome news of work and research which shares our aims and are happy to provide updates on our initiatives through the WRAP website and our e-newsletter.
Subscribe to our newsletter at www.wrap.org.uk/retail/register_for.html.

Bioactive components from berries: Human health effects

Dr Gordon McDougall
SCRI

Berries are a rich and palatable source of a range of nutrients and phytochemicals which can have effects on human health.As well as being good sources of dietary fibre and nutritionally-important minerals, they can provide high levels of vitamin C and high levels of other antioxidant phytochemicals.The Scottish Crop Research Institute (SCRI) has long-established breeding programmes for black currants, raspberries and strawberries and our diverse germplasm has allowed us to develop market-leading varieties of these berries.

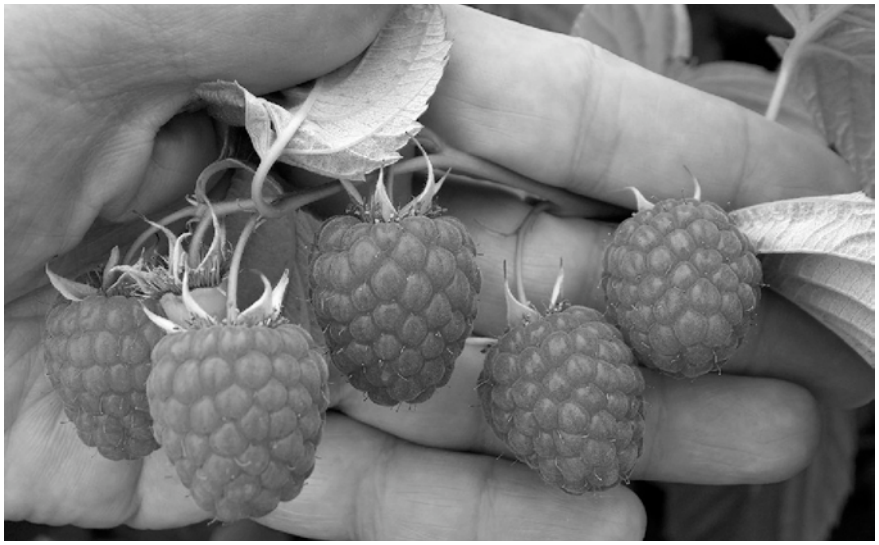

Fig. 1 The new raspberry variety, Glen Fyne

For example, the new raspberry variety, Glen Fyne, has good colour and a characteristic sweet and aromatic flavour combined with agronomic properties and shelf life equivalent to the market-leading Glen Ample.

As the potential health benefits of berries become established, SCRI is focussing on these areas as well as the traditional breeding targets related to sensory appeal, appearance, flavour, shelf-life and pest resistance.

The presentation highlighted our research on the evidence for bioactivities of berries and berry components related to human health, mainly in the fields of cardiovascular disease (CVD), cancer and diabetes.

