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An Introduction to Faba Bean (*Vicia faba* L.)

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Faba bean is an annual legume botanically known as *Vicia faba* L.Globally, it is third most important feed grain legume after soybean (*Glycine max*) and pea (*Pisum sativum* L.) (Mihailovic *et al.*, 2005). The crop is known by many names, most of which refer to a particular subgroup rather than the whole species. Faba bean (*Vicia faba* L.), Broad bean, Horse bean, Windsor bean, Tick bean (small types), are few names in english, Bakela (Ethiopia), Boby kurmouvje (former USSR), Faveira (Portugal) Ful masri (Sudan) Feve (French) and Yeshil Bakla (Turkey) are the few names used in different parts of world. In India it is popularly known as Kala Matar and Bakala in Hindi. It is among the oldest crops in the world. The Chinese used faba bean for food almost 5,000 years ago, they were cultivated by the Egyptians 3,000 years ago (by the Hebrews in biblical times) and a little later by the Greeks and Romans. Most likely, it was introduced into India during the Sultanic period (1206-1555) (Naqvi, 1984). Faba bean is called *baqla* in Persian and that is the name in Hindi today. Interestingly, Dara Shikoh (c.1650) mentioned the word *baqla* in the Nuskha Dar Fanni-Falahat (Razia Akbar, 2000), the Ain-i-Akbari (c.1590) where call to it *rajmaan*, probably from *rajmash*, which is known as kidney bean. Europeans living in India grew it as a garden crop (Watt, 1889).

Fig.1.1. Close-up of faba bean crop under field condition

Faba bean being as fabulous crop, serving human society in various of ways at global level, but but in India it is categorized as minor, underutilized, less utilized, and still not fully exploited crops. Its green pod is mainly used as vegetables and dry cotyledons as source of protein. It is one of the best crops that can be used as green manure and one of the best bio factories of nitrogen by fixing 130-160 kg N/ha. It can be grown in diver's agro-climatic conditions. It can also be produce

Fig. 1.2. Field sight of faba bean crop

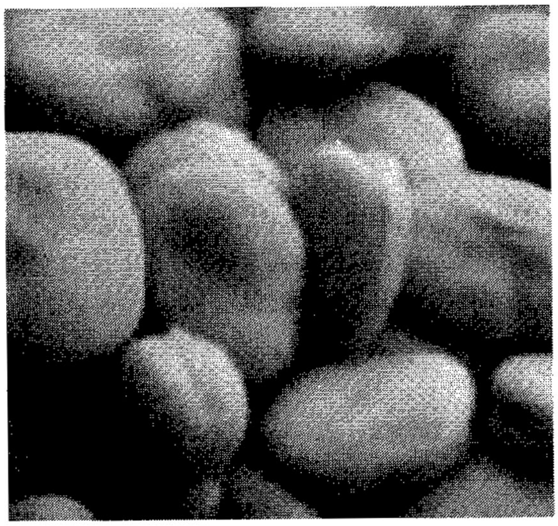

Fig. 1.3. Close-up of green faba bean

as on residual soil moisture with minimum inputs as it is relatively more tolerant to biotic and abiotic stress. Being responsive to added inputs, unfortunately it is grown by poor farmers on poor and marginal land. Productivity of this amazing crop is very poor in India in comparison to other countries. Although it is a wonder leguminious crop of India its full potential has not yet been utilized.

According to United Nation, Food and Agricultural Organization (FAO), Faba bean is grown in 58 countries (Table 1.1). China is currently the world's leading producer with 60 per cent of the total production. Other important producers are Northern Europe, The Mediterranean, Ethiopia, Central and East Asia and Latin America. In the United States and Northern Europe, faba bean are used almost exclusively for livestock pasturage, hay and silage. Presently faba bean is a major crop in many countries including China, Ethiopia, and Egypt, and is also widely grown for human food throughout the Mediterranean region and in parts of Latin America. Egyptians are leader in consuming the faba bean and about 75 per cent of daily per capita protein intake of Egyptians is of vegetable origin, mostly cereals and beans. They consume about 14 g per capita per day of faba bean, which accounts for about 3 g of protein. Mediterranean`s and Chinese heavily depend upon faba bean to supply much of their dietary protein. In the Mediterranean region almost all the faba bean crop is dried, and only small amounts are consumed fresh. In India it is cultivated in different states in considerable area particularly in the state of Utter Pradesh, Bihar, Punjab, Haryana, Jammu & Kashmir, Rajasthan, Karnataka, Madhya Pradesh, Gujarat etc. In India it is basically an minor leguminous crop grown in localized pockets.

Production and International Trade

According to FAO (Table 1.2) the world production of dry faba bean seeds in 1999-2003 amounted to 3.90 MT/year from 2.60 Mha. The main producing countries are China (1.9 MT/year from 1.2 Mha), Ethiopia (405,000 tones, /year from 370,000 ha), Egypt (396,000 tones / year from 134,000 ha) and Australia (242,000 tones /year from 164,000 ha). The annual production in sub-Sahara Africa in 1999-2003 was estimated at 510,000 tones, almost entirely from Ethiopia (405,000 tones) and Sudan (100,000 tones). The annual world production of dry faba bean seeds declined from about 5 MT (from 5 Mha) in the early 1960s to about 4 MT from 2.7 M ha) in the early 2000s.The reduction in area under cultivation in China from about 3.5 M ha in the early 1960s to about 1.25 M ha in the early 2000 accounted for the largest share of the reduction in production. In contrast, the annual production in sub-Sahara Africa increased during the same period from 230,000 tones (250,000 ha) to 540,000 tones (450,000 ha).

The world production of green faba bean seeds in 1998-2003 was estimated at 940,000 t/year from 2.6 M ha, with Algeria (118,000 tones/year), China (114,000 tones /year) and Morocco (112,000 tones /year) as the largest producers (Table.1.3). The production of green faba bean seeds in tropical Africa and Asia is negligible.

World exports of dry faba bean seeds in 1998-2002 amounted to 475,000 tones. The main exporting countries were Australia (201,000 tones), the United Kingdom (114,000 tones), China (63,000 tones) and France (53,000 tones). The main importers in this period were Egypt (197,000 tones), Italy (169,000 tones) and Spain (52,000 tones).The exports from African and Asian countries are negligible (Table. 1.4).

Table 1.1. Major countries producing faba-bean

Country	Production (000 MT)
China	2,700
Ethiopia	277
Egypt	262
Italy	206
Mexico	79
Czechoslovakia	71
France	65
Morocco	65
Brazil	62
Tunisia	54
Turkey	53
Spain	51
Sudan	22
Peru	21
Iraq	17
Total	**4,178**

Source: FAO, Production Yearbook 2006.

Table 1.3. Production of green Faba Bean during 1998-2003.

Country	Production (MT)
China	0.114
Algeria	0.118
Australia	0.164
World	0.940

Table 1.2. Area and production of dry Faba Bean during 1999-2003.

