

SEFARI

LEADING IDEAS
FOR BETTER LIVES



Leading ideas on Food



Royal
Botanic Garden
Edinburgh



Scottish Government
Riaghaltas na h-Alba

Leading ideas for food



The Scottish Environment, Food and Agriculture Research Institutions (SEFARI) work together to deliver the Scottish Government's Strategic Research Programme, a major mid-to-long term planned programme of scientific research that helps inform Scotland's policy making and practices in environment, agriculture and food. The current SRP runs from 2022 until 2027.

This booklet highlights the SRP's research in food which is designed to help us have healthy diets that are safe, nutritious as well as being environmentally and economically sustainable. Food security is also a very important part of this research.



This five-year Programme is part of a wider scientific research Portfolio across Scottish Government's Environment, Natural Resources and Agriculture (ENRA) policy agenda. This Portfolio includes the Centres of Expertise who individually specialise in addressing policy requirement for water, climate change, plant health and animal disease outbreaks. Underpinning national research capability at SEFARI is also an important part of the Portfolio.

SEFARI Gateway represents the Portfolio to ensure the government, industry and stakeholders across society can access the research and expertise. This knowledge exchange is a two-way process with the team at Gateway listening to stakeholders so that the Portfolio research can adapt and respond to their requirements.

Hemp helping Scotland to Net Zero




“Economic evaluation suggests that the hempseed market will grow at 11% to \$1.6 billion”

Agricultural hemp could become a new ‘cash-crop’ for Scottish agriculture and play a key role in helping achieve net zero.

SEFARI research has identified that the low carbon agricultural crop has an exceptional nutritional profile, the hemp flour being rich in protein (36%), fibre (26%) and micronutrient minerals such as magnesium, calcium and zinc. This evidence was instrumental in persuading Scottish farmers to grow hemp and resulted in the production of the first commercial hemp cold-pressed oil in 2022. Rowett scientists are supporting the network for this new sector and are founding members of the Scottish Hemp Growers Group. Looking at the many ways in which commercial hemp food products can be incorporated into the food supply chain to aid a healthier diet is a key area of research. Utilising every part of the crop is a priority. By-products from hemp oil production such as hemp cake (hemp flour) are being researched as nutritional supplements as well as in animal feed for both cattle and chickens to replace the imported soya. Scientists are also developing the processing sector and have secured funding from Innovate UK to explore replacing imported wheat with hemp flour in staple bakery goods consumed by hard-to-reach communities; working with a large bakery company that supplies major supermarkets. Economic evaluation suggests the global hempseed market will grow to \$18.6 billion by 2027. Further BBSRC funding has been secured to develop a hemp growing media to replace the imported coir for vertical farming and soft fruit production. Hemp research is being recognised UK-wide; in 2023 it won Green Gown Award for research with impact for regenerating Scotland's hemp industry for health, climate, and a green economy.

Supporting the growth of Scotland's Seaweed Industry



“Farmed seaweeds were also shown to contain many of the same levels of micronutrients as wild seaweeds ”

SEFARI scientists have provided evidence to support the growth of the Scottish Seaweed Industry, thanks to research funding from the Scottish Government.

They have found that Scottish seaweeds can contain safe, dietary-relevant amounts of vitamin B₁₂ and could therefore provide a sustainable, plant-based source of this exclusively animal-derived nutrient.

This work involved collaboration with the Scottish Association of Marine Science (SAMS) and The Scottish Seaweed Industry Association (SSIA), and this finding provides a marketing opportunity that could help build sales for the sector.

Research also tested and demonstrated that many Scottish seaweed species can provide safe, dietary-relevant amounts of many other micronutrients, including iodine, iron, magnesium and potassium.

Farmed seaweeds were also shown to contain many of the same levels of micronutrients as wild seaweeds and therefore equally able to contribute as a source of these nutrients when produced at scale. Furthermore, a simple processing procedure of seaweed can drastically reduce the high iodine content of certain seaweeds to safe, dietary-relevant levels, which, with optimisation, will benefit the industry by allowing the release of additional seaweed species for human consumption.

A SEFARI researcher is working with a seaweed company and has secured further funding from a UK Research Council to support and add value to the research of the strategic programme. Discussions are ongoing with other seaweed companies on funding opportunities to help address wider industry issues concerning seaweed nutrients and their potential benefit as part of our diets.

