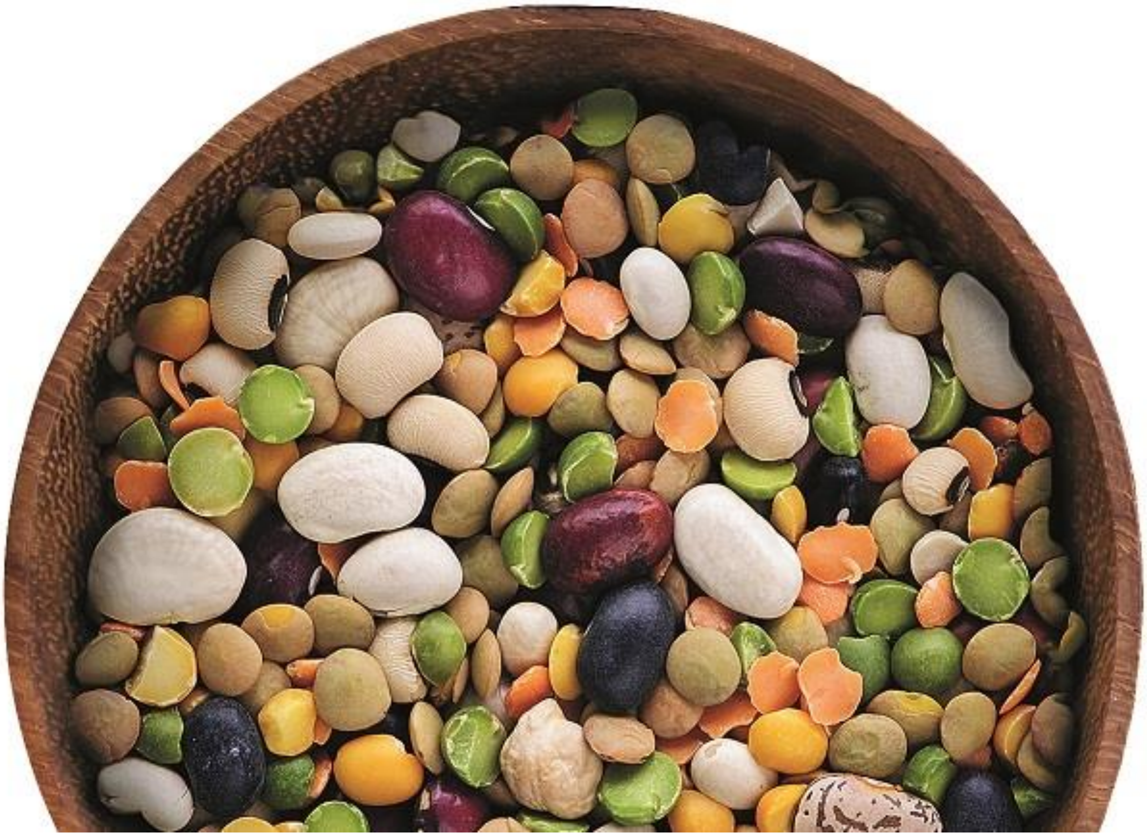
Data for Life Cycle Analysis proof of concept

Deliverable 3.1 (D18)

Lead Author and Institution: Marta Vasconcelos (UCP)



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Deliverable Description & Contributors

- **Due date**: 30th November 2018
- **Actual submission date**: 31st January 2018
- **Project start date**: 1st April 2017
- **Duration**: 48 months
- **Work package**: Nutrition and Product Development (WP3)
- **Work package leader**: Marta Vasconcelos (UCP)
- **Deliverable Title**: Data for Life Cycle Analysis proof of concept
- **Nature of deliverable**: Report
- **Dissemination level**: Public

Deliverable description: Nutritional profile data for grain legumes will be gathered and provided for the Life Cycle Analysis proof of concept (WP5). Profiling will include that of including macro- and micro-nutrients and prebiotic properties (of selected legumes). This data will also help identify the relative suitability, and trade-offs, of different legume species for food- and feed-applications.

- **Contributors**
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Contents

1. Executive summary

The initial approach of TRUE partners for Life Cycle Assessment recognised that only very small differences in 'nutrient density scores' (NDS) exist between commodities or products despite the use of data from many different nutrients. Thus, WP3 and WP5 agreed to reduce the number of nutrients analysed. This limited approach is in-line with the most recent methodologies reported in peer-reviewed literature which found that only seven specific measures were necessary to provide a nutrient density score, that are relevant for the Life Cycle Assessment (LCA) development. These seven measures are: 1 and 2, essential- and saturated-fatty acids; 3, plant protein; 4, dietary fibre; 5, added sugars; 6, sodium; and 7, energy *per* 100 g of food product. Using this approach, six legume-based (vegan) products were developed by IGV using lentil (*Lens culinaris* Medik.), yellow-pea or green-pea (*Pisum sativum* L.). These were analysed for their nutrient composition in the following named products: 1, Pea ProteinFLAKES; 2, Pea ProteinCRISPIES; 3, Red Lentil & Curry Pasta; 4, Green Pea and *Spirulina* (*Spirulina platensis*) Pasta; 5, Green pea and *Chlorella* (*Chlorella vulgaris*,) Pasta; and, 6, Yellow Pea & Linseed Pasta. These products were analysed for provisions in terms of the seven nutrients listed above.

