1 Global Production, Trade, Processing and Nutritional Profile of Dry Beans and Other Pulses

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INTRODUCTION

Legumes (dry beans and other pulses) occupy an important place in human nutrition, especially among the low-income groups of people in developing countries. Although terms *legumes, pulses,* and *beans* are used interchangeably, they have distinct meanings. For example, a legume refers to any plant from the *Fabaceae* family, including leaves, stems, and pods, while edible seeds from the legume plant are called pulses, which include beans, cowpeas, chickpeas, lentils, and peas, to name a few (HSPH 2020; Perera et al. 2020). Food legumes have significant importance in human diet and animal feed worldwide and occupy an important place in the global food supply chain besides promoting sustainable agricultural production systems (Pratap et al. 2021).

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Legumes typically have pea-blossom type flowers, herbaceous to woody stems, a generally well-defined taproot, nitrogen-assimilating bacteria within nodules associated with the fibrous root system, bivalved seeds in varying numbers borne in single-celled pods that readily separate into halves at maturity, an annual lifecycle, and grow throughout the world from the tropics to high mountainous regions (Hardenburg 1927). Legume plants serve as hosts for nitrogen-fixing bacteria (*Rhizobium*) through symbiotic colonization within nodules that develop among the plant root system. Thus, legume crops are soil nutrient enhancers that build soil nitrogen levels through suitable crop rotations of legumes with non-nitrogen fixing cereal grains (Bliss 1993; Martinez-Romero 2003).

Dry beans and other pulses are a good source of protein (significantly higher than that of cereals), dietary fiber, starch, minerals, and vitamins (Kutos et al. 2002; Hayat et al. 2014; Kamboj and Nanda 2018). They are a staple food and are a low-cost source of protein in developing countries where protein energy malnutrition (PEM) is prevalent (Van Heerden and Schonfeldt 2004). The inclusion of pulses in the daily diet has many beneficial physiological effects in controlling and preventing various metabolic diseases such as diabetes mellitus, coronary heart disease, and colon cancer (Tharanathan and Mahadevamma 2003). Further, pulses belong to the group that elicits the lowest blood glucose response and contain considerable contents of phenolic compounds. The role of legumes as therapeutic agents in the diets of persons suffering from metabolic disorders has gained a significant interest in recent years (Mudryj et al. 2014; Yao et al. 2020).

Figure 1.1 shows comparative nutritional benefits of dry beans versus cereal grains. Nutritionally, the higher content of protein and dietary fiber and lower content of carbohydrates and fat of legumes offer better dietary options and health benefits. In recent years, beans have been cited for imparting specific positive health potentiating responses (hypocholesteremic response, mitigation of diabetes and colonic cancer, and weight control) when properly positioned in the diet (Hayat et al. 2014; Clemente and Olias 2017; Kamboj et al. 2018; HSPH 2020).

Numerous factors influence utilization, including bean type and cultivar selection, cropping environment and systems, storage conditions and handling infrastructure,

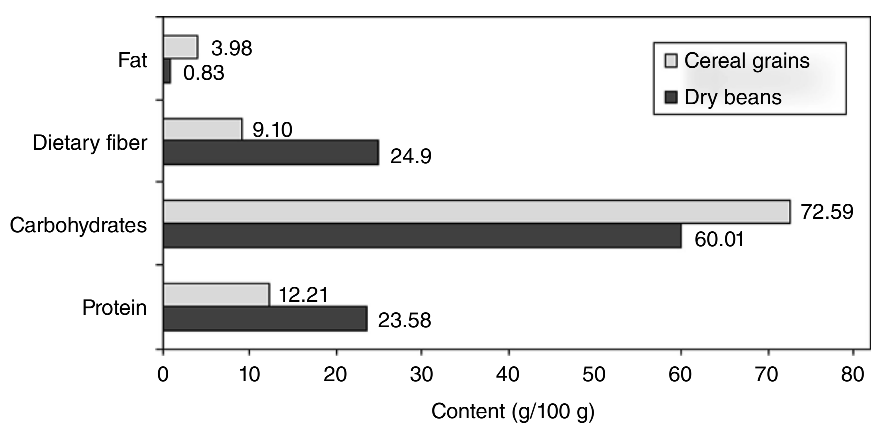

Fig. 1.1. Nutritional benefits of dry beans versus cereal grains (data for dry beans is average of pinto, navy, red kidney, and black beans, and average of wheat, corn, sorghum, and oat for cereal grains). Source: Based on data from USDA (2021).

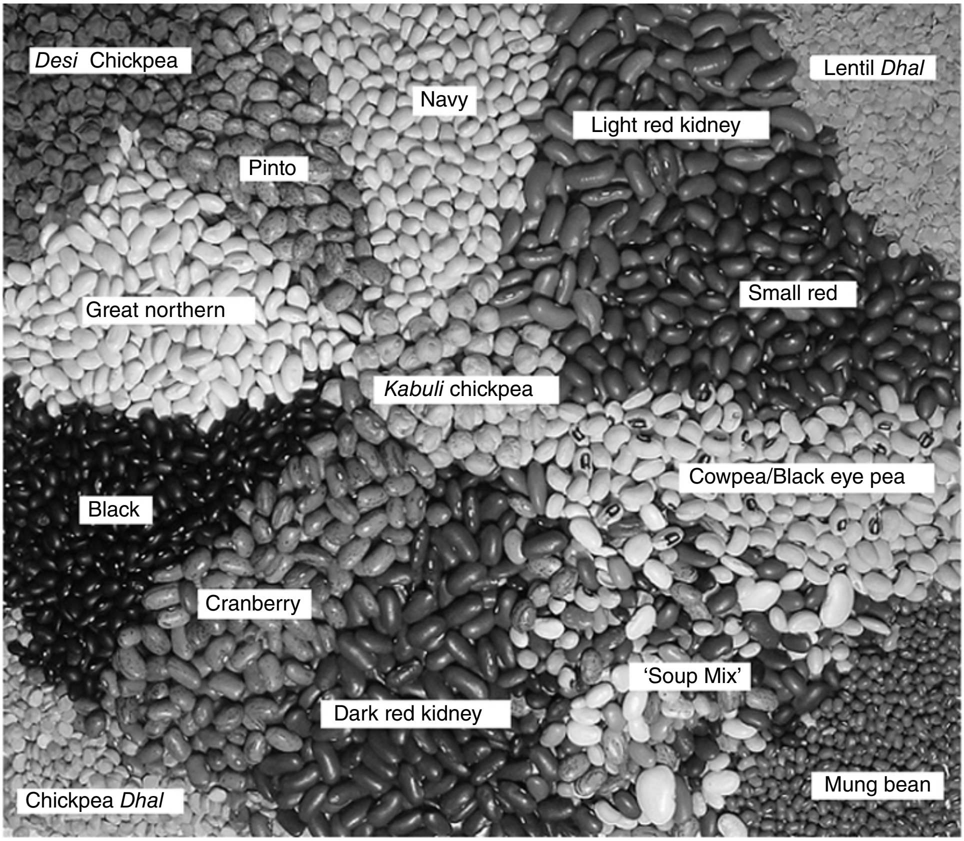

Fig. 1.2. A selection of common dry beans and pulses. (For color detail, please see color plate section.)
Source: Original image by author, M.A. Uebersax.

processing, and final product preparation. Further, nutrient content and bioavailability are dramatically influenced by these conditions. Antinutritional factors (trypsin inhibitors, lectins, and phytic acid) have long been recognized as concerns and require appropriate processing conditions to ameliorate adverse effects. However, it is noted that some of the antinutrients may have therapeutic value, e.g., tannins and phenolics (Uebersax et al. 1989; Sathe 2012).

Legume crops demonstrate global adaptability, genotypic and phenotypic diversity, and multiple means of preparation and dietary use. **Figure 1.2** shows a selection of common dry beans and other pulses. The common bean (*Phaseolus vulgaris* L.) is considered the most widely grown among more than 30 *Phaseolus* species described in the literature. It has undergone wide production distribution from its origins in Mexico, Central America, and the Andean region of South America. Beans have extensive domestication and cultivation and has been utilized in a variety of food preparations (Hidalgo 1988). Scientific (genus and species) and common names for various food legumes are:

- *Phaseolus vulgaris* L. (common bean, field bean, haricot)
- *Vigna unguiculata* L. (cowpea, black-eye pea, crowder pea)

- *Cicer arietinum* L. (chickpea, *garbanzo*, Bengal gram, gram, *Chana*)
- *Lens culinaris* Medik. (lentil, *Masur*)
- *Vigna aureus* (mung bean, green gram, golden gram)
- *Cajanus cajan* L. Millsp. (pigeon pea, Congo pea, red gram, Angola pea, yellow *dhal*)
- *Phaseolus lunatus* L. (lima bean, butter bean)
- *Vicia faba* L. (broad bean, faba bean, horse bean)
- *Vigna aconitifolia* Jacq. (moth bean, *mat* bean)
- *Pisum arvense sativum* L. (common or garden pea, pois, arveja, Alaska pea, *muttar*)
- *Glycine max* (L.) Merr. (soybean, soya, *haba soya*)

This chapter provides an overview of important aspects of the production and global trade of legumes, production and consumption trends, use as a diverse food resource, value-added products, nutritional and health significance, constraints to utilization, and the role of legumes in world food security.

