Diversifying use of cool season food legumes through processing

R. JAMBUNATHAN[1], H.L. BLAIN[2], K.S. DHINDSA[3], L.A. HUSSEIN[4], K. KOGURE[5], L. LI-JUAN[6] and M. M. YOUSSEF[7]

[1] *Crop Quality Unit, ICRISAT, Patancheru P.O., Andhra Pradesh 502 324, India*
[2] *American Dry Pea and Lentil Association, 5071 Hwy 8 W, Moscow, Idaho 83843, USA*
[3] *Department of Chemistry and Biochemistry, Haryana Agricultural University, Hisar 125 004, Haryana, India.*
[4] *Department of Nutrition, National Research Centre, El-Tahrir Street, Giza, Dokki, Egypt.*
[5] *Faculty of Agriculture, Kagawa University, 2393 Ikenobe, Miki-cho, Japan*
[6] *Faba Bean Germplasm and Breeding, Zhejiang Academy of Agricultural Sciences, Hangzhou China, and*
[7] *Department of Agricultural Industries, Faculty of Agriculture, University of Alexandria, El Chatby, Alexandria 21526, Egypt*

Abstract

Traditional methods of processing food legumes such as decortication, boiling, roasting, frying, puffing, germinating, and fermenting are used in one form or the other in preparing legume products for consumption in different regions of the world. These processing methods contribute to improved product quality as well as nutritional quality. Extrusion cooking, textured vegetable product, quick-cooking products, weaning foods, and beverages are some of the technologies that have good potential in the improved utilization of cool season food legumes. There is also a growing trend to market legume products as value-added snack items. To expand the markets worldwide for these new products, it is necessary to provide products that are more attractive, convenient, and are nutritionally equal or superior to other established popular products in the market. Other less explored but potentially promising avenues include the use of components of legumes as therapeutics, in dairy industry, and as food preservatives. Leaf protein concentrate also offers scope for use as a protein source for livestock and humans, and in cell culture.

Introduction

The last decade witnessed the development of many products originating from grain legumes with diverse functional, nutritional, and biological activities. Production will depend on development of markets for such products, as well as the balance between costs of raw materials and processing, and the return generated by the recovery and functionality of proteins and starch from dry and wet processing of grain legumes.

Increasing the uses and diverse applications of legumes other than soybean has been enhanced by processing them into protein-rich and starch-rich fractions. Convenience and appearance are the major reasons for additional processing. Food legumes traditionally have been consumed as staple items in many parts of the world. Removing the seedcoat, splitting, and polishing the legumes not only makes a more attractive product but reduces the cooking time. This is a process that has been used for hundreds of years.

In today's economy there is a growing trend to market many food legumes as value-added products. This is particularly true in countries such as Japan, Taiwan, Thailand, and the USA where the economies are strong. These value added snack items are becoming increasingly popular with the younger generation whose tastes are changing and who now have the resources to purchase these items. Increased advertising through magazines and television have also been a factor in creating an increased demand and acceptance for snack items.

F.J. Muehlbauer and W.J. Kaiser (eds.), Expanding the Production and Use of Cool Season Food Legumes, 98–112.

Faba Bean

Faba bean (*Vicia faba* L.) can be fractionated using air-classification or by a wet process (Bramsnaes and Olsen, 1978; Tyler *et al.*, 1981, Gueguen 1983, Sosulski and Sosulski, 1986). The efficiencies of protein (70 to 80%) and starch (88 to 93%) recoveries from faba bean and field pea (*Pisum sativum* L.) were found to be higher by the dry process than respective recovery figures (73 to 79%) obtained from wet processing (Sosulski and Sosulski, 1986). However, wet processing was reported to be more effective in removing toxic constituents (Arntfield *et al.*, 1985). Pilot scale processes have been developed by Bramsnaes and Olsen (1978), Murray *et al.* (1981), Gueguen (1983), and McCurdy and Knipfel (1990).

Faba bean and pea concentrate prepared by air classification has been reported to reduce the cooking losses to negligible values for boiled meat patties where 30% of the meat was substituted by legume protein concentrate (Vaisey *et al.*, 1975). The air-classified products contain about 20 to 25% starch which might be responsible for a significant part of the water-and-fat-binding properties of these products.

By sensory evaluation of the legume beaf-patties, Vaisey *et al.* (1975) found that dried pea flavor and bitter after taste were the dominant flavor characteristics and were attributed to the presence of lipoxygenase activity in faba bean. The mechanisms of both the faba bean and pea flavor have been suggested to be similar to that of the soybean (*Glycine max* L.) and could be solved by partial enzymatic hydrolysis of the protein extract with microbial proteolytic enzyme, isolated from *Penicillium du ponti* (Vieth *et al.*, 1983). Mixtures of whey skim milk and faba bean protein in which faba bean grain made up to 15 to 45% by weight, proved to have good emulsifying capacity, foam stability and could form gels (Fayed and Morshed, 1990).

