Chapter 1. Common Bean (*Phaseolus vulgaris*)

*This chapter deals with the composition of common bean (*Phaseolus vulgaris *L.). It contains elements that can be used in a comparative approach as part of a safety assessment of foods and feeds derived from new varieties. Background is given on bean production worldwide, common bean processing for industrial canning and other uses for human and animal consumption, followed by appropriate varietal comparators and characteristics screened by breeders. Nutrients in common bean seed, as well as main anti-nutrients, toxicants and other constituents, are then detailed. The final sections suggest key constituents for whole-grain analysis of new common bean varieties for food use and for feed use.*

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Background

*General description of common bean (*Phaseolus vulgaris *L.)*

Common bean (*Phaseolus vulgaris* L.) is a major grain legume which is consumed worldwide for its edible seeds and pods (Heuzé et al., 2013) (Figures 1.1 and 1.2). Wild common bean [*Phaseolus vulgaris* L., tribe Phaseoleae, family Leguminosae (Schrire, 2005)] is present throughout Central and South America (Gepts and Debouck, 1991; Freytag and Debouck, 2002). All cultivated varieties grown in the world today originate from two independent domestication events of wild populations at different pre-Columbian times (Kaplan and Lynch, 1999; Piperno, 2012) in western Mexico (Kwak et al., 2009) and in central Peru (Chacón-Sánchez et al., 2005). Human selection has generated dozens of landraces in each region (Singh et al., 1991). After 1492, the common bean was taken to South-Western Europe (Rodiño et al., 2006), the Mediterranean region (Angioi et al., 2010), (mostly eastern) Africa (Westphal, 1974), parts of Asia (Zhang et al., 2008) and back to the Americas (Albala, 2007; Gepts et Bliss, 1988).

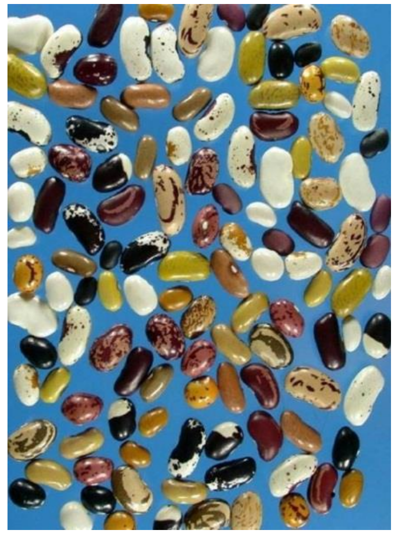
Figure 1.1. Pods of bush-type common bean

Source: Courtesy of D.G. Debouck, CIAT (2015).

Given this geographical and ecological expansion, the common bean is known by a variety of names under generic "bean" terms such as "frijol" in Spanish-speaking Latin America, "feijão" in Brazil, "judia" in Spain and "haricot" in French (Voysest and Dessert, 1991).

The common bean is an herbaceous vine. While it is an annual and monocarpic plant, some of its most primitive forms and wild relatives are pluri-annual and polycarpic vines in montane forests in Mexico and Central America (Freytag and Debouck, 2002). Cultivars vary widely, with bush determinate and vining indeterminate growth habits, and are selected for earliness. Further description of the common bean taxonomy, centres of origin and diversity, reproductive biology, genetics, hybridisation and introgression, general interactions with other organisms (ecology), common pests and pathogens, and biotechnological developments can be found in the Consensus Document on the Biology of Common Bean (*Phaseolus vulgaris* L.) (OECD, 2015).

Figure 1.2. Shape and colour diversity in common bean seed



Source: Courtesy of D.G. Debouck, CIAT (2015).

The common bean is typically cultivated in a mono-crop system and mechanically harvested (Figure 1.3). Although leaves and rarely flowers are consumed by humans (Purseglove, 1968), its main products are seeds, which are harvested either before or after physiological maturity as green pods such as snap beans (also known as “green beans”) or dry beans respectively. Both forms have given rise to an important canning industry and, recently, frozen dried food products have also appeared on world markets. Most dry bean varieties are consumed after boiling; grains of some landraces, mostly central Andean, are consumed after toasting (Tohme et al., 1995). Dried stems and pods have been used as hay for animal feeding (Hendry, 1918; Westphal, 1974).

Figure 1.3. Large field of common bean crop (Pimampiro canton, Ecuador)

Source: Courtesy of D.G. Debouck, CIAT (2015).

Production

The common bean is produced in subtropical and tropical regions, most often by smallholders, and constitutes a major staple crop in both developing and developed countries. Mainly used for human consumption, the common bean is the most important grain legume in the human diet at global level. According to the Consultative Group on International Agricultural Research, the common bean provides protein, complex carbohydrates and valuable micronutrients for more than 300 million people in the tropics. In many areas, beans are the second most important source of calories after maize (CGIAR, n.d.).

Quantification of the world production of the common bean is difficult, first because a substantial part of the crop is consumed on-farm, with limited sale on local markets, and has not been documented. The second reason lies in the fact that some dry beans subject to national and/or international trade are not discriminated at the species level. As a result, a category reported as “pulses” or “beans” may include several legume species other than the common bean (*P. vulgaris* L.) such as other *Phaseolus* sp. beans and even some *Vigna* sp. (Lackey, 1981; Voysest, 1983; FAOSTAT, 2019). Finally, the diverse products of the common bean, while all derived from the same species, may be counted under different categories. For example, snap beans (green beans) may be tallied separately from dry beans (Voysest and Dessert, 1991).

According to FAO estimates, the global bean production (covering not only the common bean) has risen from 16.6 million tonnes (Mt) in 1988-90 (3-year-average) up to the record of 29.3 Mt in 2015-17. This significant growth results from the increase of both cultivation areas and yields over the past 30 years, with the Americas and Asia as the most important producing regions (Table 1.1). According to other sources, South America alone is producing 30% of the global common bean (Heuzé et al., 2013).

Table 1.1. Estimated global dry beans production, 1988-2017

In million tonnes (Mt)[1]

Region	Years (3-year average)[2]									
	1988-90	1991-93	1994-96	1997-99	2000-02	2003-05	2006-08	2009-11	2012-14	2015-17
Asia	8.05	7.77	7.63	7.17	8.07	8.97	9.67	10.57	11.20	14.03
Americas	5.59	6.14	6.77	6.46	6.79	6.86	7.43	7.23	7.39	7.50
Africa	2.30	2.75	2.55	2.72	3.33	3.41	4.08	5.27	6.21	6.70
Europe	0.60	0.53	0.52	0.63	0.57	0.47	0.38	0.44	0.56	1.01
Oceania	0.02	0.02	0.03	0.05	0.05	0.05	0.04	0.05	0.04	0.03
World	**16.56**	**17.21**	**17.50**	**17.03**	**18.82**	**19.77**	**21.60**	**23.56**	**25.40**	**29.27**

Notes: 1. Data on dry beans are aggregated and include several species: the common bean (*Phaseolus vulgaris*), other bean species (*Phaseolus* sp.) and, for several countries, some *Vigna* species.

2. Each column represents an average of three years, i.e. 1988-90 represents an average of the seasons 1988/89, 1989/90 and 1990/91 in the Southern Hemisphere.

