How to increase sustainable, home-grown legume cultivation, and consumption across Europe

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Preface by the TRUE-Project Coordinator

Dr. Pietro Iannetta (James Hutton Institute, Scotland, UK)

Legumes are a special group of plant species and include crops such as peas and beans, and crucially they require no synthetic nitrogen fertiliser. This is because legumes acquire their nitrogen naturally from the air, via a process called **biological nitrogen fixation**. Also, after legumes are harvested the nitrogen-rich crop residues left in-field is a manure, further offsetting synthetic nitrogen use for the other crops which follow. This is significant because around ¼ of agriculture's greenhouse gas emissions are due to the inefficient use and management of nitrogen. This nitrogen is highly reactive, with consequent and severe negative impacts upon ecosystem function, including water and air pollution, the latter including greenhouse gases. **Ensuring that more legumes are grown locally will reduce this climate change cost significantly.**

It is therefore critical to realise that optimising nitrogen-use efficiency can do as much to reduce climate change as soil carbon sequestration. Yet, considerations regarding the natural-nitrogen provision of legumes are consistently marginalised. Home-grown legumes, and home-grown legume-based food products, **can** deliver consumer expectations for protection of the environment and biodiversity. Also the delivery of healthy diets, since legumes are also a sustainable source of highly nutritious food. Despite their environmental and health benefits, to humans and farmed animals, plus biodiversity and ecosystem functions more broadly, in industrialised food system typical of the global north, **home-grown legume-based food-systems have not been realised in common farming practice.** This points to a vast untapped potential for legume-based systems in Europe. This is critical, since **if legumes are not 'home-grown', their environmental benefits are forfeited.**

The TRUE-Project has identified and implemented transitions paths to help increase the cultivation and consumption of home-grown legumes, and legume-based products across Europe - helping realise the multi-functional benefits of legumes across value-chains from farm-to-fork, and even field-to-bottle. **The TRUE-Project aims to identify and implement a better-balance for environmental, economic- and social- securities** for all citizens, facilitating excellent standards of nutrition to deliver improved health and well-being for people, farmed animals, biodiversity, and improved ecosystem functions through enhanced soil, water, and air qualities.

Supply chains, or **'value chains'** as I prefer to call them – since business structures should reflect what society values - are a web of linked components spanning agricultural suppliers, cropping and the aggregation of yields, to processing and the application of food technologies, to distribution, marketing, and consumption (FAO, 2019). It is critical that **innovations** are devised and implemented in all three aspects. From **production,** through **processing**, and so to **purchasing**: the 3 P's, or "**The 3 Peas**" if you like! **Integration of innovations** across all three value chain elements is essential to trigger and facilitate the necessary increase in market demand for ***home-grown legumes.***

Here, we take the opportunity to highlight just some of the innovations and approaches identified and developed by the **TRUE-Project**, and hope it serves as both an inspiration and of practical use for home-grown legume innovators, wherever they may be.

The 3 P’s

Production

Highly innovative practices and tools are needed to realise legume-based cropped systems. Innovations must improve the commercial potential of legumes, through increased production, improved resource use efficiency, and reduction of inputs such as nitrogenous fertiliser, and pesticides. In essence, increasing legume inclusion in cropped systems promotes crop-diversification, and resilience of the natural resources on which production depends - including the resilience of communities and businesses. The range of TRUE-Project innovations span from dairy farming in Ireland and agroforestry practices in Kenya, to the identification of new elite rhizobia strains for optimised nitrogen-fixation, and the development of novel machinery-based solutions. Such innovations should not be seen as stand-alone solutions, but rather should be integrated as necessary within the cropped system, and across value chains networks.

Production:

including mechanisation, agricultural-input suppliers, and agronomy for yield of grain, or other biomass, for food, feed, and industrial uses.

Processing:

all and any processes which add value through increased utility of the legume material which is harvested.

Purchasing:

the structure and management of and for markets, including tools for improved marketing, labelling, to increase purchase and consumption of legumes- and legume-based products.