Hydrolyzed Vegetable Proteins (HVP)

Hydrolyzed Vegetable or Plant Proteins (HVP or HPP) are defined as mixtures composed of amino acids and peptides, which are obtained by hydrolysis of vegetable proteins and frequently other substances, such as salt (Olsman, 1978). The industrial interest in hydrolyzed vegetable proteins (HVP) grew sharply after Ikeda's discovery in 1908 of monosodium glutamate (MSG) as the major ingredient and flavor compound in HVPs. This know-how was the start for its commercial production in Europe, and proved to be a commercial success in bouillon cubes.

On an industrial scale, HVP are prepared either enzymatically or by acid hydrolysis. Either process converts proteins into peptides and amino acids, whereas the carbohydrates are converted into sugars which degrade to a large extent into products like hydroxymethylfurfural and levulinic acid (Olsman, 1978). Under the conditions of HVP production, or during the concentration process, part of the amino acids, sugars or sugar degradation products are converted in nonenzymic browning reactions.

Enzymatic hydrolysis offers an attractive way of increasing the solubility of vegetable proteins. However, the bitter peptides, identified as those fractions having leucine at the termini, are not decomposed. Vieth *et al.* (1978) used a microbial thermophilic enzyme, isolated from *Penicillium du ponti*, with specificity similar to pepsin for hydrolysis.

The legal position of HVPs has been discussed by Codex Alimentarius Commission, which considered HVP as food ingredient and as food additive. There is no evidence from the available information to indicate that HVPs, applied as flavoring agents at their current levels, pose a public hazard. However, the commission stated that evidence is insufficient to determine the reported adverse effects (lesions in the central nervous system) and HVP's are not deleterious to infants when added as flavoring agents to infant or baby foods. The industry had already decided to abandon the use of HVP as flavor agents in these foods. Murata *et al.* (1988) reported that acidic, neutral, and alkaline proteinases originating from microorganisms and plants were capable of coagulating faba bean milk protein. The curd was made up of 73% of the faba bean milk protein. However, pea milk-protein did not coagulate under these experimental conditions.

Chemical Modifications of Grain Legumes

Acylation is the most extensively studied modification of legumes. Schmandke *et al.* (1982) tested acylated faba bean proteins, with different degree of substitutions (0 to 78%) and recommended their use to increase the viscosity of gelatine solutions. Treatment of faba bean protein with succinic anhydride (succinylation) is reported to increase its water and oil absorption capacity by 25 and 40%, respectively. Moderately succinilated (27%) faba bean protein improved substantially its emulsifying activity, emulsifying capacity, and emulsion stability.

Isolation of Compounds with Biological Activities

Up to 80% of the total protein in grain of faba bean and pea is in the cotyledons as a non-metabolic reserve. This globulin protein contains legumin and vicilin in the ratio of 2-3:1. Arntfield and Murray (1985) and Gueguen and Schaeffer (1984) described appropriate methods for the isolation of legumin and vicilin.

Hypocholesteremic Compounds

Spadoni *et al.* (1981) reported that rats fed faba bean concentrate in a diet with high fat content reduced the total plasma cholesterol significantly and increased the bile excretion. The authors suggested that protein concentrate of faba bean had a hypocholesteremic effect through modifying the pattern of bile acid excretion. The identification of the hypocholesteremic factor and its isolation in purified form is needed.

Faba Bean Products

The most popular dishes made from faba beans are *Medamis* (stewed beans), *Falafel* or *Ta'meya* (deep fried cotyledons paste with some vegetables and spices), *Bissara* (cotyledons paste poured into plates), and *Nabet* soup (boiled germinated beans). Processing methods of these products and their nutritive values have been described previously (Youssef *et al.* 1986, 1987; Shekib *et al.*, 1989; Ziena *et al.*, 1991). *Medamis* and *Falafel* taken with bread are very popular breakfast food and snack sandwiches for the majority of Egyptians (Ragab, 1988). A less popular product *Fool Mekalley*, is made from faba beans by roasting and consumed as a snack.

China has the largest area of faba bean in the world. Excluding faba bean crops grown for green manure, the current production area is about 1 × 10^6 ha, output is close to 2 × 10^6 t and average yields are about 1700 kg per hectare. Faba bean is an important winter and spring legume in China. Faba bean grains are an important item in the daily food of the Chinese people as a nutritious food, rich in protein (24 to 34%) and amino acids. They are made into many kinds of traditional foods. Faba bean has been utilized as staple and non-staple foods in different styles. An agronomist G. Q. Xu (AD 1562–1633) in Ming dynasty evaluated faba bean as a versatile foodstuff and so did scientists in Qing dynasty (AD 1616–1911) (Li, 1987).

For a long time, farmers in northwestern China have commonly mixed faba bean flour with other flours such as maize flour to make meals. Due to improved national economy and better living standards of people, there was an increasing demand for foods with desirable quality. Food processing methods of faba bean have also changed considerably and products are expected to have superior color, smell, and taste. At present, non-staple foods of faba bean have a ready market in China and elsewhere. Faba bean foods are divided into three classes based on their processing and cooking methods.