Country	Area (Mha)	Production (MT)	Productivity (kg/ha)
China	1.20	1.90	1.58
Ethiopia	0.37	0.405	1.09
Egypt	0.134	0.396	2.96
Australia	0.164	0.242	1.48
World	2.60	3.90	1.5

Origin

Faba beans are small-seeded relatives of the garden broad bean. Faba bean is assigned to the Central Asian, Mediterranean, and South American centers of Diversity and believe to be a native to North Africa and southwest Asia, and

Table 1.4: Status of Export and import of faba bean.

Export		Import	
Country	Quantity (tones)	Country	Quantity (tones)
Australia	201,000	Egypt	197,000
United Kingdom	114,000	Italy	169,000
China	63,000	Spain	52,000
France	53,000	**Total**	475,000
Total	475,000		

extensively cultivated elsewhere. Cubero (1974) postulated a Near Eastern center of origin, with four radii to Europe along the North African coast to Spain, along the Nile to Ethiopia, and from Mesopotamia to India. Secondary centers of diversity are postulated in Afghanistan and Ethiopia. However, Ladizinsky reported the origin to be Central Asia. The wild progenitor and the exact origin of faba bean remain unknown. Several wild species (*V. narbonensis* L. and V. *galilaea* Plitmann and Zohary) are taxonomically closely related to the cultivated crop, but they contain $2n = 14$ chromosomes, whereas cultivated faba bean has $2n = 12$ chromosomes. Numerous attempts to cross the wild species to cultivated faba bean have failed. Although usually classified in the same genus *Vicia* as the vetches, some botanists treat it in a separate monotypic genus as *Faba sativa* Moench. It is an annual herb with coarse and upright stems, unbranched 0.3-2 m tall, with 1 or more hollow stems from the base. The leaves are alternate, pinnate and consist of 2-6 leaflets each up to 8 cm long and unlike most other members of the genus; it is without tendrils or with rudimentary tendrils. The plant flowers profusely but only a small proportion of the flowers produce pods. Flowers are large, white with dark purple markings, borne on short pedicels in clusters of 1-5 on each axillary raceme usually between the 5th and 10th node; 1-4 pods develop from each flower cluster, and growth is indeterminate though determinate mutants are available. About 10-15% of the plants in a population are cross-fertilized and the main insect pollinators are honey and bumble bees. There is a robust tap root with profusely branched secondary roots. Based on seed size, two subspecies were recognized, *paucijuga* and *faba*. The latter was subdivided into var. *minor* with small rounded seeds (1 cm long), var. equina with medium sized seeds (1.5 cm) and var. *major* with large broad flat seeds (2.5 cm). Cubero suggested four subspecies, namely: *minor, equina, major,* and *paucijuga*. Taxonomically the crop belongs to Section Faba of the Genus *Vicia*. It is a rigid, erect plant 0.5-1.7 m tall, with stout stems with a square cross-section. The leaves are 10-25 cm long, pinnate with 2-7 leaflets, and of a distinct glucose grey-green colour; unlike most other vetches, the leaves do not have tendrils for climbing over other vegetation. The flowers are 1-2.5 cm long, with five petals, the standard petal white, the wing petals white with a black spot, and the keel petals white. The fruit is a broad leathery pod, green maturing blackish-brown, with a densely downy surface; in the wild species, the pods are 5-10 cm long and 1 cm diameter, but many modern cultivars developed for food use have pods 15-25 cm long and 2-3 cm thick. Each pod contains 3-8 seeds; round to oval and 5-10 mm diameter in the wild plant, usually flattened and up to 20-25 mm long, 15 mm broad and 5-10 mm thick in food cultivars.

Agroclimatic Requirement

Fig. 1.4. Faba bean at active growth stage

Faba bean, being a legume are capable of fixing atmospheric nitrogen, which results in increased residual soil nitrogen which is further use by subsequent crops. It is one of the best known 'break' crop which enhances cereal yield, because it decreases the occurrence of 'take-all' and 'cereal cyst nematode'. It tolerates water logging better than other legumes. All operations can be undertaken by using cereal equipment. Stubble residue is valuable stock feed. The faba bean is very cold hardy, but cannot take excessive heat during flowering. As faba bean mature, the lower leaves darken and drop, pods turn black and dry progressively up the stem. Faba bean tend to shatter if left standing until maturity. This annual legume grows best under cool and moist conditions. Hot dry weather is injurious to the crop, so early planting is important. Faba bean tolerates frost. Rainfall of 650-1000 mm per annum evenly distributed is ideal for faba bean. Medium textured soils are ideally suited for faba bean production. It prefers loamy types of soil with pH ranging from neutral to alkaline (pH of 6.5 to 8.0). Since the crop requires a good moisture supply for optimum yields, moderate moisture supply is necessary. Faba bean do not tolerate standing water. Moisture requirement is highest about 9-12 weeks after establishment. It is grown as a winter annual in warm temperate and subtropical areas; hardier cultivars in the Mediterranean region tolerate winter temperatures of -10°C without serious injury whereas the hardiest European cultivars can tolerate up to -15°C. Faba bean are slow to emerge and takes 10-25 days, seeds must be in constant contact with moisture until seedlings are well established. The time from seeding to harvest ranges from 80 to 140 days depending upon the cultivars and climatic conditions. Faba bean should be grown only once every four years in the same field to avoid a build-up of soil-borne diseases.

Cultural Practices

Since faba bean are slow emergers, for best results a fine tilth over a firm seedbed is required. Good seedbed should be prepared, to insure good soil to seed contact. Rolling after seeding should be considered on stony or extremely cloddy soil. Seed should be tested for germination before sowing. Newly released inoculums, called faba bean *inoculums*, and has replaced the group *E strain* of *inoculums*. If sowing on areas that have not grown beans, inoculate before sowing. Faba bean, which can be grown as a cultivated row crop or as a non-cultivated narrow-row crop like small grains, respond favourably to narrow row spacing. It is better to grow faba bean with 20-30 cm row and 15-20 cm plant to plant spacing. It is recommended to use seed from a healthy crop. In general, 120-130 kg seeds is required for one hectare sowing (seed size of 35 g/100 seeds) having 80% germination. In a study ranging from 80 to 300 kg, the optimum seeding rate was 160 kg/ha when planted in 18 cm rows. Although high rates of sowing and narrow rows tend to produce higher yields, seed cost is an important restriction to optimum seeding rate. Planting depth is critical, since the hard, dry seed takes longer to absorb water and germinate. Deep planting (6-10 cm) is necessary to get the seed below the surface so it doesn't dry out.