History and origin

Beans may be called "the food of the ancients," with literature recording the cultivation of beans, lupins and lentils in the Nile Valley dating as early as 2000 BCE. Common beans originated in Latin America (high Andeas, Guatemala and Mexico) where its wild progenitor (*P. vulgaris* var. *mexicanus* and var. *aborigenous*) has a wide distribution ranging from northern Mexico to northwestern Argentina (Gepts 2001; Grigolo and Fioreze 2018). *Phaseolus* beans are recognized as an exclusive New World Crop of American origin despite their wide distribution worldwide. Secondary centers of diversification are East Africa and Europe, since the *Phaseolus* beans were introduced by Spaniards and Portuguese in the sixteenth and seventeenth centuries (Angioi et al. 2010; Schumacher and Boland 2017). Beans have played a part in the superstitions, the politics, and the warfare of ancient peoples. Magistrates were elected in Greece and Rome by the casting of beans into helmets. Certain kinds have been credited with medicinal value (Hardenburg 1927).

Originally domesticated in Central and South America, dry beans moved northward through Mexico and spread across most of the United States. These beans were commonly grown with corn and sometimes squash (Schumacher and Boland 2017). The early Europeans, first in the New England States of the US, then generations later in the upper Midwest (Great Lakes region), found that the white pea bean and many other dry beans provided a fine staple for a subsistence diet. The settlers explored and adapted to growing dry beans that the native Indians apparently had never exploited. They traded their excess production to non-bean-growing neighbors for goods, services, or cash.

The *Iroquois* Indians grew a small, round pea bean (*Indian* bean) with corn and squash ("three sisters" cropping system); this bean later became known as the "navy bean" because of the large demand that developed for this bean for naval and marine food supply purposes.

PRODUCTION AND TRADE

Dry beans and pulses are grown widely in different regions of the world. **Table 1.1** shows regional production of dry beans, cowpeas, and other pulses in 2019. The total world production of these grain legumes was over 68 million metric tons, with Asia alone contributing 50.67%, followed by Africa (27.80%, and Americas – North, Central, and South (15.62%). The major regionally produced legumes were lentils, chickpeas, mung beans, pigeon peas, and other local pulses (Asia), cowpeas and vetches (Africa), dry beans, lentils, and chickpeas (Americas), lentils, lupins, vetches, and other pulses (EU region), and lupins and vetches (Oceania).

The significance of dry beans and pulses is made clear by the worldwide distribution of their production and consumption, as summarized below:

- *East Asia:* China, Cambodia, Indonesia, Japan, Korea Rep., Myanmar, Philippines, Thailand, Vietnam
- *South Asia:* Bangladesh, India, Nepal, Pakistan, Sri Lanka
- *West Asia/Middle East:* Iran, Israel, Jordan, Lebanon, Saudi Arabia, Turkey, Yemen
- *North America:* USA, Mexico, Canada
- *Central America and Caribbean:* Costa Rica, Cuba, Dominican Republic, El Salvador, Guatemala, Haiti, Honduras, Nicaragua, Panama
- *South America:* Argentina, Bolivia, Chile, Colombia, Ecuador, Paraguay, Peru, Uruguay, Venezuela
- *Europe:* Albania, Austria, Benelux, Bulgaria, France, Germany, Greece, Hungary, Ireland, Italy, Poland, Portugal, Romania, Spain, Sweden, United Kingdom, Russian Federation
- *East Africa:* Burundi, Ethiopia, Kenya, Rwanda, Somalia, Sudan, Tanzania, Uganda, Zaire
- *West Africa:* Algeria, Egypt, Morocco, Tunisia
- *South Africa:* Angola, Lesotho, Madagascar, Malawi, Republic of South Africa, Swaziland, Zimbabwe

Table 1.1. Regional production of dry beans and other pulses in 2019 (metric tons).

Pulse crop	Asia	Africa	Americas	Europe	Oceania
Beans	14,369,312	7,052,612	7,039,866	367,412	73,470
Cowpeas	197,970	8,616,443	65,039	23,877	nr[1]
Chickpeas	11,879,525	693,369	876,132	516,069	281,200
Lentils	2,438,955	188,545	2,446,103	124,756	535,842
Vetches	94,569	324,719	97,230	239,487	6,790
Pigeon peas	3,680,651	666,875	78,443	nr	nr
Lupins	91	75,381	63,595	393,146	474,629
Other pulses	2,063,857	1,432,126	41,065	1,003,043	12,938
Total	*34,724,930*	*19,050,070*	*10,707,473*	*2,667,790*	*1,384,869*

[1]Not reported
Source: FAO (2020).

Global production and trade

The world production of dry beans was 28.9 million metric tons (MT) in 2019, which represented an increase of 64.74% as compared to 17.5 million MT in 1990 (**Figure 1.3**). From 2010 to 2019, dry bean production increased by 4.3 million MT, or 17.33%, whereas in the preceding 20-year period (1990–2009), global production increased only by 4.5 million MT (17.33%). *Note: The percentages shown are slightly off in this section since these were not calculated from the rounded off data (to one decimal point) reported here*. Regionally, Asia accounted for 49.72% of global production, followed by Africa and Americas (North, Central and South), with 24.40% and 24.36% share, respectively. The total area under dry beans cultivation was 33.1 million hectares in 2019, which represented an increase of 25% compared to 1990's 26.5 million hectare. These figures illustrate that most of the production increases during nearly three decades were achieved through genetic improvements and applying good agricultural practices (GAPs) rather than through increases in area under cultivation.

The total world production of pulses (chickpeas, lentils, lupins, pigeon peas, vetches, and other minor pulses) in 2019 was 30.7 million MT, which represented an increase of 66.42% compared to 18.4 million MT in 1990 (**Figure 1.3**). Chickpeas (14.3 million MT) and lentils (5.7 million MT) accounted for 65% of the total pulses production. From 1990 to 2009, pulses production increased by 4.5 million MT, whereas a 7.9 million MT increase was reported in just a 10-year period from 2010 to 2019. With respect to regional distribution, Asia led the global production with 65.60% share, followed by Americas (11.72%), and Africa (11.00%).

The total area under pulses cultivation was 31.4 million hectares in 2019, which showed an increase of 6.3 million hectares or 25.20% since 1990. However, area under cultivation decreased significantly from the preceding year (2018), which was an all-time high of 38.1 million hectares. It is noted that most of the increase in area was recorded from 2010 to 2019, while it remained somewhat flat during the preceding 20 years (1990–2009).

The total world production of cowpeas was 8.9 million MT in 2019, which was more than four times as compared to 2.1 million MT in 1990 (**Figure 1.3**). However, from 2010 to 2019, an increase of only 25.47% was recorded, compared to 7.1 million MT in 2010. The area under cowpeas cultivation since 1990 exhibited a significant growth, i.e., from 5.7 to 14.4 million hectares. In contrast to dry beans and pulses, the boost in cowpea production appeared to be related mainly to the increases in the cultivated area. Nonetheless, technological advances too have contributed partially to higher production of cowpeas globally.

The average yield of dry beans, all pulses, and cowpeas was 874, 1124, and 616 kg/hectare, respectively, in 2019. As was the case with the total production and area under cultivation, yields of dry beans, all pulses, and cowpeas since 1990 have recorded a 32.26, 32.08, and 60.78% increase, respectively.