Source: FAOSTAT (2019), “Crops – Beans, dry – Production quantity, years 1988 to 2017”, http://faostat.fao.org (accessed on 10 July 2019). Aggregate may include official, semi-official, estimated or calculated data.

The five top producer countries of dry beans during the 2013-17 period were, in annual average, India (5.8 Mt), Myanmar (4.9 Mt), Brazil (3.0 Mt), the United States (1.3 Mt) and Mexico (1.2 Mt), followed in ranking order by the People's Republic of China and several African countries: the United Republic of Tanzania, Uganda, Kenya and Ethiopia (FAOSTAT, 2019).[1]

Common beans are mainly consumed in countries where they are produced. Countries with the highest rates of bean consumption per capita (mostly in Central and South Americas, the Caribbean, East Africa and some Asian economies) produce beans and also import them at varying levels, depending on the harvest, for meeting internal demand. Considering the global imports and exports of dry beans between 2012 and 2016, it seems that 12% to 18% of the world annual production (around 3.9 Mt on average) is traded internationally. China, Myanmar and the United States are the main exporters, with India and the European Union being the largest importers (FAOSTAT, 2019).

Processing

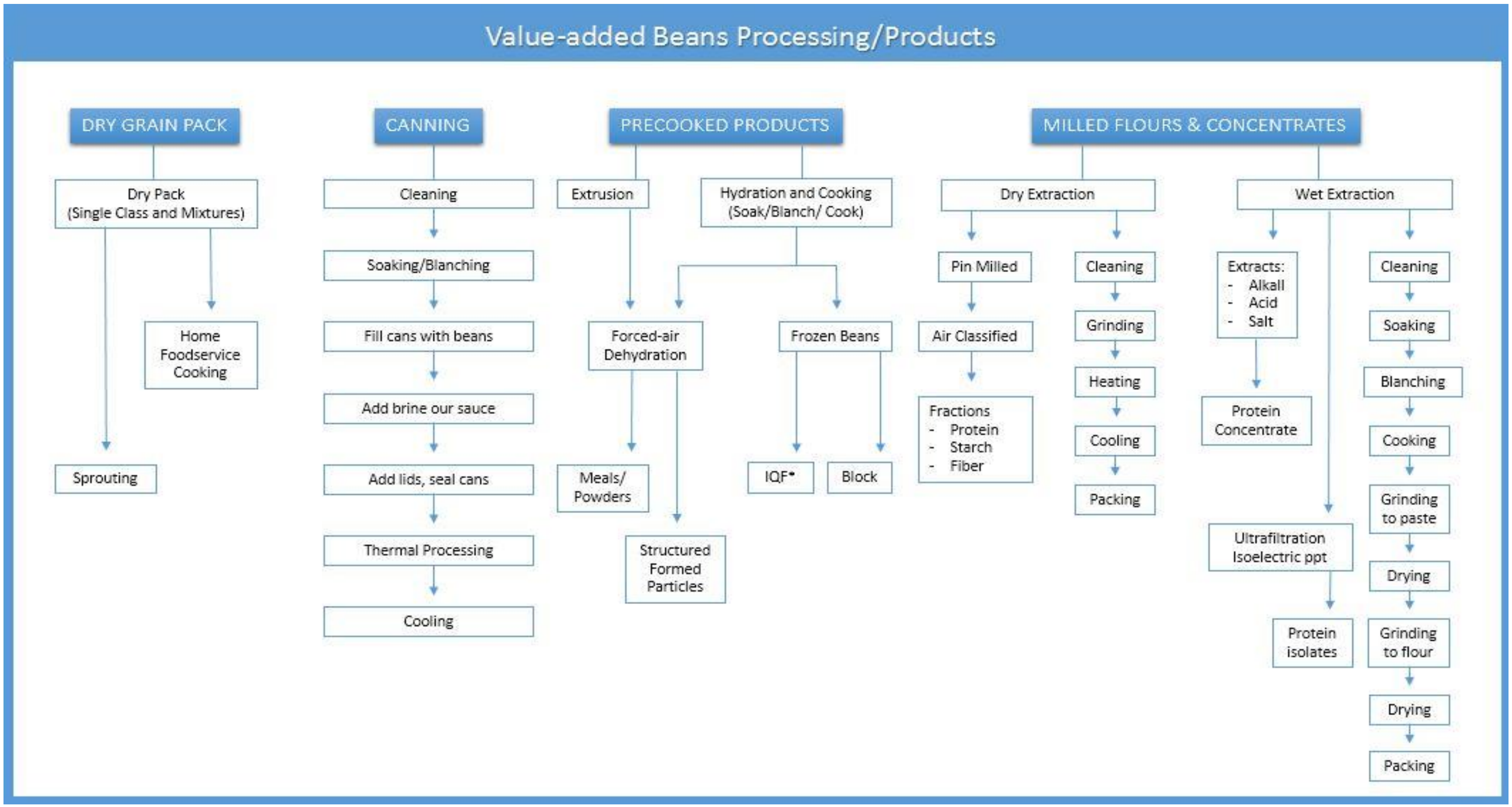
After harvest, beans are cleaned and then processed into final consumer products or ingredients. Products such as packaged dry beans, canned beans, baked beans, bean pastes, puffed snacks, texturised vegetable protein as meat analogues, cereal products, soups, frozen beans and bean flours all result from processing. The most commonly used processing methods for value-added common bean products are presented in Figure 1.4.

Canning is one of the most common forms of bean processing. Canned beans are a convenient alternative to dry beans which require long cooking times. An estimated 90% of navy beans and 45% of pinto beans (both types of common bean) consumed in the United States are sold as canned products (USDA-ERS, 2010). In developing countries, canned beans are most commonly a product for higher-income consumers (Jackson et al., 2012).

The canning process involves seven major steps (Figure 1.4):

- First, seed sorting and cleaning are performed to remove poor quality, diseased and damaged seed, stones and debris.
- Next, beans are equilibrated to 12%-16% moisture. Higher moisture values reduce the shelf life and lower values increase seed damage and splitting (Matella et al., 2012).
- A soaking and/or blanching step follows. Soaking times may vary from 30 min to 12 h at room temperature. Blanching is high heat treatment for 30 min or less prior to canning. The purpose of both treatments is to increase the water content of the seeds and uniformity of the final product.
- Beans are added to cans, followed by hot brine or sauce. Brine is a mixture of sugar, salt and calcium chloride. The calcium helps to maintain bean firmness. Sauces most commonly used in canning are tomato-based but there are many commercial products available with diverse flavour additives.
- Lids are added to the cans, which are sealed and processed in a canning retort for 52 min to 325 min at 116 to 121°C, depending on can size and brine or sauce type.
- Cans are cooled with water to an internal temperature of 38°C and are equilibrated for two weeks prior to use (Hosfield and Uebersax, 1980).

Figure 1.4. Methods of processing for value-added bean products



* Individually quick frozen.

Sources: Adapted from Siddiq and Uebersax (2012) and White and Howard (2013).

