

POTENTIAL FOR BENEFIT OF LUPIN ON OBESITY AND CARDIOVASCULAR DISEASE RISK IN HUMANS

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ABSTRACT

Lupin kernel flour is a novel food ingredient high in protein and fibre. The macronutrient composition of the diet appears to be an important factor influencing appetite acutely, and possibly body weight in the longer term. Protein and fibre have been identified as the most satiating nutrients in acute studies, and enrichment of bread with lupin kernel flour can reduce appetite acutely. Higher protein and fibre intakes can also improve weight loss in energy-restricted diets, but the effects of longer-term regular consumption of lupin-enriched foods on body weight have yet to be assessed. Results of population and intervention studies suggest that increasing protein and or fibre at the expense of refined carbohydrate in the diet may reduce the risk of cardiovascular disease via effects on blood pressure, blood cholesterol and glucose and insulin metabolism. It could be anticipated that increasing protein and fibre intakes from lupin will improve these risk markers, but additional studies are needed to address this hypothesis.

KEYWORDS

lupin, obesity, cardiovascular disease, protein, fibre, appetite, blood pressure, blood lipids

INTRODUCTION

Lupin kernel flour is a novel food ingredient derived from the endosperm of lupin, a grain legume. It contains 40 to 45% protein, 25 to 30% fibre, and negligible sugar and starch (Evans *et al.* 1993). It can be incorporated into high carbohydrate foods resulting in significant increases in protein and fibre, reductions in refined carbohydrate, and little change in product acceptability (Lee *et al.* 2006). Results of several studies suggest the potential for benefit of a diet higher in plant protein and dietary fibre. A practical approach to increasing protein and fibre content of processed foods is to incorporate high protein and fibre ingredients such as lupin kernel flour.

APPETITE AND OBESITY

Obesity is now a major public health problem worldwide. A possible approach to fight the obesity epidemic involves understanding of the role of dietary

components in the control of food intake. This has the potential to assist in the prevention of weight gain and facilitation of weight loss via effects on appetite.

ACUTE EFFECTS ON SATIETY AND ENERGY INTAKE

The nutrient composition of the diet appears to be an important factor controlling satiety and energy intake, at least short-term (Vandewater and Vickers, 1996; Halton and Hu, 2004; Hu, 2000; Burton-Freeman, 2000). Evidence that a high protein compared to a high carbohydrate diet (Vandewater and Vickers, 1996; Halton and Hu, 2004), or a high fibre compared to a low fibre diet (Pereira and Ludwig, 2001), is more satiating and results in reduced subsequent energy intake is convincing. Therefore, foods high in protein or fibre, replacing energy from carbohydrate, have the potential to increase satiety and reduce energy intake. At present, there is little information on effects of dietary approaches that increase both protein and fibre. Such diets may influence satiety via effects on appetite-regulating hormones such as ghrelin, a peptide that is released from the stomach and acts on the central nervous system to stimulate food intake (Horvath *et al.* 2001). The protein and fibre content in the diet may be an important determinant of ghrelin secretion (Erdmann *et al.* 2004), thereby influencing post meal satiety and subsequent energy intake.

A recent study has found that enrichment of bread with lupin kernel flour can reduce appetite acutely. Lupin-enrichment of bread significantly reduced within meal food intake by approximately 30%, food intake at a subsequent meal by approximately 15%, and self-reported hunger and fullness for 3 h following a fixed energy meal (Lee *et al.* 2006). In addition, lupin-enriched bread compared to white bread at breakfast significantly altered the 3 h post meal plasma ghrelin response. The changes in plasma ghrelin were consistent with the observed acute effects on satiety and energy intake (Lee *et al.* 2006). Furthermore, incorporation of lupin kernel fibre into processed foods was found to result in higher post meal satiety up to 4.5 h, and lower energy intake by approximately 15% over the test day (Archer *et al.* 2004).

OBESITY AND WEIGHT LOSS

A high protein intake relative to high carbohydrate (Hu, 2005; Halton and Hu, 2004) and a high fibre intake (Burton-Freeman, 2000) can improve weight loss in energy-restricted diets. The effects of such dietary changes in ad libitum diets are less clear (Halton and Hu, 2004; Horvath *et al.* 2001). Thus, the long-term benefits of regular consumption of high protein, high fibre low carbohydrate diets on body weight are yet to be established.

The effects of longer-term regular consumption of lupin-enriched bread on body weight have yet to be assessed. If the observed acute effects on appetite are sustained during regular consumption, a significant reduction in energy intake and weight loss would be expected.

CARDIOVASCULAR DISEASE RISK FACTORS

Results of several studies suggest the potential for benefit of lupin-enriched foods on cardiovascular disease risk factors. Major risk factors for cardiovascular disease include high blood pressure, elevated blood cholesterol concentrations, and hyperglycaemia and insulin resistance.