Fried Products

Fried products of faba bean are used as popular refreshments and made by simple processes (Zhang, 1987). Salty faba bean is made by boiling with salt, crisp faba bean by frying with sand or salt. Fragrant faba bean products such as "aniseed faba bean", "spiced faba bean", and "unusual aromatic bean" are prepared by adding varied flavoring agents. Among them, fried "orchid bean" is the most popular one. Cakes and pastes of faba bean are also commonly consumed. A majority of such products is made in individual families for their own use and some also made by small factories.

The orchid faba bean is made by the following process. Faba beans are cooked in boiling water until they can be easily pricked through by a needle. They are dried and each bean is cut both vertically and horizontally to make a cross. The beans are dried in air to remove surface wetness and fried in oil under high flame. When the top splits and the hulls change color from yellow to red, the beans are removed and cooled. Salt could be added for taste before they are eaten.

The spiced faba bean (Wu Xiang Dou) is made by the following process. Selected faba beans are washed and boiled in water. Salt, Chinese prickly ash, staranise, aniseed, and Cassia bark cinnamon are added and cooked under low flame. The quantity of addition of these ingredients are based on the amount of faba bean used and individual preferences. When the shape of a bean can be changed by a gentle bite (to indicate the texture), beans are removed and dried in air. A second procedure is to fry the beans until the hull splits a bit, licorice powder is then added and fried to dry the beans.

Brewed Products

Brewing industry in China has a long history with an outstanding record (Jiang, 1988). As a result of the development of science and technology, improvements have been made in the brewing industry of China. Being rich in proteins and various amino acids, faba bean has been used to brew different kinds of sauces. They are made by mixing faba bean with flour, salt, and water using a special process. Faba bean pastes with specific flavor such as chili, sesame, chicken, ham, beef, and "huoguo paste" are prepared by adding specific flavoring ingredients to faba bean paste in Sichuan and Anhui provinces. "Juancheng" brand faba bean paste made in Pi country, Sichuan province and "Anqing" chili faba bean paste made in Anhui province are famous. Sauce is one of the essential factors for making delicious Chinese dishes. Proper proportion of different flavoring ingredients is also very important besides the superb cooking skills needed in preparing these Chinese products.

Starch Foods

Starch has variable usage as it can be used directly as food or processed into varied non-staple foods (Huang, 1987). Starch extracted from faba bean can be further processed to make high grade bean starch vermicelli and noodles sheet jelly. Products of faba bean starch have been used in regular meals and they have similar quality as many bean products and much better quality than other starch products. Cooked, boiled, and mashed faba bean has also been used to produce dumpling and steamed bread by adding oil, sugar, sweet osmanthus and orange skin. Sometimes, sesame and sugar are added to make refreshments such as bean sweet and sesame bean sweet. In summary, faba bean has a great prospect in making traditional, popular, high grade, and instant foods.

Beans (*Phaseolus vulgaris* L.), peas, and black eye peas (*Vigna unguiculata* L.) are cooked or canned with chunks of beef and tomato sauce. According to El-Ashway *et al.* (1985) and El-Hashmy *et al.* (1985), cooking of the aforementioned leguminous seeds by both traditional and pressure cooking methods improved their sensory properties as well as protein quality. Until only four decades ago, faba bean has been an important part of the Japanese diet in various forms such as the main item of food, the subsidiary food item, protein curd, and fermented sauce and paste. Today, this bean has become very popular among most Japanese, especially young people, as snack items. Kagawa-ken (a state in Japan) is famous for making them. Some of the popular products are, fried beans, processed fried beans with sugar, sesame, ginger, red pepper, green laver, and curry. Press cakes are also prepared with faba bean flour and sugar and cut into different shapes for consumption.

Utilization of Faba Bean Plant

The efficient utilization of whole green crop or plants is important for meeting the future world demand for food, especially protein for humans and livestock (Pirie, 1978). The effect of fertilizer on the distribution of different fractions of plant harvested at three stages are reported (Kogure and Ohshima, 1991a,b).

Faba bean cultivar "Boshu-wase" was grown under zero level (I), standard level (II) (28 kg ammonium sulfate, 45 kg superphosphate, 18 kg potassium chloride), and three times the level (III) of fertilizer. Fertilizer was applied at the beginning of flowering stage. Samples were collected at 0 days (start of flowering), 15 days (end of flowering), and 30 days (pod-developing). The top portion of the plant material was cut and disintegrated in a pulper. It was then squeezed and fractions of green juice (GJ) and fibrous residue (FR) were obtained. GJ was heated (70°C) after adjusting it to pH 4 with HCl. The coagulated leaf protein concentrates (LPC) and brown juice (BJ) were separated by centrifugation (Kogure and Ohshima, 1991a,b). FR was placed in bottles and ensiled for about six months (Ohshima and Kogure, 1984) (Figure 1). Total non-

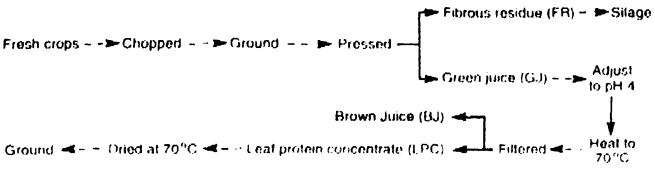

Figure 1. A flow diagram for the laboratory fractionation of green crops.

constructive carbohydrate (TNC) was determined by Somogyi-Nelson method and total nitrogen (N) by Kjeldahl method.