There are many ways to process the common bean into flour (Figure 1.4). One approach uses heat to inactivate the enzymes as a pre-cooking method. The steps include cleaning, soaking, blanching, cooking, grinding into a paste, drying, grinding again into flour, drying and packing. Another approach is dry milling, without pre-cooking the flour. In this case, bean seeds are ground into flour, followed by heating and packing. Both approaches generate breakfast and snack food products, as well as a texturing ingredient in tortilla chips, baked products, pasta and extruded products.

Uses

Although the major industrial food use of the common bean is canned beans, processing of the different types of bean through various treatments results in a range of ingredients for food and feed and value-added products: composite flour, extruded products, bread, cakes, pasta and tortillas and others, as presented in Table 1.2.

Table 1.2. Bean processing and products

Bean type	Pre-treatment	Product
Navy	Untreated (washed, dried, split); Treated (washed, dried, split, roasted)	Conventional bread
Great Northern	None	Pup loaf bread
Navy/Pinto	Dry roasting, air classified bean flour/protein concentrate	Straight dough bread
Black/Navy/Pinto/Small Red	Flour blends of 15%/25%/35% of hard red spring (HRS) wheat flour	Tortilla-wheat/bean
White/Red	Soaked 18 h, boiled 60 min	Corn bean tortillas
Flor de Junio Marcela	Cooked 95°C, 85 min, dried, ground	Corn bean tortillas
Black	Blended (paddle type mixer), twin-screw extruder, 20% moisture	Extruded product
White/Mexican	Counter-rotating twin-screw extruder	Extruded product
Navy/Small Red	Bean flour + corn starch (15%/30%/45%) co-rotating twin	Extruded product
Pinto/Bayo/Flor de Mayo	Soaked 18 h, 25°C, dehulled, dried 50°C	Extruded product – Single screw
Navy	Commercial navy bean flour	Extruded product
Navy/Pinto/Black	Dry roasting, dehulled, pin-milled, air classified fractions	Composite flour (10%)
Pinto/Great Northern/Small Red/Kidney	Blend 10%/20%/30% bean flour	Composite flour
Bean (unspecified)	Dehulled	Extender in beef sausage
Navy/Pinto	Isolated and purified starch	Bean starch noodle
Navy	Dried to 5%-10% moisture	Udon noodles
Navy/Pinto	Dried 24-30 h at 94-100°F to 10% moisture	Spaghetti (0%-25% bean)
Navy	Cotyledon flour precooked 12 min in boiling water, oven-dried 40°C overnight	Pasta
Bayo Victoria	Pressure cooked, blended in a food processor	Pasta
Navy	Unheated and heated 240°C/2 min, dehulled, hulls	Cake (roasted bean hulls)
Navy/Pinto/Black	Dry roasting 24°C/1 min, dehulled, pin milled, air classified	Fried doughnuts
Navy/Pinto	Milled to bean flour specifications	Pancake formulation
Navy/Pinto	Roasted (270°C/1 min)	Shortbread cookie
Navy	None	Master mix
Navy	Whole bean, hulls	Cookies
Navy	Soaked 99°C/45 min, steamed 104°C/30 min, macerated and drum dried	Cookies
Navy/Pinto	Roasted (270°C/2 min)	Pumpkin bread
Navy/Pinto	Dehulled, pin milled, air classified	Extruded snack

Source: Adapted from Maskus (2010), “Pulse processing, functionality and application”.

Appropriate comparators for testing new varieties

This document suggests parameters that common bean breeders should measure when developing new modified varieties of *Phaseolus vulgaris*. The data obtained in the analysis of a new common bean variety should ideally be compared to those obtained from an appropriate near-isogenic, non-modified variety, grown and harvested under the same conditions. The comparison can also be made between values obtained from new varieties and data available in the literature or chemical analytical data generated from other commercial common bean varieties.

Components to be analysed include key nutrients, anti-nutrients and toxicants. Key nutrients are those which have a substantial impact on the overall diet of humans (food) and animals (feed). These may be major constituents (fats, proteins, and structural and non-structural carbohydrates) or minor compounds (vitamins and minerals). Similarly, the levels of known anti-nutrients and allergens should be considered. Key toxicants are those toxicologically significant compounds known to be inherently present in the species, whose toxic potency and levels may impact human and animal health. Standardised analytical methods and appropriate types of material should be used, adequately adapted to the use of each product and by-product. The key components analysed are used as indicators of whether unintended effects of the genetic modification influencing plant metabolism have occurred or not.

Breeding characteristics screened by developers

The majority of common bean production occurs under low input agriculture on small-scale farms in developing countries (Miklas et al., 2006). Under such conditions, yield is mostly below its potential for the crop. Consequently, yield increase by attenuation of limiting factors is the focus of many breeding programmes (McClean et al., 2008).

Improving common bean nutritional quality, stress tolerance or resistance to pests and diseases are key objectives for various breeding programmes (Angenon et al., 1999; Suárez et al., 2008). Diseases and insects represent crucial biotic stressors that farmers have to face when growing this crop (Broughton et al., 2003). Among the fungal, bacterial and viral diseases that can affect common bean, at least five major ones are widespread: anthracnose, angular leaf spot, common bacterial blight, bean golden yellow mosaic virus and bean common mosaic virus, while several others are important locally or regionally (Broughton et al., 2003). A common bean variety that is resistant to bean golden mosaic virus (BGMV) has recently been developed (Aragão et al., 2013). Most commonly, breeders aim for resistance to one or two diseases and/or pest insects within the same variety. Since wild *Phaseolus* species present traits such as pest and pathogen resistance that are usually infrequent among cultivated common beans, they may be a potential source of novel alleles (Acosta-Gallegos et al., 2007).

The development of varieties with improved tolerance/resistant to other biotic stressors and to abiotic stressors is another important goal. Breeding programmes are developing agronomic traits such as nitrogen fixation. Other characteristics are also being explored by common bean breeding programmes, such as the increased content of specific nutrients including protein, minerals and vitamins.

Nutrients

*Composition of common bean (***Phaseolus vulgaris** *L.) – General points*

This document addresses composition data relating to seeds only, not green pods (snap beans or green beans), dry shelled pods and stems.

The common bean is morphologically variable and adaptable to different environments, creating a wide range of local varieties. As a consequence, the nutritional composition of the common bean is impacted by various factors such as genotype, geographical origin, environmental and growing conditions (Broughton et al., 2003).

Constituents of common bean seed

Proximate composition

The proximate composition of raw common beans of a number of commercial varieties from Brazil, Madeira Island and the United States is shown in Table 1.3.

Carioca bean grains have a cream background with tan stripes; Pérola is the most common carioca variety in Brazil. The cooking process affects mainly the fibre content of Carioca beans (Pires et al., 2005).

