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BEAN/COWPEA CRSP MONOGRAPH NO. 1

BEANS AND COWPEAS AS LEAF VEGETABLES AND GRAIN LEGUMES

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ABSTRACT

Of the more than 185 legume species consumed as leaf vegetables, the cowpea is the species most widely consumed as a leaf vegetable. Cowpeas *Vigna unguiculata* leaves are common as cooked vegetables in the drier and warmer regions of West, East and Southern Africa. Bean *Phaseolus vulgaris* leaves are more prevalent in the cooler highlands of East and Southern Africa.

The leaves of both species are frequently dried for use during seasons when vegetables are scarce. The inclusion of dried leaves in the local diet is an important cultural adaptation, since losses in leaf vegetable quality is a common postharvest problem throughout the world. Bean and cowpea leaves retain greater amounts of essential vitamins after drying than other locally popular leaf vegetables. Considering the nutritional value on a cooked and on a kg/ha/day basis, both bean and cowpea leaves are competitive with their seeds.

Production research on both crops as leaf vegetables is limited. Results indicate that there is sufficient genetic variation and physiological potential to permit successful development of cultivars for leaf and seed or leaf production systems.

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BEAN AND COWPEAS AS LEAF VEGETABLES AND GRAIN LEGUMES

Legumes are consumed for their seed and leaves around the world, especially in Asia and Africa. The leaves of more than 185 legume species, cultivated or gathered from the wild, are consumed raw, as cooked greens, as additives to starchy staples, and as potherbs for soups and stews (Table 1).

Bean Leaf Production and Consumption

The consumption of bean Phaseolus vulgaris leaves is reported from the tropics in general (22,34,48,49), from Indonesia (22,58), and from southern and eastern Africa: South Africa (77), Zimbabwe (13), Zambia (60), Malawi (23), Tanzania (67), Kenya (31,32,36) and Uganda (42,71).

In Java, Indonesia, bean leaves are eaten raw in salads (22). Ochse reported in 1931 that both young and old leaves were steamed and eaten, while only the young leaves of most other legume vegetables were eaten (58).

In South Africa, bean leaves are commonly eaten by the black people as a cooked green called morogo or m'fino. In the inland highveld, some peoples dry the bean leaves in the sun to store for the dry season. Dried morogo is frequently available year-round, in urban as well as rural markets. In the city of Soweto, approximately half of a sample of one hundred families from various ethnic groups ate morogo three or more times per week. In the small town of Komatipoort, 480 km east, the proportion was 80 percent. In some parts of South Africa, morogo is eaten even more frequently, as in Transkei (77).

The Shona, Kalanga and Zezuru people of Zimbabwe eat bean leaves as cooked greens regularly, with a peanut paste or stew when available. As in South Africa, surplus leaves are sun-dried and stored for the dry season (13). In Zambia, fresh bean leaves are cut up and boiled with salt or trona (crude sodium carbonate) and are eaten immediately, or are dried in the sun for two or three days (60).

In Malawi bean leaves are harvested during the pod filling stage (Lawrence Janicki, 1984 personal communication, Chitedze Agric. Res. Stn., Lilongwe, Malawi). The fresh leaves are sundried on mats and stored in sacks. Although young leaves are preferred, older leaves are also eaten, usually cooked with sodium carbonate, trona or potash to soften them. The Chewa and other peoples eat bean leaves with peanut paste (82,13) or stew (B. M. Indire-Lavusa, 1984 pers. comm., Ministry of Agriculture, Kenya). Leaves are also marketed fresh (23) and dried (83). The price of bean seeds in Malawi was Malawi Kwacha (MK) 0.11 (US$ 0.13) per kg in 1975, with fresh leaves selling for MK 0.11 (US$ 0.02) per kg (25). The difference in market value approximates the difference due to water in the leaves.

Bean leaves, called magaraka in Lulogobli, majani ya maharagwe in Kiswahili and nyeni cia maboco in Gikuyu (B. M. Indire-Lavusa, pers. comm.), are also widely eaten in Kenya, Uganda and Tanzania. In Uganda, bean leaves are commonly eaten fresh-cooked (42) and are dried for dry season consumption (71). They are used to supplement the staple food dish as a sauce, a relish added to meat and fish, and mixed with the bean seed itself (42, B. M. Indire-Lavusa, pers. comm.). The Alur, Jonam, Kakwa, Lugbara or Uganda eat the leaves regularly (71), as do the Ganda and Gisu of SW Uganda (B. M. Indire-Lavusa, pers. comm.).

In Kenya, bean leaves are important in the higher rainfall areas (where most beans are grown). Intercropping is the standard practice, usually in rows between other crops, but sometimes in small patches. When leaves are used as a vegetable, the plant is usually not left to set seed but uprooted before flowering at three to five weeks of age. Occasionally, however, leaves are picked just prior to senescence when the pods are full but not yet dry. In this case both leaves and seeds are used.

