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Cardiovascular and renal benefits of dry bean and soya bean intake

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Dry beans and soya beans are unique foods because of their rich nutrient content. These legumes contain complex carbohydrates, vegetable protein, dietary fibre, oligosaccharides, phytochemicals (especially the isoflavones in soya), and minerals.

Soya protein is recognised as a 'complete' protein, with a protein digestibility-corrected amino acid score of 1, equivalent to the gold standard, egg albumin. Its dietary fibre components include both soluble and insoluble fibres, which offer many health benefits, and the isoflavones genistein and daidzein, which are unique to soya beans, have numerous biologic functions. Finally, the minerals in beans are readily available, which is important in reducing several health risks.

Nutrient profile

Some of the major nutrients provided by dry beans and soya beans are shown in *Table 1*. Dry beans provide more complex carbohydrates than soya beans. Both types of beans have limited amounts of simple carbohydrates. The oligosaccharides – raffinose, stachyose, and verbascose – in dry beans and soya beans give legumes some of their notoriety because they are not hydrolysed in the small intestine and are fermented to short-chain fatty acids (SCFAs) and gas in the colon.

Dry beans are inexpensive sources of plant protein with the potential to be used worldwide as substitutes for animal protein sources. The protein content of most beans (uncooked) averages 20 to 25% by weight, whereas the protein content of soya beans is approximately 36% by weight. Although dry beans are rich in essential amino acids, they fall short in methionine and tryptophan content, requiring the consumption of larger amounts of protein to meet the nutritional requirements for these essential amino acids. In contrast, soya protein food is equivalent in quality to animal protein sources.

Isolated soya protein has the same protein digestibility-corrected amino acid score as casein and egg protein. The fat content of dried beans averages only 1% by weight, with unsaturated fatty acids predominating. Soya beans are richer sources of fat (18 to 20% by weight) and contain saturated, monounsaturated, and polyunsaturated fatty acids (15, 23, and 58% of total fat, respectively). The polyunsaturated fatty acids in soya beans are linoleic acid and a-linolenic acid.

Dry beans contain a mixture of soluble fibre, which significantly lowers cholesterol and blood sugar concentrations, and insoluble fibre, which aids in gastrointestinal function. Beans contain an average 6g total and 2g soluble fibre per serving. Up to 30% of the fibre in soya beans is soluble. Soya fibre measurably lowers the postprandial increase in serum glucose concentrations but has only a modest effect on serum cholesterol concentrations. Uncooked soya beans contain 5,4g total and 2g soluble fibre per serving. Many soya foods, such as soya beans, soya nuts, green soya beans, soya flour, textured soya protein and tempeh, are rich in fibre; isolated soya protein, however, does not include dietary fibre.

Dry beans and soya beans are low in sodium but are excellent sources of

Table 1: Nutrition profile of dry beans and soya beans, expressed per 100g dry weight.

Nutrient	Dry beans	Soya beans
Complex carbohydrates (g)	56	21
Simple carbohydrate (g)	4	9
Stachyose (mg)	1 848	3 300
Raffinose (mg)	336	1 600
Protein (g)	22	36
Total fat (g)	1	19
Saturated fat (g)	0,3	2,8
Monounsaturated fat (g)	0,11	4,4
Polyunsaturated fat (g)	0,55	11,2
Ratio of a-linolenic to linoleic acid (mg)	0,252:0,301	1,3:9,9
Insoluble fibre (g)	11	10
Soluble fibre (g)	6	7
Calcium (mg)	154	276
Magnesium (mg)	172	280
Potassium (mg)	1 140	1 797
Iron (mg)	6,4	16
Zinc (mg)	2,5	4,8

minerals, including calcium, copper, iron, magnesium, phosphorus, potassium, and zinc. The content and bioavailability of minerals in dry beans and soya foods vary according to the processing methods and phytate content.

Coronary artery disease

Cardiovascular disease is a major medical and public health concern in Western and developing countries all over the world. Dietary interventions to reduce heart disease risk include attention to the consumption of types of fatty acids, dietary fibre, isoflavones, and antioxidants. Dry beans and soya foods contribute to all these areas.

Fatty acids

Dry beans are essentially fat-free and act to displace fat from the diet. Many soya foods have moderate amounts of oil that is predominantly unsaturated. Linoleic acid (51%) is the predominant fatty acid of soya food and has specific actions on eicosanoid synthesis and metabolism, lipid peroxidation, and platelet aggregation, some of which may be detrimental.