Fertilizer accelerated the growth and development of plants and increased the biomass and yield of raw material for fractionation (Table 1) (Kogure *et al.*, 1977). The concentration of carbohydrate in raw material increased in contrast to the amount of nitrogen and ash with increased applications of fertilizer. The carbohydrate concentration in BJ was two-to-three fold greater than the corresponding LPC and FR in early stages of growth, but it increased in LPC and FR at the pod-developing stage, especially in LPC. Nitrogen concentration in LPC, which was remarkably high, declined rapidly towards the pod-developing stage. Nitrogen concentration in FR and BJ was similar at various sampling times and at different fertilizer amounts. The ash concentration was high in BJ throughout the three stages while it declined in LPC and FR, especially in FR at the later stages. The quality of silage prepared from FR at each stage of sampling of plant and at different fertilizer amounts was good.

Fertilizer dressing caused the vigorous growth of plants and increased the carbohydrate concentration of raw material. Due to this, the nutritional value of LPC was improved by changing the balance of carbohydrate to nitrogen concentration. This observation would be useful for the utilization of the plant as a human food in the near future. The fractionation process resulted in the uniform distribution of carbohydrate content in FR and in removal of the detrimental elements for better lactic acid fermentation during the ensiling process of FR (Ohshima and Kogure, 1984). Soluble carbohydrates and ash containing the detrimental elements were separated into BJ. It was concluded that faba bean plants grown with high amounts of fertilizer and cut at the pod-development stage can be fractionated and utilized. This procedure results in high yield of chemical components, value-added LPC, good quality of FR silage, and valuable BJ.

Dry peas are a good example of a growing snack market made from legumes. Two major types of value-added snack items currently are made from peas. The usual process is to soak peas overnight and fry them in hot oil. Palm oil is most commonly used. Sometimes peas are coated with other materials such as rice flour before frying to provide different flavoring. The product is then seasoned and packaged. The larger marrowfat type pea is preferred by most consumers for this process.

Table 1. Characteristics of raw material, three fractions and FR-silage

Sampling time	0 day	15 days			37 days		
Fertilizer level	I	I	II	III	I	II	III
Raw material (RM) Yield (g m²)	149.0	[illegible]	[illegible]	[illegible]	219.0	[illegible]	418.0
Total Non-constructive Carbohydrate (TNC)							
RM (%)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	24.8
LPC (%)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
FR (%)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
BJ (%)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Nitrogen (N)							
RM (%)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
LPC (%)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
FR (%)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
BJ (%)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Ash (%)							
RM (%)	11.8	[illegible]	[illegible]	[illegible]	[illegible]	9.0	[illegible]
LPC (%)	9.4	6.1	10.0	5.8	6.9	6.0	7.1
FR (%)	12.2	12.3	12.4	8.7	6.4	6.9	6.6
BJ (%)	12.0	12.8	15.9	10.1	10.0	12.4	10.7
FR-silage							
pH	3.84	3.87	3.89	3.74	3.79	3.81	3.79
Lactic acid (%)	2.91	2.59	2.65	2.81	2.41	2.32	2.47
TVFA (%)[1]	1.34	1.15	1.55	1.26	1.11	1.05	1.13
NH_4-N (%TN)[2]	4.4	5.2	5.6	4.2	6.2	5.8	6.0

[1] Total Volatile Fatty Acid.
[2] Percent of Total Nitrogen. Fertilizer level I, II, III (see text)

The second major value-added snack product from peas is made by grinding the peas into a fine flour that is then forced under pressure through an extruder to create different shapes. The extruded shapes are fried, seasoned, and packaged.

Lentil (*Lens Culinaris* L.)

Legumes contain antinutritional factors including trypsin inhibitors, hemagglutinins, and flatulence causing oligosaccharides (Liener, 1980). Heating and germination have been found to be effective in reducing the concentration of antinutritional factors in lentil (Batra *et al.*, 1986; Batra, 1987; Batra and Dhindsa, 1989), pigeonpea (Vasishta *et al.*, 1986), and chickpea (Bansal *et al.*, 1988).

Seven genotypes of lentil *viz.* L-9-12, L-82-3, L-82-4, L-82-6, L-82-7, LH-21, and LH-311 were studied. Trypsin inhibitor activity (TIA), haemagglutinin activity (HA), and oligosaccharides were estimated in dry heated, autoclaved, and boiled samples of lentil (Batra *et al.*, 1986; Vasishta *et al.*, 1986; Batra and Dhindsa, 1989). All the genotypes possessed TIA (Table 2). Autoclaving of lentil seeds for 20 minutes or heating in boiling water for 10 min inactivated TIA completely. Moist heating was more effective than dry heating. Purified trypsin inhibitors are, in general, resistant to heat (Taukamote *et al*., 1983). Trypsin in horse gram appears to be thermostable even during cooking (Ghorpade *et al*., 1986). Soaking of lentil seeds in water and subsequent germination resulted in progressive loss of TIA. Limited proteolysis of the inhibitor protein may be the basis for such a loss in activity (Wilson and Tan-Wilson, 1983).