The leaves are steamed, boiled or fried alone or in combination with other vegetables, depending on use and availability. Various local spices and trona may be used to alter the leaves' consistency. Most are eaten as an accompaniment to a high-carbohydrate food stuff such as maize, sorghum, cassava, banana, etc. (B. M. Indire-Lavusa, pers. comm.). However in Kenya, bean leaves are not an important market commodity, even at the local level, although some will be sold, particularly in drier areas or in periods of famine or shortage (B. M. Indire-Lavusa; Nifredah Lavusa, 1984 pers. comm., Min. of Cooperative Development, Kenya).

Cowpea Leaf Production and Consumption

Most published references on the use of cowpea *Vigna unguiculata* leaves as a green vegetable come from sub-Saharan Africa, with a few others from Indonesia (58) and from the general region of Asia and the Pacific (49). In many parts of Africa cowpea leaves rank among the top three or four leaf vegetables in the diet in terms of quantity consumed (B. M. Indire-Lavusa, pers. comm.). An old saying of the Bapedi of the Transvaal (South Africa) is, "Meat is a visitor but spinach (cooked greens usually cowpea) is daily food" (76).

Names given in various lanquages include *owe* in Yoruba and *maka* in Hausa (Nigeria) (21); *hako niebe* in Foulbe and *kiwa* in Nsa (Cameroon) (67); *obo*, *boo* and *amuli* in Aluri and Jonam, *nyete* and *laputu* in Relli and Kakwa, *osubi* and *osunyiri* in Lugbara, *osubi* and *osu* in Madi, *goramul* in Acoli and Lango Laro, and *gobbe* in Luganda (Uganda) (70); *nyeni cia mathoroko* in Gikuyu (Kenya) (36); *ny'emba* in Sishona (Zimbabwe) (13); and *monawa* in Sesotho (Lesotho and South Africa) (29). Other names include *makunde* in several parts of Witanzania and in Kinyaruanda (Rwanda), and *likuvi* in Lulogo'oli (Kenya) (B. M. Indire-Lavusa, pers. comm.).

In Africa cowpeas are commonly sown by broadcasting seed, and then thinning the population for consumption before flowering (40,44,72). According to Oomen and Grubben, some African farmers believe that a moderate harvest (about 2T/ha) of cowpea stem tips and leaves at flowering increases seed yield, while removing over 4T/ha of tips and leaves reduces seed yield (34,40,60). When grown strictly as a leaf vegetable, a dense sowing of seedlings is harvested three to six weeks after planting by cutting at ground level or by uprooting (44,60). February to April is the major cowpea season in Malawi (83).

In higher rainfall areas of East Africa cowpeas are grown much more for leaves than for seeds (2,51), the seeds becoming equally important only in drier or more marginal farming regions (B. M. Indire-Lavusa, pers. comm.). Cowpea leaves are important in Uganda in the Teso and Lango districts (2,51) as well as in Buganda and parts of eastern Uganda.

Cowpeas are either grown alone or as a mixture intercropped with various other leaf vegetables, maize, beans, pigeon peas, bananas and others. They may be broadcast or sown in rows at intervals of about 10-20 cm in the row with 20 cm between rows. A common practice in Kenya when sowing cowpeas in rows is to sow five or more seeds per hole. Harvesting may be done as soon as there are enough (five-ten) leaves on the stem--usually at three weeks--when only the top few leaves are removed, or it may be done much closer to flowering at about six or seven weeks. In the former case the harvesting continues throughout the season until flowering, when the whole plant is uprooted. Some harvests continue after flowering; but once pod-filling begins, the plants are left to go to seed. In this case both leaves and seeds are harvested. Cowpea leaves are available in Western Kenya year-round, since planting is done continuously throughout the year. The main season however is March to November when seeds are mature and dry (B. M. Indire-Lavusa, pers. comm.; Nifredah Lavusa, pers. comm.).

The sale of cowpea leaves in markets is reported from Ghana (79), Benin (23), Mali (20), Cameroon (72), Ethiopia (79), Uganda (51) and Kenya (36,39,40, 60). It is most probable that the leaves are sold in many more countries in these regions especially Tanzania (B. M. Indire-Lavusa, pers. comm.).

In southern Benin, where cowpeas are grown for both seeds and leaves, the leaves are sold in great quantities because of the low price (84). Cowpea leaves are sold in all parts of Cameroon except perhaps the north-central region around Adamaoua. In the extreme north they are sold both fresh and dried (80).