The results revealed that the Pea ProteinFLAKES had the highest kcal (401 kcal 100 g^{-1}) and sodium (1.32 g 100 g^{-1}) contents. Whereas, the Pea ProteinCRISPIES had the highest protein (76 g 100 g^{-1}), omega 6 (0.6 g 100 g^{-1}), and saturated fatty acid (2.1 g 100 g^{-1}) contents. The Yellow Pea & Linseed Pasta showed the highest content in dietary fibre (9 g 100 g^{-1}) and highest essential fatty acid content (12.97 g 100 g^{-1}).

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1.1 Purpose of the Deliverable

EU-TRUE (see Annex I) Work Package (WP) 3 (Nutrition and Product Development) activities involve mostly investigation and development of novel-food and -feed products to replace imported protein and carbohydrate sources, and to respond to consumer's demands for more-sustainable produced foods, better health and well-being. WP3 works with producers and industry to create and deliver novel legume-based and animal-feeds which are tested and validated for high nutritional- and functional-value. Examples include food (bread and baked products), animal feeds (aquaculture and poultry), and beverages (fermentation-based industries: beer, neutral spirits). WP3 also works towards tying legume nutritional facts in recipes to infield ecosystems services. WP3 is closely linked to WP5 (Environment), which evaluates diet using Life Cycle Analysis (LCA). LCA has been defined, by Muralikrishna and Manickam (2017), as "*a cradle-to-grave or cradle-to-cradle analysis technique to assess environmental impacts associated with all stages of a product's life, which is from raw material extraction through materials processing, manufacture, distribution, and use*".

In the context of TRUE, LCA will help WP5 produce guidelines to help shape national programmes aimed at using legumes as a vehicle to reduce the current negative environmental- and healthcare-impacts of food production and consumption. The Nutrient Rich Foods Index has been suggested to help identifying healthy, affordable foods (Drewnowski, 2010). It is a formal scoring system that ranks foods on the basis of their nutrient content. It is known that food groups offer diverse nutritive values and costs with eggs, dry beans and legumes, amongst commodities having the lowest-cost sources of protein, and beans having one of the most favourable overall nutrient-to-price ratios, even when compared to many vegetables and fruit (Drewnowski, 2010). An extensive literature review and study of different statistical approaches to determine the nutrients that best explain variation in healthy eating scores and food nutrient density (*e.g.* Arsenault *et al.*, 2012; Blonk *et al.*, 2011; van Dooren *et al.*, 2017; EFSA, 2010), was carried out. From this, we recognised that very small differences in NDS was found to exist between commodities or for products, even though these approaches use data from many different nutrients. Thus, it was decided in accordance with van Dooren *et al.* (2017), that seven nutrients would provide the necessary data for LCA development. In order to test this methodology, it is necessary to gather the nutritional composition of legume-based products. The purpose of this deliverable is therefore to provide nutritional data for LCA Proof of Concept to be taken up by WP5.

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2. Materials and Methods

2.1 Materials

As models, six legume-based vegan products supplied by IGV were analysed for their nutrient composition. The products were: 1, (*Pisum sativum* L., pea) ProteinFLAKES; 2, (pea) ProteinCRISPIES; 3, Red Lentil & Curry Pasta; 4, Green Pea and *Spirulina* (*Spirulina platensis*) Pasta; 5, Green pea and *Chlorella* (*Chlorella vulgaris*) Pasta; and 6, Yellow Pe a & Linseed Pasta. These products were analysed for provision of: essential fatty acids; saturated fatty acids; total protein; plant protein; dietary fibre; added sugars; sodium; and, kcals using the methods described in Section 2.2. Figure 1 (A-F) illustrates the vegan legume-based products used for nutritional analysis.

Figure 1. Images of the food samples analysed for nutritional composition. The products consisted of: **A**, Pea ProteinFLAKES; **B**, Pea ProteinCRISPIES; **C**, Lentil & Curry Pasta; **D**, Green Pea & *Spirulina* Pasta; **E**, Green Pea & *Chlorella* Pasta; and **F**, Yellow Pea & Linseed Pasta.

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2.2 Methods

The nutritional analysis was performed at IGV on the six IGV developed products, as described below. The nutritional data are used to generate the IGV Nutritional Declaration Forms as exemplified in Annex II (Figures 2-4) and will also be used to inform the LCA proof of concept analysis.