Fig. 1.5. Faba bean on raised bund

Fig. 1.6. Visual observation to diagnose nutrient deficiency symptoms of faba bean

Nutrient Requirements

Legumes require neutral to alkaline soil for maximum N fixation by nodule through symbiotic bacteria. Soils should be tested and, if necessary, limed to at least pH 6.0. Dolomitic limestone would need to be applied at regular interval least one year prior to faba bean production. Soils need to have P and K Soil test levels in the medium to high range to ensure adequate fertility levels for maximum crop yields. These soil test levels are at least 11 ppm P and 81 ppm K depending on subsoil category. Soils should be tested and, if necessary, supplied with P_2O_5 and/or K_2O prior to seeding. Nutrients equivalent to crop removal should be applied annually in order to maintain adequate soil test levels. Therefore maintenance P_2O_5 and K_2O fertilizer in Table1.5 is based on that necessary. If top growth is removed for silage, higher application are needed. Some N may be needed to ensure a good start since faba bean is a shallow rooted annual legume planted very early. Table 1.5 also gives recommended N rates dependent on both crop yield and soil organic matter content. If no soil test is available add

Table 1.5. Annual nitrogen, phosphate and potash recommendations for faba bean.

Grain yield (Kg/ha)	Nitrogen Soil organic matter % Low (<=5)	High (>=5)	Phosphate P_2O_5 (Kg/ha)	Potash K_2O (Kg/ha)
1000-2500	15			20
2500-4000	25	10	15	30
4000-6000	35	15	20	40

65 kg/ha of single superphosphate, or its phosphorus equivalent, for every tonne per hectare of grain expected to be harvested.

Faba Bean and Nitrogen Economy

Fig. 1.7. Faba bean at flowering stage

Faba bean is excellent crop for cropping systems because its unique ability to fix atmospheric N_2 symbiotically, which is heavily, depends on the sufficient populations of effective *rhizobia*. It can accumulate N both from soil and the atmosphere. The relative contribution from each source to maintain faba bean N requirement for growth will be heavily influenced by the concentrations of available soil mineral N in the root zone. It is essential to be able to determine the potential net N benefit of faba bean in order to appropriately adjust the supply of fertilizer N for later crops in the rotation. Slower rates of N accumulation by faba bean during the first months after seedling emergence, after two months of growth the rate of N accumulation was greater in faba bean. Due to their indeterminate growth habit faba bean continued assimilating N for a longer period, reaching about 315 kg N ha^{-1} after 110 days. The N concentration in the faba bean crop biomass is around 5% a few days before flowering; during the initial stages (30 days) of reproductive growth the N concentration declined rapidly to 2.5-3%, due to the biomass accumulation rate being faster than the N assimilation rate and the N concentration remained at this level until maturity. Faba bean accumulates N from N_2 fixation at an increasing rate until initiation of the maturation process unless other factors such as water availability restricts the N_2 fixation process earlier in growth.

Plant Growth Promoting Microorganisms (PGPM)

Efforts to increase yield and yield stability of faba bean should complement work to improve the sustainability of cropping systems, particularly in terms of soil fertility. The ability of the crop to fix atmospheric nitrogen, as well as to assimilate soil N, provides opportunity to balance nitrogen export in grain with input from the atmosphere. In order to maximize N_2 fixation in the *Vicia faba* L.

legume-*rhizobia* symbiosis, both host and micro-symbiont must be considered. In recent years there has been a renewed interest in the use of soil microflora, when applied to seeds, roots or tubers, is able to colonize plant roots and stimulate plant growth and crop yield. The mechanism by which these bacteria and fungi stimulate plant growth are not well understood but it has been suggested that production of plant hormones, enhancement of plant nutrient uptake, suppression of pathogens in the plant *rhizosphere*, solubilization of phosphorus, rhizospheric nitrogen fixation or conversion of materials to a form useful to the plant may be involved. Beneficial *rhizobacteria* are termed either plant growth promotory *rhizobacteria* (PGPR) or plant health promotory *rhizobacteria* (PHPR) according to their mode of action may induce plant growth promotion through different direct or indirect mode of action. These plant growth promotory bacteria can enter into a symbiotic relationship with plants (i.e. *Rhizobium*-legume symbiosis), but non-symbiotic, free-living soil bacteria can also promote plant growth. In last few decades a large array of bacteria including species of *Pseudomonas, Azospirillum, Azotobacter, Klebsiella, Enterobacter, Alcaligenes, Arthrobacter, Burkholderia, Bacillus* and *Serratia* have reported to enhance plant growth. The direct promotion by PGPR entails either providing the plant with plant growth promoting substances that are synthesized by the bacterium or facilitating the uptake of certain plant nutrients from the environment. The indirect promotion of plant growth occurs when PGPR prevents deleterious effect of one or more phytopathogenic microorganisms. Ecological interactions between rhizobia and other soil bacteria have been of interest in recent years because of their agronomical interactions. Many scientists have reported enhancement of nodulation and growth of a wide variety of faba bean and other forage legumes, due to positive interactions between *Rhizobium* species and *diazotrophic* soil bacteria.

Weed Management

Faba beans are poor competitors with weeds, particularly in the seedling stage. This makes integrated weed control essential for successful crop production. Select fields with light weed pressure. One deep ploughing of faba bean fields 7 to 10 days before planting and after planting coupled with two hands weeding at 30 and 45 days after planting prove effective for weed management.

Fig. 1.8. Faba bean plant emerging in natural condition competing with weeds

Pest's Management

The major insect pests and disease which reduces the quantity and quality of faba bean are Red-legged earth mite (*Halotydeus destructor*) is a black-bodied mite with red legs; it damages seedlings as they emerge. Symptoms include leaves that turn silvery, then brown and shrivelled. Lucerne flea (*Sminthurus viridis)* is a

Fig. 1.9. Close-up of aphids infestion on faba bean at early growth stage

small (2.5 mm), wingless, light green hopping insect. It chews through leaves in layeŗs resulting in "window-pane" like holes. The crop shrivels and becomes stunted. The caterpillar damages the maturing seed in the pods. The newly hatched caterpillars are small (1-2 mm) and therefore are easily missed when crops are being inspected. When mature (40-50 mm long) they have a yellow-white stripe downs each side of the body and a dark stripe downs the centre of the back. Leaf, stem and pod spot is a major disease problem. It is caused by the fungus *Ascochyta fabae*. Grey-brown spots form on leaves. Small fruiting bodies may appear on leaves after rain. On stems and pods, dark-coloured spots appear which may spread to the seed. Stems may collapse. Chocolate spot is another major problem. It is caused by *Botrytis fabae*. The symptoms are reddish or chocolate brown spots on leaves and reddening of stems. The spots may enlarge and merge, forming a black mass on the leaves (blighting), which is followed by defoliation and lodging. Chocolate spot and Ascochyta usually require a minimum of two sprays for control. Dense crops, water logging and wet weather favour outbreaks of these diseases. Rust (*Uromyces viciae-fabae*) appears as orange-brown pustules with a light green halo on leaves, which can spread to stems.