Table 1.3. Proximate and total dietary fibre composition of different common bean varieties

Beans (raw mature seeds)	Protein (g/100 g DW)	Total lipid (fat) (g/100 g DW)	Ash (g/100 g DW)	Carbohydrate, by difference[1] (g/100 g DW)	Moisture (g/100 g FW)	Fibre, total dietary (g/100 g DW)
Black beans[a]	24.28	1.60	4.05	70.07	11.02	17.42
Cranberry (roman) beans[a]	26.29	1.40	3.78	68.53	12.39	28.20
Kidney beans, all varieties[a]	26.72	0.94	4.34	68.00	11.75	28.21
Navy beans[a]	25.40	1.71	3.78	69.11	12.10	17.41
Pink beans[a]	23.30	1.26	4.07	71.37	10.06	14.12
Pinto beans[a]	24.16	1.39	3.90	70.55	11.30	17.50
Small white beans[a]	23.91	1.34	4.25	70.50	11.71	28.20
Pérola, Carioca (beige)[b]	24.96	1.78	4.65	68.61	13.07	21.94
Madeira Island beans[c] (59 accessions)	18.55-29.69 mean: 23.27	0.57-2.86 mean: 1.65	3.64-5.67 mean: 4.57	63.32-75.32 mean: 70.51	6.45-16.65 mean: 10.87	..

Notes: DW = dry weight basis; FW = fresh weight basis. .. : missing value or not available.

1. Carbohydrate (by difference), DW = 100% - (crude protein% + crude fat% + ash%); this value includes total dietary fibre.

Sources: Adapted from: a. USDA-ARS (2014), *National Nutrient Database for Standard Reference, Release 27*, http://ndb.nal.usda.gov/ndb/search/list (accessed on 29 July 2014), data were converted to dry weight basis using mean moisture value; b. Delfino and Canniatti-Brazaca (2010), "Interação de polifenóis e proteínas e o efeito na digestibilidade proteica de feijão comum (*Phaseolus vulgaris* L.) (…)" http://www.scielo.br/pdf/cta/v30n2/03.pdf, data already provided on dry weight basis; c. Gouveia, et al. (2014), "Nutritional and mineral variability in 52 accessions of common bean varieties (*Phaseolus vulgaris* L.) from Madeira Island", http://dx.doi.org/10.4236/as.2014.54034, data mean and range already provided on dry weight basis.

Gouveia et al. (2014) evaluated the composition of 59 accessions of common bean varieties (52 Madeiran landraces, 5 standard and 2 commercial varieties) grown under the same field conditions in Madeira Island, to minimise the impact of the environmental factors. Regional common bean varieties exhibited great variability in the proximate parameters, presenting, on average, better nutritional performance with high protein and mineral contents compared to standard and commercial varieties.

Carbohydrates

Carbohydrates are monosaccharides and disaccharides (sugars), oligosaccharides and polysaccharides (starch, resistant starch and non-starch). Carbohydrates content in beans is mainly composed of starch, with small amounts of monosaccharides and disaccharides. Of carbohydrates, 17% to 23% has been reported to be pectin, cellulose and hemicellulose (Shiga et al., 2009). The total starch content ranges from 23.4% to 64.3% (Jacinto-Hernández and Campos, 1993; Jacinto-Hernández et al., 2002; Gouveia et al., 2014).

Beans contain a high ratio of slowly-digestible to readily-digestible starch compared with other starchy foods. Most common beans contain 27% to 40% amylose, a linear polymer of α-1-4 glucose units (Hoover et al., 2010), whereas most other starchy vegetables contain 20% to 30% amylose. Beans also contain a substantial amount of resistant starch, considered as dietary fibre. Resistant starch resists digestion by amylase in the small intestine and progresses to the large intestine for bacterial fermentation in the gut producing the short-chain fatty acids, acetic, butyric and propionic acids (Chung et al., 2010). Dry beans contain a substantial amount of carbohydrates as raw fibre in the form of cellulose and hemicellulose (Geil and Anderson, 1994).

Protein

Mean protein content shown for some common bean types in Table 1.3 varies from 23.27% to 26.72% dry matter. Madeira Island types/varieties had a protein mean content of 23.27 g/100 g with a range of 18.55 to 29.69 g/100 g (Gouveia et al., 2014). Bhatty et al. (2001) and Siddiq et al. (2010) reported a range of 20.43 to 23.62 g/100 g. Northern Portuguese beans and improved Ethiopian beans have been reported to contain total protein content ranging from 17.96 to 27.45 g/100 g (Coelho et al., 2005), and 17.96 to 22.07 g/100 g (Shimelis and Rakshit, 2005) respectively. Rodiño et al. (2001; 2003) have shown mean protein content of Portuguese beans and Iberian Peninsula beans to be 30.7 g/100 g (Rodiño et al., 2001) and 31.4 g/100 g respectively. Oliveira (2005) demonstrated that black, white and pink varieties have a protein content of 25% or more.

Table 1.4 presents the content of amino acids in common bean, based on elements collated from the USDA-ARS database (detailed by bean types, 2015), and the Feedipedia database (Heuzé et al., 2013). The amino acid profile of common bean protein is characterised by its deficiency in sulphur amino acids (methionine and cystine) and tryptophan, with methionine considered as the limiting amino acid. The amino acid most prevalent in all beans is glutamic acid (Table 1.4).

Table 1.4. Amino acid content (g/100 g, dry weight basis) of common beans

	USDA-ARS[1]							Feedipedia[2]
	Black beans[1]	Cranberry (roman) beans[1]	Kidney beans, all varieties[1]	Navy beans[1]	Pink beans[1]	Pinto beans[1]	Small white beans[1]	All common beans
Moisture content per 100 g	11.02	12.39	11.75	12.1	10.06	11.33	11.71	10.90
Alanine	1.02	1.10	1.12	1.03	0.98	0.98	1.00	0.99
Arginine	1.50	1.63	1.65	1.16	1.44	1.24	1.48	1.59
Aspartic acid	2.94	3.18	3.23	2.96	2.82	2.56	2.89	2.65
Cystine	0.26	0.29	0.29	0.21	0.25	0.21	0.26	0.27
Glutamic acid	3.70	4.01	4.07	3.52	3.55	3.41	3.64	3.67
Glycine	0.95	1.03	1.04	0.91	0.91	0.90	0.93	0.97
Histidine	0.68	0.73	0.74	0.58	0.65	0.63	0.67	0.69
Isoleucine	1.07	1.16	1.18	1.08	1.03	0.98	1.06	1.09
Leucine	1.94	2.10	2.13	1.96	1.86	1.76	1.91	1.93
Lysine	1.67	1.80	1.83	1.46	1.60	1.53	1.64	1.61
Methionine	0.37	0.39	0.40	0.31	0.35	0.29	0.36	0.27
Phenylalanine	1.31	1.42	1.44	1.32	1.26	1.23	1.29	1.34
Proline	1.03	1.11	1.13	1.27	0.99	1.21	1.01	0.87
Serine	1.32	1.43	1.45	1.34	1.27	1.32	1.30	1.36
Threonine	1.02	1.11	1.12	0.81	0.98	0.91	1.01	1.04
Tryptophan	0.29	0.31	0.32	0.28	0.28	0.27	0.28	0.32
Tyrosine	0.68	0.74	0.75	0.55	0.66	0.48	0.67	0.84
Valine	1.27	1.38	1.40	1.41	1.22	1.13	1.25	1.24

Notes: 1. Data converted from fresh weight to dry weight basis using given moisture level; 2. Data converted from percentage of protein (average) to dry weight basis using given crude protein percentage of dry matter.

