Vegetable Protein: a winner?

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A key constituent of the body, protein is essential for life: structural proteins, hormones, enzymes, the immune system – these and more depend on it. The recommended daily intake for a healthy adult is either 0.8g per kilo of body weight (EFSA, 2012) or a dose that delivers 10-15% of daily calorie intake (WHO, 2005).

In 1960 the average world consumption of protein accounted for approximately 11% of the total calorie ration, or approximately 25g per person per day. Today consumption has climbed to around 36g, of which animal protein forms the larger increase (a trend correlating with GDP (Combris, 2013)): while vegetable protein consumption has increased by 15%, that of animal protein has doubled, although with enormous variations from one country to another. Protein consumption figures should also be viewed in the light of the fact that over one third of global cereal production (800 million tonnes in 2011 - FAO stat, Food and Agriculture Organization of the United Nations) is incorporated in the feed of animals reared for their meat (protein).

Such trends are associated with general changes in lifestyles and standards of living. These raise the problem of the environmental cost of producing protein, as well as the question of how, against a background of regional economic inequality, an ever-growing world population is to be fed while taking into account issues like the sustainability of food consumption patterns, availability, the preservation of natural resources and climate change.

The French National Health and Nutrition Programme recommends that the ratio between animal and vegetable protein consumption should be balanced equally (Rémond, 2012). Since it would be both difficult to attain or even accept universal animal protein availability at the level it has reached in the most developed countries, it goes without saying that vegetable protein availability should be increased. An added advantage of doing this would be that vegetable protein offers a great number of special benefits, many of which are still not fully appreciated.

Good nutritional quality

<u>General considerations and methods of evaluation and comparison</u>

Despite its importance, the nutritional value of protein has often been neglected. Animal protein tends to be regarded as the benchmark even though its excessive consumption may have negative consequences for both the individual and the environment. The nutritional quality of protein depends on the amino acid profile of the source and on its digestibility. Of the 20 different amino acids that make up proteins, 8 are essential because they are not synthesised by the body. We therefore have to depend on our food to obtain their benefits. The main sources of vegetable protein (Fig. 1) are the leguminous (such as the pea), cereals, oilseeds, root vegetables, green leaves and fruit; each of these has a specific composition (Fig. 2) and bioavailability – and therefore varying nutritional values.

Protein content in %				
Meat Fish Egg	Milk Dairy Products	Leguminous seeds	Cereal seeds	Fresh Fruit Fruit Tubers
13 - 22	3.5 - 26	16 - 30	6 - 13	0.5 - 5

Fig. 1: Protein content (in %) of various sources of food protein. According to Quillien and Gueguen, 1997.

Generally speaking, vegetable sources of protein are less concentrated and have a lower caloric value than animal sources, but are richer in complex carbohydrates, fibre, vitamins, minerals and unsaturated fat (oilseeds). At the same time they are lower in saturated fat and cholesterol, which may bring metabolic and cardiovascular benefits.

Fig. 2: Protein content of some vegetable sources. Taken from the USDA National Nutrient Database, 2013.

Type of food	Protein (g/100g)	Protein (g/1000kcal)
Cereals		
Wheat	12,4	36,87
Oats	16,89	43,42
Rice	7,08	19,45
Wild rice	14,73	41,26
Leguminous plants		
Peanuts	25,8	45,5
Broad beans	26,12	76,6
Lentils	25,38	72,71
Split peas	24,55	71,99
Soybean (tofu)	11,83	90,55

Some results tend to show that a diet with more animal than vegetable protein could pose the risk of osteoporosis in elderly women. By contrast, there is a correlation between increased consumption of vegetables and a lower incidence of cancer (plus an increase in life expectancy). A healthier overall lifestyle (physical exercise and reduced consumption of alcohol, tobacco, etc) also plays its part, as does a correlation with a more favourable body composition (less fat).

Bioavailability, i.e. the proportion of amino acids that, after digestion and absorption, becomes available to the metabolism, is on the whole lower in vegetable sources, with individual amino acid compositions sometimes less well balanced. One of the limiting factors arises from the variability of amino acid deficiencies: for instance, cereals and some seeds often contain less lysine than many leguminous plants which, in turn, have a deficiency in sulphur-containing amino acids. Threonine and tryptophan, too, are seen to be less available in a variety of vegetable proteins. This explains the importance and usefulness of combining various vegetable sources to prepare proteins blends or concentrates, consistent with the recommendations of eating several different sorts of fruit and vegetables on a daily basis to ensure a good nutritional balance.