Soya food also provides a-linolenic acid (7%), an n23 fatty acid not commonly found in plant food, which has specific effects on eicosanoid synthesis and metabolism and appears to have favourable effects on platelet reactivity. Although effects of the individual fatty acids in soya have not been documented, the low saturated fat content makes soya food a good choice for a heart-healthy diet.

Dietary fibre

In a thorough literature review of clinical studies in humans, Glore *et al.* reported that soluble fibre produced significant reductions in total serum cholesterol concentrations and LDL cholesterol concentrations in 88 and 84%, respectively, of the studies reviewed.

Most clinical studies in humans have used either high-fibre food or fibre supplements. Many studies have documented the hypocholesterolaemic effects of dry beans. Metabolic ward studies suggest that dry bean intake has the potential to decrease serum cholesterol concentrations of hypercholesterolemic subjects by approximately 10%. Soya fibre supplementation has a modest hypocholesterolaemic effect in animals and humans. Because most of the studies with soya protein have used isolated soya protein that does not contain soya fibre, the hypocholesterolaemic effects of soya protein were unrelated to soya fibre intake.

Soya beans, with or without their fibre, appear to decrease serum cholesterol concentrations through their protein or isoflavone contents.

Legume protein

Soya beans and dry beans may exert a major cholesterol-lowering effect through their vegetable protein content. In experimental animal models, feeding a variety of different plant proteins is associated with lower serum cholesterol concentrations than with feeding a variety of different animal proteins. Legume proteins appear to have specific hypocholesterolaemic effects.

Clinical studies using soya protein for cholesterol reduction date back to 1967, when Hodges *et al.* showed the cholesterol-lowering properties of soya in male prison inmates. More than 40 studies have found soya to be effective at reducing cholesterol when added to or replacing animal protein in the diet.

Isoflavones

Soya isoflavones, structurally similar to oestrogens, interact with oestrogen receptors and may decrease serum cholesterol concentrations by similar mechanisms. Anthony *et al.* reported that monkeys fed isoflavone-rich soya protein isolate diets had significantly better serum lipid values (lower total cholesterol and higher HDL cholesterol concentrations) than monkeys fed isoflavone-poor soya protein isolate diets. Whereas the administration of the antioestrogen tamoxifen is accompanied by an increase in serum triacylglycerol concentrations, soya protein administration is associated with a decrease in serum triacylglycerol concentrations.

Antioxidants

Soya isoflavones have antioxidant properties. Because LDL oxidation has a central role in the pathogenesis of atherosclerosis, these soya isoflavones may have protective effects against atherogenesis in humans. LDL oxidation initiates a cascade of events that includes accelerated platelet aggregation, injury to arterial endothelial cells, and, in the subendothelium, the production of cytokines, adhesion factors, growth factors and other molecules that facilitate development of foam cells and fatty streaks. In vitro studies suggest that genistein and daidzein inhibit LDL oxidation in the subendothelium of vessels in a similar manner to that of vitamin E.

Kidney disease

The relation between excess protein intake and reduced kidney function has long been recognised and is considered when making dietary recommendations, especially to persons at risk of diabetic nephropathy. The Brenner hypothesis states that excessive protein intake causes hyperfiltration and glomerular hypertension, which results in the progressive deterioration of kidney function and leads to nephropathy.

We put forth the 'soya protein and diabetes kidney disease hypothesis', suggesting that substituting soya protein for animal protein will protect against development of kidney disease in diabetic individuals and be effective in reversing or slowing the progression of established kidney disease in diabetic individuals.

Limited evidence suggests that protein from dry beans may also have renal protective effects, but more investigation of this area is required. This section will review evidence supporting our hypothesis that substituting soya protein, or perhaps other vegetable protein, for animal protein has protective or restorative benefits for diabetic individuals with or at risk of nephropathy.

Protein and kidney function

After a large protein meal, blood flow to the kidneys increases significantly. In healthy subjects, an increase in renal blood flow of 10% occurred after a large protein meal, whereas an increase of 33% occurred in subjects with chronic renal disease.

Beef meals increase renal blood flow and glomerular filtration rates more than chicken or fish. Soya protein does not affect renal blood flow or glomerular filtration rates. The mechanisms responsible for these changes are not understood and are still under investigation.