Energy (Kcal)

Energy was calculated from the proportions of the ingredients (FAO, 2003). The calculations for carbohydrates and energy in kcal and kJ are as follows:

Carbs = 100 – Moisture – minerals – Protein – Fat – fibres

Energy (kcal) = (Fat x 9) + (carbs x 4) + (Protein x 4) + (fibres x 2)
Energy (kJ) = (Fat x 37) + (carbs x 17) + (Protein x 17) + (fibres x 8)

The calorific value is calculated using the following conversion factors:

- Carbohydrates (excluding polyhydric alcohols): 17 kJ g^{-1} - 4 kcal g^{-1}
- Polyhydric alcohols: 10 kJ g^{-1} - 2.4 kcal g^{-1}
- Protein: 17 kJ g^{-1} - 4 kcal g^{-1}
- Fat: 37 kJ g^{-1} - 9 kcal g^{-1}
- Salatrims[1]: 25 kJ g^{-1} - 6 kcal g^{-1}
- Ethyl alcohol: 29 kJ g^{-1} - 7 kcal g^{-1}
- Organic acids: 13 kJ g^{-1} - 3 kcal g^{-1}
- Dietary fibre: 8 kJ g^{-1} - 2 kcal g^{-1}
- Erythritol: 0 kJ g^{-1} - 0 kcal g^{-1}

Protein (Nx6.25)

Protein was assessed *via* the Kjhendal Method, using the protocol acquired from the German Society for Fat Research (ASU) L 17.00-15 (German Society for Fat Science, 2018). The Kjhendal method is a globally recognised reference method and comprises three main steps:

1. the sample is first digested in strong sulfuric acid in the presence of a catalyst, which helps the conversion of the amine nitrogen to ammonium ions;
2. ammonium ions are then converted into ammonia gas, heated and distilled. The ammonia gas is led into a trapping solution where it dissolves and becomes an ammonium ion once again; and,
3. amount of the ammonia that has been trapped is determined by titration with a standard solution, and a calculation made.

[1] **S**hort **a**nd **l**ong chain **a**cyl **tri**glyceride molecule**s** (salatrims) reduced-calorie fat substitutes.

Sugars

For sugar determination, an *in-house* method based using High Pressure Anion Exchange Chromatography / Pulsed Amperometric Detection (HPAEC / PAD) (Thermo Fisher Scientific, 2013) was performed, as described in brief below.

The sample to be analysed was finely ground and weighed into a volumetric flask. After adding 70-80 mL of demineralised water, the water-soluble sugars were extracted from the sample at 60 °C. After cooling, the volumetric flasks containing the sample were filled with water, shaken well and filtered to remove solids. For HPLC analysis, the liquid extracts were diluted (usually 1:25) depending on the sugar content expected. HPLC separation of the sugars (glucose, fructose, lactose, sucrose and maltose) was achieved using anion exchanger column using sodium hydroxide solution as eluent. Detection was performed in an electrochemical detector using pulsed amperometry on a gold electrode. Final quantification was performed in comparison to external standards of known sugar content.

Essential fatty acids

The well homogenised, possibly pre-dried and finely chopped sample is broken-down with hydrochloric acid and the digestion liquid is filtered through a filter moistened with hot water. The filter residue is completely removed from the acid by washing it out with hot water, dried and extracted with petroleum ether. The residue obtained after distillation of the solvent is dried and weighed. The fat content is calculated from the difference between the initial weight and the final weight and expressed in g 100 g^{-1}. The determination is carried out according to the, "*German standard method for the analysis of fats*". The method is retrieved from the Deutsche Gesellschaft für Fettwissenschaften e.V. (German Society for Fat Sciences, 2018) specifically *via* the Official collection of examination methods according to § 64 LFGB (DGF) C VI 11d.

Saturated fatty acids

The determination is carried out according to the, "*German standard method for the analysis of fats*". The method is retrieved from the Deutsche Gesellschaft für Fettwissenschaften e.V. (German Society for Fat Sciences, 2018) specifically *via* the Official collection of examination methods according to § 64 LFGB (DGF) C VI 11d.

Total dietary fibre

The content of total dietary fibre represents the amount of organic constituents, which are gravimetrically measured after extraction and enzymatic digestion of non-fibre material according to the method described below. The method is used for the analysis of dietary fibre substances primarily hemicelluloses, pectins, other non-starch hydrocolloids, resistant starch, cellulose and lignin.