Fig. 1.10. Close-up of faba bean leaf spot at seedling stage

Harvesting

Faba beans turn black when they are ripe. Harvesting should begin while stems are still slightly green. Harvesting should begin when the lowest two bunches of pods begin blackening or when most seed easily detaches from the hilum. At this stage the moisture content of the beans is from 30 to 35%. Swathing in this moisture range provides the highest bulk density and 1000-kernel weight. The high moisture content requires a fairly long drying period in the swath, so it is advisable to lay a fairly light swath. Swathing faba bean is usually not difficult. In severely lodged crops, a pickup reel is quite effective. Generally, 15-18% moisture in the seed at harvest is enough to overcome a tendency to shatter. Rapid drying at high temperatures often causes stress cracks. The maximum moisture content for a 'straight grade' of faba bean is 16%. The average yield is 1.6 t/ha. Yields may range from 1.2 to 3.5 t/ha. Much higher and lower yields have been observed on individual plots, crude protein percentage has ranged from 27 to 32%.

Bee Pollination

Faba bean is a partially allogamous species (Self-fertile with about equal amount of self and cross-pollination occurring depending on the presence of insect pollinators). The Apoides play a decisive role in the pollination of allogames lines. The importance of bees in cross-pollination of this plant and the improvement of its production has been demonstrated and recognized by several authors. Inadequate pollination is considered as a major obstacle to achieve the potential yield and improved seed quality of faba bean. Insects appear to be the major pollinators of faba bean. Numerous studies have shown the importance of honey bees as pollinators of faba bean in Australia and overseas. An experiment conducted with caged plots confirmed, increase in seed yield of *Vicia faba* L. in the presence of pollinating insects during the flowering season. The plants that were accessible to pollinators provided more pods per plant, more seeds per pods; the pods were longer and the seeds were heavier than the encaged plants. Among the pollinating insects of *Vicia faba*, in the Tizi Ouzou area (Algeria), the wild bee *Eucera pulveracea* Dours was the most abundant and seemed to be the most effective pollinator. His visits were all able to fertilize the flowers. On the contrary, several floral visits of the honey bee *Apis mellifera* L. and all visits of *Xylocopa violacea* were "nectar robbery" through the holes made by the bumblebees at the base of the corolla.

Fig. 1.11. Pollination is being performed by honey bee while collecting nectar

Varietal Improvement

Seed is the basic unit of agriculture without quality seed we cannot harvest good crops. The production of high quality seed with high analytical quality, species and cultivar purity, high germination capacity, vigour and uniformly large size, free from weeds and seed borne diseases and low moisture content is a formidable task requiring technical skill and knowledge of cytogenetics and plant breeding. Maintaining the genetic purity of the seed is utmost importance and will enable grow-

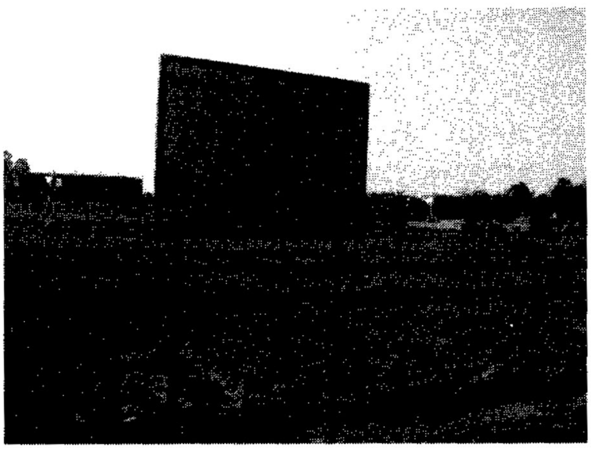

Fig. 1.12. Multi location evaluation of new develope faba bean varieties

ers to exploit the full benefits of introducing improved varieties seeds. The breeding method of faba bean is intermediate between autogamy and allogamy. The differences in floral biology incited breeders to define the best breeding method to be used for faba bean improvement. The methods used by breeders are derived from those used for self-pollinated crops, namely introduction and germplasm collection, pure line selection, single plant selection, selection and hybridization, with modifications required by the particular breeding system and the desire to maintain partial heterozygosity in the plant population. In addition to the traditional breeding procedures, the development of a system for restoring male sterile fertility in faba bean provides the mechanism for the establishment of hybrid varieties. A population improved for a particular quantitative inherited characteristic by recurrent selection procedures, may be generated and used in the development of open-pollinated cultivars or as a source of variability for further improvements by other methods, including the development of inbred lines for use in synthetic varieties. In India only few varieties counted on finger namely Pusa Sumit and Vikrant (VH-82-1) has been released at National level, however some state level release has been also reported, mainly from JNKVV, Jabalpur clearly indicate that there is urgent need to develop considerable amount of high yielding varieties for this orphan/ neglected crop.

Fig. 1.13. Promosion genotypes at active growth stage

Biotechnological Approach for Faba Bean Improvement

Several biotechnology techniques would very useful for faba bean breeding. Protoplast fusion and regeneration or by embryo-rescue assisted interspecific crossing, e.g. resistance to black aphid, as occurring in the related species *Vicia johannis*, could be introduced to *Vicia faba* L. These techniques are not yet available for faba bean. The same is true for any approach to produce doubled haploid lines. Genetic transformation based on *Agrobacteria* is possible. Several RAPD markers linked to a gene determining hypersensitive resistance to race 1 of the rust (*Uromycese viciae-fabae*) have been reported. Molecular breeding for resistance to broomrape, ascochyta blight, rust and chocolate spot have been obtained. The use of marker assisted selection (MAS) can complement conventional field breeding by speeding up the selection of desirable traits and increasing selection efficiency. Recently, markers linked to a gene controlling growth habit or to select against traits affecting the nutritional value of seeds (tannins, vicine and convicine content) have also been reported.

Faba Bean Modelling

Crop models such as CERES and CropSyst treat canopies as homogeneous entities without attempting to define canopy geometry, other than through row structure. A functional-structural modelling approach can improve canopy simulation, in particular of indeterminate crops such as faba bean. A major challenge is to incorporate the plasticity of the canopy. Functional-structural models can accomplish this by introducing variation in several ways and at different levels of canopy composition. ALAMEDA is a functional-structural model of a faba bean (*Vicia faba* L.) crop that addresses these issues. An L-system provides the basic conceptual and program structure within which functional relationships can be connected. In this way it plays a comparable role to physical plant structure that provides the linkage between morphology and physiological processes spatially distributed over plant components. In accordance with results of previous studies with faba bean, the stem was selected as the main building module. An associated growth model is linked to calculate the lengths of the vegetative organs, and leaf allometries are used to compute leaf area. ALAMEDA is currently being extended by including a model of radiation interception and functions from classic models, for example, the variation of specific leaf area with temperature as specified in CROPGRO-legume.

Fig. 1.14. Plant sampling in progress for further analysis

Zero Tannin Faba Bean Varieties

High tannin (10% or higher seed tannin levels) cannot be fed at high levels to livestock. In the 1970's normal high tannin (more then 10%) was grown as a silage protein crop (for cattle) and still some was even marketed to Egypt and other countries for human consumption. Zero tannin (less than 1% seed tannin level) is now available which can be directly processed and fed to swine and meat poultry. These older tannin types originated from Europe (Germany and The Netherlands) and tannin types are still grown as a livestock feed in Europe because most of the feed is pelletized and the heat in pelleting destroys the tannin problem. The feed quality of zero tannin faba bean is excellent and the production factors for this crop are quite simple and easy to obtain. The large potential of the new zero tannin faba bean (variety 'Snowbird') are mainly as a feed for swine and meat poultry. 'Snowbird' faba bean is a medium maturing cultivar (110-120 days to maturity) based on early seeding. Seed size is approximately 550 grams/1000 seeds. The general property of normal faba bean seeds are given in Table 1.6.