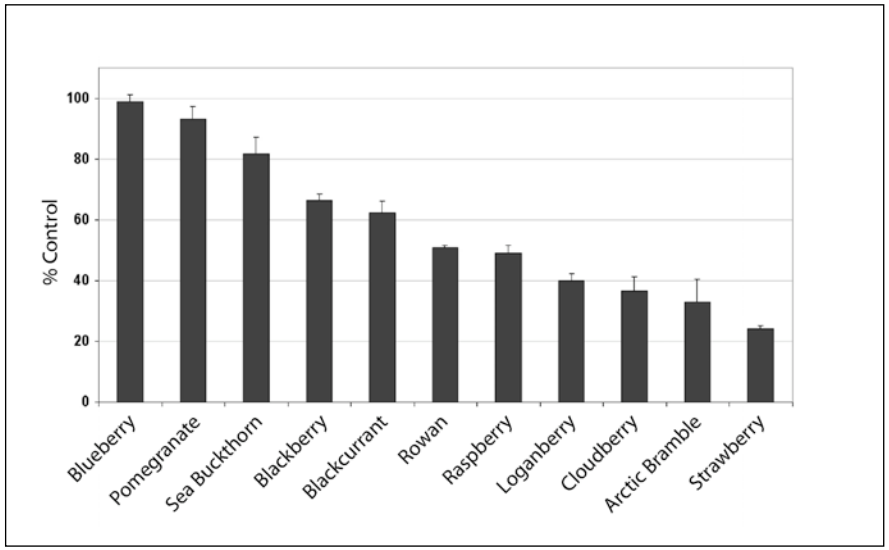

Fig. 2 Inhibition of colon cancer cells by different berry extracts

For example, the ability of different berry extracts to inhibit the growth of cultured colon cancer cells is shown in Fig. 2. The pattern suggests that polyphenols from strawberry and raspberry are more effective than those from blueberry or pomegranate in this model. Through a comparison of the polyphenolic composition of the extracts, we can begin to identify components with high anti-cancer potential.

We have used the same model throughout much of our work. We use the best available and disease-relevant *in vitro* screens, *ex vivo* tissue and cell models and intervention studies (carried both in house and with our biomedical collaborators) to glean evidence for beneficial role of berry polyphenols against cardiovascular disease, glucose control in type 2 diabetes and obesity.

In a different area, we have found that berry extracts can inhibit pancreatic lipase in model studies (Fig. 3). This enzyme is crucial for the release and uptake of fatty acids from dietary fat during digestion and is the target for anti-obesity drugs, such as Orlistat. Berry polyphenols inhibit lipase at concentrations easily obtainable after normal ingestion and could modulate the known effects of berries on obesity and fat intake. It is intriguing that raspberry (RB), is so effective. Modulation of blood lipid levels after meals could influence cardiovascular disease, strokes, type 2 diabetes and obesity.

We have also been involved in an intervention study with researchers at Ninewells Hospital, University of Dundee to tease out the effects of berry intake and cardiovascular effectiveness in humans. Funded through a charity: www.chss.org.uk/research_and_funding/documents/heart_research_jan_07_000.pdf and not yet complete, we have found that berry intake can favourably influence parameters important for the maintenance of cardiovascular health. SCRI are also monitoring the levels of components in plasma after berry intake, to identify the active components.

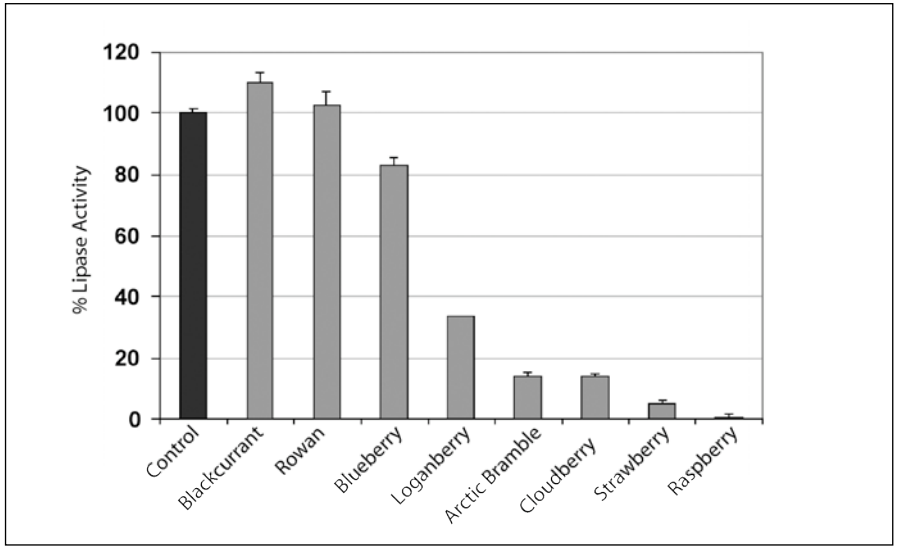

Fig. 3 Inhibition of pancreatic lipase by different berry extracts

Such studies on the bioavailability and metabolic fate of the active components are essential to understand the mechanisms underlying the beneficial effects noted. We are currently extending our work to studies on neuroprotective effects of berry components and their effects on Alzheimer's disease in a multi-partner European Union-funded programme: www.uku.fi/brainhealthfood/project.shtml.