Sources: 1. USDA-ARS (2015), *National Nutrient Database for Standard Reference, Release 27 (revised) – Version May 2015*, http://www.ars.usda.gov/ba/bhnrc/ndl (accessed on 15 June 2015); 2. Heuzé et al. (2013), *Common Bean (*Phaseolus vulgaris*)*, http://www.feedipedia.org/node/266 (accessed on 23 March 2015).

The protein digestibility of raw beans varies from 25% to 60% and can be increased up to 93.2%, depending on the bean variety and cooking process (Batista et al., 2010; Kiers et al., 2000; Jacinto-Hernández and Campos, 1993; Jacinto-Hernández et al., 2002). Jacinto-Hernández and Campos (1993) showed that increases in protein digestibility after cooking was very variable, with some varieties showing 8%-12% higher digestibility compared to raw beans, while others only improved digestibility by 3%-4%.

The nutritional value of beans is increased by heat processing, especially under moist heat (Gallardo et al., 1974, cited by Poel et al., 1990). This is due to denaturation of anti-nutritional factors, such as trypsin inhibitors and phytic acid (Burns, 1987, cited by Poel et al., 1990), and improved accessibility of the bean proteins to enzymatic degradation (Romero and Ryan, 1978).

Lipids/fatty acids

Beans contain only a small amount of lipids, with the majority of fatty acids being unsaturated (Anderson et al., 1999). Total fat/lipids content in some varieties of common beans ranges from 0.57 to 1.78 g/100 g of dry matter (Table 1.3). The total saturated, monounsaturated and polyunsaturated fatty acid contents of some types of common bean are presented in Table 1.5.

Table 1.5. Fatty acid content (g/100 g, dry weight basis) in raw mature grain of common beans

Bean types	Total saturated	Total monounsaturated	Total polyunsaturated
Black	0.326	0.109	0.543
Black Turtle	0.206	0.069	0.344
Cranberry (roman)	0.277	0.093	0.462
Great Northern	0.318	0.047	0.426
Kidney, all types	0.106	0.056	0.403
Navy	0.149	0.113	0.767
Pink	0.263	0.088	0.438
Pinto	0.208	0.203	0.361
Red Kidney	0.136	0.072	0.517
Small White	0.268	0.090	0.448
White	0.194	0.066	0.323
Yellow	0.597	0.201	0.994

Note: Data were converted to dry weight basis using mean moisture value.
Source: Adapted from USDA-ARS (2014), *National Nutrient Database for Standard Reference, Release 27*, http://ndb.nal.usda.gov/ndb/search/list (accessed on 29 July 2014).

Vitamins

Common beans in particular contain water-soluble B vitamins; these include thiamine (3.9 to 11.4 mg/kg dry matter), riboflavin (1.0 to 2.9 mg/kg), niacin (3.3 to 26.8 mg/kg), vitamin B6 (0.4 to 5.7 mg/kg) and pantothenic acid (2.7 to 10.1 mg/kg) (Table 1.6). Common beans are also a prominent source of dietary folate – vitamin B9 – (0.2 to 5.8 mg/kg) (Table 1.6) (Rychlik et al., 2007). Common beans contain only small amounts of vitamin C, and little to no fat-soluble vitamins (Geil and Anderson, 1994) because of the low level of lipids in beans.

The vitamin content measured in common beans varies widely depending on commercial market classes, origin, environment and analytical methodology used for analysis (Table 1.6). Variation is greatest in folate (vitamin B9) content (Rychlik et al., 2007).

Cooking, like other food treatments, introduces another source of direct and indirect variability. Commercial methods of preparation of canned beans can cause significant loss of water-soluble vitamins, whereas home-cooked common beans seem to have less effect on nutrient retention (Augustin et al., 1981).

Table 1.6. Vitamin composition (mg/kg, dry weight basis) of common beans

Bean types	Folate	Thiamine	Riboflavin	Niacin	Pantothenic acid	Vitamin B_6
Black[1]	5	10.1	2.2	22.0	10.1	3.2
Black Turtle[2]	3.2	11.1	2.4	20.9		3.4
Black Turtle[3]	0.4-0.8	4.1-4.8	1.1	12.2-12.9	4.5-4.6	1.8-4.5
Cranberry[2]	2.1	9.7	2.7	15.7		3.6
Cranberry[3]	0.5	4.6-5.2	1.4-1.7	11.0-11.8	3.6-3.7	1.8
Dutch Brown[3]	0.2-0.4	4.7-5.2	1.4	12.3-16.1	4.1-4.4	1.8
Great Northern[1]	5.4	7.3	2.7	21.9	12.3	5.0
Great Northern[2]	1.0-1.7	9.4-9.8	2.6-2.9	14.9-19.2		4.0-5.7
Great Northern[3]	0.7-1.2	4.8-4.9	1.3	7.1-10.4	5.1-5.4	1.3-3.6
Kidney[1]	1.8-2.6	11.4	1.5-2.2	21.5		4.5-4.6
Kidney[2]	4.5	6.0-6.3	1.8-2.5	12.5-23.3	5.0-8.8	2.4-4.5
Light Red[3]	0.4	8.9-10.9	2.2-2.4	3.3	2.7-3.6	0.4-2.5
Navy[1]	1.8-2.6	9.4-9.8	1.4-2.3	24.3-26.8		4.8-5.0
Navy[2]	1.2-4.1	6.6-8.8	1.9	14.9-24.9	3.5-8.5	2.4-4.9
Navy[3]	0.7-1.5	4.2-9.1	1.1-2.0	6.0-16.6	2.7-3.6	0.4-2.5
Pink[1]	4.8-5.8	9.2	1.5	11.6-14.4		5.0-5.7
Pink[3]	0.7-1.5	5.6-6.7	1.2	9.0-9.9	4.0-4.8	1.6-2.4
Pinto[1]	4.6	8.6-9.9	1.4-2.3	17.8		4.8
Pinto[3]	0.7-1.1	6.2-7.6	1.2	9.4-12.9	3.1-4.4	1.6-2.0
Red Kidney[3]	0.6	3.9-7.3	1.6	9.1-12.9	4.1-4.8	1.7-2.5
Small Red[1]	1.8	9.6	1.6	12.5		5.3
Small Red[3]	0.7-1.0	5.0-6.4	1.1	7.3-8.4	3.8-4.3	1.5-1.9
Small White[1]	3.0	8.9	1.6	19.9		4.9
White[2]	4.4	4.9	1.6	5.4	8.3	3.6
White Kidney[3]	0.2	6.5-8.0	1.0-1.3	9.8-12.6	3.5-3.6	1.4-1.7
Overall range	**0.2-5.8**	**3.9-11.4**	**1.0-2.9**	**3.3-26.8**	**2.7-10.1**	**0.4-5.7**

Sources: 1. Augustin et al. (1981), "Variation in the vitamin and mineral content of raw and cooked commercial *Phaseolus vulgaris* classes", http://onlinelibrary.wiley.com/doi/10.1111/j.1365-2621.1981.tb04467.x/pdf;
2. Tiwari and Singh (2012), *Pulses Chemistry and Technology*;
3. Wang and Daun (2004) *The Chemical Composition and Nutritive Value of Canadian Pulses.*

Minerals

The bean ash is constituted by several minerals (Table 1.7). The mineral content depends on market class/variety and environmental conditions during cultivation. Regarding minerals occurring at higher quantities, ranges reported are 0.09-4.25 g/kg of the dry matter for calcium (Ca), 1.0-3.26 g/kg for magnesium (Mg), 2.30-8.42 g/kg for phosphorous (P) and 13.0-24.9 g/kg for potassium (K). A considerable variation in levels was also observed for minerals occurring at lower quantities in germplasm from different sources, as shown by Dwivedi et al. (2012).

