NUTRACEUTICAL PROPERTIES OF WHITE AND NARROW-LEAVED LUPIN

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ABSTRACT

Today there is a growing interest for the use of legume proteins in human nutrition. Lupin flour and lupin protein are in fact flexible ingredients suitable for the preparation of different food items that may be very well accepted by consumers. The health benefits deriving from lupin protein consumption have been investigated both in animal models and in a clinical study. Protein from both white and narrow-leaf lupin, when given to rats fed a classical cholesterol-cholic acid regimen, led to significantly lower levels of both plasma cholesterol and triglycerides *vs*. control animals. In addition, in a rabbit model of atherosclerosis white lupin protein decreased the formation of the atherosclerotic lesions vs. the control fed a casein diet. The cholesterol-lowering activity was confirmed in a pilot clinical study that also suggested a possible hypotensive activity.

KEYWORDS

health benefits, cholesterol, hypertension

INTRODUCTION

Owing to different reasons, from ethical and environmental issues to the demand of health benefits, there is a growing application of vegetable proteins in human nutrition. Up to now, the most used vegetable protein is still soy protein that, besides well-known nutritional characteristics, has also useful nutraceutical properties: in particular, it has been shown to successfully reduce cholesterolemia both in experimental animals and in humans with cholesterol elevations of genetic or non-genetic origin (Anderson *et al.* 1995; Bakhit *et al.* 1994; Descovich *et al.* 1980; Gaddi *et al.* 1987; Sirtori *et al.* 1977; Sirtori *et al.* 2007; Sirtori *et al.*1998).

In the last few years, however, there is also a growing interest for other legumes as a source of protein for human nutrition. Lupin has been the object of a number of studies especially in countries where soy products still encounter some resistance by consumers for reasons including unfamiliarity, the typical 'beany' off-flavour, and the genetic modification issue.

White lupin is a traditional Mediterranean crop used for over 4000 years in human and animal nutrition. Its positive characteristics include a neutral flavour, a protein content comparable to soybean, a good amino acid composition (Caligari *et al.* 2006; Mariotti *et al.* 2002; Sujak *et al.* 2006), a low content of antinutritional factors and the absence of phytoestrogens *et al.* 2000). This last feature that on the one hand may avoid the potential problems that have been recently indicated for these hormone-like components (Jefferson *et al.* 2007; Sirtori *et al.* 2005), on the other allows a direct evaluation of the activity of the 'protein' *per se*, independent of other components. Lupin meal and lupin protein concentrates or isolates are flexible ingredients suitable for the preparation of different food items that may be very well accepted by consumers, such as imitation-milk and meat products, baked products, pasta, creams and spreadable products. In Europe lupin protein are also currently added in the preparation of numerous gluten-free products.

HEALTH BENEFITS OF UPIN CONSUMPTION

Hypercholesterolemia is a major risk factor for coronary heart disease, shown through both prospective and intervention studies. Dietary modification remains the preferred initial treatment option for improving this risk factor rather than instigating the use of drug therapy. Since epidemiological evidence demonstrates the effectiveness of legume consumption on lowering the risk of hypercholesterolemia, the regular consumption of legumes is promoted by health organisations in Western countries to reduce the incidence of this disease. In this context, several groups, mainly located in Europe or in Australia, have investigated in detail the health benefits deriving from lupin protein consumption both in animal models and in the clinics.

WHOLE LUPIN SEED

The effect of blue lupin meal on cholesterol metabolism has been investigated in pigs fed cholesterol-enriched diets in comparison with casein (Martins *et al.* 2005) in a 3-week study (groups of six pigs for each treatment). Diet-induced hypercholesterolemia was inhibited by the blue lupin diet through a substantial decrease in plasma low density lipoprotein cholesterol (LDL-C): liver esterified cholesterol and total cholesterol were also reduced, while hepatic LDL receptor synthesis and HMG-CoA

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reductase activity were increased, and intestinal bile acid reabsorption was stimulated. The neutral sterol output was higher in blue lupin than in casein fed pigs, indicating that the hypocholesterolemic effect may be explained by impaired intestinal cholesterol absorption, probably involving increased bile acid reabsorption. Being this treatment based on the whole kernel it is impossible to sort out the bioactive component or components.

LUPIN FIBRE

Lupin contains much more fibre than other legumes. A recent randomised crossover dietary intervention study (Hall *et al.* 2005) has examined the effect of a diet containing *L. angustifolius* kernel fibre (LKFibre), compared to a control diet without LKFibre, on serum lipids in men. A total of 38 healthy males completed the intervention consuming a LKFibre-rich diet or a control diet for 1 month each. Both diets had the same background menus with seven additional experimental foods that either contained LKFibre or did not. Depending on energy intake, the LKFibre diet was designed to contain an additional 17 to 30 g/day fibre beyond that of the control diet. Compared to the control diet, the LKFibre diet reduced total cholesterol (TC) (4.5%) and LDL-C (5.4%). No effects on HDL-C, triacylglycerols, glucose or insulin were observed. These favourable changes to some serum lipid measures in men, combined with the high palatability of the tested foods, suggest that this ingredient may become useful in the formulation of functional foods.

