The diversity of end-uses for legumes

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Abstract: Legumes have been reinvented in a multitude of innovative products (drinks, cereal bars, bread, meat replacers, snacks, flours, and several others) often combining ancient traditions of legume consumption 'with a spin', incorporating new legume technological knowledge in food (and feed) product innovation. Results suggest that consuming even only 80-100 g per day may be enough to maintain overall health, improve gut microbiota, and even help prevent cardiovascular diseases, diabetes, obesity, and/or cancer. However, the transition to legume consumption and utilisation has been slow and hampered by many cultural, societal, political, and economic impediments. Here we summarise the results from a selected number of initiatives presented at the Legume Innovation Network webinar entitled, "The diversity of end-uses for legumes". These aimed to enable the comeback of legumes and their placement in a diversity of end uses, becoming more prominent in human diets and animal feeds. The diversity of topics ranged from innovation for consumers and citizens, exploring the European food and feed system, to demonstrating developments in academic and industrial R&D, with a focus on health and nutrition.

Food production needs to be improved to help realise more sustainable systems which are less dependent on mineral nitrogen and phosphorus inputs, use water more efficiently, and offer significantly lowered levels of greenhouse-gas emission, and increased carbon sequestration (1). In this context, more sustainable eating patterns have been suggested, based on the increased intake of plant-based protein in place of animal-based protein (2). Incorporating low-cost legume grains, that are rich in nutrients and demand low N synthetic nitrogen fertiliser requirements, into daily food items, can improve the nutritional and sustainability profile of national diets (3). Increased awareness of the need to move to sustainable-food systems via -consumption is revitalising legume production and food purchasing patterns across Europe. This has led to a compilation of innovations and initiatives that aim to re-establish legumes as a foundation for the food-system transformation. Many factors may have led to the exclusion of legumes from consumers diet in the past, including: 1) a low environmental or agroecological awareness; 2) the marginalisation of knowledge regarding legume´s health/nutritional benefits; 3) the long cooking and/or preparation time required for legume grains; and 4) their potential secondary effects via non-nutritional components. Strategically, the global food industry has been increasingly orienting its activity to tackle these consumer obstacles and this is reflected in contemporary food-fashion or dietary trends (e.g., flexitarian, vegetarian, gluten-free, etc.) in their innovation portfolios, increasing the incorporation of legumes and legume-based ingredients. This has led to the development of healthier and more sustainable food products at an

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unprecedented scale.

This webinar therefore summarised initiatives that aim to enable the return of legumes and their more-equal placement via improved understanding regarding versatility, and so diversity of end uses. Such capacity realisation will facilitate an increase in their prominence in human diets and animal feeds. The session focused on innovation for consumers and explored the European food- and feed-systems, showcasing both developments in academic and industrial R&D sectors.

A first contextualisation of legumes uses and trends in foods was given by Marie-Benoit Magrini and Tristan Salord. It was evidenced that the majority of the new food products being currently developed are soybean-based (4). However, increasingly, new food products also include pulses such as chickpeas, lentils, and peas. Main drivers for legume inclusion in legume innovations are their sustainability in the environmental dimension and their associated health attributes. On the other hand, one of the main factors locking-in legumes exploitation is that the full diversity of legume types or species is yet to be utilised in practice.

To enable the use of legumes in different contexts and for product development, it is important to improve the existing technological methods for processing. Kathleen Zocher explained that legumes can be used as fresh, frozen, or canned, and highlighted that the grains can also be further treated in by shelling, roasting, squeezing, milling, freezing, flaking, pelletising, polishing, or extruding (for example). All of these must account for the presence of potential non-nutritional factors that can hinder legumes digestibility, and that might have a more worrying impact in the feed sector.

As the trend for using legume isolates is increasing, starch processing or oil, protein and fibre extraction methods were also noted. On this subject, Benjamin Voiry presented the current investments in pea and faba bean protein isolate extraction in Europe. The easy adaptation of these protein isolates to different end-uses makes them convenient to add nutrition whilst responding to the demand for dairy and meat alternatives enriched with protein. This demand is generally associated with consumers who have an interest in healthy lifestyles, and who are generally concerned with diet-related issues. This constitutes a major market opportunity for investment. It was also highlighted that all legumes' components must be valorised, not only the protein fraction, but also the hull, starch, and fibre fractions. In that, yellow peas are currently the main crop being used for fractionation, and the full range of available legume diversity should be explored further.

Clearly, legumes' health benefits are one of the major drivers to enable their inclusion in current diets (5). Helena Ferreira presented scientific evidence on these health benefits (Figure 1), and on the effects of shifting from an omnivorous diet to a plant-based diet. The author presented a dietary intervention study and showed that there are specific human biomarkers which can be associated with a plant-based diet, and specifically to pulse consumption, since major metabolic changes were observed.

