Bioactivity of legume components

Bio-fonctionalités des composants de légumineuses

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Legumes are recognised to contain not only nutrients but also functional compounds, that may provide a health benefit beyond basic nutrition. However, research needs to be focused on bioavailability of micronutrients and bioefficacy of non-nutrient compounds to increase the potential of legumes as functional foods and confirm their role in health promotion and disease prevention.

About legume benefits

Besides being an excellent source of protein, legumes are rich in minerals and trace elements (magnesium, potassium, calcium, iron, zinc, copper and manganese). As beans are good sources of magnesium and potassium, they may decrease the risk of cardiovascular disease by helping to lower blood pressure. Legumes contain several B-vitamins. They have low levels of total and saturated fats and are cholesterol-free.

Beans, especially *Phaseolus* spp. L., are a major source of soluble fibre (Table 1), and it is this fibre fraction that helps to lower cholesterol levels and may reduce the risk of heart disease. In addition, soluble fibre helps to regulate blood glucose levels. As they have a low glycaemic index (a measure of the rise in blood glucose after a food is consumed), legumes are useful in the diets of diabetics.

Some evidence also indicates a protective effect of legume fibre on the risk of development of colon cancer.

Beans contain a number of non-nutrient physiologically active compounds (phytochemicals), including simple phenolics, especially flavonoids (phytoestrogens and catechins), polyphenols (tannins), phytates, saponins, alkaloids and sterols. Many of these compounds have been reported to be able to reduce the growth of different types of cancer cells and to lower cholesterol levels.

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Table 1. Content in major bioactive compounds of dry legumes (% dry weight basis).

Legume species	Phytic acid	Polyphenols*	Tannins**	α-Galactosides	Dietary fibre		
					Total	Soluble	Insoluble
Common bean							
white varieties	1.0	0.3	nd	3.1	18.5	2.3	16.2
brown varieties	1.1	1.0	0.5	3.0	18.4	2.3	16.1
Faba bean	1.0	0.8	0.5	2.9	21.1	1.6	19.5
Lentil	0.6	0.8	0.1	3.5	14.7	1.2	13.5
Chickpea	0.5	0.5	nd	3.8	14.0	1.2	12.8
Pea	0.9	0.2	0.1	5.9	12.0	1.1	10.9
Soyabean	1.0	0.4	0.1	4.0	11.9	0.9	11.0

*Tannic acid equivalents; **catechin equivalents; nd = not determined.

Several research findings have shed light on the real risk of adverse health effects from the so-called 'antinutritional factors' present in the seed: such risk has been limited mainly to the high content of heat-stable (non-protein) compounds (such as tannins and phytic acid), and to the well-known hazard of specific compounds for susceptible subjects (i.e. vicine and convicine for people affected by favism).

Plant breeding methods have the potential to change legume seed composition so that specific antinutritional factors are reduced. However, the use of processing procedures, such as thermal treatments, fermentation, germination and soaking, that are effective in reducing antinutrient levels remains an important strategy.

Trace element bioavailability

Legumes are good sources of trace elements, especially iron, zinc, copper and manganese. It has been recognised that some trace elements, especially iron, zinc and copper have a role in health besides their established nutritional function: maintaining gastrointestinal mucosal integrity and improving immune response to infections are two such examples.

Trace elements of plant origin, however, are often poorly available. In legume seeds, iron is present in the non-heme form, which is far more sensitive to enhancers and inhibitors of diet origin than heme iron. Amino acids (mostly cysteine), ascorbic acid, citric acid, and fructose enhance iron absorption, whereas phytate, polyphenols, oxalate and even calcium are inhibitors (7). Similarly, amino acids such as histidine and cysteine are promoters of zinc absorption; only phytate has been demonstrated to be a strong inhibitor of zinc bioavailability, but other known inhibitors are oxalate, fibre, EDTA, and polyphenols (especially tannins). The latter are inhibitors of copper absorption, too.

Trace element bioavailability can be improved by processing, such as germination and fermentation, that increase the activity of endogenous phytases and polyphenol-degrading enzymes. More research is needed to establish the effect of cooking on trace element bioavailability, taking into account that indirect effects on mineral bioavailability may result from modifications in protein solubility and digestibility (1, 3).

The planning of strategies for improving bioavailability will benefit from increasing knowledge of the chemical form of trace elements in plant foods and their speciation during processing and gastrointestinal digestion.

The prebiotic effect

Because humans lack the enzymes capable of digesting the raffinose-like sugars in beans, bacterial fermentation in the colon may cause intestinal discomfort. On the other hand, non-digestible α-galactosides (like raffinose) have recently been hypothesised to have prebiotic properties, similar to those ascribed to inulin and other fructooligosaccharides of cereals. A prebiotic is a non-digestible food ingredient that affects the host beneficially by selectively stimulating the growth of helpful commensal bacteria in the colon.