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Breeding climate-smart 'Scotch Beef'

“research showed that efficient beef production with less methane emissions is achievable”



Red meat is very important for Scotland's economy generating an economic output of £926million and providing the high quality and iconic 'Scotch Beef' brand. However, there is an environmental impact caused by cattle through their production of methane.

The cow's largest stomach, the rumen harbours a very dense microbial system – the microbiome - comprising different Bacteria, Protozoa, Fungi and Archaea. This ecosystem within the rumen is essential in cattle due to its ability to convert indigestible fibrous plant material (like grass) into absorbable nutrients used to produce high quality beef. As an unnecessary by-product of the microbial conversion of feed, in particular fibrous grass, the rumen microbial Archaea population produces methane, which is expelled through the animal's mouth and nose into the atmosphere.

In collaboration with the world-leading breeding company Genus plc and the Universities of Edinburgh and Aberdeen, SEFARI scientist's award-winning research showed that efficient beef production with less methane emissions is achievable using a newly developed breeding strategy referred to as microbiome-driven breeding. Based on beef data at SRUC, this strategy can potentially result in:

- Mitigation of methane emissions permanently by up to 17% per generation with further cumulative reductions in subsequent generations
- Improvement of feed conversion efficiency permanently by up to 15% in each successive generation of selection

Advantages of this breeding strategy include cost-effectiveness, improvement of animal health and meat fatty acid profiles ensuring healthier human diets.

Barley flours developed from ancient grains for healthy food reformulation



“Black barley delivers valuable nutrients and has potential to reduce blood glucose and cholesterol”

Food reformulation is one of the most effective ways the food industry can help improve our diet. Reformulation can include; reducing the amount of calories, fat, sugar and salt in food products, reducing portion sizes and lastly, increasing the amount of beneficial compounds, such as fibre, micronutrients and other phytochemicals.

Our research found that barley flours developed from ancient grains are valuable ingredients for food reformulation and can support food and drink innovation. They contain high amounts of beta-glucan, an important fibre for reduction of blood lipids, and are rich in micronutrients and phytochemicals. An important characteristic of these black, purple, yellow and brown barleys is that they can go from field to table with less processing and potentially be more climate-resilient, as well as requiring less pesticides and nutrients. One large slice of bread containing the black barley flour (65 g) delivered the required amount of beta-glucan to reduce blood cholesterol, as well as the recommended nutrient intakes for several micronutrients. When consumed, the black barley bread also produced a significant reduction in blood insulin and a trend to reduce blood glucose when compared to traditional white bread. During the evaluation of the acceptability of these products evidence showed that biscuits were considered the most difficult to remove from the diet and that both biscuits and bread should be targets for reformulation.

Through the Scottish Government’s Strategic Research Programme (SRP) a clear plan for reformulation of flour-containing products was developed. Funding was secured from Innovate UK to work with a Scottish bakery business to transition healthy sustainable crops into staple baked goods at scale.

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Scotland's Economic Opportunity in the Blueberry Market

“research into Scottish wild blueberries offers much potential to select more viable commercial variants”



Demand for blueberries (*Vaccinium* spp.) is at record levels. The majority of domestic demand is met by imports. However, European wild blueberry occurs throughout Scotland, being most abundant in the Highlands, particularly in the north and west especially around spruce and pine dominated heath forests.

SEFARI staff analysed the genetic diversity of 6 wild Scottish blueberry populations and discovered that there is local adaptation to different climates, pollinator abundance, and soil richness in Scotland, which in turn offers much potential to select more viable commercial variants.

Scientists estimated basic summary statistics of genetic diversity, genetic distances among samples, inferred population genetic structure and estimated rates of gene flow, using multivariate statistics and Bayesian methods.

In the UK, demand for blueberries has been fuelled, in part, by consumer interest in their health benefits. Blueberries remain one of the richest sources of antioxidants among the fresh fruits and are rich in compounds that have been linked to the prevention of macular degeneration, anti-cancer activity, improved night vision and reduced risk of heart disease.

European blueberry is predominantly pollinated by bumblebees so larger areas of planting would enhance habitats for bumblebees. More insects feed on European blueberry than on any other plant in pinewoods, and these in turn provide a food source for wild birds so it is a good indicator species for pinewood diversity.