Autonomous “prime mover” with minimal soil footprint

This prototype facilitates innovative management of forage-legume based intercrops, improves soil quality through reduced compaction and resource use efficiency through accurate placement of crop management materials, and offers greater nutrient-use efficiency, lowering inputs, providing labour savings through automation.
To find out more: click here

New rhizobia strains for common bean

KEFRIFIX: legume root nodule nitrogen-fixing bacteria (rhizobia) held in a sugar-industry co-product as a novel carrier medium. The approach is used to deliver elite rhizobia inoculants for in-field use to improve nodulation, nitrogen fixation and growth of target crops, compared with indigenous or standard inoculants in the region. Applied during sowing, the product presents a high rhizobia density (>109 rhizobial cells g^{-1}) and are currently applied to common bean and Tephrosia species.
To find out more: click here

Lowering the carbon and ammonia footprints of pasture-based dairy production

Biological nitrogen fixation by white and red clover produces little or no nitrous oxide or ammonia emissions. Using these on dairy farms the carbon footprint of milk produced can be lowered by up to 40% and ammonia footprint by up to 50% compared with the national Irish average.
To find out more: click here

Forage legumes in dairy management systems

In Scotland, dairy farming using home-grown forage legumes has the potential to offer environmental benefits. When comparing four dairy management systems, a localised farming regime feeding home-grown lucerne and spring beans attracted the lowest area-based emissions. This more self-sufficient system was associated with the lowest emissions per kilogram of fat and protein corrected milk, when calculating footprints using mass allocation of feeds rather than economic allocation. Where possible, foot printing calculations should incorporate variation in diet digestibility and crude protein content.

To find out more: click here

Direct drilling of cereal crops into biomass crop stubble

Direct-drilling of seeds (i.e. avoiding ploughing), reduces carbon and nutrient loss to the environment. This also reduces field operations and therefore fuel and machinery use. The carbon footprint of cropping is therefore reduced throughout the crop cycle. This approach would inform agronomic advice to growers and crop planning for the cooler, wetter climates such as is found in north-west Europe.

To find out more: click here

New agroforestry practice for smallholder farmers in western Kenya

The use of relay-intercropping, sowing a second crop into a field area before the first crops life cycle has ended, enhances soil fertility and health and so boosts crop yields. Here, annual crops are undersown as relay intercrops in a woody-legume (agroforestry) based system, where grain-legume cultivation overlaps with that of non-legumes (cereals/maize). This is optimised using elite-rhizobia inoculants in a novel carrier medium, and application of phosphorous fertiliser at planting. Higher yields are achieved without synthetic nitrogenous fertiliser use.

To find out more: click here

New efficient crop rotation schemes

In Mediterranean winter conditions, the cultivation of faba bean as green manure, optimises the yield and quality performance of a following common bean cultivated organically during the warm season. Highly productive organic crop rotation schemes comprise N-fixing legume crops followed by N-utilising legume crops. The approach promotes the sustainable production of high-quality legume-based products and encourages the cultivation of legume species with high N-fixing activity as a renewable organic nitrogen source for organic agriculture.

To find out more: click here

Creating novel common bean types using grafting

Grafting is commonly used to generate unique and improved root-shoot combinations to enhance crop resource use efficiency, multiple stress tolerance, biomass production, and yield. Here, high performing plant root material is combined with high performing above-ground ariel (or 'scion') components. The newly grafted novel plant types can produce higher yields, and here in the case of common bean, more fresh pods in terms of total weight and number – so boosting production efficiency.

To find out more: click here

Processing

Innovative or optimised processing methods for raw materials are vital to ensure that legume-based products enter the food and feed market, resulting in increased demands for legumes. Examples include optimised extrusion processes as well as optimised methods for the brewing and distilling of legumes for the alcohol beverage industry.

Optimised Extrusion Processing

The processing of legume grains (pea, red lentils, green beans, yellow beans, faba bean) was improved by using a twin-screw extruder. The novel extrudates include flakes, nuggets, crispies, balls, and protein rich noodles based on different legumes (e.g., spaghetti based on yellow and green bean and spirelli pasta based on faba bean, green bean, and red lentil). Feed formulations have also been developed using the extrusion technique.

To find out more: click here

Processing for the beverage alcohol industry

The methods for processing faba beans kernels as an adjunct for beer production have been optimised (Black et al., 2021). The knowledge gained from beer production was then applied to the production of distilled spirits. These optimised processes led to the launch of Cool Beans® - Faba Bean IPA (gluten free, and vegan beer produced with 30 % faba bean kernels) and Nàdar – Gin and Vodka (new range of alcoholic beverages: the world's first climate positive gin and vodka made from neutral spirit (alcohol) derived from only peas). In addition, this optimised brewing process yielded a spent-grain co-product, which is an excellent high-protein poultry feed.

