GRAIN LEGUMES SOME NUTRITIONAL ASPECTS

G.P. Savage

Department of Biochemistry and Microbiology,
Lincoln University, Canterbury.

ABSTRACT

Various grain legume seeds are used as a major supplementary source of protein in many developing countries. The proximate composition of most of the grain legumes are quite similar, a common feature is their low concentration of fat. The protein quality of many legume seeds is affected by the presence of a number of anti-nutritive factors which may be reduced by suitable processing or cooking. The sprouting of legume seeds has received increased interest, particularly as an improvement in the nutritive value and palatabiltiy occurs during this process. Although legume seeds are widely used in the diets of millions of people, little research has been carried out on their nutritional quality as it relates to human nutrition. Strains should be identified which contain lower levels of anti-nutritive factors and selections should be made to find strains with reduced flatus potential. Selections of grain legumes should also be made to find strains containing elevated levels of the essential amino acid methionine. Increased consumption of legume seeds particularly in the sprouted form should be recommended for western-type diets as the fibre and the saponin content appears to have a beneficial effect on blood cholesterol levels. Lowered blood cholesterol levels would have a significant effect on the incidence of coronary heart disease in western countries.

INTRODUCTION

The death of a person before the age of 65 should be regarded as a considerable loss of economic and personal potential. Greater efforts should be made to consider the reasons for such early deaths. The data in Table 1 highlights some of the major causes of death in the age range 15 to 65 in the New Zealand population. A great deal of money is spent on the reduction of various forms of accidents. Smoking related causes of death e.g. lung cancer is also receiving a great deal of attention.

Deaths related to nutrition and eating habits for instance, colon cancer and coronary heart disease (CHD) have not received as much attention until recently. The main problem is the long term nature of the development of these diseases and the effect that genetic factors have on these nutritional related diseases.

One of the most interesting features of the health statistics in New Zealand is the gradual fall in the mortality rate due to coronary heart disease from 1968 to 1986. During this period, however, there has been a steady rise in both male and female colon cancer deaths each year.

A reasonable proportion of the deaths caused by colon cancer and CHD can be attributed to the average New Zealand diet which tends to contain high levels of saturated fat and low levels of dietary fibre.

Table 1: Selected causes of death in the whole New Zealand population in 1986 in the age range 15 to 65 (Department of Health, 1986).

	Men	Women	Total
Air accidents	18	4	22
Car accidents	485	141	626
Lung cancer	299	116	415
Colon cancer	112	223	335
Coronary heart disease	1,261	370	1,631
All other causes	2,384	1,635	4,023
Total all cases	4,559	2,493	7,052

The mortality data in Table 1 clearly shows that coronary heart disease accounts for 25 % of the deaths in New Zealand in the age group 15 - 65.

In countries were legumes are consumed to a greater

extent e.g. Mexico and Egypt, the deaths due to heart disease are relatively low when compared to New Zealand or the United States (Table 2). It may be that this data is not really comparing like with like but it can be seen that in Egypt and Mexico for instance high death rates are caused by poor housing, sanitation and poor access to medical care. In Mexico 10 % of all deaths each year are due to gastro-enteritis, 10 % due to pneumonia. The leading causes of death in Egypt are bronchitis and asthma each causing 5 % of total deaths. Thus many people may die before they have the opportunity to develop coronary heart disease. It is unfortunate that there are no countries with a high standard of health care where high legume containing diets are consumed. It is interesting to note that some countries do not even report their basic statistics to the United Nations.

Table 2: Selected causes of death, rates per 100,000 people in each country (United Nations, 1982).

	Year	Coronary heart disease	Pneumonia	Gastro-enteritis
NZ males	1986	236	-	-
NZ females	1986	125	-	-
NZ males + females	1980	152	36	-
USA males + females	1978	288	24	0.8
Egypt males + females	1978	15	33	7
Mexico males + females	1978	22	61	60

The widely accepted theory as far as CHD is concerned is that high levels of saturated fat in western type diets lead to raised blood cholesterol. This, in turn, leads to atherosclerosis and an increased incidence of heart attacks (Carlson & Bottiger, 1972).

A number of studies indicate that legume seeds or their constituent proteins and fibre may lower serum cholesterol in both man and experimental animals (Jenkins *et al.*, 1983). Contrary to popular opinion dietary cholesterol contributes an average of no more than 10 % to serum cholesterol concentrations - therefore the association between dietary cholesterol and CHD is weak (Oliver, 1976).

One way to reduce the saturated fat and the cholesterol content of the diet is to recommend a reduction in ruminant meat, milk and milk related products in the diet. To do this effectively, it is best to recommend a realistic replacement in the diet. The addition of legumes to the diet are a reasonable way to reduce the overall fat content because of their generally low fat content (Table 3).