Total dietary fibre was determined gravimetrically using the method described by the International Association for Cereal Science and Technology (ICC) No.156 (ICC, 2019). The method is designed for the determination of the total dietary fibre content of food in general and of cereal foodstuffs in

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particular. Samples, defatted if necessary, are gelatinised in the presence of heat stable alphaamylase, and then enzymatically digested with protease and amyloglucosidase to remove digestible protein and starch. Four volumes of ethanol are added to precipitate the soluble dietary fibre. Total residue is filtered off and washed with ethanol and acetone. The residue is then weighed after drying.

When needed, the remaining material may be analysed for protein and ash content, respectively. Subtracting the amounts measured for protein, ash and a blank control from the dry weight of the filtered residue yields a value for total dietary fibre content.

Sodium (Na)

Sodium (Na) was determined using atomic absorption spectrometry (graphite tube AAS, flame AAS). The acidified sample or the measuring solution obtained after pressure digestion of the sample is sprayed into the air-acetylene flame of an atomic absorption spectrometer. The absorbance is measured at a wavelength of 589.0 nm and expressed as sodium mass concentration according to the calibration. The standard method is used to determine the content of sodium, potassium, calcium and magnesium in fruit and vegetable juices in food - official method L 31.00-10, edition November 1983 (German Society for Fat Research (ASU) L 00.00-19/1+31.00-10).

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2.3 Results

The results of the nutritional analysis are summarised in Table 1.

Table 1 Nutritional composition (kcals; total protein; plant protein; added sugars; essential fatty acids; saturated fatty acids; dietary fibre and sodium) of the selected IGV-selected products: Pea *ProteinFLAKES*; Pea *ProteinCRISPIES*; *Red Lentil & Curry Pasta*; *Green Pea & Spirulina Pasta*; *Green Pea & Chlorella Pasta*; and, *Yellow Pea & Linseed Pasta*.

		Pea Protein FLAKES	Pea Protein CRISPIES	Red Lentil & Curry Pasta	Green Pea & Spirulina Pasta	Green Pea & Chlorella Pasta	Yellow Pea & Linseed Pasta
Kcals		401	385	333	329	334	333
Protein*		62.4	76	26.1	22.7	22.6	24.3
Plant protein*		62.4	76	26.1	22.7	22.6	24.3
Added sugars*	*Glucose*	< 0.10	< 0.10	0.26	= 0.41	= 0.41	= 0.47
	Fructose			0.10	< 0.10	< 0.10	< 0.10
	Lactose			0.10	< 0.10	< 0.10	< 0.10
	Maltose			0.10	< 0.10	< 0.10	< 0.10
Essential fatty acids*	Omega 3	10.79	7.07	7.98	7.12	7.82	12.97
	Omega 6	0.42	0.6	0.14	0.09	0.12	0.23
Saturated fatty acids*		1.2	2.1	0.3	0.3	0.3	0.4
Dietary fibre*		2.5	2.1	5.3	6.7	6	9
Sodium*		1.32	1.26	0.73	0.678	0.678	0.709

**All values are in g 100 g^{-1}*

2.4 Conclusion

The six IGV (vegan) legume-based products were satisfactorily analysed in terms of the following nutrients: essential fatty acids; saturated fatty acids; total protein; plant protein; dietary fibre; added sugars; sodium; and, kcals. From the analysis it was possible to conclude that the least caloric product is the Green Pea & *Spirulina* Pasta. The Red Lentil & Curry Pasta, the Green Pea & *Spirulina* Pasta and the Green Pea & *Chlorella* Pasta had the lowest protein contents. The Pea ProteinFLAKES and Pea ProteinCRISPIES had the highest kcal and sodium concentrations, but also the highest protein contents (above 60 g 100 g^{-1}). The Yellow Pea & Linseed Pasta had the richest fibre and essential fatty acid content from all the analysed products. The Pea ProteinCRISPIES had the highest protein concentration. The added sugars were very low for all tested products. The information provided here will be used in WP5 for generating the Proof of Concept LCA. Further novel foods (*e.g.* fava bean tofu, lentil "pancakes") developed by WP3 are also currently being analysed nutritionally for incorporation into WP5 LCA analysis.

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Annex I – Background to the TRUE project

Executive Summary - Abbreviated

TRUE's perspective is that the scientific knowledge, capacities and societal desire for legume supported systems exist, but that practical co-innovation to realise transition paths have yet to be achieved. TRUE presents 9 Work Packages (WPs), supported by a *Intercontinental Scientific Advisory Board*. Collectively, these elements present a strategic and gender balanced work-plan through which the role of legumes in determining '*three pillars of sustainability*' – '*environment*', '*economics*' and '*society*' - may be best resolved.