The leaves are sold in some parts of Kenya only during the rainy season. In most other areas they are sold in local rural and urban markets throughout the year or as they are available. These are generally fresh leaves (B. M. Indire-Lavusa, pers. comm.). The common price in 1977 was Kenya Shillings (KShs.) 0.20 per kg, when the KShs. was valued at US $0.13 (approximately US $0.016 per kg), but this differs according to the location of markets and production. The movement of the vegetable between rural and urban areas has made it a market commodity of some local significance (B. M. Indire-Lavusa, pers. comm.).

The drying of cowpea leaves appears to be a widespread practice in Africa, having been recorded in South Africa (30,76), Botswana (33), Uganda (42,51), Cameroon (80), Nigeria (21) and Ghana (78). They are the most commonly dried leaves in Malawi (83). Insofar as fresh green vegetables are not readily available in many parts of Africa which have a long dry season, dried leaves become seasonally important. This is a significant cultural adaptation as the consumption of leaf and other vegetables out of season is limited in most traditional cultures lacking cold storage such as root cellars or salt-brining technology.

Sun-drying is customary in parts of Uganda (42). Dried cowpea leaves are ground into a powder and stored for use in the dry season when fresh leaves are unavailable, particularly in the Teso and Lango districts of northern Uganda (2,51). Cooking may precede drying, as in parts of Uganda (42), Zimbabwe (13), Botswana (33), South Africa (29,76) and Malawi (83), or the fresh leaves may be dried, as in parts of Ghana and Zambia (60). As in Uganda, the drying is usually done as a preservation of the leaves for use in the later seasons, particularly in Botswana (33; Doyle Baker, 1984 pers. comm., ATIP, Min. of Agric., Mahalapye, Botswana) and South Africa. This sometimes is not enough, however, as dried cowpea leaves stored in great quantities in parts of Zimbabwe are often used up well before the next rainy season (13).

The Pedi, a Sotho people of northeastern Transvaal (South Africa), prepare dried _morogo_ from cowpea, pigweed (_Amaranthus_ spp.) and melon leaves, among others, by boiling them for about one and a half hours. The pot is dumped onto a rock or hard earthen floor, and the leaves are kneaded to a pulp and squeezed into pellets. The golf-ball-size pellets are dried on the flat rock in the sun for three days and then scraped into a sack for storage (76). A similar pattern of boiling, pulping, drying, and storing _morogo_ is found among the Kwena of the Sotho-Tswana ethnic group of South Africa (29).

In Malawi picked leaves are dried by spreading on mats in the sun for two to three hours before being packed tightly in large (fifteen liter) clay pots, one to two liters of water is added and boiled for up to twenty minutes. The softened leaves are then spread to dry in the sun again for up to three days, at which point they are then rolled into two kg balls, covered with leaves of _Vapaea kirkiana_ and hung to store for the dry season (83).

The kitchen preparation of cowpea leaves does not differ very much from that of bean leaves, although it is possible that the former are preferred younger in many cases. In Indonesia usually only the tender leaves are steamed for food. Although some reports from Africa consider the third and fourth leaves from the apical ends of the shoots as the best leaves for eating (2), it is more usual that entire above-ground seedlings and plucked leaves are used as pot-herbs (40,44,72). The Tlokwa-Tswana of central Botswana eat fresh cowpea leaves as a relish (33), as do many other people in eastern and central Africa (B. M. Indire-Lavusa, pers. comm.).

Dried leaves are cooked in many parts of Africa, especially during the dry season. In Malawi they are added to soups (M. W. Adams, 1984 pers. comm., Crop Science Dept., Michigan State University) and are also boiled for about an hour and served with tomatoes, peanuts and salt as a relish (83). Among the Pedi of South Africa _morogo_ is the only major addition to a monotonous diet of maize and sorghum meals, since animal protein is rarely available. During the dry season, _morogo_ pellets are crumbled over the meal (76).

Acland states that in parts of East Africa, leaves may be crushed first, fried and then boiled (2), or simply fried (71). Fresh cowpea leaves, however, are traditionally boiled in water with salt and served as cooked greens in Zimbabwe, Zambia and Uganda (13,60,71) as well as in other countries. In northwestern Uganda leaves are picked and left in the sun to wither in order to soften them. After the dirt is washed off, they are chopped finely and boiled in water with trona. After a few minutes a mucilaginous vegetable is added to the pot, with some salt, and they are cooked until tender.

Mucilaginous vegetables are used in many other parts of Africa. These may be other annual or perennial leaf vegetables, okra, or the bark and roots of various suitable trees and shrubs (B. M. Indire-Lavusa, pers. comm.). This usually makes a rich, thick sauce. Cowpea leaves are also cooked into a thick sauce in parts of southern Benin (84).