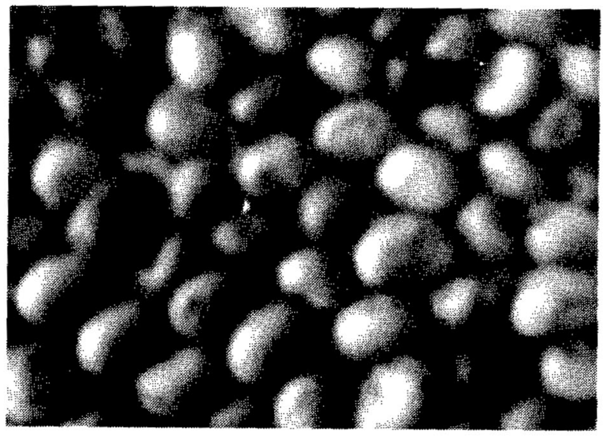

Fig. 1.15. Seeds of zero tanin faba bean

Table 1.6. Physical properties of faba bean seeds.

Particulars	Range
Moisture content (%wb)	8.5-34.9
Bulk density (kg/m^3)	761-883
Kernel density (kg/m^3)	1393-1373
Angle of repose (^{o})	20.6-29.3
Specific heat at 20-40 °C(kJ/kg-K)	1.54+0.026m
Thermal conductivity at 66.6 °C (W/m-K)	0.33
Thermal diffusivity at 66.6 °C (m^2/s)	1.14 x 10-7

Production Strategies for Zero Tannin Faba Beans

For tannin free faba bean production one should choose a field with no perennial weed problems-last pre harvest fields. Do not sow faba bean on previously high nitrogen (manured) fields. Seed sowing should be done into optimum soil moisture condition, minimum of 4 cm depth or deeper seeding should be done if necessary. Sowing should be done in a manner that 4 plants per sq. ft. must be maintained. Proper inoculants and a small amount of phosphate is must in total fertilizer for most of the fields. Make crop weed free and if needed proper herbicide viz., Reglan etc. should be applied in appropriate quantity and manner. Harvesting should be done by straight cut or direct reaping, when seed moisture is about 18-20%. Harvested crop should be left in the field to dry up to the level of 16% moisture.

Faba Bean in Cropping Systems

Fig. 1.16. Faba bean in cropping systems

Faba bean (*Vicia faba* L.) is grown world-wide as protein source for food and feed, but at the same time it offers ecosystem services such as renewable inputs of nitrogen (N) into crops and soil via biological N_2 fixation, and a diversification of cropping systems.

The season-to-season fluctuations in grain yield of agricultural crops and the progressive replacement of traditional farming systems, which utilized legumes to provide N to maintain soil N fertility, with industrialized, largely cereal-based systems that are heavily reliant upon fossil fuels (N fertilizers) and heavy mechanization are some of the explanations for this decline in importance. Past studies of faba bean in cropping systems tend to focus on the effect of faba bean as a pre-crop in mainly cereal intensive rotations, whereas similar information on the effect of preceding crops on faba bean is lacking. Faba bean has the highest average reliance on N_2 fixation for growth of the major cool season grain legumes. As a consequence the N benefit for following crops is often high, several studies have demonstrated substantial savings (150-300 kg N/ha) in the amount of N fertilizer required to maximize the yield of crops grown after faba bean. There is, however, a requirement to evaluate the potential risks of losses of N from the plant-soil system associated with faba bean cropping via nitrate leaching or emissions of N_2O to the atmosphere as a consequence of the rapid mineralization of N from its N-rich residues. It is important to develop improved preventive measures, such as catch crops, intercropping, or no-till technologies, in order to provide farmers with strategies to minimize any possible undesirable effects on the environment that might result from their inclusion of faba bean in cropping system. This needs to be combined with research that can lead to a reduction in the current extent of yield variability, so that faba bean crop may prove to be a key component of future arable cropping systems where declining supplies and high prices of fossil energy are likely to constrain the affordability and use of fertilizers. This will help address the increasing demand by consumers and governments for agriculture to reduce its impact on the environment and climate through new, more sustainable approaches to food production.

Quality Parameters

Faba bean seeds are very low in saturated fat, cholesterol and sodium. It is also a good source of dietary fibre, protein, phosphorus, copper and manganese, and a very good source of Folate. Wide variation of protein content (20-41%) has been reported. When rainy/ spring and winter faba bean are compared, winter beans have slightly higher concentrations of protein than the latter. Protein concentration is influenced by both genetic and environmental factors and it has been reported that inheritance of this trait is additive with some partial dominance. Amino acid content varies from 36-69 mg for *methionine*, 44-94 mg for cystine and 333-400 mg for lysine. *Legumine* is the predominant globulin and has a larger proportion of *arginine, threonine* and *tryptophan*. Utilizable protein, protein digestibility and biological value are reported to vary from 14.8-15.5%, 82-92% and 45-55%, respectively.

Protein and Amino Acids

The faba bean has high protein content (Table 1.7 and 1.8). The variation among populations of different origins ranges between 26 and 41 per cent. Protein content does not seem to be greatly affected by either seed weight as thousand grain weight or seed yield per plant. The crude protein content of the seeds varies widely depending on many factors, for example variety, fertilizer application, and location of growth. The seed coat may contain less protein and more carbohydrate in comparison to cotyledons and whole seeds. The protein quality, like that of most other leguminous proteins, is lower than that of most animal foods because it is moderately deficient in the amino acid *methionine* (Table 1.8). However, the faba bean has, in contrast to cereals, a high content of *lysine* and also of *arginine*. An increase in the protein level involves a certain decrease in the

Table 1.7. Nutrition Information (per 100 g).

Nutrient Balance	Per cent contribution of dry matter	Nutrient Balance	Per cent contribution of dry matter
Energy	344 calories	Zinc	1.00 mg
Moisture	10.1g	Copper	0.24 mg
Carbohydrate	59.4 g	Manganese	0.41 mg
Protein	24 g	Selenium	2.59 mg
Fats	1.3 g	Vitamin A	15.00 I U
Ash	104 mg	Vitamin C	0.29 mg
Saturated Fat	0.06 g	Vitamin K	2.88 mcg
Monounsaturated Fat	0.06 g	Thiamine	0.12 mg
Polyunsaturated Fat	0.18 g	Methionine	53 mg
Total Omega-3 fatty acids	12.00 mg	Riboflavin	0.12 mg
Omega-6 fatty acids	151.76 mg	Niacin(mg)	0.71 mg
Calcium	36.0 mg	Vitamin B6	0.06 mg
Iron	1.47 mg	Folate	104.12 mcg
Magnesium	43.0 mg	Pantothenic Acid	0.18 mg
Phosphorus	124.71 mg	Choline	30.59 mg
Potassium	268.24 mg	Tryptophan	162 mg
Sodium	5.00 mg		

level of sulphur-amino acids as well as of *lysine*, which means that there is a negative correlation between sulphur-amino acid content and protein per centage in the seeds. This negative correlation is probably explained by the fact that storage proteins, which are relatively low in sulphur-amino acids, constitute a higher proportion of the protein fraction of the seeds. This problem can be overcome as it is possible to complement the diet with other proteins in which the sulphur-amino acids are not the limiting factor, such as wheat products (bread or macaroni). For example, cooked faba bean, salad, and bread are a popular dish in Egypt, as is faba with macaroni in certain parts of Italy.