TRUE realises a genuine multi-actor approach, the basis for which are three *Regional Clusters* managed by WP1 ('*Knowledge Exchange and Communication',* University of Hohenheim, Germany), that span the main pedo-climatic regions of Europe, designated here as: *Continental*, *Mediterranean* and *Atlantic,* and facilitate the alignment of stakeholders' knowledge across a suite of 24 Case Studies. The Case Studies are managed by partners within WPs 2-4 comprising '*Case Studies*' (incorporating the project database and *Data Management Plan*), '*Nutrition and Product Development*', and '*Markets and Consumers'.* These are led by the Agricultural University of Athens (Greece), Universidade Catolica Portuguesa (Portugal) and the Institute for Food Studies & Agro Industrial Development (Denmark), respectively. This combination of reflective dialogue (WP1), and novel legume-based approaches (WP2-4) will supplies hitherto unparalleled datasets for the '*sustainability WPs*', WPs 5-7 for '*Environment*', '*Economics'* and '*Policy and Governance'.* These are led by greenhouse gas specialists at Trinity College Dublin (Ireland; in close partnership with Life Cycle Analysis specialists at Bangor University, UK), Scotland's Rural College (in close partnership with University of Hohenheim), and the Environmental and Social Science Research Group (Hungary), in association with Coventry University, UK), respectively. These *Pillar WPs* use progressive statistical, mathematical and policy modelling approaches to characterise current legume supported systems and identify those management strategies which may achieve sustainable states. *A key feature* is that TRUE will identify key *Sustainable Development Indicators* (SDIs) for legume-supported systems, and thresholds (or goals) to which each SDI should aim. Data from the *foundation WPs* (1-4), to and between the *Pillar WPs* (5-7), will be resolved by WP8, '*Transition Design',* using machine-learning approaches (*e.g. Knowledge Discovery in Databases*), allied with *DEX* (*Decision Expert*) methodology to enable the mapping of existing knowledge and experiences. Co-ordination is managed by a team of highly experienced senior staff and project managers based in The Agroecology Group, a Sub-group of Ecological Sciences within The James Hutton Institute.

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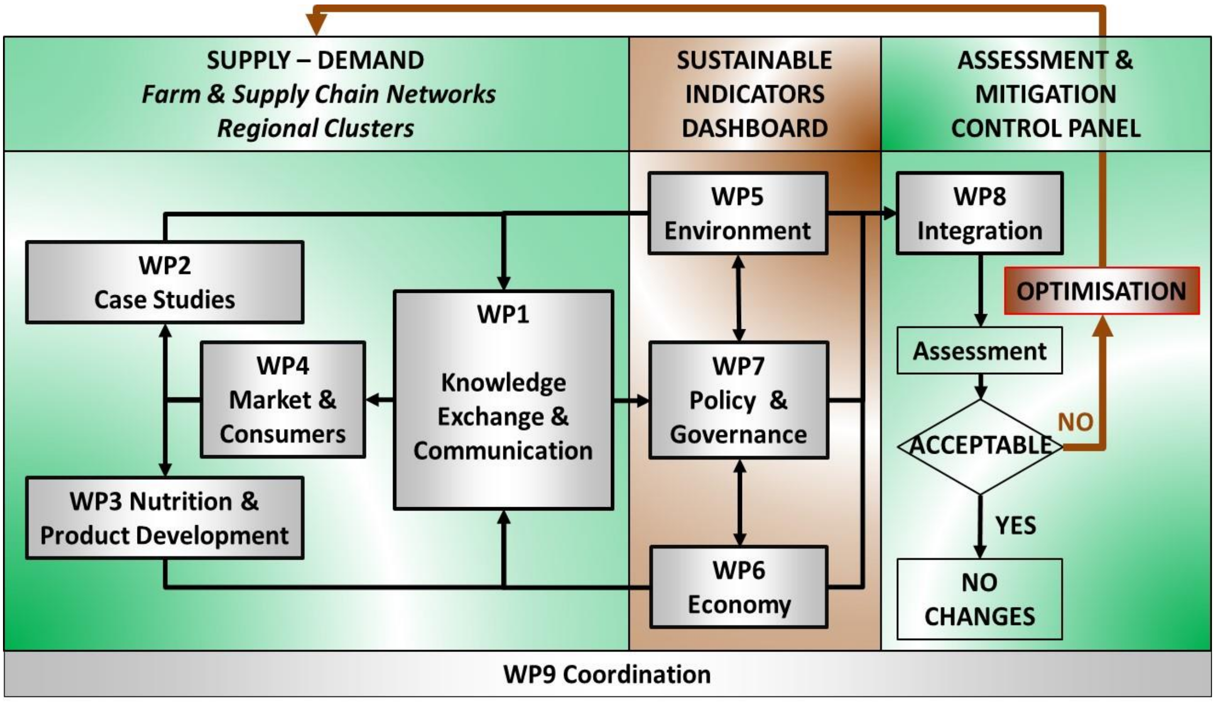
Work Package Structure - Diagram

Flow of information and knowledge in TRUE, from definition of the 24 case studies (left), quantification of sustainability (centre) and synthesis and decision support (right).