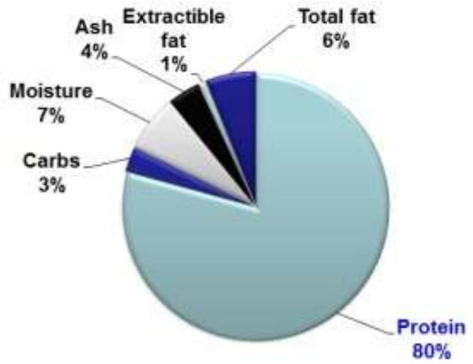
As comparative reviews of protein digestibility of some common foods have shown (FAO/WHO, 1991), the results obtained using rat or human balance methods are similar because of the similarities of proteins' digestion process. This research has produced an accurate assessment of digestibility by calculating the difference between the inputs and faecal outputs of nitrogen compounds, expressed in the form of a nitrogen input percentage, after correction for the faecal nitrogen by metabolic losses observed in a protein-free diet (true digestibility = nitrogen ingested minus (faecal nitrogen minus faecal metabolic nitrogen)/Ingested nitrogen).

Evaluation of protein quality is then carried out using the Protein Digestibility-Corrected Amino Acid Score or PDCAAS. Despite its limitations and the current search for an even more precise and realistic means of nutritional quality evaluation, the PDCAAS offers a uniform and tested methodology that allows various proteins to be accurately compared (FAO/WHO, 1991). In this connection, a PDCAAS value of 100% corresponds to a protein that after digestion has supplied 100% or more of the indispensable amino acids.

<u>The industrial reality</u>

The agri-food industry develops vegetal proteins as ingredients, which they obtain from wheat, soybean, pea and lupin. These "vegetal raw materials" have enhanced bioavailability and concentration. The protein concentration depends on the types of product, i.e. the flours, concentrates or isolates whose nutritional or functional applications may differ. The concentrates can contain up to 80% protein (35-80%) whereas the isolates may contain up to 90%. Hydrolysates are isolates or concentrates that have been pre-digested by specific enzymes. All these preparation and transformation processes have an impact on the digestibility of the products obtained by modifying, for example, the extent of the indigestible carbohydrate network present in the plant through impacts on network structure, or even by eliminating anti-nutritional factors. In addition, the concentration or extraction processes selected may themselves influence the technological or nutritional functionalities of the products. Lastly, special attention today is also focused on the efficiency – in other words, the speed – with which the amino acids are used by the body. Related to this characteristic, the protein composed of these amino acids is called “slow” or “fast” (Boirie, 2004).

The yellow pea (or feed pea)



The yellow pea (*Pisum sativum*) is a leguminous plant with seeds rich in protein (a composition that varies with variety, environment, culture, genetics, etc). The protein concentration is approximately 25%, an amount somewhere between cereals (10-15%) and soybeans (35%). Growing the pea in a crop rotation system has the advantage of being beneficial for the environment since it requires little water or fossil-based energy and no nitrogen fertilizer, while also helping to cut down greenhouse gas emissions. In addition it increases the yield of the crops planted after it and, moreover, requires less acreage to produce 1 kg of protein than many other plants. Beyond that, pea protein can satisfy the nitrogen needs of humans (Mahé *et al.*, 1997) and demonstrates good digestibility and nitrogen retention properties (Gausserès *et al.*, 1997).

During its industrial processing, anti-nutritional factors (lipoxygenases, lectins, tannins and protease inhibitors) are eliminated by “clean” separation (without chemical solvents). The concentrate that results therefore contains few anti-nutritional factors, few complex sugars and a low fat content with a favourable fatty acid profile (80% unsaturated fatty acids). It also has increased bioavailability.

The intestinal digestibility of Roquette’s NUTRALYS® pea protein, based on animal studies, has been evaluated at approximately 97.3% (as against 98% for casein) whereas the PDCAAS was estimated at 85% in children aged between 3 and 10 years and 93% in adults (Yang *et al.*, 2012). The quality of this protein is therefore similar to that of casein, eggs and soybeans, and much better than that of the conventional sources of vegetable protein. Furthermore, its aminogram is rich in the lysine that plays an important role in growth and bone health; in the branched-chain amino acids (isoleucine, leucine and valine) important for muscle cell composition; in the arginine that sustains physical effort and the efficacy of the immune system; and in glutamine, a source of energy for the muscles during stress.