To find out more: click here

Novel Formulation for Aquaculture

A variety of feed formulations have been produced that include legume-based ingredients, including:

- *lupin meal for Whiteleg shrimp and seabass;*
- *faba bean protein concentrates for Atlantic salmon; and,*
- *mixed grain legumes formulations for Atlantic salmon and European seabass.*

These newly formulated feeds have been successfully tested and can be used immediately to replace all soybean and proportions of fishmeal in conventional diets for the different species. These have environmental advantages: 1) soybean in conventional diets generally comes from overseas and most of it is genetically modified soy (reduced CO_2 emission, no use of GMO material); and 2) replacement of proportions of fishmeal as an unsustainable resource (overfishing problem), reduced CO_2 emissions (long transportation routes of fishmeal).

To find out more: click here

Purchasing: markets, retailers, and consumers

Markets, including crop aggregators, marketing specialists, wholesalers, procurement professionals, providers of catering services, and retailers are **hugely influential components** of the food system. Their central position allows them to have critical influence on upstream processes (what is grown and how), and down-stream processes in terms of available commodities, ingredients, or products. They serve as **key information and knowledge dissemination points**, to raise awareness of legumes benefits and their many and diverse range of unique selling points. Innovations from the **TRUE-Project** have served to underpin awareness raising activities in the food service and gastronomy markets, by consumers, and farmers.

Market-growth for legume grains, and other legume-based products is accelerating year-on-year in response to consumer demand for healthier, climate-friendly, and sustainable food and drink products. The TRUE-Project has developed and launched or validated a proof-of-concept of several innovative legume-based products which offered a range of **unique selling points**, including protein-rich; high nutrient density; plant-based; local and/or provenanced. The credentials of some products were accounted and validated by specific tools - such as **Life Cycle Analysis**.

The TRUE-Project has published a series of e-recipe books containing a plethora of legume dishes from across Europe. These are aimed to encourage consumers to discover the versatility legumes can provide in everyday diets.

These can be downloaded from the TRUE website: click here

"Choose Beans" - Initiative

This initiative introduced legumes as a real option in Eurest's restaurants, by providing help to catering operators in implementing pulse-based menus which encouraged consumers to make healthier, pro-legume choices. This was implemented in early-years schools, and also via public procurement in hospitals, and other social-care facilities. The approach was also adopted by commercial companies, and factories served by Eurest. The approach has been recognised and awarded by the Portuguese Government. Additionally, the impact of this national initiative was bolstered by the publications of 3 recipe books dedicated to legume dishes, based upon a celebration of their traditional use in Portuguese food-culture and high nutritional-densities.

Available here *Find out more here*

Legumes: Europe's culinary Treasures

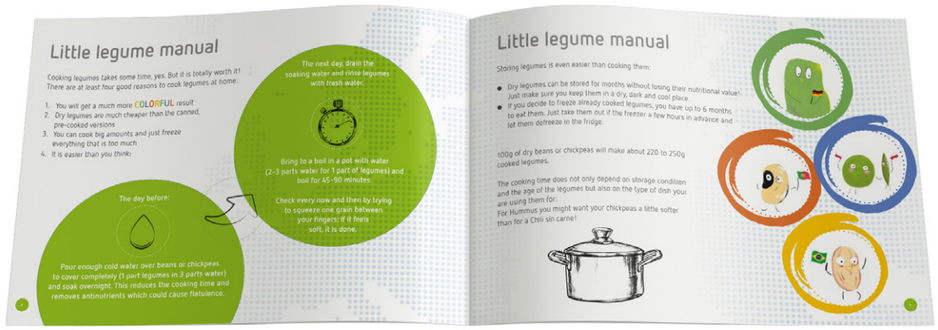
This book showcases examples of recipes featuring pulses and demonstrates the local legume traditions that have prevailed in Europe for many centuries, and the cultural roots that are connected to them. The nutritional values and ecological footprint data of each recipe underpin the benefits of legumes for both health and the environment. This book is available digitally in English and German to reach a wide audience.

Available here

Easy Peasy Legume Recipes

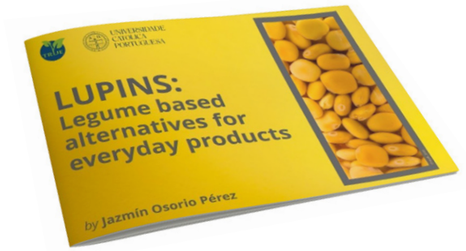
This book introduces children to legumes and legumes dishes. Little legume characters lead children and their parents through the book, taking them on a journey around the globe. They do not only provide general information on legumes, cooking and storing processes but also background stories, “Did you know“- facts and tips on the preparation. Kids can carry out easy tasks during the cooking process while experiencing the joy of preparing a meal from scratch. This book has been translated into 9 languages.