Some oligosaccharides have functional effects, such as improvement of glucose control and modulation of the metabolism of lipids, that are similar to those of soluble dietary fibre. Moreover, possible enhancing effects of non-digestible carbohydrate on mineral (calcium, magnesium, iron) absorption has been reported (8).

Prebiotic properties of non-digestible oligosaccharides contained in legume seeds (raffinose, stachyose, verbascose) need to be assessed in further studies.

How bioactive are phenolics?

Phenolic compounds, including their major subcategory, flavonoids, have been studied extensively in legumes. Both highly polymerised polyphenols, that is tannins (M_r 500-5,000), and low molecular weight phenolics (phenolic acids, flavonoids) have been found to be present (0.01-4.0 g/100 g of dry weight). Low molecular weight phenolics of legumes are predominantly of flavonoid origin, although the concentration varies widely among the different legume species.

Oligomeric proanthocyanidins (2-10 catechin units), compounds with a wide range of pharmacological activity, including protection against collagen destruction, antimicrobial and ulcer activity, have been found recently in significant amounts in the testa of lentil seeds (*Lens culinaris* L.) and in broad beans (*Vicia faba* L.) (0.16 g/100 g).

Bioavailability assessment is of key importance to the bioactivity claimed for most of the legume phenolics (6). Gallic acid and catechin are well-absorbed and the soy isoflavones (phytoestrogens), genistein and daidzein, appear to be sufficiently bioavailable to humans to act *in vivo*. However, contrasting data on their potential in preventing hormone-dependent cancers (for example, breast and prostate) have been provided.

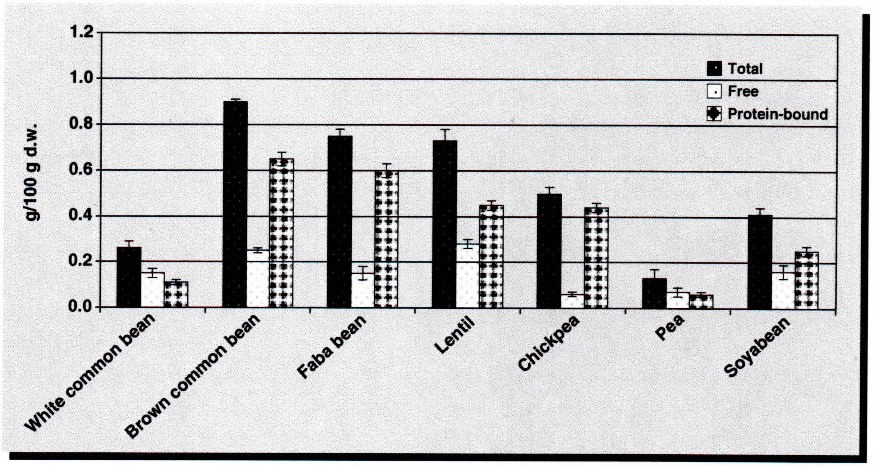

Figure 1. Total, free and protein-bound polyphenols in different legume species (M. Carbonaro, unpublished results).

Not enough data have been collected hitherto on the absorption and bioefficacy of the other flavonoids from legumes. The degree of polymerisation, galloylation and glycosylation also affects the antioxidant properties of catechins and proanthocyanidins. Their absorption through the gut barrier is probably limited to the molecules with a low degree of polymerisation and to metabolites (partially unknown) formed by the colonic microflora. Moreover, most polyphenols have a high affinity for proteins. Interaction with proteins has been reported to impair bioavailability of phenolics (catechin, tannic acid) in the small intestine (2). A significant number of legume phenolics have been found to be bound to proteins in the seed (Figure 1).

It appears that further studies of the bioavailability of phenolic non-nutrient compounds of legumes and the related influencing factors are still required. The possibility of systemic effects or local effects in the gut also needs to be ascertained.

Legume proteins are bioactive

Legume seed proteins, notably those from soyabean, have been demonstrated to exert cholesterol-reducing properties, thus representing powerful bioactive components (4). Moreover, bioactive peptides from soy digestion have been found to exert activity on the immune system and on the gastrointestinal tract.

Recently, lupin proteins have also been shown to present similar properties to those of soyabean in relation to cholesterolaemia, thus representing an alternative to soy proteins in Western Europe. Evidence of the possible use of a protein from lupin (conglutin γ) in the control of glycaemia has also been presented (5).

Phaseolus vulgaris L. contains a proteinaceous inhibitor of alpha-amylase, named phaseolamin, which was first discovered in 1975, and has attracted much interest in recent years because of its ability to slow down starch digestion.

Recent research findings have highlighted an increasing number of health benefits from legumes and considerable other research is being performed on legume bioactivities.

Although legumes are certainly rich in compounds that may potentially protect from the risk of cancers and from cardiovascular disease, the results of epidemiological studies do not yet provide any conclusive conclusion regarding these points. However, there is already sufficient scientific evidence to recommend increasing consumption of legumes from different species rich in bioactive compounds to improve health and well-being. ■

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