Protein-restricted diets remain the mainstay in nutrition management of chronic renal disease. Most recent clinical studies indicate that dietary protein restriction can slow the progression of renal disease in nondiabetic or diabetic patients. In a comprehensive meta-analysis of the effects of protein-restricted diets on the progression of renal disease, data suggested that these diets reduced the risk of renal failure or death in nondiabetic patients.

Soya protein and renal function

Meal studies indicate that soya protein does not alter postprandial renal blood flow or glomerular filtration rates, whereas animal protein significantly increases these indexes.

Longer-term intakes of soya protein diets were associated with lower renal blood flow, glomerular filtration rate, and fractional clearance of albumin than animal protein diets. Of interest in this area, vegan and lacto-ovo-vegetarian subjects without renal disease had lower glomerular filtration rates and less urinary albumin excretion than omnivores; however, the vegans also had lower protein intakes, on average, than the omnivorous subjects.

Long-term studies also indicate that soya protein intake protects kidneys, whereas excessive animal protein intake may be harmful to kidneys. In animal models of kidney disease, rats fed soya protein had much slower progression of renal disease than rats fed casein. Human studies have not been optimally controlled but suggest that substituting soya protein for animal protein decreases proteinuria in individuals with chronic glomerular disease. In a study of diabetic individuals with nephropathy, Jibani *et al.* noted that a vegetarian diet significantly decreased proteinuria compared with their baseline omnivorous diet.

Diabetic nephropathy

In diabetic individuals, long-standing hyperglycaemia leads to chronic renal vasodilatation, glomerular hyperfiltration, cellular injury, glomerulosclerosis, mesangial proliferation, and, finally, proteinuria and uraemia. Hypertension, almost universal in people with type 2 diabetes, accelerates this process.

Many individuals with type 1 and type 2 diabetes have higher renal blood flow and glomerular filtration rates and lower renal vascular resistance than nondiabetic individuals. Only one-third of diabetic individuals develop nephropathy, and it is likely that those that do have a genetic predisposition for this condition. Hyperfiltration may be an early indicator that diabetic individuals are at high risk of developing nephropathy.

Dietary protein restriction appears to slow the progression of diabetic nephropathy. In a carefully controlled and random parallel study in diabetic individuals, a low-protein diet was associated with a decline in glomerular filtration rate and a slight decrease in proteinuria with nephropathy compared with the usual diabetic diet. A meta-analysis also concluded that protein-restricted diets slowed the progression of diabetic nephropathy.

Further research is required to examine our hypothesis that substituting soya protein for animal protein will protect against the development of kidney disease in diabetic individuals and will be effective in reversing or slowing the progression of established kidney disease in diabetic individuals.

Because of the extensive evidence of detrimental effects of excess protein intake and of the beneficial effects of restricting protein and substituting vegetable for animal protein, it seems prudent to recommend that diabetic individuals moderate their protein intake and select vegetable protein instead of animal protein when practical.

Table 2: Protein and isoflavone contents of selected soya products.

Food	Serving size		Protein content	Isoflavone content	
	Weight	Volume		Per protein	Per serving
	g		g/100g	mg/g protein	mg/serving
Mature soya beans, uncooked	46,5	¼ cup	37	5,1	87,8
Roasted soya beans	43	¼ cup	35,2	5,5	83,5
Soya flour	21	¼ cup	37,8	5,5	43,8
Textured soya protein, dry	30	¼ cup	6	5,2	94
Green soya beans, uncooked	128	½ cup	16,6	3,3	70,1
Soya milk	228	1 cup	4,4	2	20
Tempeh, uncooked	114	4 oz	17	3,1	60,5
Tofu, uncooked	114	4 oz	15,8	2,1	38,3
Soya protein isolate, dry	28	1 oz	92	2,2	56,5
Soya concentrate, dry	28	1 oz	63,6	0,3	12,4

Values are representative and presented for illustrative purposes. Isoflavone content varies widely among soya bean varieties and from product to product depending on the manufacturing process and source of soya protein.

Practical considerations

Dry beans and soya beans are good sources of quality protein and can be substituted for animal protein sources. Dry beans bring complex carbohydrates with low glycaemic indexes and a favourable mixture of soluble and insoluble fibres to the table, and soya beans provide high-quality protein and unique isoflavones. Information about the isoflavone content of various soya products is provided in *Table 2*.

In our experience, most consumers can find ways of incorporating soya products into their daily diets. The health advantages far outweigh the slight inconvenience involved in changing shopping habits and eating patterns.

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