Table 2. Effect of heating and germination on trypsin inhibitor activity[1] and phytohaemagglutinin activity[2] in lentil seeds/flour[3]

Treatments	Trypsin inhibitor activity	Phytohemaglutinin activity
Control	672	2126
Dry heating		
1 h	119	14
2 h	59	3
Autoclaving		
10 minutes	90	155
20 minutes	Nil	14
Heating in boiling water		29
10 minutes	Nil	13
20 minutes	---	
Soaking		
24 h	254	969
Germination		
3 days	230	330
6 days	84	90

[1] µmol of tyrosine released per g material.
[2] Expressed in terms of maximum dilution of the seed extract in which agglutination could be observed.
[3] Each value in this table is an average of seven values representing seven genotypes and each value for single genotype is based on four determinations (duplicate extract for each sample and duplicate estimation for each extract).

Heating in boiling water is the most effective means of destroying HA in lentil (Table 2). More than half of HA was eliminated when seeds were soaked in water for 24 h, and the decrease in HA continued with time up to 6 days of germination. In cereals, HA has been associated with several protein fractions (Newburg and Concon, 1985). Assuming a similar situation in legumes, differences in HA and its response to heat and germination may be due to differences in amount and proportion of different protein fractions contributing to haemagglutinin activity.

Oligosaccharide concentration in lentil increased irrespective of the heating procedure (Table 3). Even though oligosaccharide concentrations in the seeds did not change much on heating in boiling water for 10 minutes, the increase was evident when taking into account the oligosaccharides leached out into the surrounding water. The observed increase might be due to non-enzymatic hydrolysis or to the release of oligosaccharides from bound macromolecules including higher molecular weight alpha-galactosides which may also be protein in nature.

Table 3. Effect of heating and germination on oligosaccharides concentration (g/100 g dry weight) in lentil seeds/flour

Treatments	Oligosaccharides Sucrose	Raffinose	Stachyose	Total
Control	1.71	1.11	0.83	3.65
Dry heating				
10 minutes	2.46	2.34	2.21	7.01
20 minutes	1.59	1.02	1.17	3.78
Autoclaving				
10 minutes	2.20	1.29	1.06	4.55
20 minutes	2.33	1.69	1.04	5.06
Heating in boiling water				
10 minutes	1.27	0.95	1.38	3.60
Seeds	0.35	0.11	0.22	0.68
Medium	1.62	1.06	1.60	4.28
Total				
20 minutes				
Seeds	1.69	1.48	1.77	4.94
Medium	0.63	0.54	0.34	1.51
Total	2.32	2.02	2.11	6.45
Soaking 24 h				
Seeds	1.81	1.36	1.05	4.22
Medium	0.20	0.04	0.04	0.28
Total	2.01	1.40	1.09	4.50
Germination				
3 days	1.14	0.40	0.32	1.86
6 days	1.74	0.00	0.00	1.74

[1] Each value in this table is an average of values representing seven genotypes and each value for single genotype is based on four determinations (duplicate extract for each sample and duplicate estimation for each extract).

Although a slight increase in total as well as individual oligosaccharides occurred at 24 h soaking of seeds in water, all oligosaccharides decreased 3 days after germination. At 6 days after germination, raffinose and stachyose had disappeared completely, while sucrose showed a proportionate increase.

Increase in sucrose at the expense of stachyose and raffinose at 3 days after germination, further strengthens the view that raffinose and stachyose are hydrolyzed to produce sucrose during germination. Germination of lentil seeds for 6 days is perhaps the most reliable means for complete elimination of raffinose and stachyose, the most gas forming sugars, and therefore, may be used in the preparation of lentil based food products.

Lentil seeds are widely consumed in Mideastern countries in the following four forms: 1) whole seeds are cooked with tomato sauce, 2) soup, 3) paste prepared from decorticated seeds with rice and carrots, and 4) *Koshary*. *Koshary* is a very popular dish especially in Cairo, Egypt. It is prepared by blending rice and whole or decorticated lentil seeds in the ratio of 2:1 (w/v). Chemical composition and nutritive value of *Koshary* have been extensively investigated (Shekib *et al.*, 1985; Shekib *et al.*, 1986, 1987). It was observed that proteins of *Koshary* exhibited moderate concentrations of lysine and sulfur-containing amino acids that are the first limiting amino acids in rice and lentils, respectively.