Helping Scottish Food Exports

“results show the significance to consumers of ethical attributes such as animal welfare, carbon neutrality as well as natural products”



Scottish Government funded research will provide tailored data to help Scottish food producers to more effectively target export markets.

Scientists are crunching existing massive data sets provided by Mintel’s Global New Production Development (GNPD) into summary reports on several destination markets such as Australia, New Zealand, United States. The reports also look at 96 food categories including meat and dairy products. The results show the significance to consumers of ethical attributes such as animal welfare, carbon neutrality as well as natural products, characteristics that fit well with several Scottish food products.

To give just a couple of examples of the data that could be provided: Scottish meat producers exporting to Mexico will see that the demand for meat products with low allergens is growing in importance yet ethical animal credentials are less of a factor for Mexican buyers. While in Africa environmentally friendly packaging is becoming a greater influence for consumers.

Destination countries that were particularly relevant to Scottish exporters were selected in collaboration with key industry bodies such as Scotland Food & Drink and Food & Drink Federation Scotland. Scottish Agricultural Organisation Society (SAOS) and Quality Meat Scotland were also consulted.

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Building better crops; potatoes, tomatoes and aubergines

“we have identified genes linked to resistance to globally important pests such as late blight”



Enhancing our agricultural crops to be more resilient against pests, pathogens and the changing climate is a key priority for food security. SEFARI scientists are part of a large global team working in this important area, with collaborators in Peru, China and North America, focusing on improving resilience in tomato, potato and aubergine.

Crop wild relatives – wild species related closely to cultivated crops – are the main source of novel traits used in breeding to improve resilience, and we have identified genes linked to resistance to globally important pests such as late blight.

So far, our research has:

- Produced a map of mutation-prone sites in the potato genome that can be used to select the best plants for breeding
- Identified new species of crop wild relatives related to tomato, potato and aubergine
- Constructed a global database of crop wild relatives, their traits, and their relationships, showing the material available for breeding programmes
- Revealed that crop wild relatives growing next to potato fields contain resistance genes that can be harnessed for breeding better crops – they do not, as previously thought, act as reservoirs for infection

This work is continuing, to find useful traits in wild species that can be bred into cultivated lines.

How can fibre help Scotland be healthier?



“Clear statistically significant reductions in weight gain were observed with single fibres only”

Overconsumption and obesity have become serious human problems. Our previous work has shown that high fibre diets can act as a natural brake on our food intake, but we need a better understanding of how this works within the gut. This project provides more informed and accurate dietary policy advice for healthier weight management, helps the food industry produce healthier foods, and importantly, helps advocate the benefits of more sustainable plant-based diets to the public.

We investigated the effects on intake of high-fat diets when supplemented with a single fibre type, either pectin, fructo-oligosaccharide (FOS), or a mixed fibre diet (pectin, FOS, beta-glucan and inulin) when fed to mice.

The primary result was that mixed fibre intake, which is more typical of human consumption than diets with single fibre types only, were not effective at reducing body weight gain. Clear statistically significant reductions in weight gain were observed with single fibres only, whilst indicating that pectin was more effective than FOS, but no effects were observed with equal amounts in total, of mixed fibres.

This research provides insight into which types of fibre should be introduced into the diet to help healthy weight management. This could be particularly helpful for food reformulation.



“The major concern is that most people have the flawed understanding that non-vegetable foods such as meat, fish, eggs and dairy produce contain fibre”

As well as identifying which fibres were most effective in weight management, SEFARI researchers discovered that consumers are unaware of how much fibre they eat, how much they should eat or how much is in their food, irrespective of age or deprivation (IMD) area. This is despite the evidence that consumers are quite knowledgeable about many foods that do contain higher levels of fibre. The major concern is that most people have the flawed understanding that non-plant foods such as meat, fish, eggs, and dairy produce contain fibre.

Our results show that:

- Most people obtain their fibre without realising or actively thinking about it
- Although price is important, it is not a barrier for most in preventing increased fibre intake irrespective of socio-economic status
- Palatability does not appear to be an issue either
- Most consumers would choose high fibre-labelled foods
- Despite understanding the potential benefits, fibre consumption is not currently a priority in terms of health goals, particularly amongst the more elderly respondents

Overall, consumers need to understand fibre is only found in plant-based foods. Furthermore, the health benefits of increased fibre are being missed, thus education appears to be the single most important tool. Food fortification would be recommended too as an aid to increasing fibre intakes.