Leading producers of dry beans, cowpea, chickpea, lentil, lupin, pigeon pea, vetches, and other minor pulses are shown in **Table 1.2**. Myanmar, India, Brazil, China, and Tanzania top-five *dry beans* producing countries in 2019, with a production of 5,846,622 MT, 5,310,000 MT, 2,906,508 MT, 1,297,867 MT, and 1,197,489 MT, respectively. Combined, these five countries contributed about 57% of the total world production. Uganda, USA, Mexico, Kenya, and Burundi were the other countries among the leading dry beans producers. Nigeria, Niger, Burkina Faso, Ethiopia, and Kenya were the top-five *cowpea* producers,

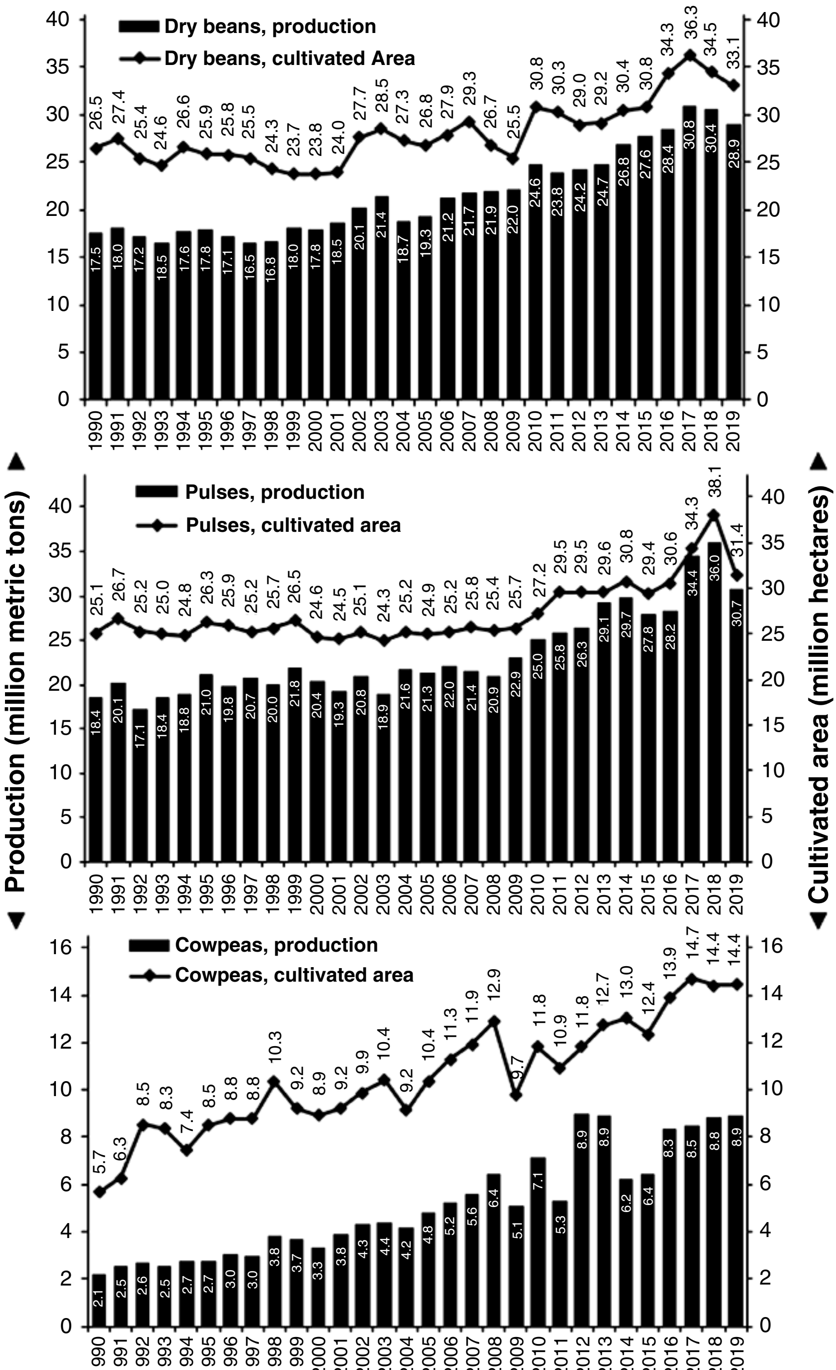

Fig. 1.3. World production (bars) and area under cultivation (lines) of dry beans, pulses, and cowpeas (1990–2019). *Dry beans data include pinto, navy, kidney, lima, black, great northern; pulses data include chickpeas, lentils, lupins, pigeon peas, vetches, and other minor pulses.*
Source: FAO (2020).

Table 1.2. Leading dry beans and pulses producing countries in 2019 (metric tons, MT).

Dry beans		Cowpeas		Chickpeas		Lentils	
Myanmar	5,846,622	Nigeria	3,576,361	India	9,937,990	Canada	2,166,900
India	5,310,000	Niger	2,386,735	Turkey	630,000	India	1,227,820
Brazil	2,906,508	Burkina Faso	652,454	Russian Fed.	506,166	Australia	533,755
China	1,297,867	Ethiopia	374,332	Myanmar	499,438	Turkey	353,631
Tanzania	1,197,489	Kenya	246,870	Pakistan	446,584	Nepal	251,185
Uganda	979,789	Mali	215,436	Ethiopia	435,193	USA	244,400
USA	932,220	Cameroon	215,016	USA	282,910	Bangladesh	175,384
Mexico	879,404	Ghana	202,735	Australia	281,200	China	164,239
Kenya	747,000	Senegal	184,137	Canada	251,500	Ethiopia	119,329
Burundi	619,151	Sudan	161,000	Mexico	202,846	Russian Fed.	116,618
World Total[1]	*28,902,672*	*World Total*[1]	*8,903,329*	*World Total*[1]	*14,246,295*	*World Total*[1]	*5,734,201*
Lupin		**Pigeon pea**		**Vetches**		**Other pulses**	
Australia	474,629	India	3,315,440	Ethiopia	312,680	India	912,609
Russian Fed.	166,271	Malawi	464,787	Russian	163,163	U.K.	230,139
Poland	145,690	Myanmar	347,395	Mexico	97,230	Mozambique	221,886
Morocco	67,928	Tanzania	90,088	Turkey	51,767	Spain	213,420
Chile	45,606	Kenya	87,912	Syria	33,978	Kyrgyzstan	180,379
Germany	25,600	Haiti	44,868	Belarus	31,739	Viet Nam	160,186
Greece	22,900	Dominican Rep.	25,322	Serbia	28,018	Poland	154,760
Peru	16,458	Nepal	16,538	Morocco	7,795	China	143,177
Ukraine	10,760	Uganda	14,223	Palestine	6,914	Tanzania	142,289
South Africa	7,224	Congo	6,510	Australia	6,790	Thailand	134,123
World Total[1]	*1,006,842*	*World Total*[1]	*4,425,969*	*World Total*[1]	*762,795*	*World Total*[1]	*4,553,029*

[1]Including all other countries not listed
Source: FAO (2020).

with Nigeria and Niger together accounting for 67% of the total world production. The cowpea production in the USA has been on a decline in recent years, with 2019 production of 11,750 MT, which was 65,570 MT in 2010.

Among pulses, India ranked first in *chickpea* production with 9,937,990 MT, or about 70% of total world production in 2019. Turkey, Russian Federation, Myanmar, and Pakistan were the other countries in the top-five chickpea producers. *Lentil* production is led by Canada (2,166,900 MT) followed by India, Australia, Turkey, and Nepal. Canada's share of total lentil production in the world was nearly 38%. Australia was the top producer of *lupins*, with a 47% share of total world production, followed by Russian Federation, Poland, Morocco, and Chile; these five countries accounted for 89% of lupins produced in 2019. India, Malawi, Myanmar, Tanzania, Kenya were the top-five *pigeonpea* producing countries, with India alone producing about 75% pigeonpeas. Ethiopia, with 41% of total world production, was the top producer of *vetches* in 2019, while India led in the production of *other minor pulses* with 20% global share.

Among all pulse crops, only dry beans, chickpeas, and lentils are traded globally on a wider scale (FAO 2020). Cowpeas and other pulses are traded in the world market on a much

Table 1.3. Leading dry beans, chickpeas, and lentils exporting and importing countries in 2019 (metric tons).

Exporters:					
Dry beans		**Chickpeas**		**Lentils**	
Myanmar	1,097,218	Russian Fed.	470,439	Canada	2,116,910
Argentina	457,041	Australia	406,157	Australia	498,992
USA	451,733	Turkey	212,598	Turkey	308,545
China	350,649	USA	154,784	USA	262,404
Canada	342,563	Mexico	133,309	UAE	209,780
Uganda	175,000	Canada	129,922	Kazakhstan	181,809
Ethiopia	165,265	India	123,493	Russian Fed.	150,818
Mozambique	164,055	Tanzania	111,459	Syria	19,678
Uzbekistan	151,077	Argentina	103,928	Egypt	17,401
Brazil	123,106	UAE	61,830	India	17,338
World Total[1]	*4,587,193*	*World Total*[1]	*2,177,431*	*World Total*[1]	*3,899,913*
Importers:					
Dry Beans		**Chickpeas**		**Lentils**	
India	520,965	Egypt	5,672,922	India	822,398
Brazil	150,660	Pakistan	410,083	Bangladesh	472,411
Turkey	145,240	India	371,883	Turkey	401,168
USA	139,850	Bangladesh	241,076	UAE	268,139
China	134,956	Turkey	114,770	Sri Lanka	167,810
Italy	131,527	UAE	105,076	Pakistan	123,735
Mexico	123,653	Iraq	77,083	Iraq	100,059
UK	116,543	Algeria	75,377	Colombia	86,475
Pakistan	103,871	Saudi Arabia	60,786	Canada	83,154
Viet Nam	94,559	Spain	56,979	Sudan	79,353
World Total[1]	*3,453,050*	*World Total*[1]	*7,796,178*	*World Total*[1]	*3,770,132*

[1]Including all other countries not listed
Source: FAO (2020).

smaller basis but FAO does not report data on these pulse crops. The major exporting and importing countries for dry beans, chickpeas, and lentils are listed in **Table 1.3**. Myanmar, Russian Federation, and Canada were the top exporters of dry beans, chickpeas, and lentils in 2019, with 23.92, 21.61, and 54.28% share of total exports, respectively. Other countries among top-five exporters were Argentina, USA, China, and Canada (dry beans), Australia, Turkey, USA, and Mexico (chickpeas), and Australia, Turkey, USA, and UAE (lentils). The top-five importing countries were India, Brazil, Turkey, USA, and China (dry beans), Egypt, Pakistan, India, Bangladesh, and Turkey (chickpeas), and India, Bangladesh, Turkey, UAE, and Sri Lanka (lentils). It is noted that UAE, which is not a major producer of chickpeas and lentils, imports these quantities in bulk and exports them in bulk and retail size packaging.