Chickpea

Chickpea is a major food legume in many countries including Algeria, Myanmar, Ethiopia, Iran, India, Malawi, Morocco, Pakistan, Spain, Syria, Tanzania, Tunisia, and Turkey. Desi and kabuli are two types of chickpea that are grown in the world. However, more than 80% of the world production of chickpea is of the desi type. The use and versatility of chickpea has been well recognized for many centuries. Various aspects of chickpea including production, nutritional quality, postharvest technology, utilization, and marketing have been reported in detail (Saxena, 1987). The Indian subcontinent is the largest producer of chickpea in the world. It also accounts for a much larger variety of usage of chickpea than any other region in the world. A meeting held at the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT, 1991) discussed specifically the utilization of tropical legumes including chickpea. Scientists from 21 countries including Bangladesh, India, Spain, Pakistan, Turkey, Ethiopia, Sudan, West Asia, and North Africa region participated in this meeting. A brief mention of the products reported by these participants is given below:

In the Indian subcontinent, desi chickpea is usually consumed in the form of *dhal* (decorticated split cotyledons) or dhal flour (*besan*). In Bangladesh, most of the chickpea produced is consumed in the form of *dhal*, followed by dhal flour. Chickpea flour is also mixed with wheat flour to make *roti*. These preparations are also common in India, Pakistan, and Nepal.

A popular Egyptian dish, *Lokmet El-kadi* is prepared from chickpea wheat flour and other ingredients. In Ethiopia, legumes are eaten in the form of sauce to supplement the cereal-based staple diet. Some of the products in which chickpea is used are *nifro* (boiled and served by itself or mixed with other cereals), *kollo* (roasted), and *dabo* (fermented wheat and chickpea are mixed and baked).

In India, in addition to *dhal* and *besan*, whole dehulled grain, sprouted grain, immature pods, seeds, and mature green seeds are some of the other forms in which chickpea is consumed. The secondary processing of dhal may involve dry or moist heating, e.g., roasting, steaming, and frying. Puffed chickpea production is a cottage industry in India.

Processing methods of chickpea have certain built in advantages both from nutrition and convenience aspects. Soaking of chickpea reduces cooking time considerably and also reduces the trypsin inhibitor, haemagglutinating activity and flatulence- inducing sugars as some of them are leaked out. Although the concentration of these inhibitors and antinutritional factors are not high enough to cause major concern, the processing method reduces the concentration further.

During the roasting of dhal, the chickpea becomes brown due to Maillard reaction and the aroma and quality of seed improves. On puffing, the seed becomes light from shrinkage of the endosperm and loss of water. The seed starch is thus dextrinized.

In Spain, a chickpea product *Cocido* (boiled chickpea) is quite popular. The price of chickpea also varies from 2 to US$ 3 kg^{-1} in some towns. Canning of chickpea could offer new opportunities for consumers. In the Sudan, chickpea is consumed as *balilah* (boiled chickpea with salt and sesame oil, an energy food eaten especially during fasting period of Ramadan) and *tamia* (soaked dhal ground to a paste, which, after addition of spices, is deep fried).

In Turkey, chickpea is added to improve the taste of many dishes e.g., *nohutlu pilav* (*pulao*), *nohutlu kabak* (sweet squash dish), *asure* (dessert), and *eksili corba* (soup). Roasted white and yellow chickpea are eaten as plain, salted, or sugared nuts. Fermented product and canning of chickpea offer scope for future utilization though at present it is used in small quantities.

In the Mediterranean region of West Asia and North Africa, 75% of all kabuli chickpea grown is consumed as three products: *Tisqeh* (boiled, mixed with soaked bread, olive oil, and yogurt), *Falafel* (mashed with peppers and herbs, and deep fried) and *Homos bitehench* (*Mousabaha*) [boiled mashed chickpea, mixed with pulverized sesame (tihench), olive oil, lemon, and herbs]. Chickpea noodles are made in Myanmar (Burma) through an elaborate process and are quite popular.

Diversifying the use of chickpea

Mathur *et al.* (1964) reported that an epidemiological survey in Agra, India, revealed lower levels of serum cholesterol and a lower incidence of ischemic heart disease in people who consumed chickpea as a staple diet than those who did not consume chickpea. Two isoflavones, biochanin and formononetin, isolated from chickpea have been reported to reduce the concentration of cholesterol (Siddiqui and Siddiqi, 1976). However the results of therapeutic effects of chickpea on human beings are not conclusive and require further investigation. Any confirmed effect in humans would open new avenues of utilization of chickpea.

The process of dry extrusion generates heat by friction and is capable of cooking, partial sterilization, expansion, partial dehydration, enzyme inactivation, and shaping of the product. Products like these can yield convenience foods of high nutrient density, and have good scope for diversifying the use in expanded snack foods and breakfast foods.

Quick-cooking whole seed and dhal can be popularized. Treatments with salt solutions and enzymes have shown promising results and are advantageous in that they diversify chickpea usage. Sprouted chickpea (called *Quanti* in Nepal) improves the availability of vitamins and minerals and also enhances the flavor. Similarly, fermented products like *tempeh*, *natto*, and *kinema* can be prepared from chickpea and popularized.

Chickpea starch is used in textile industry and in the manufacture of plywood. An indigo-like dye is obtained from chickpea leaves. The stems and leaves have high concentration of malic, malonic, citric, and oxalic acids that are used in medicine. There is further scope in utilizing the chickpea in industry.