Thus, despite the fact that methionine and cysteine constitute the proportion of limiting amino acids in this protein, a mix of 20 % pea protein with 80% wheat flour (PDCAAS 45) results in an estimated PDCAAS of 100 (on the basis of the FAO 2008 recommendations).

Applications for the daily food diet

The specific but varying composition of various protein preparations obtained from different vegetable sources enables the minimum daily intake recommendations to be achieved, either by consuming a sufficient quantity of proteins that have a complete profile, or by consuming an adequate variety of incomplete ones, or, as previously mentioned, by mixing the two. In the case of the supply of ingredients for the food industry, various formats exist enabling needs to be met: these needs can be as varied as those of conventional human food requirements (meat, soups, sauces, pasta, pastries, etc); specific nutrition (bars, powder mixes, etc); specialised nutrition (seniors, vegetarians, etc.); and even medicalised nutrition (clinical nutrition).

Vegetable protein and health

It is universally recommended that sports enthusiasts and elderly people should increase their daily protein intake (Campbell *et al.*, 2007; Wolfe *et al.*, 2008). Protein is known to be more satietogenic at isocaloric value than carbohydrates or fats. Little is known about the influence of protein (vegetable/animal) on appetite, calorie intake or weight control, but it would appear that vegetable protein can be as effective as animal ones. (Anderson *et al.*, 2007; Liao *et al.*, 2007). Insulin and the glycemic control (Duranti *et al.*, 2006, Ascensio *et al.*, 2004) could also be influenced by the nature of the protein. As far as bone health is concerned, there is little evidence that vegetable protein would be more efficient than animal ones such as milk proteins (Jesudason and Clifton, 2011).

Compared with vegetable protein, the consumption of animal protein has also been positively linked with overweight and obesity (Bujnowski *et al.*, 2001). While vegetarianism plays a very minor role in France (2%), it is more widespread in Germany and Italy, as it is in the USA (25 million) and in India (40% of the population). Many studies have shown that vegetarians tend to be in better health than non-vegetarians. However, we should not forget that these studies are based on model populations in which little or no alcohol is consumed, smoking is avoided and regular physical exercise prevalent. The influence of lifestyle on the benefits observed should not be underestimated. Generally speaking, such model populations are characterised by lower Body Mass Index values (reflecting greater determination to control food intake, to take more regular physical exercise and to consume more fibre) as well as by a lesser risk of type 2 diabetes, cardiovascular disease, etc. Such features must of course also be influenced by the overall composition of food intake (including oils, carbohydrates, anti-oxidants, etc) and not just simply of the protein component (Lamisse, 2013).

In line with these trends, the World Cancer Research Fund/American Institute for Cancer Research (2007) has drawn up its own recommendations for protecting against cancer: cutting down the proportion of foods with a high caloric density (added sugars, low fibre, rich in fat); increasing and varying the consumption of vegetables, fruit, whole grain cereals and dry vegetables; reducing the consumption of red meat (beef, pork and lamb); and avoiding processed meat products.

Some vegetable proteins are included in the regularly updated list of major allergens (including lupin, soybean, gluten and nuts) and this entails an obligation to label. Conspicuously, *pisum sativum* is not on this list, with no epidemiological evidence for allergy to pea protein available. Similarly, no data can be found on pea allergies (NIAID-Sponsored Expert Panel, 2010), although there is data on cross allergies.

Conclusion

Vegetal protein offers health benefits with advantageous nutritional profiles, in particular by mixing its sources. The bioavailability of protein preparations can be improved through the production and extraction processes. Vegetable protein production's sustainability profile is also highly attractive when compared with animal protein, given the former's advantageous economic and ecological cost-benefits, which include preservation of the environment.

Even with these self-evident potential advantages, research work is of course still necessary, on the one hand to obtain a better understanding of vegetable protein's nutritional parameters; and on the other to improve our knowledge of human physio-pathological needs. The research will help to identify the complementarities and synergies between the two. Meanwhile, technological improvements can help to make it possible to incorporate protein matter of vegetable origin in most food applications.

Looking to the immediate future the power of vegetable proteins is now offering yet more alternatives. Amongst these are microalgae, of which an example is Roquette's *Chlorella sp*. Containing more than 50% proteins and opening up exciting perspectives, its high quality composition deserves urgent attention.

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