US production and trade

The total US production of dry beans was 1.78 million MT in 2020. North Dakota, Michigan, and Minnesota were the three leading dry beans–producing states in 2020 (**Table 1.4**); together, these three states represented about 76% of total US production, with 41.62%, 17.27%, and 16.69% share, respectively. Michigan was once the leading

Table 1.4. Leading dry beans producing states in the US for selected years since 1990 (metric tons).

State[1]	1990	2000	2010	2020	% Change (1990–2020)
North Dakota	254,270	386,765	521,500	739,683	+190.90
Michigan	276,623	209,563	192,273	306,847	+10.93
Minnesota	89,820	121,928	139,182	296,635	+230.26
Nebraska	254,219	163,586	145,136	177,148	–30.32
Idaho	180,859	87,178	115,727	84,637	–53.20
Colorado	217,184	100,590	57,000	55,425	–74.48
Washington	46,333	32,514	62,545	52,835	+14.03
Wyoming	49,025	38,712	46,545	32,361	–33.99
California	155,356	104,604	66,455	31,701	–79.59
Other states	121,267	102,521	99,136	nr[2]	--
Total (U.S.)	*1,644,956*	*1,347,961*	*1,445,499*	*1,777,272*	*+8.04*

[1]Ranked by 2020 production data
[2]Not reported (USDA stopped reporting data since 2019 for Montana and Texas, which comprised other states)
Source: USDA-ERS (2011), USDA-ERS (2020a).

dry beans–producing state; however, North Dakota has now been the leader for over two decades. Since 1990, Minnesota and North Dakota have recorded significant increases of 230.26% and 190.90%, respectively. Five states have shown a decrease in dry beans production since 1990, with percent decrease shown in parenthesis: California (79.59%), Colorado (74.48%), Idaho (53.20%), Wyoming (33.99%), and Nebraska (30.32%).

Lucier and Davis (2020) reported that the US imported dry beans from 69 countries and the top-five countries reported by the Department of Commerce include Canada, Mexico, Nicaragua, China, and India, which together represented 72% of all US dry bean imports. The most predominant dry bean classes imported in the 2019–2020 season were mung beans (23%), kidney beans – dark red, light red, and other kidney beans (19%), black beans (12%), and pinto beans (9%). Mung beans in the United States are mostly used for bean sprouts in salads or used in soup mixes and bean flour. US dry bean exports overall are down by 4% in 2020, which continued a downward trend in recent years.

Pinto and navy beans have been the two leading classes of dry beans produced in the US (**Figure 1.4**). While pinto beans continue to lead all classes; more recently, chickpeas, lentils, and black beans have surpassed navy beans, as per 2019 production figures. Both pinto and navy beans have recorded significant decreases in production since 1990, i.e., 50% and 54%, respectively. By contrast, since 1990 chickpeas have experienced a phenomenal growth of about 230-fold increase in production as the popularity of plant-based proteins and products (e.g., hummus) continues to grow among consumers. Similarly, both lentils and black beans have recorded a 4.6-fold increase in production. Kidney beans production has remained fairly flat over a 30-year period, whereas great northern and lima (baby and large) beans have experienced a significant decrease over the same period.

Small red, pink, and blackeye beans are other classes of commercial significance, with 28,805, 14,784, and 13,158 metric tons production, respectively, in 2019. Data on cowpeas was not reported for 2019 by USDA, most likely, due to decreasing production; however, 65,570 metric tons of cowpeas were produced in the USA in 2010.

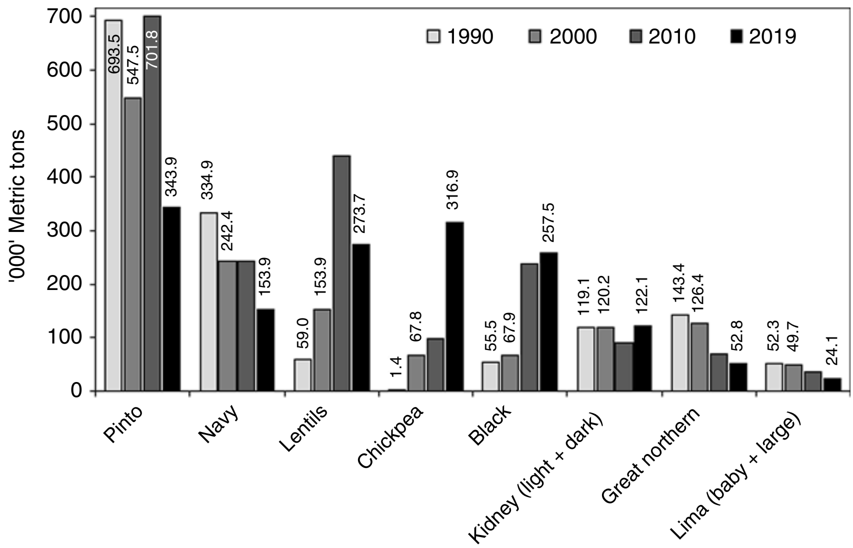

Fig. 1.4. Different classes of dry beans and pulses produced in the US for selected years since 1990. Source: USDA-NASS (2020).

CONSUMPTION TRENDS OF DRY BEANS

The per capita average bean consumption was 2.58 (5.68 lbs) kg in 2017 in the world. Several African nations were shown to be among the highest per capita consumers of bean products. Rwanda ranked the highest in bean consumption per capita, with 34.80 kg (76.56 lbs), followed by Uganda with 24.80 kg (54.56 lbs) and Tanzania with 15.30 kg (33.66 lbs) in 2017 (Anon. 2020). The regions of highest bean and other pulses consumption in 2013, according to FAOSTAT, included all of Latin America. The highest per capita consumption of 21.40 kg (47.08 lbs) was in Nicaragua, followed by 17.32 kg (38.10 lbs) in El Salvador, 16.07 kg (35.36 lbs) in Brazil, and 10.08 to 12.12 kg (22.18 to 26.66 lbs) in Costa Rica, Mexico, Honduras, and Guatemala.

The per capita consumption of dry beans and other pulses in the United States, Europe (encompassing the EU), and other industrialized economies has generally and consistently been substantially lower than that observed in other regions of the world (Schneider 2002). Bouchenak and Lamri-Senhadji (2013) reported that among European countries, higher legume consumption was observed around the Mediterranean, with per capita yearly consumption between 2.92 kg (6.42 lbs) and 8.40 kg (18.48 lbs), while in Northern Europe, the per capita consumption was significantly lower, i.e., less than 1.83 kg (4.03 lbs) per year. Watson et al. (2017) noted that due to decreasing consumption of legumes in EU countries, the share of cultivated area under grain legumes out of total arable area has decreased from about 7% in 1960 to under 3% in 2013.

Since 1970, the US per capita consumption of dry beans has ranged from a high of 7.65 lbs (3.48 kg) in 2000 to 5.40 lbs (3.48 kg) in 1980 (**Figure 1.5**), with the most recent figure of 6.90 lbs (3.14 kg) in 2019. Cooked bean consumption is recognized to be greatest in the southern and western areas of the country. About 55% of black beans, one of the fastest-growing classes in terms of per capita use, are consumed in the southern region of the country. People of Hispanic origin consume 33% of all cooked dry edible bean products.