Starch and Oligosaccharides

Scanning electron micrographs of the cotyledons and the starch and protein fractions of the faba bean revealed changes in the surface of the cells dur-

Table 1.8. Protein content (per centage on dry basis) and amino acid composition (g/16N).

Compound	Mean ± s.e.
Lysine	7.08 ± 0.09
Histidine	2.63 ± 0.03
Arginine	9.61 ± 0.40
Aspartic acid	11.85 ± 0.69
Threonine	3.63 ± 0.04
Serine	4.63 ± 0.06
Glutamic acid	19.04 ± 0.72
Proline	4.24 ± 0.06
Glycine	4.18 ± 0.04
Alanine	4.19 ± 0.04
Valine	4.63 ± 0.04
Isoleucine	4.25 ± 0.05
Leucine	7.68 ± 0.11
Tyrosine	3.15 ± 0.04
Phenylalanine	4 37 ± 0 07
Methionine	0.84 ± 0.05
Half-cystine	1.28 ± 0.03
Crude protein	30.98 ± 0.51
Per centage of dry matter	87.38 ± 0.06

ing germination of the seed. The starch granules appeared to be very fragile and proteins began to break into small fragments after eight days of germination. There was a decrease in amylose, amylopectin, and raffinose during germination. Sucrose and fructose increased during the four day germination period, but decreased thereafter. Raffinose decreased gradually during the six-day germination period and was not detectable after eight days. Faba bean starch had oval or irregularly shaped granules which were larger in average particle size than those of corn starch. It also had higher amylose content, gelatinization temperature range (61 to 69°C), and water-binding capacity, but a lower swelling power and solubility at 90°C compared with wheat and corn starch. The microscopic structure of broad beans has been studied using scanning electron microscopy (SEM). They examined the cells in the cotyledon and found granules of about 25-40 μ in diameter, surrounded by irregularly shaped protein bodies of 1-5 μ in diameter. The cell walls were about 2 μ thick and had a ribbed or furrowed inner surface. Photomicrographs showed only slight differences in the appearance of cotyledon cell structure between the dry and soaked faba bean, and the size of the starch granules increased after soaking.

Uses

Cultivated faba bean is used as human food in developing countries and as animal feed, mainly for pigs, horses, poultry and pigeons in industrialized countries. It can be used as a vegetable, green or dried, fresh or canned. It is a common breakfast food in the Middle East, Mediterranean region, China and Ethiopia. The most popular dishes of faba bean are Medamis (stewed bean), Falafel (deep fried cotyledon paste with some vegetables and spices), Bissara (cotyledon paste poured onto plates) and Nabet soup (boiled germinated beans). Feeding value of faba bean is high, and is considered in some areas to be superior to field peas or other legumes. It is one of the most important winter crops for human consumption in the Middle East. Faba bean has been considered as a meat extender or substitute and as a skim-milk substitute. Sometimes it is also grown for green manure, but more generally for stock feed. Large-seeded cultivars are used as vegetable. Roasted seeds are eaten like peanuts in India. Straw from faba bean harvest fetches a premium in Egypt and Sudan and is considered as a cash crop. The straw can also be used for brick making and as a fuel in parts of Sudan and Ethiopia. The important uses of faba beans are as under :

Culinary Uses

Faba beans are eaten while still young and tender, enabling harvesting to begin as early as the middle of spring for plants started under glass or overwintered in a protected location, but even the main crop sown in early spring will be ready from mid to late summer. Horse beans, left to mature fully, are usually harvested in the late autumn. The beans can be fried, causing the skin to split open, and then salted to produce a crunchy snack. These are popular in China, and also in Thailand where their name means 'open-mouth nut'. Some of the important preparation like Stewed Faba Bean (Fool Medames): Most people eat stewed faba bean for breakfast and supper as well as in sandwiches at any time of the day. Many additives such as oil (cottonseed oil), salad, spices (pepper and cumin), lemon juice and eggs are used, while cheese is a usual adjunct of faba bean dishes. The sandwiches of stewed faba bean consist of almost 80 per cent bread (prepared from wheat flour) and about 20 per cent cooked faba bean mixed with oil, salt, spices, and salad. The dried seeds are stewed in about twice their volume of boiled water, on a flame which is only high enough to keep the content gently boiling for 10-12 hours until the beans become soft. Soaking the beans in water before cooking shortens the cooking time. The cooking time for dried beans may also be shortened by pressure cooking, in which case fat must be added to prevent excessive foaming, which could prove dangerous by clogging the vent of the pressure cooker. Stewed beans, cooked under pressure, cook down to less volume than beans cooked gently. The green immature pods of faba bean or stewed faba bean can also be cooked in tomato sauce prepared from fried onion, fat, spices, and tomato juice. Bean Cakes (Falafel or Taamia): The most common way of preparing faba bean is in the form of dried cakes, which are widely used in the Middle East as a breakfast and supper delicacy, usually in sandwiches containing 70 per cent wheat bread, 20 per cent falafel and 10 per cent green salad. The decorticated dried beans are soaked in water for 12 hours and then the water is drained off. Small amounts of garlic, spring onion, parsley, dill, and spices (salt, pepper, and cumin) are added for flavouring. The mixture is then crushed into a thick paste. When ready, the mass is removed from the mortar and allowed to stand for some time. The paste is finally shaped into small, round pieces and deep-fried in boiling cottonseed oil until the surface turns from green to a uniform brown. Germinated Beans (Fool Nabet): Germinated and cooked faba bean is a traditional meal in Egypt. The dried seeds are soaked in water for about 12 hours then germinated for three days. The germinated beans are then cooked in boiling water for about one hour and served after adding spices, fried garlic or onion, and pieces of dried bread (Nabet soup). In the preparation of stewed faba bean (medames), the cooking time required to reach the optimum eating quality varies among cultivars. The so-called "soft" cultivars which cook in a shorter time are preferred over the "hard" cultivars. The cooking quality of faba bean can be evaluated by the following parameters.