Improving sustainable roundworm control for 'Scotch Lamb'



“SEFARI scientists have developed a free online tool which provides farmers and vets with an instant...visual demonstration of the clinical impact of faecal egg count. This will help the sheep industry optimise anthelmintic treatments ”

Roundworms are arguably one of the most important production-limiting disease syndromes globally. Control of these infections commonly relies on the use of anthelmintics, but uptake of diagnostic tools such as faecal egg counting to aid timing of treatment and checking their effectiveness are poor.

The Scottish Government's Preparing for Sustainable Farming scheme which includes diagnostics for roundworm control highlighted that undertaking animal health and welfare interventions can help assess the welfare of livestock, improving their health and increasing productivity. Barriers to the uptake of these tools include an understanding of need, how to effectively collect and process samples, how to interpret and apply findings on farm.

To aid producers SEFARI scientists have developed, with additional funding from the Veterinary Medicines Directorate, a FREE online tool called FEC Check. The tool draws together a wide range of relevant resources on all aspects of faecal egg counting from collection of samples through to visualising results providing context for making decisions. The strength of the tool is that it provides farmers and vets with an instant, and easy to understand, visual demonstration of the clinical impact of faecal egg count results and incorporates a decision tree for dealing with results that suggest there is resistance to more than one class of wormer.

The online tool is designed to encourage wider uptake of diagnostics such as faecal egg counting among the sheep industry to optimise anthelmintic treatments, to promote animal health and welfare, to maintain productivity, to slow selection for resistance and reduce our environmental impact.

Reducing synthetic fertilisers and pesticides through intercropping



“benefits included higher crop yield and better yield quality, improved soil fertility, enhanced biodiversity”

Field trials in collaboration with farmers from across Scotland and overseas have demonstrated that cultivating different crops together in the same space can make agriculture more resilient and environmentally sustainable.

SEFARI scientists have coordinated Scottish Government and EU-funded research projects quantifying the costs and benefits of these potentially sustainable farming practices.

The benefits included higher crop yield and better yield quality, improved soil fertility, enhanced biodiversity, more efficient use of resources such as water, reduced dependence on synthetic fertilisers, and potentially reduced pesticide use.

Intercropping frequently involves growing cereals such as barley, wheat, or oats alongside legumes such as peas, beans, or clover. Legumes are a highly nutritious food source and act as natural fertilisers, absorbing nitrogen from the air and converting it to biologically useful forms. Legumes can support companion crops such as cereals. They enrich the soil through roots and stems left in the field after harvest.

The way food systems currently operate often leads to widespread global over-use of synthetic fertilisers and pesticides as well as intensive farming of single crops, which contribute to environmental damage. Climate-friendly practices are required to help ensure that the agriculture sector plays a positive future role in tackling major global challenges of food security and world hunger, climate change and biodiversity loss.

Berries can help to protect against cancer, type 2 diabetes and Alzheimer's



“evidence that specific components could slow the growth rate of colon cancer cells”

SEFARI scientists have produced new insights into how berries could deliver multiple health benefits against some of the world's most serious diseases.

As well as being an excellent source of nutrition, berries contain important non-nutrient components that interact with the human body in complex ways. These components have been purposed to protect against cardiovascular disease, cancer, type 2 diabetes and neurodegenerative diseases such as Alzheimer's.

Polyphenols are compounds that occur naturally in plant foods, including berries, as well as red wine and dark chocolate. Polyphenol groups include anthocyanins, which are pigments that give raspberries, blueberries, and blackcurrants their distinctive red, blue and purple colours.

Studies included lab trials with cell and tissue cultures to study the impact of polyphenols on certain diseases. For example, a long-term collaboration with the University of Ulster has shed light on which raspberry components survive in the digestive system. It provided evidence that specific components could slow the growth rate of colon cancer cells.

Methods developed to monitor the survival of berry components in the body have been applied to understand exactly how they are absorbed and used in the body. This knowledge has been applied to studies looking at potential beneficial effects for other major diseases including Alzheimer's.

Insights into how berry polyphenols behave in the body is an important step towards the broader goal of accelerated breeding of berry varieties capable of delivering maximum health benefits.



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