In the long term, we hope to identify the bioactive components responsible for the beneficial effects, assess their variation in natural populations and breed for higher levels of these components in our varieties, using the elite germplasm collection and genetic expertise present at SCRI.

Food borne pathogens and fresh produce

Dr Linda Nicolaides
NRI, University of Greenwich

Words to come

Reducing pesticides and pesticide residues

Prof. Jerry Cross
East Malling Research

Fruit growers in the UK rely on pesticides for pest and disease control but consumers have a deep seated dislike and mistrust of them. It is anathema that fruit crops, grown in the 'Garden of England', consumed fresh as part of a healthy diet, are intensively treated with pesticides that are regarded by the public as harmful to the environment and human health. Overcoming dependence on pesticides is arguably the greatest and amongst the most important challenges faced by fruit growers. The challenge is recognised by the European Parliament which is implementing a 'Thematic Strategy on Sustainable Use of Pesticides', requiring national action plans to greatly reduce pesticide use, that will result in greater restrictions on commercialisation and use of pesticides.

The main challenge will be moving from a 'Rational and Safe Use of Pesticides' agenda to proper Integrated Pest Management (IPM). IPM is a decision-based process involving coordinated use of multiple tactics (natural, genetic, cultural, biological, biotechnological methods etc.) for optimising control of all classes of pests (i.e. pests, diseases, weeds) in an ecologically and economically sound manner. Some progress towards true IPM has been made in UK fruit growing but current pest and disease management falls short in many ways, depending on crop. A number of potentially transformative new technologies are being developed which are likely to be adopted into commercial practice in the near future. For pest control in soft fruit for instance, new semiochemical based monitoring and control methods have been developed for capsid bugs, blossom weevils, midges and raspberry beetle. Dependence on Botrytis fungicides will be reduced by protected cropping coupled with better, lower temperature cool chain marketing. For other diseases (e.g. scab on apple, mildews), change will eventually have to be made to varieties with durable disease resistance, an opportunity offered by cis-genesis technology, a form of GM technology where only genes from crossable donor plants are transferred. Cis-genic scab resistant Gala has been produced by the Swiss Federal Institute of Technology, Zurich. Public acceptance of the enormous benefits of this technology is necessary before it can be used.

In the shorter term there is an agenda to greatly reduce, ideally to eliminate, the occurrence of pesticide residues. Retailers do not wish to be 'named and shamed' by the official reporting of residues below legal limits. Markets are now focussed on residue presence or absence and the numbers of residues that occur above threshold levels they set well below Maximum Residue Levels, e.g. 30% of MRLs. Eliminating residues poses different levels of difficulty on different crops. The New Zealand apple industry has risen to the challenge and will in future be supplying UK retailers with residue free apples. Has the UK apple industry got the will to match them? There are two factors that are making the task of eliminating residues difficult and frustrating.

These are:

1) the lowering of official reporting limits for various pesticides from 0.05 to 0.01 mg/kg (enabled by the new LC-MSMS analysis technology).
2) varying results obtained in pesticide residue analysis in different accredited laboratories. This large variation (up to 10 fold) in results from different laboratories is considered to be largely due to sample taking and preparation rather than the chemical analysis itself.