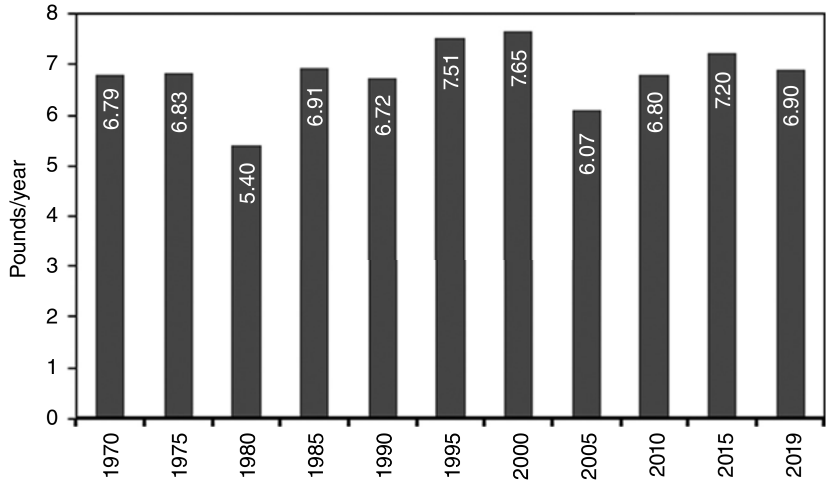

Fig. 1.5. US per capita consumption of total dry beans since 1970.
Source: Adapted from USDA-ERS (2020b).

Relative to their share of the population, low-income consumers consume substantially more navy, lima, and pinto beans than those consumed by mid or high-income groups (Lucier et al. 2000). A 2017 survey reported that less than 5% of US population consumed legumes daily, and that legume consumption declined in US adults, which warrants improved communication about the benefits of regular legume consumption (Perera et al. 2020).

Perera et al. (2020) further reported that although research has shown that regular consumption of legumes can prevent obesity, metabolic syndrome, cardiovascular diseases, and colorectal cancer, regular legume consumption in the US is so low that such levels of consumption were unlikely to confer any nutritional and health benefits. These authors indicated that a limited knowledge about ways to conveniently incorporate legumes into the diet may constraint consumers from eating recommended amounts of legumes to fully realize their nutritional and health benefits.

Dry beans are not a staple in the United States and per capita consumption has shown mixed trends since 1970. Rising incomes, urbanization, single adult household structure and numbers of women in labor force have adversely affected bean consumption. Most consumer preferences are shifting in favor of convenience foods and commodities, which require reduced food preparation time. Traditionally, dry bean products did not lend themselves to these emerging trends in consumer choices; however, advances in complex formulations and complete baked beans recipes have been innovative and greatly improved the convenience and high-quality acceptability (Siddiq and Uebersax 2012).

DRY BEANS AND OTHER PULSES AS A DIVERSE FOOD RESOURCE

The common dry bean and other pulses demonstrate global adaptability, genotypic and phenotypic diversity, and undergo multiple means of preparation and dietary use. Dry bean consumption patterns vary dramatically by geographic region and among cultures.

Determinants include a broad spectrum of social interactions and traditions that discriminate among bean types (color, size, and shape) and among means of preparation and end product use. These patterns of use have significant public health impact (Uebersax 2006).

Numerous culinary quality traits of beans contribute to their acceptable use but are frequently underestimated in their influence. These include: *Accessibility and Storage* – local indigenous versus commercial production and open marketplace versus packaged procurement (on-site point of purchase quality assessment, frequency, and quantity of purchase). In-home storage and meal-planning dynamics (stability, knowledge, water availability); and *Preparation and Quality* – the extensive constraints associated with preparation and cooking (water and fuel availability, sanitation, and time). Characteristic palatability attributes include integrity, texture (firmness and consistence), taste, and flavor (Uebersax 2006).

The use of dry beans and pulses may be considered from either a traditional or a value-added perspective. Traditionally, dry beans are cooked, fried, or baked to be in soups, eaten as vegetables, or combined with other protein foods to make a main dish. Commercially, beans have commonly been packaged in dry-pack form intended for home preparation or processed by canning in brine or tomato-based sauce (Siddiq and Uebersax 2012).

Traditional utilization

Utilization of dry beans and other pulses in many regions still entails long and tedious preparations. The consumer has traditional purchase criteria that include appearance (color, gloss, or sheen), size and shape (typical of the expected class), and overall quality (splits, defects, and debris) of the seed. A significant concern is in purchasing "hard beans" or "old beans," since these beans take longer to cook and lack desired quality attributes after cooking (Borget 1992; Sozer et al. 2017).

In many developing countries, women provide a central role focused on sustaining the family's food security. Traditional cooking of dry edible beans in these countries involves excessive expenditure of time and fuel. The development of appropriate preparation technologies for use at the household and village-level would facilitate processing and dietary availability of beans and other pulses (Siddiq and Uebersax 2012).

Beans and maize in blended dishes are deeply imbedded throughout Latin American cultures and transcends to other people groups. This is due in part to the inherent complementation of amino acids resulting in a more complete protein food. Sub-Saharan Africa utilizes a wide range of dry beans and other pulses (i.e., cowpea, chickpeas, lentils, and others). These are typically water cooked and eaten as porridge. The subcontinent of India uses the greatest quantity and most diversity of pulse-based foods as staples, prepared in very specialized recipes and forms. The consumption of legumes in Southeast Asia is somewhat moderate, where both mature seeds and immature pods are consumed. Further, sprouted legume seeds are consumed fresh or dehulled and roasted or ground for use in soups or side dishes (Khader and Uebersax 1989; Borchgrevink 2012).

Value-added processing and products

Beans typically require dry cleaning and sorting, gentle handling to assure a minimum degree of mechanical damage, and soaking and blanching prior to filling and thermal processing. The popularity of convenience foods such as dehydrated, extruded, frozen, and microwavable food products has provided a venue for the development of new bean products or bean formulations (**Figure 1.6**). The use of pulses was projected to expand as plant-

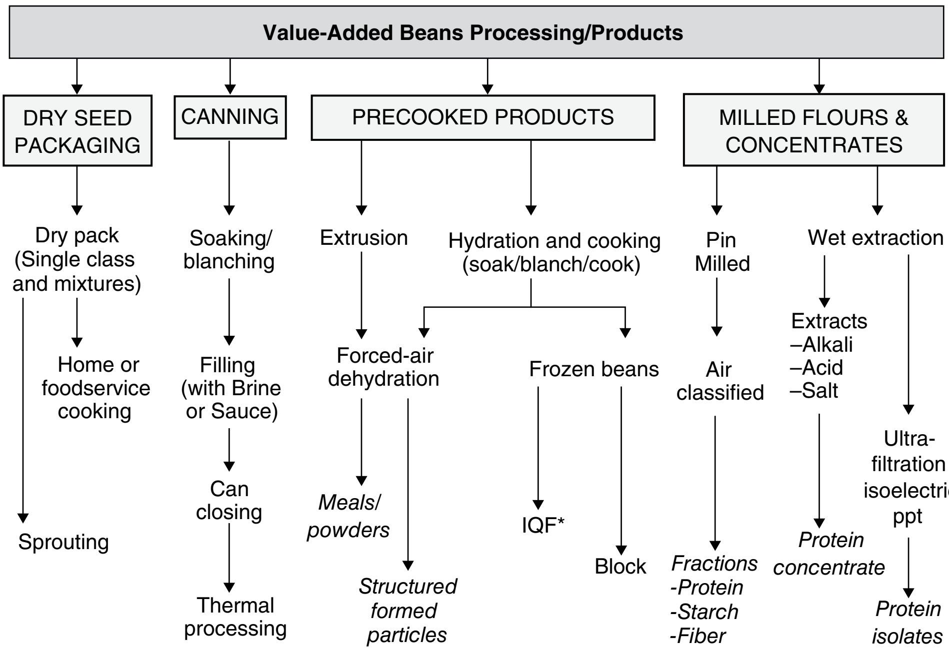

Fig. 1.6. A sampling of valued-added dry bean products (*Individually quick frozen)
Source: Adapted from Uebersax et al. (1989, 1991).

based protein alternatives for meat. Further, in combination with cereal raw materials, they may find new applications, meeting both sensory and nutritional needs of consumers worldwide (Sozer et al. 2017).

Selected categories of dry bean-based products utilized in industrialized regions include packaged dry beans, canned beans (beans in brine or specialty sauces), precooked bean products (precooked and dehydrated bean flakes and powders), extruded and pasta-type products, specialized food ingredients (meals, flours, concentrates, powders, and flakes), quick-cooking beans, and frozen beans. In the developed nations, canned products consistently dominate bean usage (based on individual frequencies of use data and total sales volume) compared with dry beans distributed in prepackaged retail offerings or through direct bulk dispensing (Siddiq and Uebersax 2012). Legume derived ingredients, i.e., flours and isolates, are being used on increasing levels for processing a variety of products, such as baked goods, fried products, and extruded snacks (Fernando 2021; Hall 2021).