Livestock Feed

The faba bean does not possess any components toxic to animal or man. It is possible to feed the bean to all types of livestock or poultry provided it is cracked or crushed. No further processing is required. Canadian research showed no significant difference in milk production when cows were fed grain rations containing either faba beans or soybean meal as the protein supplement. Studies indicate that the dry matter digestibility of faba beans is somewhat lower than soybean meal and solubility of the protein is also lower in faba bean as compared to soybean meal. The fiber is higher and fat lower in faba bean versus soybean meal. The faba bean is about 25% protein, and is higher in energy than soybean (Table 1.9). Most results suggest that substituting two parts of faba bean for one part soybean and one part cereal grain gives equal or better rates of gain.

Table 1.9. Comparative nutrient content of faba bean, barley and soybean meal.

Chemical composition	Faba bean % dry matter	Barley grain	Soybean meal
Crude protein	27.0	11.0	45.0
Digestible protein	22.6	8.8	41.8
Calcium	0.15	0.08	0.37
Phosphorus	0.50	0.35	0.67
Lysine	1.5	0.4	3.3
Methionine-cystine	0.5	0.2	1.6

Forage/Silage

Faba bean plants make high quality silage. Swathing should take place when the lowest seed pods begin blackening. The swath should be left to wilt for one to three days. In a three-year experiment in Rosemont, MN, horsebean sown at 180 lbs/a produced 4,370 lbs/a of dry forage containing 10.5% protein. A mixture of 60 lbs horsebean and 64 lbs oats produced 5,613 lbs of dry forage containing 10.1% protein. This and other data suggest that an oat/faba bean mixture for silage might be superior in production of protein per acre than oats alone.

Ethnic and Traditional Medicinal Uses

In ancient Greece and Rome, beans were used in voting; a white bean being used to cast a *yes* vote, and a black bean for no. Pythagoras called on his disciples to abstain from beans. It is, however, uncertain whether they were meant to abstain from eating beans or from involving themselves in politics. In Ubykh culture, throwing beans on the ground and interpreting the pattern in which they fall was a common method of divination (*favomancy*), and the word for "bean-thrower" in that language has become a generic term for seers and soothsayers in general. In Italy, faba beans are traditionally sown on November 2, All Souls Day. Small cakes made in the shape of faba beans (though not of them) are known as *fave dei morti* or 'beans of the dead'. According to tradition, Sicily once experienced a failure of all crops other than the beans; the beans kept the population from starvation, and thanks were given to Saint Joseph. Broad beans subsequently became traditional on Saint Joseph's Day altars in many Italian communities. Some people carry a broad bean for good luck; some believe that if one carries a broad bean, one will never be without the essentials of life. In ancient Greece and Rome, beans were used as a food for the dead, such as during the annual Lemuria festival. In some folk legends, such as in Estonia and the common Jack and the Beanstalk story, magical beans grow tall enough to bring the hero to the clouds. The Grimm Brothers collected a story in which a bean splits its sides laughing at the failure of others. Dreaming of a bean is sometimes said to be a sign of impending conflict, though others said that they caused bad dreams. Pliny claimed that they acted as a laxative. European folklore also claims that planting beans on Good Friday or during the night brings good luck. As a folk medicine, it can be used as diuretic, expectorant, or tonic.

Medicinal Uses

Potential use of faba bean is in the treatment of *Parkinson's* disease, because it is good source of *levadopa* (*L-dopa*); a precursor of dopamine, as a result of Parkinson's disease affected persons unable to synthesize dopamine which regulate motor cells. *L-dopa* is also a natriuretic agent, which might help in controlling hypertension. Some also use faba bean as a natural alternative to drugs like Viagra, citing a link between *L-dopa* production and the human libido. Epidemiological and in vitro studies which suggest that the hemolysis resulting from *favism* acts as protection from malaria, because certain species of malarial protozoa such as *Plasmodium falcipacrum* are very sensitive to oxidative damage due to deficiency of *glucose 6-phosphate dehydrogenase* enzyme, which would otherwise protect from oxidative damage via production of glutathione reductase.

Health Issues

Faba bean contains small amounts of antinutritional factors; however, their effects are less acute, and protease inhibitors are at much lower (2%) concentrations compared to soybeans. The elders generally restrict the young children from eating them raw (when unmatured) because they can cause constipation and jaundice-like symptoms. Inhalation of the pollen or ingestion of the seeds may incite the condition known as favism, a severe haemolytic anaemia, perhaps causing collapse. It is an inherited enzymatic deficiency occasional among Mediterranean People. The genetic disorder occurs in about 1% of whites, 15.0% of blacks. Faba bean are rich in tyramine, and thus should be avoided by those taking monoamine oxidase inhibitors. They contain vicine and convicine, which can induce haemolytic anaemia in patients with the hereditary condition *glucose-6-phosphate dehydrogenase deficiency* (G6PD). This condition, which is quite common in certain ethnic groups, is called 'favism' after the faba bean. The main factors responsible for favism, which can occur in susceptible people, are believed to be glucoside vicine and convicine and their hydrolytic derivatives divicine and isouramil, respectively. These anti-nutritional factors render the red blood cells of *glucose -6- phosphate dehydrogenase* deficient patients vulnerable to oxidation and destruction, which are uncommon in cooked beans. Haemaglutinins (lectins), although found in many legumes, concentration is higher in faba bean and can be troublesome. These substances are destroyed during the normal food preparation process (heat). Similarly, oligosaccharides mainly stachyose, raffinose and verbascose are also more prevalent in faba bean; these molecules contain glucose and galactose residues which can persist in sugar metabolism pathway in digestive tracts. They ferment and produce methane and other gases causing discomfort and abdominal pains. Faba bean contains other objectionable factors including, cyanogens, favogens, phytic acid, tannins, and tripsin inhibitors. The ant nutrients and toxins are associated with the seed coat, sprouting the seeds generally reduces the level of toxins.

Protease Inhibitors

Substances that have the ability to inhibit the protolytic activity of certain enzymes are found throughout the plant kingdom, particularly among the legumes. They are important because of their possible effect on the nutritive value of plant protein. General reviews on this subject are available. Faba bean contains a trypsin inhibitor was followed shortly by reports describing the isolation and characterization of this inhibitor. Several isoinhibitors were noted, two of which were purified. Both inhibitors had a molecular weight of 11.00 but differed in isoelectric points. One of the features that distinguish the Vicia faba inhibitors from most other legume inhibitors is their very broad specificity. They inhibit not only trypsin and chymotrypsin but also *thrombin, pronase, papain*, and several other proteinase of microbial origin. In faba bean, there is a twofold greater concentration of trypsin inhibitor in the hull than in the cotyledon. The trypsin inhibitor level of the whole seed is 3.2 units/g, cotyledon 2.9 units/g, and in the hull 5.6 units/g. A comparison of trypsin inhibitor level of whole faba bean (3.2 units/g) with whole soybeans (27 units/g) shows that whole soybeans contain about a nine fold higher concentration of trypsin inhibitor.