The problems that these two factors cause are illustrated by the recent history of residues on apples experienced by one of our major Producer organisations, WorldWide Fruit. Since 2001, they have made ongoing serious efforts to reduce the occurrence of residues in apples. Post harvest treatments for rots and scald have been phased out. Harvest intervals for high residue risk pesticide products have been

extended.The result has been that the average pesticide residue level has fallen from 0.29 mg/kg in 2000 to 0.14 mg/kg in 2008, a 52% reduction. If the recent use of pre-harvest sprays of boscalid + pyraclostrobin (Bellis, Signum) and cyprodinil + fludioxinil (Switch) had not occurred, the average residue level would be 0.09 mg/kg, a 3.2 fold reduction. But these efforts have been made against a background of reducing official reporting limits. Very good progress in the reduction in the frequency of occurrence of pesticide residue levels above Reporting Limits was being made until 2007, when 77% of samples were residue free. The lowering of the reporting limit of boscalid (contained in Bellis and Signum) and other active ingredients from 0.05 to 0.01 mg/kg in 2008 made elimination of residues much more difficult. In reality, WorldWide Fruit have made great progress, achieving a 5 fold reduction in the frequency of occurrence residues above 0.05 mg per kg between 2006 and 2008. But the percentage of samples with residues above the official reporting limits has risen from 23% in 2006 to 78% in 2008. The goal posts have been moved!

The UK apple industry should not give up. Experiences from other EU countries (e.g. Belgium) suggest that some of our harvest intervals for zero residues need to be extended. UK apple growers also need to consider carefully whether pre-harvest spraying for rots (e.g. with Switch or Bellis) is really necessary. The main rots of apple in the UK are brown rot, botrytis, *Phytophthora*, *Penicillium* and nectria, the importance of which varies with season and orchard, rainfall being the most critical factor. Pre-harvest fungicide application has little effect on control of brown rot but will control *Phytophthora*. However, the latter rot can be equally well controlled by selective picking in place of late fungicide application. Fungicide applied at blossom and petal fall will control other rots such as nectria.

To summarise, reducing pesticides and residues is a huge challenge to the UK fruit industry but progress is being made and will need to be strengthened. For pest control, new biological and semiochemical technologies will solve several of the most important problems. Alternative solutions are being developed for some diseases, but for others (e.g. apple scab, mildews) varieties with durable disease resistance are required. Progress is being made in reducing the incidence of residues but total elimination will be difficult in some commodities. The task is not being made easy by reductions in official reporting limits. But, it is not time to give up. Efforts should be redoubled and careful consideration given to whether or not pesticide treatments close to harvest are truly necessary.

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Promoting Assured Fresh Produce production through the Red Tractor scheme

David Clarke
Assured Food Standards

The Fresh Produce assurance scheme began in the mid-1990s and is now well established. It is one of a suite of schemes operated by Assured Food Standards covering all major agri-food sectors. The schemes reflect the needs of a modern supply chain. Consumers are increasingly interested to know where their food has come from and how it is produced, so trade buyers need to know about the operating standards of their suppliers; their reputations depend on it. In this scenario, a single trade scheme acknowledged by all trade buyers is highly preferable to duplicate inspections by every trade customer. That is the role of the Red Tractor scheme.

The scheme is operated by Assured Food Standards (AFS) a not for profit company set up for the purpose. The organisation is owned by half a dozen trade bodies including farm unions together with processor and retailer trade associations. However it is operated independently and all interested parties contribute to the development of the scheme.

The scheme standards are a comprehensive compendium of good agricultural practice covering food safety and elements of environmental protection. All livestock schemes include standards on animal health and welfare. But unlike a code of practice, observance of which is discretionary, conformance to assurance standards is checked by regular inspections. Only producers who comply with all standards will be certified, and certification is now a pre-requisite for access to most major markets. As a consequence the great majority of UK farm production comes from assured farms. In some sectors this exceeds 95%.
Fresh produce standards are comprehensive and kept under regular review. Key features include detailed controls on the storage and use of pesticides both for environmental protection and to minimise residues. There are also other significant food safety controls, notably microbiological safety of salad crops.

Until the end of the 1990s assurance schemes generally operated at a business to business level below the consumer radar. There was a growing mood in favour of a logo to differentiate assured product at point of sale and to provide a point of communication with consumers. NFU launched the Red Tractor logo in June 2000 and AFS has managed the logo ever since. A redesign of the logo in 2004/05 saw the introduction of the flag to indicate the provenance of the food, responding to concerns about the weakness in regulations concerning labelling of the origin of food.