NUTRITIONAL PROFILE AND HEALTH BENEFITS

The characteristics that make beans and pulses a good food value are *health and wellness*. It is noteworthy that consumers are increasingly selecting healthy and balanced diets proportionally higher in plant–based foods. Dry beans and other pulses have significant nutritional and health advantages for consumers since they are high in proteins and dietary fiber and very low in fat; and are environmentally sustainable, e.g., advantages associated with nitrogen fixation in soils by legumes (Uebersax 2006; Clemente and Olias 2017). Generally, rural populations consume greater levels of legumes than the contrasting urban populations, because of the dependence on locally produced foods. People of subsistent or lower-income levels generally consume larger quantities of beans, which furthers the stereotype that “beans are poor man’s steak,” which often stigmatizes and denigrates bean use and reduces expanded utilization (Siddiq and Uebersax 2012).

Nutritional profile

Legumes are a good source of protein, dietary fiber, starch, minerals, and vitamins (Kutos et al. 2002; Hayat et al. 2014; Venkidasamy et al. 2019). **Table 1.5** shows a compositional comparison of dry beans with major cereal grain crops. In comparison to these cereal grains, beans are relatively high in proteins and dietary fiber while low in carbohydrates and fat. Detailed composition of selected dry beans and pulses in presented in **Table 1.6**.

The 2015–2020 *Dietary Guidelines for US Americans* (DGA) classify mature legumes as a food group with a weekly recommendation of 1.5 cups (equivalent to 37.5 g cooked mature legumes/day) for nonvegetarians and 3 cups (equivalent to 75 g cooked mature legumes/day) for vegetarians (USDHHS and USDA 2021). The most recent DGA (2020–2025), issued in December 2020, make similar recommendations for legume consumption; however, further emphasize on reduction in added sugars and a greater focus on stages of life requirements (infants, children and adolescents, adults, pregnant/lactating women, and older adults).

Health benefits

Health benefits of legumes have been researched extensively and reported in the literature (Mudryj et al. 2014; Maphosa and Jideani 2017; Kamboj and Nanda 2018; Perera et al. 2020). The role of legumes as therapeutic agents in the diets of persons suffering from metabolic disorders has gained some research interest (Chugh et al 2017; Budhwar and Chakraborty 2020; Tiwari et al. 2020). Public health officials recommend increasing the proportion of legume-based polymeric plant carbohydrates in the diet. For example, regular consumption of dry beans in the USA, where obesity is on the rise, has been suggested to significantly improve the diet quality (Mitchell et al. 2009). In recent years, heightened consumer awareness has led to the promotion of less saturated fat, cholesterol, sugar, and salt in the diet and the preference for complex carbohydrates such as fiber from legumes. However, with growing urbanization even in the developing countries, ready-to-eat foods play a major role in the food consumption pattern (Njintang et al. 2001).

Table 1.5. Comparison of nutritional profiles of dry beans, chickpea and lentil with other grains (per 100 g).

Nutritional profile	Dry beans[1]	Chickpea	Lentil	Wheat	Oat	Corn
Energy (kcal)	341	378	352	339	389	361
Protein (g)	21.97	20.47	24.63	13.7	16.89	6.93
Carbohydrate (g)	61.74	62.95	63.35	72.57	66.27	76.85
Dietary fiber (g)	15.38	12.2	10.70	12.2	10.6	7.3
Total lipid/fat (g)	1.30	6.04	1.06	1.87	6.9	3.86
Iron (mg)	5.57	4.31	6.51	3.88	4.72	2.38
Potassium (mg)	1355	718	677	405	429	315
Folate (µg)	432	557	479	44	56	25

[1]Average of pinto, navy, red kidney, and black beans
Source: Adapted from USDA (2021).

Table 1.6. Composition of selected dry beans and pulses (per 100 g).

	Unit	Pinto bean	Navy bean	Black bean	Red kidney bean	Cowpea	Chickpea	Lentil
Proximate:								
Water	g	11.33	12.1	11.02	11.75	11.05	7.68	8.26
Energy	kcal	347	337	341	337	343	378	352
Energy	kJ	1452	1411	1425	1408	1435	1581	1473
Protein	g	21.42	22.33	21.6	22.53	23.85	20.47	24.63
Total lipid (fat)	g	1.23	1.5	1.42	1.06	2.07	6.04	1.06
Carbohydrate	g	62.55	60.75	62.36	61.29	59.64	62.95	63.35
Fiber, total dietary	g	15.5	15.3	15.5	15.2	10.7	12.2	10.7
Total sugars	g	2.11	3.88	2.12	2.1		10.7	2.03
Minerals:								
Calcium	mg	113	147	123	83	85	57	35
Iron	mg	5.07	5.49	5.02	6.69	9.95	4.31	6.51
Magnesium	mg	176	175	171	138	333	79	47
Phosphorus	mg	411	407	352	406	438	252	281
Potassium	mg	1393	1185	1483	1359	1375	718	677
Sodium	mg	12	5	5	12	58	24	6
Zinc	mg	2.28	3.65	3.65	2.79	6.11	2.76	3.27
Vitamins:								
Vitamin C[1]	mg	6.3		0	4.5	1.5	4	4.5
Thiamin	mg	0.713	0.775	0.9	0.608	0.68	0.477	0.873
Riboflavin	mg	0.212	0.164	0.193	0.215	0.17	0.212	0.211
Niacin	mg	1.174	2.188	1.955	2.11	2.795	1.541	2.605
Vitamin B-6	mg	0.474	0.428	0.286	0.397	0.361	0.535	0.54
Folate, DFE[2]	µg	525	364	444	394	639	557	479
Vitamin A, IU	IU	0	0	17	0		67	39
Vitamin E[3]	mg	0.21	0.02	0.21	0.21		0.82	0.49
Vitamin K[4]	µg	5.6	0.17	5.6	5.6		9	0

[1]total ascorbic acid;
[2]dietary folate equiv.;
[3]as α-tocopherol;
[4]as phylloquinone
Source: USDA (2021).

A diet high in beans can potentially reduce the risk of developing a chronic disease (Wu et al. 2004). Chronic diseases are conditions that typically take many years (10–30 years) to develop and include certain types of cancers, type-2 diabetes mellitus, heart disease, and other diseases of the blood system. These diseases are the most common causes of death in the United States and many other parts of the world (Geil and Anderson 1994; Hangen and Bennink 2002). Legumes elicit the lowest blood glucose response as compared to cereal grains. The inclusion of dry beans or other pulses in the daily diet has many beneficial effects in controlling and preventing various metabolic diseases such as diabetes mellitus, coronary heart disease, and colon cancer (Dilis and Trichopoulou 2009; Raju and Mehta 2009; Hayat et al. 2014; Kamboj and Nanda 2018).

Antioxidants – chemicals that destroy free radicals – are found to be very high in many types of beans. Wu et al. (2004) investigated the oxygen radical absorbance capacity (ORAC) of over 100 common foods consumed in the US. Their data showed that red kidney beans had the highest total antioxidant capacity per serving size as compared to all other foods, including many fruits and vegetables. Among all the foods analyzed in that USDA study, dry beans (small red, red kidney, pinto, and black beans) were found to have high levels of antioxidants. Generally, anthocyanin-rich fruits, such as blueberries and plums, are associated with having higher antioxidant content; however, the above three types of beans were found to have higher antioxidant capacity than even blueberries. It is noted that the ORAC data for dry beans is for uncooked seeds – cooking or canning can result in significant losses of antioxidant capacity.

The potential protective effects of dry beans in disease prevention, such as against cancer, may not be entirely associated to dietary fiber, but to phenolics and other non-nutritive compounds (Oomah et al. 2006), which can act as antioxidants, thereby hindering the formation of free radicals (Boateng et al. 2008). In addition, legumes belong to the food group that elicits the lowest blood glucose response. The large amount of water-soluble fiber is particularly effective in lowering cholesterol in the blood, whereas the water-insoluble fiber provides bulk, pushing food through the digestive system at a faster rate. Common beans are low in sodium (Buttriss and Stokes 2008), so this could be a healthy food choice for persons on a low-sodium diet.

Beans and pulses use in weaning foods

Malnutrition is prevalent in many regions of the world, often leading to stunting and wasting. Globally, 45% of 5.9 million deaths in children 5 years and under in 2015 were directly linked to malnutrition. Moreover, the malnutrition also significantly retards childhood growth (UNICEF, 2015). Therefore, nutritionally balanced weaning food must provide all the essential nutrients to meet young children's dietary needs. Generally, plant-based foods (including legumes) are used to meet the protein needs of infants and preschool children (Kumari and Sangeetha 2017; Borbi et al. 2020).