BLOOD PRESSURE

Increasing protein at the expense of refined carbohydrate in the diet may benefit blood pressure. Cross-sectional population studies generally show an inverse association between estimated protein intake and blood pressure (Appel, 2003; Elliott, 2003; He and Whelton, 1999). In randomised controlled trials, lower blood pressure with protein, in comparison to carbohydrate, is also a consistent finding (Lee *et al.* 2008). Differences in systolic blood pressure of 1.4 to 5.9 mm Hg have been demonstrated with higher protein and lower carbohydrate intakes ranging from 25 to 66 g/d. Both protein and carbohydrate may play a role in influencing blood pressure in these studies (Lee *et al.* 2008; Shah *et al.* 2007).

An increased intake of dietary fibre may also improve blood pressure. A large number of randomised controlled trials have now investigated the effects of increasing fibre intake on blood pressure. Meta-analyses of these trials found that an increase in fibre intake of >10 g/d was associated with falls in systolic and diastolic blood pressures of approximately 1 to 1.5 mm Hg (Streppel *et al.* 2005; Whelton *et al.* 2005).

Increasing both protein and fibre intakes, at the expense of refined carbohydrate, may benefit blood pressure. A previous study found that the combined effects of an additional 66 g/d dietary protein and 15 g/d soluble fibre resulted in significant additive effects to lower systolic blood pressure by approximately 10 mm Hg. The effects on blood pressure of an increase in protein and fibre intake achieved using lupin kernel flour remains uncertain.

A previous study using a salt sensitive rat model of hypertension has shown that lupin protein can attenuate the development of hypertension and improve endothelial function (Pilvi *et al.* 2006). Lupin protein has a relatively high content of arginine (Lasztity *et al.* 2001), which is a precursor for nitric oxide synthesis. Blood pressure lowering could result from an improvement in vascular tone mediated by nitric oxide, a potent endothelium-derived relaxing factor. However, it is difficult to speculate on mechanisms given that multiple factors in the diet – protein, carbohydrate and fibre – will change.

BLOOD CHOLESTEROL

Plant proteins (Anderson *et al.* 1995; Reynolds *et al.* 2006) and soluble fibres (Truswell, 1995; Brown *et al.* 1999) in the diet may lower blood cholesterol concentrations. Although a diet higher in plant protein can reduce blood cholesterol concentrations, the available evidence that plant proteins themselves can cause clinically relevant falls remains weak (Reynolds *et al.* 2006). Benefits on cholesterol may be secondary to changes in saturated fat in the diet. In addition, not all fibre in the diet appears to benefit blood cholesterol levels. Soluble fibres lower cholesterol, but insoluble fibre from cereals, which is associated with reduced risk of cardiovascular disease and diabetes, does not significantly reduce blood cholesterol concentrations.

The effects of protein and fibre rich lupin kernel flour on blood lipids remain uncertain. However, results of several animal studies suggest cholesterol-lowering effects of lupin. Whole lupin grain fed to chickens (Viveros *et al.* 2007) and pigs (Martins *et al.* 2005) has been shown to lower cholesterol. In addition protein and fibre isolates from lupin may also improve serum lipids. In rats, lupin protein isolates significantly reduced plasma total cholesterol concentrations by 21% (Sirtori *et al.* 2004). In humans, an additional 17 to 30 g/d of dietary fibre from lupin fibre isolate reduced total and LDL-cholesterol concentrations by approximately 5% (Hall *et al.* 2005). The effects of the combination of lupin protein and fibre on lipids have yet to be examined in a randomised controlled trial in humans.

GLUCOSE AND INSULIN METABOLISM

Insulin resistance and impaired glucose metabolism lead to Type 2 diabetes. There is good evidence that additional fibre intake assists in acute glycaemic control in those with type II diabetes (Chandalia *et al.* 2000). Evidence for the effect of dietary protein on glycaemic control and diabetes development is conflicting. The effect on glycaemic control of fibre and protein sourced from lupin is unknown. Consumption of bread enriched with lupin kernel flour by healthy non-diabetic individuals can lead to reduced post meal glucose and insulin responses (Lee *et al.* 2006; Hall *et al.* 2005). Acute and longer-term effects of lupin-enriched foods in diabetic subjects have yet to be investigated.

CONCLUSIONS

The unique high protein and high fibre content of lupin has the potential to increase the protein and fibre content of diets. Lupin-enriched foods can increase satiety and reduce appetite acutely. Longer-term effects on energy intake and body weight in obese individuals remain unclear. There is good indirect evidence to support blood pressure lowering by a diet enriched in lupin-derived protein and fibre, and there are some data to support the potential for cholesterol lowering and improvements in glucose and insulin metabolism. Therefore, increases in lupin-derived protein and fibre in the diet may benefit obesity and cardiovascular disease risk, but additional data from human intervention studies are needed.

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