Available here



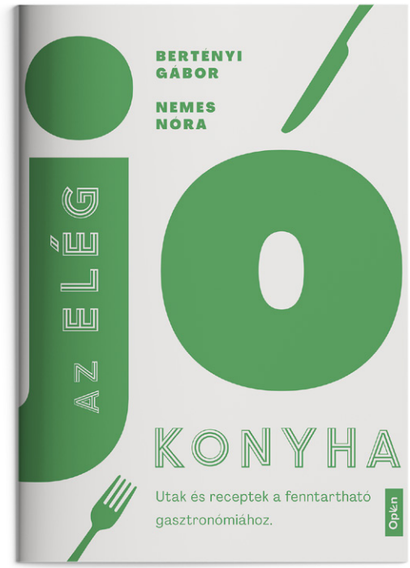
Lupins: legume-based alternatives for everyday products

A booklet was designed providing examples of vast range of dishes that can be cooked with lupin. The products developed include lupin-cocoa spread, lupin wrap tortillas/nachos, pear and lupin cookies, breaded pork with lupin flour, legume and lupin burger patties, plus lupin and cheese pizza base.



The Good-enough Kitchen

This book provides a comprehensive overview of the main aspects of sustainable food and gastronomy, from dietetics to alternative supply chains, and from protein-alternatives to zero-waste kitchen-practice. It aims to facilitate a smooth and anxiety-free transitional opportunity for receptive readers towards a more sustainable and resilient gastronomy. The main part of the book features 80 original recipes, including legume-based foods to emphasise the unique role of legumes in daily nutrition.



Guidebook to the small-scale organic cultivation of selected legume species

This guide for the small-scale organic cultivation of lesser-known and rarely-consumed legume species and varieties in Hungary describes select cultivars, and their specific cultivation needs, common diseases plus treatments, and offers suggestions as to their practical uses.

Legume-based Products

Fava Java

Legume-based drink/coffee or breakfast alternative, made with ingredients locally sourced ensuring local value chain. It delivers legumes in the novel form of a popular and highly nutritious drink, whilst also reducing CO_2 emissions by increasing legume production.

BBDonuts

A healthier alternative to existing snacks, the donuts contain faba bean as a more nutrition-dense ingredient, compared to the grain usually used (wheat). Production could stimulate local legume production and downstream value chains, and by this provide an opportunity for a local product with provenance certification in Portugal, as faba bean is a traditional food ingredient for the region.

PlantCakes

This product is a dry mix for sweet pancakes, with the partial replacement of oat flour with lentil flour. The ingredients used in this recipe are all sourced from organically cropped systems.

Lupin Yogurt

This dairy-based yoghurt is prepared with lupin kernel (dehulled grain) flour (4%). The lupin flour serves as a thickening agent and enriches the product nutritionally compared to traditional thickener.

Legume-based sausages and burgers

A vegetarian sausage with acorn (38%) and chickpea (27%) as the main ingredients was developed. This represents the first acorn-legume-based sausage. Legumes have been incorporated to improve texture and increase protein content with the additional benefit of being gluten-free. A vegan burger with 44% of chickpeas and 8% lupin was also developed.

Concluding remarks

Sustainability has emerged as the **'language of modern marketing'**, and it is critical that the products offering sustainability claims can be validated. Consequently, the development of tools which can account ecosystems functions is important, and consumers should be assured that their consumption choice is actually realising the benefits which are being offered. Success in this respect will offer forward-thinking businesses robust 'unique selling points'.

The use of home-grown legumes for the European animal- and aquaculture-feed sectors would create a demand so large that the area of legumes sown across Europe would have to increase significantly. This potential is strongest perhaps for poultry (broilers) and fish farming. Additionally, the benefits of using clover, vetches and lucerne as forage crops deserve more attention, since the productivity of many grasslands remains sub-optimal due to forage-legume exclusion. Also, with improved agronomy, bought-in cereal-based feed-dependency can be reduced, and arable land area for cultivation of other crops, including grain legumes may expand.

From the outset of the **TRUE-Project**, the partners acknowledged that taking innovations from experimental to a market-ready context requires **partnership**. It is with a view to the persistence of this vision that the **TRUE-Project** innovations are offered here: to inspire entrepreneurs to fully utilise the functional diversities offered by legumes, and to realise the importance of home-grown legumes in facilitating solutions for a healthier and more sustainable agri-food and feed-systems - locally and globally (Iannetta et al., 2021).

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