Dry beans and other pulses, due their nutrient-dense nature, serve as an important base for weaning foods. The use of appropriate preparation techniques (such as soaking/cooking, dehulling, fine grinding, roasting whole beans, germination, and fermentation) has been found to improve digestibility and reduce flatus from beans and pulses (Donangelo et al. 1995; Twum et al. 2015). The United Nations' WHO/FAO has detailed guidelines for preparation and use of weaning foods. Further, numerous US public- and private-sector groups (e.g., USDA, USAID, Gates Foundation) have made significant impact in developing weaning food mixes and guideline.

CONSTRAINTS TO UTILIZATION OF BEANS AND OTHER PULSES

A number of factors limit the use of beans and other pulses, including long soaking and cooking times necessary to adequately soften the beans, loss of valuable nutrients during bean preparation, low levels of the sulfur amino acids, low digestibility of unheated proteins, presence of antinutrients (e.g., lectins, trypsin inhibitors), high levels of phytic acid, various flatulence factors, and hard-to-cook (HTC) defects (Lucier et al. 2000; Lajolo and Genovese 2002; Uebersax et al. 1989, 1991; Maphosa and Jideani 2017). **Table 1.7** presents a summary of constraints associated with legume utilization and possible solutions to minimize negative effects related to each constraint.

Numerous factors influence the quality of the final dry bean product. These include cultivar, seed source, agronomic conditions, handling and storage of the dry product, and processing procedures during cooking or canning. Quality changes in dry beans during cooking and processing are associated with their inherent physical components and chemical

Table 1.7. Typical constraints associated with legumes utilization, their negative effects and possible solutions.

Constraint	Negative effect	Solution
Trypsin and amylase inhibitors	Decrease protein and starch digestibility	Boiling dry beans generally reduces the content by 80–90%
Phytate	Chelates with minerals resulting in poor mineral bioavailability	Dehulling, soaking, boiling, steaming, sprouting, roasting and fermentation, autoclaving, gamma irradiation
Lectins, saponins	Reduced bioavailability of nutrients	Most destroyed by cooking, soaking, boiling, sprouting, fermenting
Oligosaccharides	Flatulence and bloating	Soaking, cooking, germination, and changing boiling water
Hard-to-cook phenomenon	Energy and time consumption	Soaking legumes before cooking
Low levels of sulfur-containing amino acids	Incomplete protein source	Consuming in combination with cereals (high in sulfur-containing amino acids)
Low iron bioavailability	Poor source of iron	Consuming in combination with vitamin C rich foods to increase iron absorption
Lack of convenient food applications	Boredom of eating the same food repeatedly	New and convenient product development using whole legumes or legume ingredients
Lack of awareness and understanding of nutritional benefits of legumes	Low intake of legumes	Increasing consumer awareness of the nutritional and health benefits of legumes
Reluctance to try a new food or to change eating habits	Low intake of legumes	Development of innovative, attractive legume-based products to entice consumers

Source: Maphosa and Jideani (2017).

constituents (Hosfield and Uebersax 1980; Uebersax 1991). It must be noted that cooking and processing techniques improve the palatability, digestibility, and bioavailability through cellular separation and inactivation of antinutrional components.

A comprehensive assessment of strategies and procedures used for processing dry beans is prerequisite to improved utilization of dry beans. Implementation of a given protocol can be maximized through an understanding of the physical and chemical components, the inherent constraints and diversified processing techniques available to develop economically viable alternative and innovative products (Uebersax et al. 1991). Improved utilization of dry beans can be maximized through an understanding of how physical and chemical components function and react under given process conditions. Further, variability in the physico-chemical composition of dry beans occurs, warranting research and quality control programs directed to provide a consistent product possessing characteristics of acceptable flavor, bright color, attractive appearance, uniform texture, and high nutritional quality.

LEGUMES AND SUSTAINABILITY OF AGRICULTURAL SYSTEMS

Pulses provide environmentally sustainable source of nutrients-rich food for humans and animals, as summarized in **Figure 1.7** (GAP.org 2016). Sustainability of agricultural systems embrace long-term environmental consequences that transcend short-term productivity and efficiency objectives. A truly broad-based construct associated of sustainability

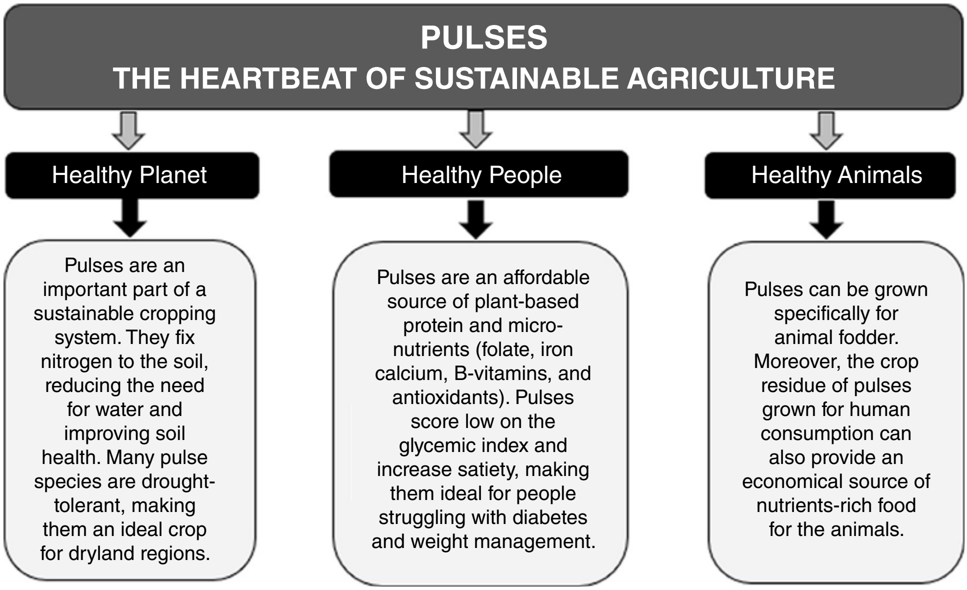

Fig. 1.7. Pulses as environmentally sustainable food source for healthy people and healthy animals. Source: Adapted from GAP.org (2016).

promotes the integration of food production practices and social needs. Thus, globally, agriculture sustainability must be considered as a social process besides technological practices and innovations. The production of legumes (dry beans and other pulses) has a rich and diverse history and serves as a global food resource within both industrially developed nations and indigenous populations. Since producing plant-based foods are by far more environmentally conservative than the animal-based ones (Gogoi et al. 2018), legumes will continue to play an increasingly major role to meet human food needs. Several elements of agricultural sustainability are clear or inherent in the production of pulses due to the considerably high total calorie and protein contents derived per unit of energy input:

- *Nitrogen fixing*. Legume crops are distinguished by their unique ability to "fix nitrogen" and thus have significant impact on their need for soil-borne nitrogen (Liu et al. 2011). By contrast, typically, major crops such as corn, wheat, and rice require added nitrogen to be productive and yield sufficiently to be economically viable. A progressive crop rotation is essential to maintain vital soil health and for managing weeds and disease pressure. Growers are generally diversified among several crops (e.g., corn, wheat, soybeans) – they are not exclusively dry bean producers on their farm acreage. Therefore, most fields are used for dry beans or other pulses every 3–5 years depending on the prescribed rotation. Not only do pulses directly benefit from the root-nodulation encapsulated symbiotic bacteria, *rhizobia*, that generate soil nitrogen, but there is significant carryover nitrogen levels that benefit the subsequent rotation crop.
- *Drought tolerance*. Dry beans and other pulses are much more drought tolerant (GAP.org 2021) than many other major crops, particularly cereal crops. Dry beans require less total water and significantly less irrigation than alternative crops since arid and

semi-arid lands require the use of supplemental water to sustain plant growth (Ye et al. 2018). Dry beans require differential levels of water during various stages of growth, which is precisely determined and controlled. Moreover, dry beans and other pulses will reproduce seed under the most drought stressed conditions where the cereal grains will fail to reproduce.

- *Field drying*. Legumes are efficient at harvest because they require no or very limited external/additional seed drying as is common with corn, wheat, rice, and other cereal grains. Beans and other pulses are naturally dried to a moisture content of around 18% prior to harvest. By contrast, typically, corn and cereal grains require artificial, forced air drying, which requires huge fossil fuel (propane) energy input to reduce moisture content suitable for stable storage without mold/bacterial development and spoilage.
- *Harvesting efficiency*. Dry beans are increasingly produced from plants possessing an upright architecture that allows for more rapid drying and direct cutting with mechanized combines rather than traditional pulling of the plants and windrowing for air drying. This energy-efficient innovation reduces overall fuel consumption compared to traditional harvest systems and avoids multiple field passes, which compact soil thereby requiring additional energy input for tillage.
- *Biodiversity and productivity*. Legumes are a world resource of biodiversity, providing significant land races of dry bean types providing genetic diversity within wide ranges of populations (Yang et al. 2021). The cultural practices associated with dry bean production, procurement, and preparation are very efficient. Additionally, research continues to enhance the productivity and efficiency of dry beans and other pulse crops that use reduced energy and agricultural inputs.