Table 1.7. Mineral composition of common beans

Beans	Calcium	Magnesium	Phosphorous	Potassium	Iron	Zinc	Copper	Manganese
	(g/Kg, dry weight basis)				(mg/Kg, dry weight basis)			
Black[1]	1.30-1.38	1.80-2.07	3.96-5.66	14.09-17.07	51.8-56.4	0-56.6	0-12.3	0-19.4
Great Northern[1]	1.67-1.76	1.96-2.31	4.63-7.03	17.77-19.61	31.4-61.3	38.1-40.9	9.3-12.3	15.9-19.0
Kidney[1]	1.09-1.62	1.59-1.99	4.61-5.94	15.93-20.15	92.9-99.7	31.6-41.9	10.9-11.3	11.6-15.9
Navy[1]	1.67-1.76	1.96-2.31	4.63-7.03	17.77-19.61	62.5-86.5	0-32.2	0-8.4	0-19.0
White[1]	2.71-4.25	2.14-3.26	2.30-3.39	14.56-20.24	117.7-120.7	0-41.4	0-11.1	0-20.3
Dark Red (Canada)[2]	0.82	1.53	5.66	17.09	66.6	28.3	7.1	10.8
Small Red (Canada)[2]	1.34	1.68	5.73	17.31	34.1	18.9	0.4	13.2
Brown (Brazil)[3]	1.09-1.79				48.1-78.2	25.1-31.9	6.1-13.6	10.0-26.3
Red (Nicaragua)[4]	1.02-1.41		4.00-4.44		61.8-71.9	21.0-25.1		
Red (Columbia)[5]			7.44		58.3-73.0	35.5-39.5		
Cream (Columbia)[5]			6.04-8.34		63.3-90.4	30.0-52.3		
Pink (Columbia)[5]			8.42		52.3	26.7		
Purple (Columbia)[5]			7.00		80.1	39.6		
Yellow (Columbia)[5]			7.52		86.1	62.4		
Beige (Brazil)[3]					53.1-68.8	33.5-42.7		
Several Mexican varieties[6]	0.09-2.0	2.0	4.6		38.0-76.0	22.0-44.0		
Red-Mottled Beans[7] **(2 varieties)**					76-81	33-34		
Madeira Island Beans[8] **(59 accessions)**		1.0-1.8 mean: 1.5	3.0-7.5 mean: 5.0	13.0-24.9 mean: 18.9	41.0-100.0 mean: 60.1	22.0-50.0 mean: 30.1	5.0-14.0 mean: 10.1	0.009-0.021 mean: 0.015

Sources: 1. Tiwari and Singh (2012), *Pulse Chemistry and Technology*; 2. Oomah, Blanchard and Balasubramanian (2008), "Phytic acid, phytase, minerals, and antioxidant activity in Canadian dry bean (*Phaseolus vulgaris* L.) cultivars"; 3.Carvalho et al. (2012), "Iron and zinc retention in common beans (*Phaseolus vulgaris* L.) after home cooking", https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3292239/; 4. Martinez Meye et al. (2013), "Content of zinc, iron and their absorption inhibitors in Nicaraguan common beans (*Phaseolus vulgaris* L.)", http://www.sciencedirect.com/science/article/pii/S0308814612012204; 5. House et al. (2002), "Potential for increasing the amounts of bioavailable zinc in dry beans (*Phaseolus vulgaris* L.) through plant breeding", http://onlinelibrary.wiley.com/doi/10.1002/jsfa.1146/pdf; 6. Guzmán-Maldonado et al. (2002), "Calidad alimentaria y potencial nutraceutico del frijol (*Phaseolus vulgaris* L.)", http://www.redalyc.org/articulo.oa?id=60828206; 7. Blair et al. (2010), "Registration of high mineral common bean germplasm lines NUA35 and NUA56 from the red-mottled seed class"; 8. Gouveia, C.S.S. et al. (2014), "Nutritional and mineral variability in 52 accessions of common bean varieties (*Phaseolus vulgaris* L.) from Madeira Island", http://dx.doi.org/10.4236/as.2014.54034.

Common beans accumulate different proportions of iron, zinc and manganese in the seed coat, embryo and cotyledons. The highest amount of these minerals is stored in the cotyledons of mature seeds (Cvitanich et al., 2011). Iron and other constituents of the grain (phytate, tannins and fibre) are distributed differently in the hull and in the cotyledon. Food processing, such as baking and brewing, not only affect the bioavailability of iron but also factors that act as agonists or antagonists of mineral absorption (Lombardi-Boccia et al., 1995). Stripping significantly decreased the dialysability of iron, while cooking had the same influence on a coloured variety, but not on a white variety. The tannin-protein interaction may be the main cause of the difference in iron dialysability (Lombardi-Boccia et al., 1995). The effect of reheating beans on their iron content has also been studied. In whole bean, without broth, no changes were detected during cooking. In the case of beans with broth, insoluble iron increased in grains. Both soluble and insoluble iron decreased in the broth (Amaya et al., 1991).

Anti-nutrients, toxicants and other constituents

Anti-nutrients and toxicants – General points

In spite of good nutritional quality, common beans contain some constituents having anti-nutritional effects. Thus, adverse effects may be induced by tannins, phytates, protease inhibitors and lectins. Kidney beans have also been reported to contain toxic cyanogenic compounds (Cho et al., 2013) but only at trace levels having no health implications for the consumer.

Main anti-nutrients

Tannins

Tannins are colourless polyphenolic constituents of legumes (Reed, 1995). Levels reported in common bean varieties range from 10.1 to 44.2 mg catechin-equivalents per gramme dry weight (De Mejía et al., 2003, Helbig et al., 2003; Cruz-Bravo et al., 2011). Beans differ in content of tannins, which affect quality as they are converted into pigments visible during dehydration and oxidation. Tannins also have the ability to interact with proteins, resulting in reduced protein and mineral digestibility (Junk-Knievel et al., 2008). Condensed tannins are present in the dietary fibre fraction and can be considered indigestible or poorly digestible (Bartolomé et al., 1995). Cooking does not destroy tannins but they are partially removed with the cooking broth (Bressani and Elias, 1980). According to Ziena et al. (1991), less than 10% of total tannins are broken down during cooking, while about 50% are washed away in the cooking liquid.

Phytate/phytic acid

Phytic acid (also known as inositol hexakisphosphate (IP6), inositol polyphosphate, or phytate when in salt form) chelates mineral nutrients including calcium, magnesium, potassium, iron and zinc, rendering them unavailable to non-ruminant animals (NRC, 1998; Liener, 1994). Phytates are concentrated mostly in the cotyledons and embryo axes (up to 3% of total seed weight) of common bean (Kasim and Edwards, 1998; Blair et al., 2012) (Table 1.8). The negative effect on the bioavailability of minerals is associated with inositol penta- (IP5) and hexa-phosphate (IP6). Phytates also interact with basic protein residues and can inhibit digestive enzymes such as pepsin, pancreatin and amylase (Agostini and Ida, 2006).