LUPIN PROTEIN

A deeper insight on the bioactive components of lupin seed was provided by studies performed on lupin protein isolates. In rats fed on a casein based cholesterol–cholic acid diet, a relatively low daily intake (50 mg/day per rat by gavage over two weeks) of total lupin protein extract significantly reduced total (-20%) and VLDL-LDL cholesterolemia (-30%), and lowered triglyceride levels (-17%). In addition, HDL cholesterol levels were about 20% higher in lupin treated rats at the end of the study, but the difference did not reach statistical significance. No changes in glycaemia were observed. The animals displayed no relevant side effects to treatment and the relative body growth on lupin was slightly higher *vs.* that of controls. This initial study indicates that lupin protein exerts a similar hypocholesterolemic activity in an established animal model, compared to soy protein.

In another investigation (Bettzieche *et al.* 2007), in order to assess the effect of lupin protein on the concentrations of lipids in plasma lipoproteins and liver and hepatic mRNA concentrations of genes involved in lipid metabolism, fed adult rats egg albumin-based diets containing either lupin protein from *Lupinus albus* or casein (50 g/kg) supplemented (hypercholesterolemic) or not (normolipemic) with a cholesterol-cholate mixture for 20 days. Lupin protein compared with casein lowered the concentrations of triglycerides in liver and circulating VLDL + chylomicrons of hypercholesterolemic rats. Hepatic mRNA concentrations of genes involved in fatty acid synthesis such as sterol regulatory element-binding protein-1c (Spielmann *et al.* 2007), glucose-6-phosphate dehydrogenase, fatty acid synthase, stearoyl-CoA desaturase-1 and acyl-CoA-glycerol-3-phosphate acyltransferase were lower and mRNA concentrations of lipoprotein lipase, hepatic lipase and apoA5 involved in triacylglyceride (TAG) hydrolysis were higher in rats fed lupin protein than in rats fed casein. Hypercholesterolemic rats fed lupin protein had higher liver cholesterol concentrations and lower levels of LDL-C than rats fed casein. This study showed that lupin protein has hypotriacylglycerolemic action possibly via down regulation of fatty acid synthesis genes and up regulation of genes involved in TAG hydrolysis.

White lupin protein was also evaluated in a rabbit model of focal soft plaque generated in common carotid arteries (Marchesi *et al.* 2007). In this model, carotid lesions are mostly constituted by extra-cellular lipids and macrophages, thus reflecting the main feature of the human arterial plaques defined as unstable, frequently associated to acute ischemic events (Chiesa *et al.* 2001). After surgery, animals were fed 3 different diets for 90 days, all with 1% cholesterol, 15% saturated fatty acids and 20% protein; the protein source was casein (CAS), lupin proteins (LUP) or 50% CAS + 50% LUP (CAS+LUP). Lower cholesterolemia was detected in the LUP vs. the CAS group at 60 and 90 days of treatment (-40.3% and -33.5%, respectively). Cryosection analyses of the carotids indicated a significant reduction in focal lesion progression in the LUP vs. the CAS group (-37.4%). This indicates that a protein isolate from *L. albus* may exert a remarkable protective activity against atherosclerosis progression.

A recent study (Pilvi *et al.* 2006) compared the effects of lupin vs. a standard chow diet on hypertension and vascular functions in spontaneously diabetic Goto-Kakizaki rats, which developed hypertension when fed a high-salt diet (containing 6% NaCl). After 2 weeks, the SBP was 18.6 mmHg lower in the lupin group than in the control group. Lupin treatment normalised the decreased vasocontraction observed in the NaCl-fed control group and improved the impaired endothelium-dependent vasorelaxation. The attenuation of hypertension is likely to be mediated by the corrected vascular dysfunction. This may possibly be related to the high content of arginine in lupin protein which may lead to an increased nitric oxide (NO) production.

Eventually, a preliminary clinical study (Nowicka *et al.* 2006), based on a lupin beverage (daily lupin protein intake = 36 g), confirmed the beneficial activities observed in the animal models. No body mass index changes were observed during the entire study, and no patients reported any significant side effects. A significant reduction of total cholesterol by 6.8% and of LDL-C by 8.0% was observed at 90 days. When selecting patients with cholesterolemia > 240 mg/dl then the respective changes were: -10.3% and -10.9%. No significant changes of triglycerides, HDL-cholesterol, ApoA-I, ApoB and fibrinogen levels were observed. On the other hand, a significant reduction of glucose (-6.7%), homocysteine (-11.8%), hsCRP (-18.3%) and of urinary F2–isoprostane/creatinine excretion (-39.6%) were observed. A significant drop in blood pressure, both systolic (-9.9 mmHg) and diastolic (-4.4 mmHg), was recorded, both at 30 and 90 days. Also in this case hypertensive individuals showed more significant reductions. In this pilot clinical study, for the first time, lupin proteins were shown not only to lower LDL-C, but also to exert potentially beneficial effects on blood pressure, while also reducing oxidative and inflammatory markers.

In conclusion, although the studies on lupin are still limited in number, they are in favour of useful health benefits related to a regular consumption of lupin foods in a well balanced diet.

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