Another dietary intervention study was presented, specifically the 'BEAN MAN', which involved the participation of 102 men. Essi Päivärinta explained that a reduction from a 760 g/week of red meat intake (25% of protein intake) to 200 g/week (5% of protein intake) complemented with legume-based products providing 20% of protein intake (pea and faba bean) led to improved blood lipoprotein profile and decreased the formation of possible carcinogenic compounds in the gut.

While the multiple contributions of legumes at the agricultural level are well documented (6), the environmental footprint

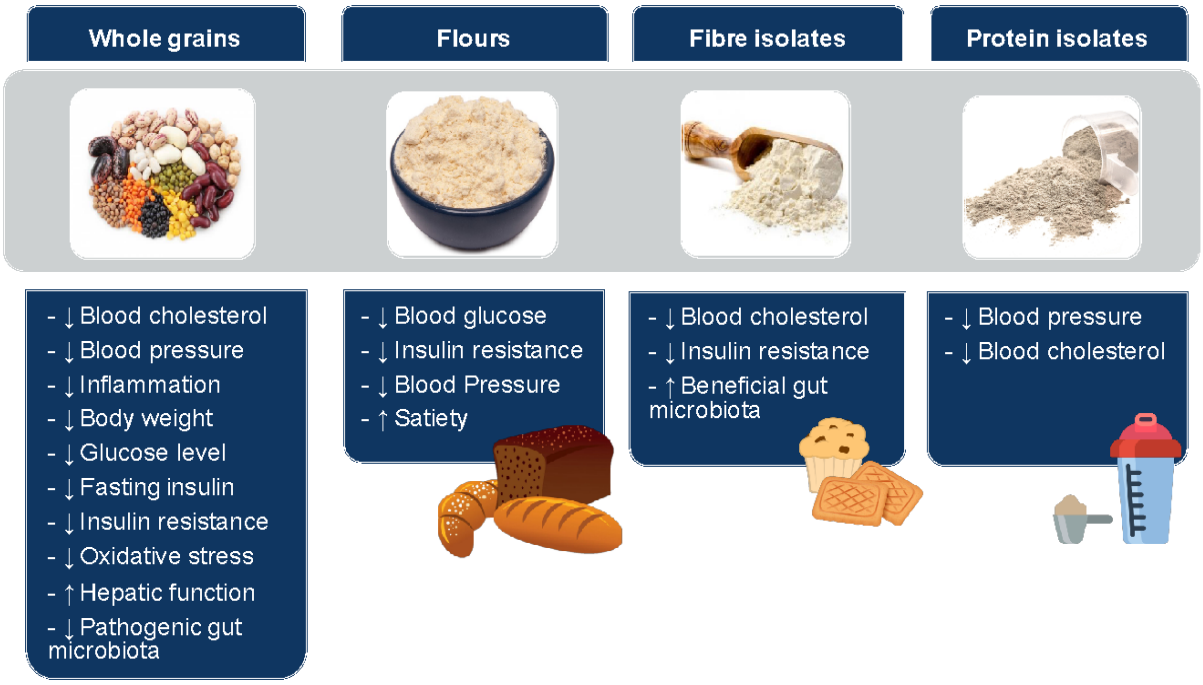

Figure 1. Health benefits of legumes as whole grains, flour and fibre or protein isolates (image prepared and kindly provided by H. Ferreira).