Project Partners - Table

No	Participant organisation name (and acronym)	Country	Organisation Type
1 (C*)	The James Hutton Institute (JHI)	UK	RTO
2	Coventry University (CU)	UK	University
3	Stockbridge Technology Centre (STC)	UK	SME
4	Scotland's Rural College (SRUC)	UK	HEI
5	Kenya Forestry Research Institute (KEFRI)	Kenya	RTO
6	Universidade Catolica Portuguesa (UCP)	Portugal	University
7	Universitaet Hohenheim (UHOH)	Germany	University
8	Agricultural University of Athens (AUA)	Greece	University
9	IFAU APS (IFAU)	Denmark	SME
10	Regionalna Razvojna Agencija Medimurje (REDEA)	Croatia	Development Agency
11	Bangor University (BU)	UK	University
12	Trinity College Dublin (TCD)	Ireland	University
13	Processors and Growers Research Organisation (PGRO)	UK	SME
14	Institut Jozef Stefan (JSI)	Slovenia	HEI
15	IGV Institut Fur Getreideverarbeitung Gmbh (IGV)	Germany	Commercial SME
16	ESSRG Kft (ESSRG)	Hungary	SME
17	Agri Kulti Kft (AK)	Hungary	SME
18	Alfred-Wegener-Institut (AWI)	Germany	RTO
19	Slow Food Deutschland e.V. (SF)	Germany	Social Enterprise
20	Arbikie Distilling Ltd (ADL)	UK	SME
21	Agriculture And Food Development Authority (TEAG)	Ireland	RTO
22	Sociedade Agrícola do Freixo do Meio, Lda (FDM)	Portugal	SME
23	Eurest -Sociedade Europeia De Restaurantes Lda (EUR)	Portugal	Commercial Enterprise
24	Solintagro SL (SOL)	Spain	SME

*Coordinating institution

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Objectives - Abbreviated

Objective 1: Facilitate knowledge exchange (UHOH, WP1)

- *Develop a blue-print for co-production of knowledge*

Objective 2: Identify factors that contribute to successful transitions (AUA, WP2)

- *Relevant and meaningful Sustainable Development Indicators (SDIs)*

Objective 3: Develop novel food and non-food uses (UCP, WP3)

- *Develop appropriate food and feed products for regions/cropping systems*

Objective 4: Investigate international markets and trade (IFAU, WP4)

- *Publish guidelines of legume consumption for employment and economic growth*
- *EU infrastructure-map for processing and trading*

Objective 5: Inventory data on environmental intensity of production (TCD, WP5)

- Life Cycle Analyses (LCA) -novel legumes rotations and diet change

Objective 6: Economic performance - different cropping systems (SRUC & UHOH, WP6)

- *Accounting yield and price risks of legume-based cropping systems*

Objective 7: Enable policies, legislation and regulatory systems (ESSRG, WP7)

- *EU-policy linkages (on nutrition) to inform product development/uptake*

Objective 8: Develop decision support tools: growers to policy makers (JSI, WP8)