Table 3: Proximate composition of some selected legumes (g/100 g) (Savage, 1988; Savage & Deo, 1989a,b).

	Lentils	Peas	Mung beans
Crude protein	19-35	16-32	18-36
Oil	1-4	1-6	1-4
Crude fibre	1-6	1-10	0.4-13
Nitrogen free extract	52-70	57-74	60-72
Ash	2-6	2-4	2-5

PROXIMATE COMPOSITION

The proximate composition of legume seeds is quite consistent. The crude protein ranges from 15.6 % to 36.0 % which is, in general, superior to that found in cereals. Oil content is low, but generally the fatty acids are unsaturated. Legume seeds contain modest levels of crude fibre, the amount in foods depend on whether the seeds are dehusked prior to cooking. In the nitrogen free extract some interesting carbohydrates are found, these will be discussed later.

SAPONINS

Saponin content of many legume seeds is the most interesting positive feature (Table 4). These saponins are sterol or triterpene glycosides which are non-toxic, but have a characteristic bitter taste. Saponins in foods significantly reduce the plasma cholesterol concentrations of the animals consuming them (Oakenfull, 1981). Saponins appear to induce adsorption of bile acids onto dietary fibre in the intestine (Burkitt & Trowell, 1975), presumably due to their strong surface-active properties. Adsorption of bile acids onto dietary fibre will cause increased faecal loss of these bile acids (bile acids are normally re-absorbed further down the intestinal tract as part of the

entero-hepatic circulation), which would be offset by increased conversion of liver cholesterol into bile acids which will tend to lower blood cholesterol levels.

Table 4: Saponins in some selected legume seeds (g/kg) (Savage, 1988; Savage & Deo, 1989a,b).

	Lentils	Field peas	Mung beans
Raw	3.7-4.6	1.1-2.5	5.7
Sprouted	-	-	27.0

An even more interesting observation (Table 4) is that during the process of sprouting mung beans, the saponin levels rise dramatically (Fenwick & Oakenfull, 1983).

MUNG BEAN SPROUTS

The Chinese have used mung bean sprouts for centuries and their wider use should be encouraged along with other sprouted legume seeds. During germination there is a significant increase in the vitamin C and folic acid content. At the same time there is a significant and useful reduction in the raffinose family of oligosaccharides, as these are used as a source of energy in the germination process. A feature of the raffinose family is that the individual mono-saccharides are α (1 → 6)-linked. This bond is not broken by mammalian digestive enzymes. Unfortunately anaerobic micro-organisms which normally inhabit the human colon, can degrade the raffinose family carbohydrates. Their metabolic activity leads to the generation of gas better known as flatus. The flatus potential of many legumes can be reduced by adequate soaking prior to cooking and rigorous autoclaving at 121 °C for 30 minutes.

The raffinose family of carbohydrates are one of the major negative features of legume seeds and research should be considered to reduce their levels in new cultivars.

The most interesting feature of mung bean sprouts is that the protein of germinated mung bean seeds is more digestible than the raw seed (Venkataraman *et al.*, 1976; Savage & Griffiths, 1988). The biological value is however, unchanged. During germination little change occurs in the amino acid content of mung beans, the main effect is the reduction of between 85 and 88 % of the trypsin inhibitor levels (Kamalakannan *et al.*, 1981; Chitra & Sadasivam, 1986).

TRYPSIN INHIBITORS

Trypsin inhibitors in seeds bind with the enzymes secreted by the pancreas such as trypsin and chymotrypsin. These digestive enzymes then cannot break down food protein. An animal's response is to secrete further trypsin and chymotrypsin which causes hypertrophy of the pancreas. It is interesting to note that these pancreatic enzymes are particularly rich in sulphur containing amino acids and this process of the additional secretion of digestive enzymes will result in a drain of these particular amino acids. This can lead to an imbalance of amino acids in the body which will be followed by increased protein catabolism. This effect is accentuated due to the fact that legume seed protein characteristically contains low levels of the sulphur containing amino acids, methionine and cysteine.

An interesting feature of the trypsin inhibitor content is that while it is easily degraded during germination of the seed (Savage & Deo, 1989) it is particularly resistant to destruction on heating. Autoclaving for 30 min at 121 °C is completely effective at destroying all the inhibitor in mung beans, while cooking at 100 °C for 60 minutes only destroys approximately 50 % of the inhibitor (Sohonie & Bhandarkar, 1955).

PROTEIN

A consistent feature of the amino acid content of legume protein is the low level of the essential amino acid methionine. From Table 5 it can be seen that some variation in this amino acid occurs between different legume seeds. These mean values hide a considerable variation in values reported in the literature (Savage, 1988; Savage and Deo, 1989a,b). This would suggest that simple selection could be used to good effect to improve the methionine content of the protein of many of the common legumes.