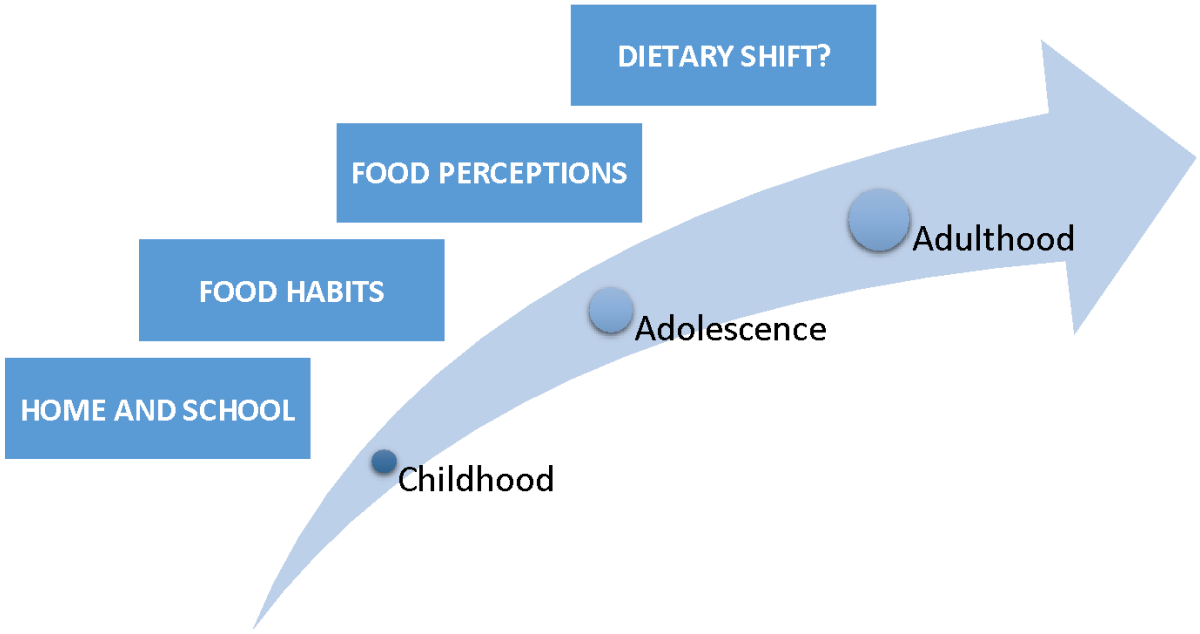

Figure 2. Modulating food habits and introducing legumes in general diets may be dependent on targeting children to develop a sustained and long-lasting dietary shift.

of legume-based alternatives to their traditional counterparts needs to be further analysed to support environmental sustainability claims. Using Life Cycle Assessment (LCA) methodology, Mike Williams showed that legume replacement of traditional food items, namely, in the case of wheat pasta (7), beef meatballs (8) and beef burger patties (9), perform significantly better over parameters associated with eutrophication and global warming burdens.

It is important to raise awareness amongst the consumers about these health and environment benefits. The "Choose Beans" initiative, presented by Elisete Varandas, helped to increase legume consumption frequency in EUREST restaurants chain by increasing legume-based options in their menus and developing more attractive recipes. Also, different consumer segments can be more susceptible to diet changes than others. Carla Santos argued that, by targeting children and developing products adapted to their preferences with legumes, a long-lasting dietary shift can be achieved by implementing healthy and sustainable food habits from a young age (Figure 2).

As shown in Figure 2, the early stage of human development and early-schooling, also play an important part in modulating and determining food habits. In 2019, an online survey was implemented in France to understand the role of legumes in institutional food services, such as school canteens. As presented by Hugo Fernandez-Inigo, the institutional food services that include legumes (only 16% of the respondents) have a strong sustainability profile. However, further actions are required to increase the inclusion of legumes even in their menus. Possible solutions may be the development of new recipes, training working professionals and increasing the awareness of legumes' health and environmental benefits.

Martha Walter presented legume-based food innovations in pasta, bakery products and extrudates for meat-like products. These showed high potential, and the baking and extrusion methodologies were successful and can be adapted to different materials. Alexandre Santos explained how the snack market poses an opportunity for improvement and for the promotion of healthy habits, and 'Bean Go' was presented as a successful case study for the development of a snack which is convenient, with few ingredients, that taste well besides being healthy. Kirsty Black presented the climate positive beer and spirits developed in scope of the TRUE project. Using faba beans as starch source, Barney's Beer has as an additional advantage the generation of high protein co-products with potential in animal nutrition (10). Using green peas, the Nàdar gin was developed, and its production was analysed for the environmental impact using LCA methodology when compared to the usage of wheat (11). This study showed that the allocated environmental footprints for pea-gin were smaller than for wheat-gin across 12 of 14 environmental impact categories considered. Such valorisation of product claims is allied to novel grain legume-specific marketing and knowledge sharing campaigns via media specialists – to help emphasise the critical importance business-research partnerships in acceleration uptake, and product appeal and resilience in the marketplace (e.g., YouTube link).

Finally, when looking at the impact of home-grown legume inclusion in feed options, Mathieu Guillevic showed how the use of legume grains in animal feed allows environmental valorisation of these crops, and increased uptake. It was demonstrated that it is important to find the best species and varieties to use as feed, as well as the better combination of treatment to improve digestibility. Testing was performed in trout, broiler (chicken) and pig diets, after appropriate processing treatments were defined. Aila Vanhatalo demonstrated the value of using faba bean and lupin as protein alternatives to rapeseed meal in dairy cow diets. This substitution achieved similar performance in terms of milk yield. However, milk protein yields were not as effective. Regarding the use of legume grains such as lupin, faba bean, pea or sustainably produced soybean as possible replacement in fishmeal, Matthew Slater highlighted the success in producing feeds for fish and shrimp. Specifically, feed formulations for

the aquaculture of salmon, shrimp and sea bass containing legumes were achieved with positive outcomes in terms of the improvement of aquacultural sustainability.

These findings and the resultant discussions showed the importance of a system wide and integrated perspective of legumes use, and how legumes can lead to strong and common ties, based on whole food system sustainability ideals, between farmers through markets to the consumer. The insights also highlight the importance of exploring legume diversity for a wider range of end-uses than is currently accommodated, and that legume breeding efforts should be mindful of providing adapted forms to local pedoclimates and added values beyond yield. For example, increasing levels of specific health promoting nutrients and compounds, and lowering levels of non-nutrients. Since, breeding for such processing and consumer focused markets may increase even further the ´home-grown legume-appeal´ to, and so market pull from, consumers across Europe.

More detailed information regarding the content presented here can be found on the Legume Innovation Network website **here**.

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