- *User friendly decision support tools to harmonise sustainability pillars*

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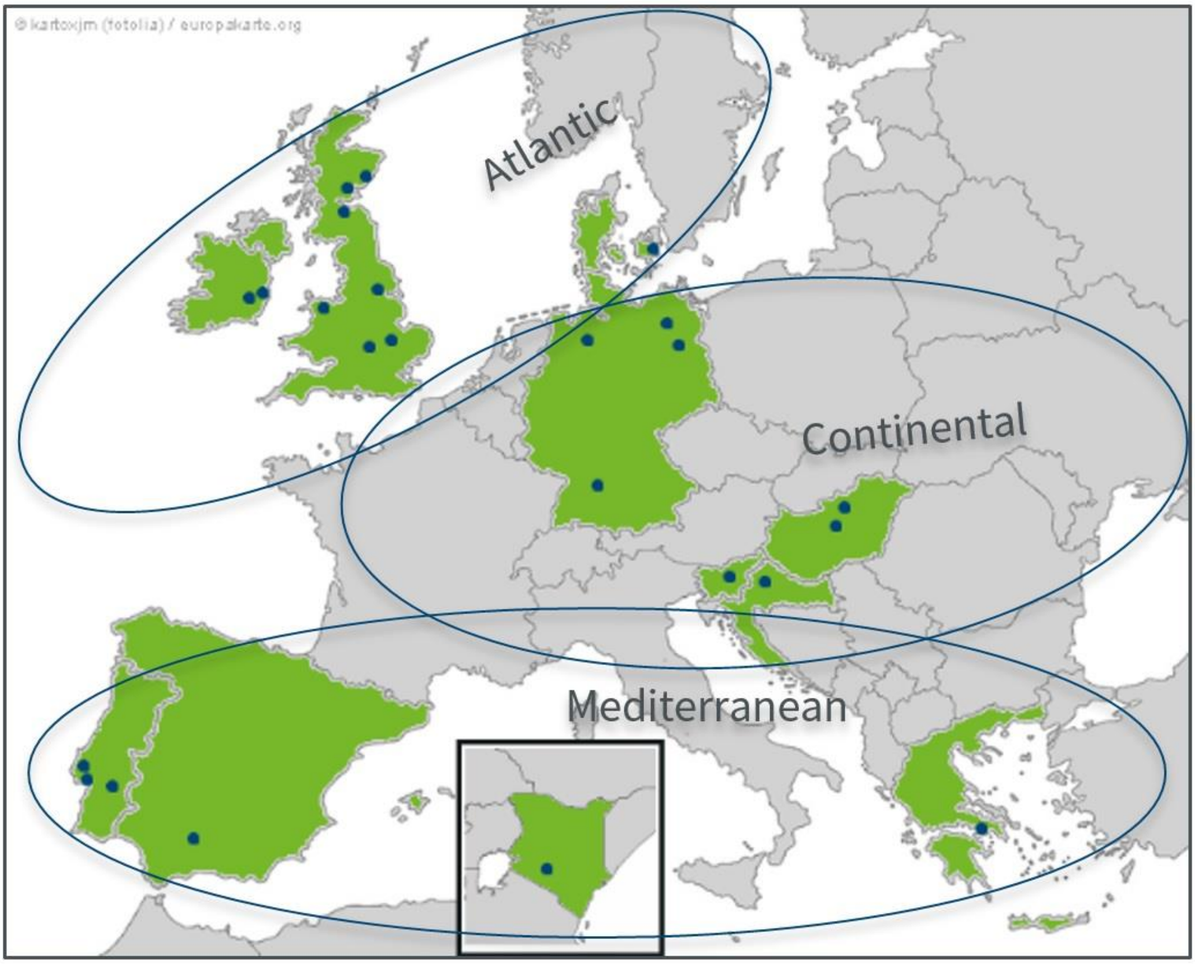
Regional Cluster & Case Studies – Diagrams



Knowledge Exchange and Communication (WP1) events include three TRUE European Legume Innovation Networks (ELINs) and these engage multi-stakeholders in a series of focused workshops. The ELINs span three major pedoclimatic regions of Europe, illustrated above within the ellipsoids for Continental, Mediterranean and Atlantic zones.

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Annex II - IGV Nutritional Declaration Form

Examples of IGV Declaration Form showing nutritional data which will support LCA analysis and protype labels presenting nutritional information and environmental impact metrics for final products.

IGV

Declaration form based on Food labeling regulations (LMVI)

CONTACT OF THE PRODUCER
IGV GmbH
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14558 Nuthetal
Germany

Department
Administration
Research and Product Management

Marketing/Sales
Mario Krause
Phone +49 33200 89-124

PRODUCER
IGV GmbH
Arthur-Scheunert-Allee 40-41
14558 Nuthetal
Germany

PRODUCT
ProteinCRISPIES
85 g Protein/ 100 g

NOTE
The food regulatory responsibility is held exclusively by the private-label producer for the compulsory food labeling of the final consumer packaging.

The IGV Declaration Form represents merely a support for the labeling of the final product. Attention should be paid especially to Health Claims according to EU regulation.

Product name	ProteinCRISPIES
Sales description	Plant-based High Protein Food
List of ingredients (ingredients with allergenic potential are highlighted in bold text)	Pea protein
Allergen information (possible cross contamination)	Allergen-free, Lactose-free, Gluten-free, may contain traces of gluten
GMO-information	GMO-free
Filling quantity information	Large containers 25kg or Big Bag In the final product 250-350 g depending on private-label producer
Durability indication	12 months storage in a dry place, at room temperature 21° C
Requirements on storage and use	At room temperature, after opening stored dry and protected from light
Producer information, Indication on the marketing	IGV GmbH Arthur-Scheunert-Allee 40-41 14558 Nuthetal
Nutrition claim	"High protein" according to Regulation EC (No.) 1924/2006

Nutritional facts	**Nutrition facts label**	**Unit (pro 100 g)**
	Energy	**1623 kJ / 385 kcal**
	Fat, of which:	8,5 g
	› **saturated fatty acids** › monounsaturated fatty acids › polyunsaturated fatty acids	2,1 g 2,5 g 3,9 g
	Carbohydrates, of which:	< 1,0 g
	› **Sugar**	0,3 g
	Dietary fibre	2,1 g
	Protein	76,0 g
	Salt	3,15 g
	Total minerals	4,75 g