Chickpea straw contains almost twice the amount of protein per kg when compared with cereal straw. If biological value is considered, 8 t of cereal straw will be equal to 1 t of legume straw. Seedcoats obtained during dehulling is also being used as animal feed. Although chickpea seed may not be used for animal feed for economical reasons, the seed and the whole plant can be used in the animal feed industry.

Nutrition is becoming an important factor in the acceptance of value-added snack items throughout the world. Snack foods have long been labeled as junk food. The snack industry is a complicated mix of radically different companies ranging from large companies with new and modern factories to tiny family-owned and operated businesses selling a single snack item. However, consumers are demanding that nutrition information be provided on the package due to the fact that consumers are becoming more nutrition conscious. Dietary guidelines today suggest we should avoid excessive intake of total fat, saturated fat, cholesterol, sugar, and sodium, and we should increase our consumption of complex carbohydrates. By nature, food legumes are high carbohydrate, high fiber, high protein, low fat foods. Fiber-rich foods such as cool season food legumes play a significant role in treating and preventing obesity, cardiovascular disease, hypertension, diabetes, and cancer. Being able to provide a product that is more attractive, convenient, and nutritionally superior is a must if food legumes are to compete in the value-added snack market. Food legumes have all the necessary ingredients to increase their share of this expanding market.

References

Arntfield, S. D., Ismond, M. A. H. and Murray, E. D. 1985. *Canadian Institute of Food Science and Technology Journal* 18: 137–143.

Bansal, K. K., Dhindsa, K. S. and Batra, V. I. P. 1988. *Journal of Food Sciences and Technology* 25: 46–48.

Batra, V. I. P. 1987. *Indian Journal of Nutrition and Dietetics* 24: 15–19.

Batra, V. I. P. and Dhindsa, K. S. 1989. *Indian Journal of Nutrition and Dietetics* 26: 78–83.

Bramsnaes, F. and Olsen, H. S. 1979. *Journal of American Oil Chemists' Society* 56: 450–454.

El-Ashwah, E. T., Abdallah, N. M., El-Hashimy, F. S. A. and Hassan, F. M. 1985. *Egyptian Journal of Food Science* 13: 11–22.

El-Hashimy, F. S. A., El-Ashwah, E. T., Abdallah, N. M. and Hassan, F. M. 1985. *Egyptian Journal of Food Science* 13: 113–128.

Fayed, H. H. and Morshed, M. A. 1990. [illegible]

Ghorpade, V. M., Kadam, S. S. and Salunkhe, D. K. [illegible] 23: 164–165.

Gueguen, J. 1983. [illegible]

Gueguen, J. and Schaeffer, F. 1984. [illegible]

Hoover, H. D. 1987. [illegible]

ICRISAT (International Crops Research Institute [illegible] *Tropical Grain Legumes*: *Proceedings* [illegible] ICRISAT Center, Patancheru, Andhra Pradesh [illegible]

[illegible] 1988. In: [illegible] House of Hubei.

Kogure, K., [illegible] *University* 29: 1–9.

Kogure, K. and Ohshima, M. 1991a. *Technical Bulletin of the Faculty of Agriculture, Kagawa University* 43: 1–10.

Kogure, K. and Ohshima, M. 1991b. *Technical Bulletin of the Faculty of Agriculture, Kagawa University* 42: 97–109.

Li, Q. L. 1987. In: *Techniques of Grain Food Processing*, pp. 294–299. Beijing, China: Food Publishing House of China.

Liener, I. E. (ed.). 1980. *Toxic Constituents of Plant Foodstuffs*. New York: Academic Press. 502 pp.

Mathur, K. S., Singhal, S. S. and Sharma, R. D. 1964. *Journal of Nutrition* 84: 201–204.

McCurdy, S. M. and Knipfel, J. E. 1990. *Journal of Food Science* 55: 1093–1101.

Murata, K., Kusakabe, J., Kobayashi, H., Akaike, M. and Murakami, M. 1988. *Agricultural and Biological Chemistry* 52: 1317–1318.

Murray, E. D., Myers, C. D., Barker, L. D. and Maurice, T. J. 1981. In: *Utilization of Protein Resources*, pp. 158–176 (eds. D. W. Stanley, E. D. Murray and D. H. Lees). Westport, Connecticut, USA: Food and Nutrition Press.

Newburg, D. S. and Concon, J. M. 1985. *Journal of Agriculture and Food Chemistry* 33: 685–687.

Ohshima, M. and Kogure, K. 1984. *Journal of Japanese Grassland Science* 30: 178–183.

Olsman, H. 1978. *Journal of American Oil Chemists' Society* 56: 375–376.

Pirie, N. W. 1978. *Leaf Protein and Other Aspects of Fodder Fractionation*. Cambridge: Cambridge University Press. 183 pp.

Ragab, M. H. 1988. *Traditional foods in Egypt and Sudan*. A report prepared by the Food and Agriculture Organization of the United Nations (FAO). Rome: FAO.

Saxena, M. C. and Singh, K. B. (eds.). 1987. *The Chickpea*. 409 pp. Wallingford, Oxon, UK: CAB International.