By using the logo to reconnect with consumers, AFS is beginning to see added value for assured British food. In the middle of October 2009, AFS announced that the amount of food carrying Red Tractor logo now exceeded £10 billion per annum at retail sales value. The logo is supported by all major UK retailers, increasingly by the discounters, by branded foods and with a growing interest from food service outlets both commercial and public sector.

The presentation showed examples of how major brands are including Red Tractor logos in their advertising on TV, in the press and at point of sale, in order to reinforce their brand values. This in turn benefits assured farmers and growers.

Using quality compost in field horticulture

Martin Wood
Earthcare Technical Ltd (on behalf of WRAP)

1. What is WRAP?
- Waste & Resources Action Programme
- Aim: achieving the European Landfill Directive targets by reducing waste and increasing recycling e.g. compost, anaerobic digestate, gypsum
- WRAP supports markets and sets standards and Quality Protocols

2. Why use compost?
- Providing long-term nutrient supply
- Improving soil conditions (biological and physical properties)
- Improving water use
- Increasing yields

3. What is Quality Compost?
BSI PAS 100 2005
- The UK-wide standard for compost
- Source-segregated waste materials
- Provides assurance by setting standards for minimum product quality
- HACCP – levels of pathogens, physical contaminants, weed seeds etc

The Quality Protocol for Compost
- Compost is a product!
- Lists the feedstocks allowed
- Provides compost analysis and guidance to comply with the regulations
- Non-compulsory

Benefits of PAS 100 + Quality Protocol
- Knowledge and traceability of inputs
- Auditable process of sanitisation and stabilisation
- Compost sold as a product not a waste
- No need for Para 7 exemption (or permit)

4. How does compost benefit crops?
- Compost is a valuable source of nutrients
- Provides P, K, Mg, S and a little N
- Provides trace elements eg Cu
- Small liming effect

Nutrients from compost available to next crop - kg per tonne of fresh weight following new RB209 guidance (figures in parentheses kg/ha if applied at 30t/ha).

Compost type	Nitrogen(N)	Phosphate(P2O5)	Potash(K2O
Green	Negligible (0)	1.5 (45)	4.4 (132)
Green/food	0.6 (18)	1.9 (57)	6.4 (192)

Compost is a good soil conditioner
- High proportion of lignin, so long-lasting effect
- Increases soil porosity (decreases soil bulk density)
- Sandy loam 3.5% organic matter with compost every year for 8 years compared to 2.2% with standard fertiliser over same period

Compost improves soil biological activity
- Increase in soil respiration
- Increase in microbial biomass N

Effect on crop yields
- Improved establishment
- Compost with some N fertiiser performed at least as well as standard fertilizer
- Onions respond very well – yield increase of 23% compared to farm standard fertiliser (after 5 years of compost application)
- Average yield increase for cereals/vegetables of 7% for compost plus N fertiliser compared to standard fertiliser

Strawberry trial at EMR
- Single application of either green compost or green/food compost compared with standard fertigation over two cropping seasons
- Growth of plants similar in all treatments
- No nutrient deficiencies in compost treatments
- Compost treatments produced good commercial yields
- Fruit quality remained high in compost treatments

Effect on soil water
- 12% increase in water holding capacity from applying green compost or green/food compost to sandy loam soil at EMR
- Increased water storage (less run-off) following heavy rain events

5. Practical steps for using compost
Step 1 - Find a compost producer
- Visit www.compostsuppliers.wrap.org.uk and search by postcode
- Specify your requirements (grade, particle size, price)
- Obtain an analysis from the producer for the compost batch supplied
- Consider haulage implications e.g. access, carriage restrictions

Step 2 - Comply with regulations
- Nitrate Vulnerable Zone regulations
- Cross compliance
- Codes of Good Agricultural Practice

Step 3 - Comply with PAS 100 requirements
- EITHER apply for a Para 7 exemption (a permit in the near future)
- OR use the Compost Quality Protocol

Step 4 - Check customer's requirements (supermarkets and other buyers).