Tannins

Faba beans contain growth-depressing factor tannin, which is located primarily in the hull, relatively heat-labile and water-soluble. Tannins may be classified as polyphenolic substances. The active substance was identified as condensed proanthocyanidin. Faba bean tannins contain molecules of *flavon-3-olene (catechin, gallacatechin)* and *flavon-3, 4-dioline (leucocyanidin, leucodelphinidine)*. These substances are present in different concentration in faba bean seeds according to variety, maturity, location and growth conditions; there is a faba bean variety free of such tannins. The addition of 4 per cent of such tannins to the chicken's diet reduced its growth. There appears to be little doubt that the growth depression caused by faba bean tannins is due to an adverse effect on protein and dry matter digestibility. This effect may be related to the fact that tannins interfere with the digestive action of *trypsin* and *α - amylase* either by binding the enzymes themselves or by binding dietary protein into an indigestible form. It is found that tannin concentration was high in coloured seed coats and low in white-coated beans. Moreover, there is a correlation between tannin concentration in the seed coat and *trypsin* inhibitor activity; the hulls have much greater amounts of trypsin inhibitor than the cotyledon. Probably most of the trypsin inhibitor activity of the hulls is attributable to tannins. Dehulling the faba bean seeds, soaking the beans before cooking, and autoclaving the beans at 130°C for 30 minutes reduces and/or destroys the tannin substances.

Phytate (Phytins)

Phytins, the mixed Ca and Mg salts of *myo-inositol-1, 2, 3, 4, 5, 6-hexakis (dihydrogen phosphate)*, also known as physic acid, are common constituents of plant tissue, especially of cereals and legumes. They are the principal form of phosphorus in many seeds; 60 to 90 per cent of the phosphorus in these seeds is present as physic acid. Beans generally have a high physic acid content ranging between 150 to 1,800 mg/100g and faba bean are relatively rich in this substance (about 250 to 350 mg/ 100 g). The phytate phosphorus content of seeds taken from single plant indicated a large variation (193 to 403 mg/100 g) and was not significantly correlated with protein content. The nutritional importance of physic acid lies in its ability to chelate several mineral elements, especially calcium, magnesium, zinc, copper, and iron, and if thereby reduces the availability of these elements in the intestinal tract. Phytic acid has been held responsible for the commonly observed interference by plant sources of protein on the availability of dietary minerals. In the case of the white-flowered faba bean varieties, phytate content and its associated iron-binding capacity appeared to be restricted to the cotyledons while seed coat extracts prepared from coloured flowered varieties had almost twice the iron-binding capacity of similarly prepared cotyledon extracts. The active constituents in the seed coats of coloured, flowered varieties were the condensed tannins. Phytic acid is present in seeds in an almost water-soluble form (as sodium or potassium salt). During processing, it becomes insoluble (as calcium, magnesium, or ferric phytate). Phytate also forms complexes with proteins, making them less soluble. There is evidence that phytate-protein complexes are less subject to proteolytic digestion than the same protein alone, depending on pH. Phytate has an inhibitory effect on the peptic digestion of ovalbumin and elastin this effect is believed to be related to its ability to form insoluble combinations with proteins in an acid medium and in a range of pH which corresponds precisely to the optimum for the action of pepsin. Phytate itself is generally considered unavailable to humans due to the lack of an endogenous enzyme system. Excess phytate in the diet - for example in the predominantly bread-and-bean diets eaten in many less developed countries - decreases the availability of some minerals, including iron, causing deficiencies. The effect of physic acid on mineral availability is influenced by many factors, such as the mineral composition of the food as well as its association with dietary protein, heat treatment, processing history of the diet, pH, and the presence of other components reducing the mineral bioavailability such as fibre, oxalates, phenolics, tannins, saponins, and histidine, which are capable of binding or interacting with minerals or physic acid to varying extents. A variety of methods for removing physic acid from seeds and vegetables were reviewed including mechanical processes such as milling and grinding operations. Reducing wheat flour extraction or dehulling of beans decreases the content of physic acid. Water extraction, during soaking and regermination, removes the natively water-soluble phytate. Enzyme action during the manufacture of bread or during the germination of the seeds, dialysis and ultra filtration to separate physic acid and protein, using the molecular size differences, are suitable ways for reducing the physic acid content. Dehulling of faba bean decreased the content of physic acid by about 30 per cent of the original values, while prolonged soaking decreased it even further. Blanching the beans after soaking was also beneficial. These data led recommend soaking of dry faba bean before cooking, especially in the countries where people use them in great amounts, as in the developing countries. Moreover, when such legumes are used for baby foods, soaking or germinating those helps prevent mineral deficiency.

Cookability Index

The penetration readings (Precision Universal Penetrometer) is a tool for determining cookability index. 100 seeds is in general used for determining the average value of cookability index. It is determined after cooking for two hours at 115.5°C. the cookability index ranged between 2.00 and 9.00 mm. Percentage of seed coat ranged between 11 and 20 per cent. Thousand seed weight (between 200 and 950 g). Hydration coefficients calculated by weighing the beans before and after cooking (1:4 beans/water at 120 °C for two hours) under specified conditions (between 200 and 300 per cent). Statistical analyses showed highly significant correlations between cookability index and hydration coefficient and per centage seed coat for the Egyptian faba bean samples (high seed coat content, mean 15.0 per cent). For the Canadian samples (low seed content, mean 12.8 per cent), highly significant correlations were obtained between the cookability index and thousand seed weight. Study showed that the length of cooking time in faba bean is controlled by characteristics of both the seed coat and the cotyledons, and is not a "hard shell" problem only. The starch properties affect the cookability; the gelatinization and phase transition temperatures were lower for the hard-cooking samples. It seems that there is a critical temperature at which gelatinization plays an active role in terms of the cookability of faba bean. This point deserves further study. Jackson and Varriano-Marston suggested that there are two types of "hard shell," one related to seed coat impermeability and the other to cotyledon impermeability. In general, the cooking time of faba bean can be shortened by soaking. If seed contains higher moisture after soaking, then they take compatibly shorter cooking time. The soaking and cooking time for dried broad beans may be shortened by hot soaking and/or pressure cooking.

Canned Faba Bean

Faba bean consumed in the home are often prepared through hydration and cooking to achieve the desired palatability and this method of preparation is very time- and energy-consuming. A canned product that simplifies or eliminates the preparation process in the home and offers long storage life may be of some value in the market-place. Experience has shown that quality changes such as unfavourable colour development and water-soluble vitamin losses will take place during canning. These changes are further complicated by the additives, such as the disodium salt of ethylenediamine tetraacetic acid (Na EDTA) and sodium bicarbonate ($NaHCO_3$), used during processing. Soaking of faba bean for 12 hours in ethylenediamine tetraacetic acid solutions (50 ppm, 100 ppm and 150 ppm) only caused a slightly lighter bean colour; soaking in bicarbonate solution (0.5 per cent, 1.0 per cent, and 1.5 per cent) increased both the drained weight and the softness of the cooked beans, and it also made the bean colour darker. The mechanism of loss for riboflavin and thiamine during the processing of faba bean was mainly leaching; very little thermal destruction was observed. None of the soaking treatments affected the retention of these vitamins.

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