Phytate content in common beans varies due to genetic differences between varieties, and environmental factors such as growing conditions, agricultural practices and location. Commonly reported levels are in the range 2.6-25.1 mg/g dry weight (Stanley and Aguilera, 1985; Estévez et al., 1991; Burbano et al., 1999; Helbig et al., 2003; Díaz-Batalla et al., 2006; Oomah et al., 2008; Martin-Cabrejas et al., 2009; Martinez Meyer et al., 2013; Pedrosa et al., 2015; Carvalho et al., 2015). In beans, phytate phosphorus constitutes a major portion of the total phosphorus content and is found preferentially in the cotyledon

(Deshpande et al., 1982), accounting for 57%-81% of total phosphorus in Navy, 68%-72% in Red Kidney, 55-80% in Great Northern and 70% in California small white beans (Reddy, 2001). Low phytate bean germplasm has recently been developed (Campion et al., 2009). The proportion of phytate being IP5 and IP6, which are the most commonly detected inositol phosphate isomers, vary widely in raw beans. IP6 is the most predominant isomer, constituting from 64% (in Red Kidney beans) to 98% (in Pinto beans) of the total phytate content (Chen, 2004).

Of the various processing methods, fermentation and germination seem to be effective in decreasing the phytate concentration, while soaking and cooking can remove from 50% to more than 80% of endogenous phytate in beans (Sathe and Salunke, 1984).

Table 1.8. Phytic acid composition (mg/g) of common beans and its components

Bean types	Whole[1, 2]	Cotyledon[1]	Dehulled[2]	Hull[2]
Black	10.4-29.3	36.1	17.09	1.91
Great Northern	5.0-27.0	32.6		
Pinto	6.1-23.8	25.6	11.48	1.30
Red	8.1-20.7	30.5	8.71	2.63
Red Kidney	12.0-26.3	34.7		
White	5.5-18.0	16.3	9.83	2.30

Sources: 1. Reddy (2001), "Occurrence, distribution, content and dietary intake of phytate"; 2. Calculated from Hu et al. (2006), "Kaempferol in red and pinto bean seed (*Phaseolus vulgaris* L.) coats inhibits iron bioavailability using an *in vitro* digestion/human Caco-2 cell model".

Trypsin inhibitors

Common beans contain trypsin inhibitors which inhibit the digestive action of the trypsin enzyme. Trypsin inhibitor activity (TI) in uncooked beans have been reported to be in the range 6.3-55.2 trypsin inhibited units (TIU)/mg (Dhurandhar and Chang, 1990; Estévez et al., 1991; Jacinto-Hernández and Campos, 1993; Sotelo et al., 1995; De Mejía et al., 2003, 2005; Morales-de León et al., 2007; Olmedilla-Alonso et al., 2013; Pedrosa et al., 2015). The level of TI in the common bean is not only dependent on bean genotype but also on the environmental conditions where it was cultivated (De Mejía et al., 2003; 2005). In cooked beans, trypsin inhibitor activity is much lower than in raw beans (Jacinto-Hernández and Campos, 1993; Jacinto-Hernández et al., 2002; Morales-de León et al., 2007).

Alpha-amylase inhibitors

Common beans are the legume with the highest amount of alpha-amylase inhibitors. Alpha-amylase inhibitors inhibit the digestive enzyme α-amylase resulting in reduced digestibility of certain carbohydrates. Various types of α-amylase inhibitors have been described in the common bean (Ishimoto et al., 1995), including three different glycoprotein isoforms. Screening of 150 Brazilian bean varieties classified by colour revealed average values between 0.19 and 0.29 α-amylase inhibitor units per mg protein and a range between 0.09 and 0.40 α-amylase inhibitor units per mg protein (Table 1.9), with no correlation between inhibitory activity and seed coat colour (Lajolo et al., 1991).

Table 1.9. α-Amylase Inhibitory Activity (AIU/mg protein) of common beans classified by bean colour

Bean colour	Range	Average
Beige	0.14-0.40	0.26
Black	0.11-0.30	0.19
Brown	0.14-0.35	0.29
Dark brown	0.19-0.33	0.25
Light brown	0.09-0.32	0.20
Pale brown	0.16-0.40	0.29
Pink	0.16-0.28	0.21
Purple	0.17-0.22	0.19
Red	0.16-0.37	0.25
White	0.14-0.33	0.23

Note: α-amylase inhibitory unit (AIU) value of 10 is defined as a 50% decrease in enzyme activity at 37°C/5 min after addition of 1% starch as substrate.

Source: Lajolo, Finardi-Filho and Menezes (1991), "Amylase inhibitors in *Phaseolus vulgaris* beans".

Lectins

Lectins are proteins that bind to carbohydrate-containing molecules and are found in a variety of foods, including legumes such as the common bean (Gupta, 1987). The biological activity of lectins has been reviewed (Grant, 1991). Lectin levels reported vary with the methodology used for analysis. Several investigators reported levels between non-detectable and approximately 10 haemagglutinating units (HU) per gramme bean assayed with a method measuring haemagglutinating activity (Sotelo et al., 1995; De Mejía et al., 2003; 2005). Burbano et al. (1999), Olmedilla-Alonso et al. (2013) and Pedrosa et al. (2015) reported 0.3-165 mg/g dry weight using an indirect ELISA assay for phytohaemagglutinin quantification. Lectins have been shown to have growth inhibitory properties and result in toxicity in animals. The haemagglutinating activity of lectins can be reduced by moist-heat treatment (Gupta, 1987), making proper cooking prior to consumption an important step in the safe consumption of common beans (Ogawa and Date, 2014). Several cases of human toxicity due to ingestion of raw or under-cooked beans have been reported (Cornell University, 2014).

Other constituents

Oligosaccharides

Common bean varieties vary considerably in terms of their oligosaccharide content (Table 1.10), including the raffinose family oligosaccharides (RFOs). Thus, raffinose levels range from about non-detectable to 14.1 mg/g dry weight, stachyose from 0.9 to 63.8 mg/g and verbascose from non-detectable to a few mg/g, depending on the variety considered (Geil and Anderson, 1994; Weder et al., 1997; Burbano et al., 1999; Queiroz Kda et al., 2002; Díaz-Batalla et al., 2006; Campos-Vega et al., 2009; Cruz-Bravo et al., 2011; Kleintop et al., 2013; Olmedilla-Alonso et al., 2013; Slupski and Gebczynski, 2014; Pedrosa et al., 2015). Díaz-Batalla et al. (2006) noted that one out of fourteen studied common bean varieties contained exceptionally high levels of verbascose (35.8 mg/g dry weight). RFOs are broken down by the enzyme α-galactosidase which is not present in the lower gastrointestinal tract. As a result, RFOs are fermented by anaerobic bacteria in the gut, resulting in flatulence (Soccol, 2012). Soaking of dry beans prior to cooking is a common practice and has been shown to reduce the content of RFOs in common bean. The amount of raffinose and stachyose removed through soaking in Mexican common bean varieties was found to range from 7% to 60%, depending on the variety considered (Table 1.10).