CONTACT DETAILS Private label buyers		
	Company	
	Contact	
	Phone	
	E-Mail	

Figure 2. ProteinCRISPIES Nutritional Fact Sheet

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Specification Sheet

IGV

Date of issue	01 Dec 2015	**Shelf life**	4 years
Product name	Organic Spirulina Powder	**Storage condition**	Store in well closed container, cool and dry
Bioanical name	Arthospira platensis	**Country of origin**	USA

Test parameters	**Specification**	**Method**
Appearance	Fine dark green powder	
Odour	Characteristic	
Moisture	≤7.0 %	AOAC 935.29A/925.09B
Ash	≤ 12.0 %	AOAC 923.03/942.05 (modified)
Particle size	100 % through 40 mesh	USP29 786
Chlorophyll	≥ 0.9 %	AOAC 940.03/942.04 (modified); Talling Driver 1963
Bulk density	0.35-0.6	USP24 NF 19616 (modified)
Total Carotenoid	≥ 370 mg%	AOAC 941.15 (modified)
β- Carotene	≥ 120 mg%	AOAC 941.15 (modified)
Phycocyanine	≥ 10 %	In-house
Protein	≥ 55%	AOAC 2001.11
Microbiology		
Standard plate count	≤ 10^5 cfu/g	AOAC 990.12
Coliform germs	negative	AOAC 991.14
E. coli	negative	AOAC 991.14
Yeast	≤ 40 cfu/g	AOAC 997.02
Mold	≤ 100 cfu/g	AOAC 997.02

The information contain in this document is accurate to the best of our knowledge but does not imply any guarantee. We are not liable for its interpretation or use: the consumer must carry out independent examination of the product for the intended use. Any relevant legislation or patents governing the use of the product should be observed.

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Figure 3. *Spirulina platensis* Nutritional Fact Sheet

This Project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 727973

Specification Sheet

IGV

Date of issue	03 July 2017	**Shelf life**	2 years
Product name	Chorella Powder	**Storage condition**	Store in well closed container, cool and dry place
Carrier	none	**Country of origin**	South Korea

Test parameters	**Specification**	**Method**
Description	green powder	visual
Odour	Characteristic	Organoleptic
Loss on drying	< 5.0 %	FCC/USP >731<
Residue on ignition	< 6.0 %	FCC/USP <281>
Heavy Metals (as Pb)	≤ 10 ppm	USP <231> Method II
Lead (Pb)	≤ 1 ppm	FCC, Lead Limit test
Cadmium (Cd)	≤ 1 ppm	Atomic Absorption Spectrometry
Mercury (Hg)	≤ 0.1 ppm	Atomic Absorption Spectrometry
Arsenic (as AS_2O_3)	≤ 1 ppm	FCC, Arsenic Limit Test
Iron	≥ 10.0 mg/100g	Atomic Absorption Spectrometry
Bulk density	> 0.3 g/ml	USP <616>
Tab density	> 0.4 g/ml	USP <616>
Crude protein	≥ 50.0	Kjeldahl Method
CGF Chlorella growth factor	> 0.4 Abs	Reference
Existed pheophorbide	< 50 mg/100g	UV/ Spectrophotometry
Total pheophorbide	< 70 mg/100g	UV/ Spectrophotometry
Chorophyll	> 2000 mg/100g	UV/ Spectrophotometry
Other materials	not include	Visual inspection
Microbiology		
TAMC	$\leq 5 \times 10^5$ cfu/g	EP7- 2.6.12
TYMC	$\leq 5 \times 10^4$ cfu/g	EP7- 2.6.12
E. coli	negative /g	EP7- 2.6.31
Salmonella	negative / 25g	EP7- 2.6.31

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Specification Sheet

IGV

Manufacturer certifies	
Irradiation	Product has not been treated with ionizing radiation and does not contain any ingredients which have treated with ionizing radiation.
GMO	Product does not contain or consist of GMO´s acc. to Regulations (EC) no. 1829/2003 and 1830/2003. Product does not require GMO-labelling acc. to Reg. (EC) 1829/2003 and 1830/2003.
BSE/TSE	Product is not derived from specific risk materials as defined in European Commission Decision 97/534/EC.
Food grade	Product is apt for human consumption
PAH 4	Product is in accordance with Commission Regulation (EU) 2015/1933 (Yearly tested on representative batch)
Allergens	Product is free of allergens according to Regulation (EC) No 1169/2011
Vegan	Product is suitable for vegan consumption.
Pesticides	Product is conform to the European Regulation, Directive 396/2005/CE and its modifications.

Data as received by our supplier / manufacturer. This information is given without obligation and does not exempt the buyer from carrying out own investigations and tests in order to ascertain the products specific suitability for the purpose intended. The buyer is solely responsible for the application, utilisation and processing of the products, and must observe the laws and government regulations and the consequential rights of any third party.

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Figure 4. *Chlorella vulgaris* Nutritional Fact Sheet

This Project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 727973