BEANS AND OTHER PULSES IN WORLD FOOD SECURITY

Global food security continues to be a worldwide concern. Beans and pulses contribute to world food supplies and food intake significantly. The significance of agricultural research for crop improvement and enhanced utilization of dry beans and pulses is evident through the scale and diversity of programs (Siddiq and Uebersax 2012). Under CGIAR (Consultative Group on International Agriculture Research), there are a number of research centers focusing on dry beans and pulses; e.g., International Center for Tropical Agriculture (CIAT, Cali, Columbia), International Crops Research Institute for the Semi-Arid Tropics (ICRISAT, Hyderabad, India); International Center for Agricultural Research in the Dry Areas (ICARDA, Alleppo, Syria); and the International Institute of Tropical Agriculture (IITA, Ibadan, Nigeria). According to CGIAR (2011), “impressive gains have been made with improved common beans, developed with farmer participation through regional networks in East, Central and Southern Africa; e.g., 30–50% yield increase from 1995 to 2010. This improved bean production, while strengthening household food and nutrition security, also provides women with surplus grain to sell in local markets.

In addition, numerous other countries through their international development agencies emphasize and support similar research programs on beans and pulses improvement. Selected such agencies include: Australian Agency for International Development (AusAID), Canadian International Development Agency (CIDA), International Development Research Centre (IDRC, Canada), German Agency for International Cooperation (GIZ), Japan International Cooperation Agency (JICA), Swedish International Development

Cooperation Agency (SIDA), and Department for International Development (DFID, United Kingdom).

The Food and Agricultural Organization of the United Nations (FAO) endeavored to make people more aware of the nutritional value of pulses, of their contribution to sustainability, and more reliable food by declaring 2016 as the International Year of Pulses (IYP 2016). This declaration intends to facilitate cooperation within food production systems to better use protein in pulses. The IYP 2016 aimed to heighten public awareness of the nutritional benefits of pulses as part of sustainable food production aimed towards food security and nutrition (**Figure 1.8**).

In the United States, the USAID (Agency for International Development) has long played a role in the dry beans and pulses improvement programs globally. Significant impact has been achieved through the collaborative research support program (CRSP) efforts on dry beans, cowpeas, and pulses. Current research foci are: increasing pulse productivity through genetic improvement, increasing pulse productivity through integrated crop management, increasing pulse utilization for improved nutrition and health, and strengthening pulse value chains (USAID 2012). The Pulse CRSP contributes to economic growth and food and nutrition security through knowledge and technology generation that strengthens pulse value chains and enhances the capacity and sustainability of agriculture research institutions that serve pulse sectors in developing countries of Africa and Latin America. Overall, the Pulse CRSP supports over 30 projects in about 20 countries (USAID 2012). **Figure 1.9** shows the geographical distribution of these projects.

In 2018, USAID-funded *Feed the Future Innovation Lab for Legume Systems Research*, a five-year research capacity building development program, was established at Michigan State University (FTF 2021). This current initiative builds on prior USAID-funded research and training. Past programs include the Feed the Future Innovation Lab for Collaborative Research on Grain Legumes (2013–2017), which was an extension of the USAID Dry

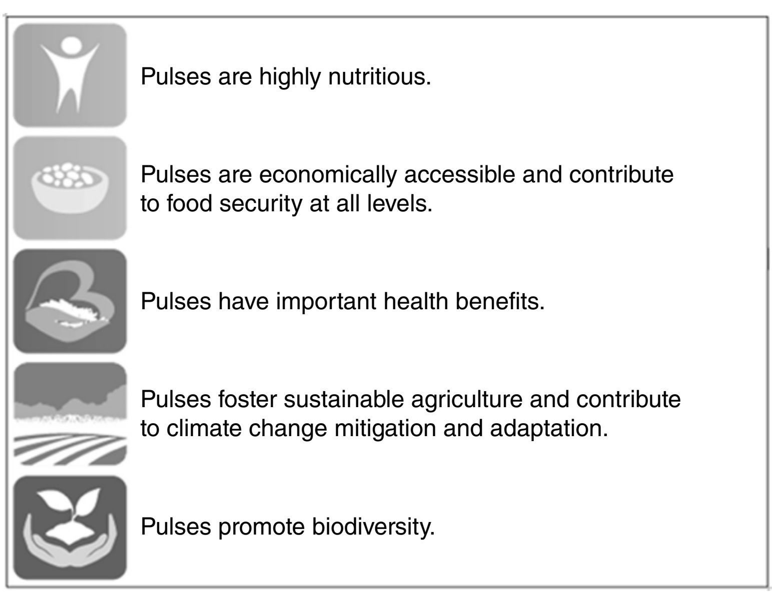

Fig. 1.8. Nutritious pulses for sustainable future – key messages.
Source: IYP (2016)

Fig. 1.9. Countries with USAID's Pulse CRSP supported projects.
Source: USAID (2012).

Grain Pulses Collaborative Research Support Program (Pulse CRSP) (2007–2012) and various earlier awards under Bean/Cowpea CRSP (1980–2007). This sustained federal support of research programs on grain legumes is due, in part, to important role legumes play in improving the livelihoods of smallholder farmers through income and farm productivity. The overall goals of the program project management are to increase sustainable and inclusive agricultural growth, strengthen the resilience of communities and agricultural and economic systems, and enhance the diets of individuals living in West and southern Africa (Nigeria, Niger, Mali, Ghana, Benin, Burkina Faso, Senegal, Mozambique, Malawi, and Zambia) and the United States (FTF 2021).

The Legume Systems Innovation Lab focuses on collaborative projects associated with two primary crops, common bean, and cowpea. These crops provide exceptional levels of nutrient dense staple foods. Further, it is fully recognized that legumes are especially important for women in many regions of the world, as they are often the producers, traders, and consumers of the crop. Collaborating international legume scientists and partner institutions enhance the global mission of improving livelihoods and nutritional impacts throughout legume value chains. Support of graduate student research training is critical to improving the research capacity of scientists in developing countries and is an important goal of this program (FTF 2021).

Dry beans in food aid programs

Dry beans are an important component of US foreign food aid programs. The USAID list the following beans and pulses as eligible for food aid programs in selected developing countries: black, blackeye, great northern, kidney (dark and light), navy, pink, pinto, small red, garbanzo, (chickpeas), lentils, and peas (USAID 2018). The targeted use of food aid programs and assistance with procurement and distribution of dry beans and/or partially prepared ingredients (flours, powders, meals, or extrudates) or fully prepared products (canned, precooked-dehydrated, and extruded) will directly expand use in the most urgently needed populations. Utilization of prepared dry edible beans has consistently been advocated by both governmental and nongovernmental organizations (NGO). These nutrition programs are particularly important to infants and children. Dry edible beans are also frequently considered for applications in regions experiencing sustained crop failure (Siddiq and Uebersax 2012).

Several organizations within other nations provide significant levels of food aid to area of need, and most convey direct shipments of pulses because of the high nutrient density. These organizations/nations include Canadian International Development Platform (CIDP), UK Department for International Development (DFID), German Corporation for International Cooperation (GIZ); French Development Agency (AFD), Japan International Cooperation Agency (JICA), and Swedish International Development Cooperation (SIDA), to name a few.

SUMMARY

The trends in the production and consumption of legume-based products are dynamic and are influenced by the challenges of global production. Increased use can be readily influenced by public policy, educational strategies, and industrial innovation. The evidence for health promoting aspects of legume-based foods is strong and should receive more attention by consumers. In developed countries of Europe and North America, beans are generally prepared by commercial food processing operations and consumed as canned beans in brine or sauce. The market and overall consumption of beans and formulated bean products are expected to increase and to further segment as they are positioned as nutritionally rich and healthy foods. However, the development of high-quality bean products in convenience foods categories such as dehydrated, frozen, and extruded formats appear to be an open opportunity.

The food industry, in cooperation with public research programs (universities and research centers) and other professional organizations, should focus efforts to incorporate dry beans and other pulses into innovative products that are economically viable, readily accessible to consumers, convenient to use, and of high culinary quality. The clearly recognized healthy attributes of beans deliverable in both subsistent and developed diets should be exploited for long-term improvement in positive health outcomes. The factors limiting the consumption of dry beans in industrial economics may, in part, be attributable to an inadequate level of innovation for developing value-added products adapted to modern consumer needs for convenience while specifically linked to high-quality eating experiences. Opportunities to improve the use of dry beans and pulses require integration and expansion of public and private sector interventions that are socially and culturally appropriate.

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