Bees and Food Security

Robin Dean
CJ WildBird Foods Ltd.

Of the more than 16,000 bee species across the world, only a handful are suitable for utilisation as managed crop pollinators. Commercial pollinators include both social species (like bumble and honey-bees) and solitary bees including alkali mining bees and a variety of Leafcutter Bees. With recent fears over the decline of honeybee numbers, concerns have been raised about our ability to sustain a proper service to agriculture.

- Honey bees and the various species of bumble bee are not the greatest pollinators, in fact they are almost accidental pollinators, the only saving grace being our ability to move large numbers into an agricultural environment with very little notice

- Solitary bees are much more efficient as pollinators, with as much as 150 times more pollen transferred, bee for bee, compared to honey bees

- The UK has approximately 250 species of solitary bee, of which possibly 10 have potential as managed or semi-managed pollinators in orchard environments

We need to investigate potential alternatives, and the Red Mason Bee, *Osmia rufa*, is definitely one of the stronger candidates, being a native of mainland Europe and the UK as well as having been used in semi-managed pollination programmes in the former Eastern Block.

The Osmia family have also been used with great success in Japan and in the horizon-to-horizon almond orchards of southern California. The pedigree of this small solitary bee is impressive as work in Serbia, Germany, Belgium and now England has shown. As well as expecting the normal things that go along with enhanced pollination delivery, there has been a surprise or two. In a trial orchard, the effects of the Osmia bees were quite apparent. The trees had fruit with fantastic consistency of set, wonderful colour and ripening synchronicity. Testing the Streif Index (an industry software tool to determine optimum picking date), researchers discovered some anomalies. The trial orchard was slightly retarded against the control orchard in spite of better colour on the fruit, but the real talking point was the difference in firmness of the fruit. The trial orchard was 1.6kg (around 15%) of pressure above the control. Such a large variance was wholly unexpected, and researchers felt the need to check against another set of figures in case the large variance was due to poor performance of the control orchard. Averaging the results from 12 other orchards, indicated the trial orchard was still 1.1kg above the mean of 9.7kg. These figures tally with research work done in New Zealand showing a correlation between good pollination and long-term storage potential.

Increased pollination efficacy will mean the grower has to deal with increased thinning, which in turn means higher labour costs early in the production process. However the potential cost savings in storage, and higher production figures are likely to offset this earlier cost by a considerable margin.

The bonus of using a managed or semi-managed pollination service is, however, much greater than just the fruit size. Recent developments in bio-control technology have pinpointed beneficial pathogens that can be used for control of botrytis and some insect pests. The bees (both honey and bumble bees) are persuaded to walk though a maze on the way out of the hive, and in the process become coated with freeze-dried inoculums. Bees have a negative static charge and this holds the spores onto the bee, until she grounds herself (all worker bees are female), and then a small number of spores drop onto the flower

where they activate by absorbing water from the flower tissue. These spores remain in situ while an insect pest arrives or until a pathogen like botrytis penetrates the flower.

The recent large declines in native pollinator populations are by no means attributable to a single factor, although pesticides (neonicotinoids mainly) are being blamed. The current state of research does not support this position, and of greater impact is a lack of suitable forage and, in the case of solitary bees, a lack of nesting habitat.

Even on crops supposedly wind pollinated, good bee populations can make a significant difference. Work done in Poland on oil seed rape showed up to a 40% increase in crop yield on fields with high pollinator densities. With an increasing demand on agriculture to feed a growing world population, there are two options. Increase land in production, or increase yield on current cropped area. As land is a finite resource, the only practical answer is to enable farmers to increase crop yield. Intelligent management of field margins can enhance native pollinator populations, which in turn provides benefits far in excess of pollination alone.

Drivers of bee decline are complex and intertwined; no single factor can bear overall responsibility. This decline can be halted or even reversed with relatively small changes in agri-environment management. Research needs to be targeted at understanding habitats and behaviour patterns. The ideal pollination system will rely on multiple species to buffer the effects of decline in any one species.