Table 1.10. Oligosaccharide content in Mexican common bean varieties

Concentration (mg/g)

Variety	Dry grain		Soaked grain	
	Raffinose	Stachyose	Raffinose	Stachyose
Bayo Victoria	4.43	36.66	2.57	14.08
Azufrado Higuera	1.63	26.98	1.94	22.14
Flor de Durazno	2.20	31.33	1.61	16.48
Azufrado Peruano	2.06	34.27	1.73	20.41
Bayo Zacatecas	5.39	26.39	2.08	10.76
Azufrado Regional 87	1.72	23.32	1.82	20.32
Bayo Mecentral	6.16	9.43	3.36	8.03
Flor de Junio M.	5.38	28.06	3.78	18.75
Negro Otomí	3.87	26.76	2.45	16.36
Flor Mayo M38	3.94	26.50	3.74	24.48
Alubia	5.65	20.56	3.13	12.82
Negro Jamapa	7.04	35.22	6.00	24.76
Negro 8025	6.55	23.62	4.73	21.53

Source: Jacinto-Hernández et al. (2006), http://naldc.nal.usda.gov/naldc/download.xhtml?id=IND43805445&content=PDF.

Other carbohydrates in common bean include pectic substances, arabinogalactans and xyloglucans (Reddy et al., 1984; Sathe and Salunkhe, 1984). Like RFOs, these polysaccharides are subject to anaerobic fermentation (Geil and Anderson, 1994).

Saponins

Saponins are secondary plant metabolites that exist in a wide variety of edible legumes (Shi et al., 2004; Guajardo-Flores et al., 2012; Calvert et al., 1981). In common bean, they are particularly found in the seed coat. The most abundant saponin in the extracts of black bean seed coats is soyasaponin Af (Chavez-Santoscoy et al., 2013).

Phenolics

The major phenolic compounds of beans are simple phenolic acids and flavonoids. Highest phenolic content is found in the dark, highly pigmented bean varieties, in particular in their seed coat or hulls (Oomah et al., 2005) that are rich in flavonols, flavonoids, anthocyanins and tannins. Seed coat polyphenols are partly responsible for the post-harvest seed darkening and hard-to-cook phenomenon in beans (Marles et al., 2008; Campos-Vega et al., 2012). A single gene seems to control post-harvest darkening. In Pinto beans, the slow-darkening trait is controlled by a recessive allele (Junk-Knievel et al., 2008). Total phenolic content (50-1104 mg/kg) and the spectrum of the various phenolic constituents vary widely among and within market classes of common bean, depending on genetic and environmental factors.

The most abundant simple phenolic compounds in common beans are ferulic acid, sinapic acid, vanillic acid, caffeic acid, p-coumaric acid and p-hydroxybenzoic acid, their reported amounts varying with the methodology used for analysis. Syringic acid, chlorogenic acid, gallic acid and vanillin have also been reported to be present (Espinosa-Alonso et al., 2006: Luthria and Pastor-Corrales, 2006; Xu and Chang, 2009).

Kaempferol, often occurring with O- and C-glycosidic linkages, is the most abundant flavonol in beans with red beans and pinto beans containing greater amounts (14-209 and 148 mg/kg respectively) than black or grey beans (20 mg/kg) (Díaz-Batalla et al., 2006). Quercetin, another flavonol is present in black (9.7-23.5 mg/kg), cream-red (6.7-9.4 mg/kg) and grey (7.9 mg/kg) beans (Diaz-Batella et al., 2006).

Anthocyanins occurring in beans are simple, non-acylated anthocyanidins, usually containing glucose as the only sugar; however, malvidin 3-galactoside has been detected in black beans (Xu and Chang, 2009). Six different anthocyanidins have been detected in the (coloured) common bean but their relative percentage may differ among ecotypes and commercial market classes of beans. Several investigators reported delphinidin (49%-81%) to predominate, with petunidin (4%-32%), cyanidin (1%-23%) and malvidin (4%-14%) occurring at intermediate level, and pelargonidin (0.4%-6.5%) and peonidin (0.5%-3.7%) less frequently (Choung, 2005; Espinosa-Alonso et al., 2006; Xu and Chang, 2009). However, López et al. (2013) reported cyanidin and pelargonidin as the major anthocyanidins in dark beans, where they were complemented with small amounts of acylated delphinidin and pelargonidin 3-glucosides.

Suggested constituents to be analysed related to food use

Key products consumed by humans

The common bean is a staple food typically consumed after having been soaked in water and cooked, or after being canned. While beans can be milled and used to produce processed products, the common bean is typically eaten as shelled beans (whole grain). For the purpose of compositional analysis, it is appropriate to analyse the whole grain once the shell has been removed.

Suggested analysis for food use of new varieties

In the context of the human diet, the common bean can provide nutrients such as proteins, carbohydrates, dietary fibre and folate. The common bean may also contain anti-nutrients such as phytic acid, trypsin inhibitor, α-amylase inhibitor and lectins. The suggested key nutritional and anti-nutritional parameters to be analysed are shown in Table 1.11.

Table 1.11. Suggested constituents to be analysed in common bean grain for food use

Constituent	Whole grain
Proximates	x
Dietary fibre	x
Amino acids	x
Phytic acid	x
Trypsin inhibitor	x
α-amylase inhibitor	x
Lectins	x
Vitamins[1]	x

Note: 1. B vitamins, namely thiamine (B1), riboflavin (B2) and folate (B9), are suggested.

Suggested constituents to be analysed related to feed use

Key products consumed by animals

Although less common than its use in human food, the common bean may be used in animal feed. While products from the common bean may be used as feed, this document only addresses seeds, not green pods (snap beans or green beans), dry shelled pods and stems.

The residue of packaging and processing of dried beans (including those from the genera Phaseolus) for human food may be added to animal diets. These may include broken, small and cull beans, which may comprise all or part of plant protein products for animal diets (AAFCO, 2015).

Suggested analysis for feed use of new varieties

The suggested key nutritional and anti-nutritional parameters to be analysed in the common bean for animal feed use are shown in Table 1.12.

Table 1.12. Suggested constituents to be analysed in common bean grain for feed use

Constituent	Whole grain
Proximates	x
Fibre fractions[1]	x
Amino acids	x
Phytic acid	x
Trypsin inhibitor	x
Lectins	x

Note: 1. Neutral detergent fibre (NDF) and Acid detergent fibre (ADF) should be substituted for crude fibre.

Note

[1] The FAO figures for dry beans are not limited to common bean only and aggregate data of other *Phaseolus* species, and for several countries other types of beans classified as *Vigna* species.

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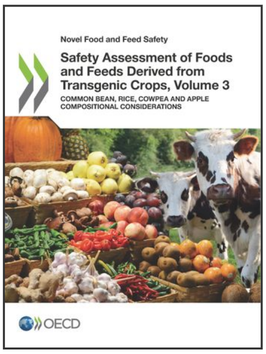

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