A considerable improvement in the protein quality of peas would occur if the legumin fraction which contains a higher sulphur amino acid content, was increased or the vicilin content was reduced. The albumin fraction in peas also has a more favourable amino acid profile and recent experiments have shown that some variation in this protein fraction does occur in cultivars already in use. Some potential for modifying the quality of peas already exists and this type of approach could easily be applied to other legume seeds.

Table 5: **Some important amino acids of legume flours (g/100 g of total amino acids). (Recalculated from Sosulski, 1983).**

Amino acid	Lentil	Field pea	Navy bean	Soya bean	Lima bean
Arginine	7.7	8.1	6.4	7.5	5.5
Cysteine	1.0	1.5	0.8	1.1	1.0
Histidine	2.4	2.4	3.2	2.2	3.0
Isoleucine	4.7	4.3	4.6	4.8	5.1
Leucine	7.8	7.4	8.4	7.6	8.7
Lysine	7.8	7.7	7.2	6.5	6.7
Methionine	0.8	0.9	1.2	1.4	1.2
Phenylalanine	5.1	4.6	5.5	5.0	6.1
Threonine	3.7	3.9	4.0	3.8	4.2
Tryptophan	1.0	1.0	1.0	1.3	1.3
Tyrosine	3.6	2.9	3.0	3.5	3.0
Valine	5.2	4.8	5.2	5.0	5.5

CARBOHYDRATES

The unusual carbohydrate content of legume seeds is the feature which most often appears to limit their wider acceptance in human foods. The raffinose family of carbohydrates (raffinose, stachyose and verbascose) are readily fermented in the hind gut. As mentioned before the levels are reduced on germination of the seed or by rigorous cooking. The data summarised in Table 6 suggests that a considerable variation in the concentration of these undesirable carbohydrates does already exist and a careful breeding programme could select less gas producing cultivars.

Legumes generally contain useful amounts of water insoluble carbohydrates (dietary fibre) which have a generally beneficial effect in the gastro-intestinal tract. Thomas *et al.* (1986) has shown that mung bean fibre also binds to bile acids in the small intestine of rats resulting in lowered cholesterol, LDL and VLDL fractions in the serum. The amount of fibre in the cooked food depends very much on whether the seed is dehusked prior to cooking. A large proportion of the fibre is contained in the testa (husk).

The testa of many legumes also contains significant amounts of tannins and phenolic acid which tend to react with the α-amino group of lysine in the protein and polymerise into tannin-protein complexes which are resistant to monogastric digestive enzymes (Sosulski, 1979). Since most of the tannins (81-85 %) are contained in the testa (Barroga *et al.*, 1985), a practical way to improve the nutritional value of the seeds is to dehusk the seed before cooking unfortunately this will involve the loss of the advantages of the fibre content of the testa. In general the darker coloured seed coats of mung beans contain higher levels of tannins (Barroga *et al.*, 1985). While Price *et al.* (1980) have shown that green pea seed coats contain no tannins presumably as a result of extensive selection of low tannin cultivars. It is interesting to note that if these polyphenolic compounds are absorbed by mammals, detoxification in the liver involves methylation which would put a further requirement on the limited methionine content of diets based on legume seed protein.

Table 6: **Carbohydrate composition of some selected legumes (g/kg) (Savage, 1988; Savage & Deo, 1989a,b).**

	Lentils	Peas	Mung beans
Raffinose	3-10	3-16	3-26
Stachyose	14-27	22-55	5-28
Verbascose	1-31	21-28	17-38
Total available carbohydrates	426-625	667	456-630
Acid detergent fibre	50-56	78	57
Neutral detergent fibre	97	58-163	71-81

SUMMARY

A breeding programme that concentrated on the reduction of the trypsin inhibitor content of legume seed protein combined with even a modest increase in the methionine content of the seed protein would have a dramatic effect on the nutritional value of legumes for both human and animal use.

A reduction in the raffinose family of carbohydrates would also improve the acceptability of many legume seeds.

The main problem with legume seeds in their use in human diets is the time needed to process them (both

soaking and cooking). This makes them an unpopular food for the modern house-person. To improve their use in this modern world, industry needs to present legume seeds processed and cooked-much like the well loved baked bean.

Sprouted legumes are making a reasonable impact on our diets as they are being presented ready to use. Their further use should be encouraged because of their improved nutritional characteristics and useful effect of lowering blood cholesterol. Legume seeds need to be processed and presented as interesting and healthy foods. They need to be better presented.

If we could encourage an increased consumption of legume seeds linked with a reduction in total fat intake and a move towards the consumption of more polyunsaturated fats I believe it would be possible to change the cause of death and the life expectancy in the New Zealand population. This effect, however, would take some time to show in our health (or disease) statistics.

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