Potential role of non-soy grain legumes in preventing hypercholesterolemia

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Abstract: Although the health benefits provided by soy protein are known from decades, especially in the area of cholesterol control, non-soy legumes have been only rarely investigated. This is a pity considering the environmental relevance of these seeds: indeed a better knowledge of their beneficial role in the diet may become an important tool to promote their consumption. We summarize here available results either from animal investigations or human trials in the area of hypercholesterolemia prevention. This body of data indicates that a regular consumption of grain legumes is useful for maintaining a correct lipid profile.

Key words: cardiovascular disease, cholesterol, coronary heart disease, grain legumes, plant protein

Introduction

Many studies have shown that the consumption of soybean protein is useful for dyslipidemia prevention (10). This activity was also strongly validated by the US Food and Drug Administration (FDA) approval of the "health claim" on the role of soy protein in reducing the risk of coronary heart diseases (FDA, Federal Register 1999: 64, 57699-57733). During the following years, this prompted some research also on other legumes that will be briefly described in this review.

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Animal studies

Whereas the first studies on the potential hypocholesterolemic effects of soybean (*Glycine max* (L.) Merr.) dated back to the '70s, it was not until the '90s that some researchers started to dedicate resources and time to non-soy legumes, stimulated by the similarities among the sequences of the main protein fractions in legumes. Most of the experimentation was performed *versus* casein or lactalbumin as control proteins using the rat model of hypercholesterolemia. Table 1 reports a summary of the results of some of these investigations, which have involved numerous legumes (for a complete list see (2)). All studies reported significant and generally very large decreases of the lipid parameters versus the control diet, with the exception of lentil that was the least effective. Certainly, these data gave clear indication that these seeds may be beneficial for dyslipidemia prevention.

Particular attention was dedicated to lupin (*Lupinus* spp.) that, owing to its exceptional protein content, may be considered a valuable substitute of soy in food formulation. In this case, besides the usual investigations on rats, other animal models were also applied, such as hamster, pig and rabbit. Rabbit is a model of the atherosclerotic plaque, since a small perivascular injury may induce the development of a focal plaque at both common carotid arteries. After recovery from surgery, animals were fed cholesterol-rich diets containing as casein (control) or a protein isolate from white lupin (treatment) for 90 days (9). Cryosection analyses of the carotids indicated a significant reduction in focal lesion progression in the lupin *vs.* the casein group (-37.4%). Therefore, lupin protein not only reduces cholesterolemia, but also exerts a protective activity against atherosclerosis progression. A study on hamster has instead shown that a lupin diet reduces the level of liver steatosis (accumulation of fat in the liver) (6).

Table 1. Effects of grain legumes on lipid metabolism evaluated in the hyperlipidemic rat model (2)

Grain legume	Tested ingredients	Duration (days)	Total cholesterol change vs. control (%)	VLD-C + LDL-C or non-HDL-C change vs. control (%)
Butter bean	Whole cooked flour	56	-24.0	-38.8
Chickpea	Cooked flour	16	-34.1	-43.2
Common bean	Whole cooked flour	56	-36.3	-53.0
Cowpea	Cooked flour	28	-48.5	-54.2
Faba bean	Whole flour	14	-36.8	-56.3
Lentil	Cooked flour	56	-6.7	-32.2
Narrow-leafed lupin	Protein isolate	28	-55.3	-61.1
Pea	Protein isolate	28	-51.6	-58.1
White lupin	Protein isolate	21	-22.7	-30.2

Human studies

The results on the clinical studies on non-soy legumes are analyzed in a few reviews (1, 4, 5) that give clear indication that a diet rich in these seeds is useful to decrease total cholesterol and low density lipoprotein cholesterol (LDL-C). We have recently published another very comprehensive review (2), whose relevant data are summarized here.

Up to now 20 papers dealing with non-soy legumes and cholesterol have been published for a total of 22 different trial arms. These studies may be classified into four groups: 1) twelve unblind studies on whole seeds; 2) one unblind study on a model beverage from white lupin (*L. albus* L.) seed; 3) two blind studies (three arms) on model foods containing whole kernel flours; 4) five blind studies (six arms) on purified fiber or proteins. Considering gender, twelve studies were on both genders, ten on males alone, and, surprisingly, none on females alone. All controlled studies were randomized, about one half had a parallel design, whereas the other had a crossover design. The durations span from 3 weeks to one year, but a 4-weeks duration is prevalent.

The quantity of legumes consumed daily in the studies of Group 1 varied as well as the number of servings per week, which spanned from 4 to 7. Most of them showed significant decreases in total cholesterol (from -8 mg dl^{-1} to -56 mg dl^{-1}) and LDL-C (from -7 mg dl^{-1} to -51 mg dl^{-1}) (2). Group 2 comprises only an uncontrolled 3-months study evaluating a daily intake of 500 ml of a model lupin drink on smokers. Significant decreases in total and LDL-C were observed in respect to the stabilized lipid values during the previous diet. Group 3 includes two blind studies on model foods containing whole kernel flour. The former, on broad bean (*Vicia faba* L.) flour mixed to smashed potato, reports segregated results for normocholesterolemic patients (mean initial cholesterol equal to 200 mg dl^{-1}) and moderate hypercholesterolemic (mean initial cholesterol equal to 240 mg dl^{-1}). Both groups of patients showed decreases of total and LDL-C that were higher in the hypercholesterolemic group. On the contrary, no significant changes were observed in the latter study, based on normolipidemic subjects who consumed bread, biscuits and pasta added with lupin flour.

With the exception of a paper on a pea (*Pisum sativum* L.) protein isolate which was practically inactive, all studies of Group 4 are on narrow-leafed lupin (*L. angustifolius* L.). The ingredients (fiber or protein isolate) were included in different kinds of foods. The kernel fiber, added in breads, muffins, and other foods, produced small, but significant decreases of total and LDL-C (7). Instead, lupin protein (25 g) incorporated into a lupin drink did not change the lipid profile in a statistically significant way versus the control. Two studies were based on dietary bars containing either the lupin protein isolate or casein (control bar). In the former comparable decreases of the lipid parameters were observed either in the treatment or in the control. This was possibly due to the lack of a run-in period aimed to stabilize the lipid parameters before the intervention, which in our experience is crucially important in dietary studies. The latter study (11) on similar bars, in which the run-in period was correctly performed, gave instead better results. In spite of their unsatisfactory sensory properties, the bars containing lupin protein produced a significant decrease of total cholesterol (-11.6 mg dl^{-1}, -4.2%), whereas no plasma cholesterol changes were observed in the control group. Finally, very interesting results were obtained in a very recent study (3), where the patients received a portfolio of different lupin food items, very similar to normal foods: in fact, statistically decreases of both total cholesterol (-11.0 mg dl^{-1}, 4.4%) and LDL-C (-6.0 mg dl^{-1}, 3.6%) were observed. Possibly, the effectiveness of this study may be explained with the improved compliance consequent to the varied portfolio of products that the subjects could easily include in their daily diet.

Conclusions

Available animal and human experimentation clearly indicates that legumes are useful in high cholesterol prevention. Different seed components may be responsible of this activity: certainly the fiber, but also the protein or, better, specific peptides derived from the proteins that are able to interfere with cholesterol metabolism in hepatic cells (8). It would thus be very advisable to increase the daily consumption of these seeds: to achieve this objective, it would be useful to have an easier access to different food items based on legumes, such as in the current market of soy foods.

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