Schmandke, H., Bottcher, H., Plaschnik, D. and Kuhrt, A. 1982. *Die Nahrung* 26: 385–390.

Shekib, L. A., Youssef, M. M., Zoueil, M. E. and Mohamed, M. S. 1987. *Alexandria Journal of Agricultural Research* 33: 192–201.

Shekib, L. A., Zoueil, M. E., Youssef, M. M. and Mohamed, M. S. 1985. *Food Chemistry* 18: 161–168.

Shekib, L. A., Zoueil, M. E., Youssef, M. M. and Mohamed, M. S. 1986. *Food Chemistry* 20: 61–67.

Siddiqui, M. T. and Siddiqi, M. 1976. *Lipids* 11: 243–246.

Sosulski, F. W. and Sosulski, K. 1986. In: *Plant Proteins: Applications, Biological Effects and Chemistry*, pp. 176–186 (ed. R. Ory). Washington, D.C.: American Chemical Society.

Spadoni, M. A., Mengheri, E., Scarino, M. L. and Vignolini, F. 1981. In: *Proceedings of the European Congress on Plant Proteins for Human Food*, p. 19 (eds. C. E. Bodwell and L. Petit). The Hague, Boston: Martinus Nijhoff Dr. W. Junk.

Taukamoto, I., Miyoski, N. and Hamaguchi, Y. 1983. *Cereal Chemistry* 60: 281–286.
Tyler, R. J., Youngs, C. G. and Sosulski, F. W. 1981. *Cereal Chemistry* 58: 144.
Vasishta, R. and Dhindsa, K. S. 1986. *Journal of Food Science and Technology* 23: 260–263.
Vasishta, R., Dhindsa, K. S. and Batra, V. I. P. 1986. *Current Science* 55: 1236–1237.
Vieth, W. R., Constantinides, A. and Bernath, F. R. 1978. In: *Proceedings of the National Science Foundation Grantee-Users Conference*, pp. 43–62. Washington, D. C., USA. NSF.
Wilson, K. A. and Tan-Wilson, A. L. 1983. *Acta Biochemica* (Poland) 30: 139.
Youssef, M. M., Hamza, M. A., Abdel-Aal, M. H., Shekib, L. A. and El-Banna, A. A. 1986. *Food Chemistry* 22: 225–233.
Zhang, Y. J. 1987. In: *Food Processing in Family*, pp. 134–146. Shanghai, China: Scientific Publishing House of Shanghai.
Ziena, H. M., Youssef, M. M. and El-Mahdy, A. R. 1991. *Journal of Food Science* 56: 1347–1349, 1352.

Improving nutritional quality of cool season food legumes

P.C. WILLIAMS[1], R.S. BHATTY[2], S.S. DESHPANDE[3], L.A. HUSSEIN[4] and G.P. SAVAGE[5]
[1] *Agriculture Canada, Canadian Grain Commission, Grain Research Laboratory, 1404-303 Main Street, Winnipeg, Manitoba, R3C 3G8 Canada.*
[2] *Crop Development Centre, Department of Crop Science and Plant Ecology, University of Saskatchewan, Saskatoon, Saskatchewan, S7N 0W0 Canada.*
[3] *Agriculture Canada Research Station, P.O. Box 3001, Morden, Manitoba, R0G 1J0 Canada*
[4] *Department of Nutrition, National Research Centre, El-Tahrir Street, Giza, Dokki, Egypt and*
[5] *P.O. Box 84, Lincoln University, Canterbury, New Zealand*

Abstract

Nutritional quality of food legumes includes the composition and functionality of the seeds. Composition is the main factor affecting nutritional value (contributions to energy and protein requirements, amino acid balance, digestibility, antinutritional factors, etc.). Functionality embraces preliminary preparation steps, digestibility, and cooking quality itself (physical aspects of food preparation, flavor, appearance, and acceptability).

Factors affecting nutritional quality include genetic make-up; growing environment, including location and season, storage, insect infestations (in the field and during storage); and other factors. Nutritional quality parameters of cool season food legumes are tabulated. The improvement of nutritional quality will be considered in the light of the heritability of the chemical and physical factors which affect it. Strategies for improvement in nutritional quality are presented.

Introduction

Cool season food legumes (CSFLs) considered include the kabuli type of chickpea (*Cicer arietinum*), dry pea (*Pisum sativum* or *P. arvense*), faba bean (*Vicia faba*), grasspea or chickling vetch (*Lathyrus sativa*), and lentil (*Lens culinaris*). Interest in the nutritional quality of foods has grown during the past two decades due partly to rising costs of red meats of all types, a concurrent increase in awareness of the benefits to human health of "white" meats (mainly fish and poultry), and the benefits of using food legumes as a protein source.

Nutritional quality embraces all factors essential for people to maintain a condition of healthy living conducive to productive work in terms of manual, mental, and athletic effort. It includes antinutritional as well as nutritional factors. But nutritional quality should also accommodate parameters such as

F.J. Muehlbauer and W.J. Kaiser (eds.), Expanding the Production and Use of Cool Season Food Legumes, 113–129.