Cooking of the leaves may be done separately from the main dish, as among the Acoli, Lango, Madi and Aluri of N. Central Uganda, or it may be done mixed in one pot with the staple. The latter is commonly done by the Ganda and Soga, particularly with bananas. Boiling and steaming are the usual methods, with the other vegetables, salt and sesame or peanut pastes.

The use of leaf vegetables in the diet is highly prized among the Jonam, Lango, Acoli and other peoples, especially for new mothers. The greens are believed to increase the mother's milk production (B. M. Indire-Lavusa, pers. comm.).

The crude hydrated sodium carbonate, trona, sometimes used in Kenya to soften the toughest vegetables, reduces the ascorbic acid content when compared to simple boiling or steaming (32). The flavor that the trona brings out, however, is perhaps a more important reason for its use than is its softening action, since it is used with young leaves as well as old ones (B. M. Indire-Lavusa, pers. comm.).

Imungi and Potter simulated in the laboratory a traditional method of cooking cowpea leaves in Kenya by putting 150 g of washed, chopped leaves into 600 ml of water and bringing the contents to a boil in a covered aluminum pot for 30 minutes. After this the leaves were cooled and drained in a collander (40). This simulation only distantly approaches the common method in many areas of Kenya, since the amount of water used in the simulation is proportionately excessive. In addition, plain boiling without the use of a spice or condiment (including potash and trona) is not a widespread practice in Kenya. The remnant water in which vegetable leaves have been boiled is not usually drained but is instead used in the meal in many areas (B. M. Indire-Lavusa, pers. comm.).

Oomen and Grubben give two cowpea leaf recipes from central Kenya. The Agikuyu and other peoples make a dish called <u>irio</u> in Gikuyu, by boiling slowly one kg each of maize and beans in a clay pot for two to four hours until almost ready. Then one kg of unripe bananas and five hundred g of chopped cowpea leaves are added to the mixture and boiled for twenty minutes. A second recipe calls for the frying of cowpea leaves in fifty g of fat with sixty g of onions (60). This is then used as a side-dish to accompany a maize, sorghum, cassava, yam or millet main course.

In many parts of Kenya the leaves are steamed, boiled, fried or grilled alone or in combination with various other green vegetables, tomatoes, onions or meats. The other greens may be themselves boiled or fried and in many cases are mucilaginous or tender-stalked plants such as *Amaranthus* spp., *Corchorus* spp., *Crotalaria* spp. or others. Local condiments are often used, particularly in stews or when the leaves are fried. These include well-known spices such as pepper, ginger, cloves and curry powder as well as locally significant ones such as sesame and peanuts as pastes or oils. The cowpea leaves are usually cooked whole, along with petioles and parts of the stem; and, if the plant had flowered before it was picked, the flowers are also included (B. M. Indire-Lavusa, pers. comm.).

Nutritional Aspects of Legume Leaves

Though legume leaves and other leaf vegetables are widely consumed, their nutritional value is largely discounted owing to their high water content and the difficulty associated with quantitatively documenting their consumption and subsistence production (8). In Table 2 the nutritional values of leaves, pods and seeds (fresh, dried and cooked) are compared for cowpea, bean and winged bean. Cooked cowpea leaves have at least two-thirds the protein, seven times the calcium, three times the iron, half the phosphorus (none of which is bound in phytic acid) and several hundred times the beta carotene and ascorbic acid of the cooked seed. Based on fresh nutrient content, cooked cowpea leaves probably have the same thiamine, eight times the riboflavin, and five times the niacin of the seed. Beta carotene and ascorbic acid retention of cooked fresh leaves and cooked dried leaves using traditional or improved solar dehydration methods indicate that both bean and cowpea leaves are superior sources of these vitamins compared with other common Kenyan vegetables (31,32). In fact, cowpea leaves have promise as a commercially canned "spinach" which is a good source of available iron, phosphorus, zinc, beta carotene, ascorbic acid and folic acid (40).

Though protein quality studies are lacking for bean and cowpea leaves, parallel studies with similar leaf vegetables are encouraging. The legume *Crotalaria longirostrata*, *chipilin*, is a common leaf vegetable in Guatemala traditionally consumed in maize flour balls. The protein efficiency ratios (PER) of *C. longirostrata* and amaranth compared in an animal feeding trial were 1.37 and 1.05, respectively. The PER of *C. longirostacata* is comparable to 1.6, the average PER of a maize/bean diet in Guatemala. When a 90:10 (dry weight basis), maize/bean diet was supplemented with 5 percent amaranth leaf, PER values increased 32 percent from 1.48 to 1.96 (10). Comparable PER was obtained in Kenya comparing kale and skim milk powder as sole protein sources. Cooking the kale was necessary to reduce antinutritional factors. The PER values were 0.8, 1.4 and 2.5 for raw and cooked kale and skim milk, respectively (57).

A feeding trial, in South Africa with children 10-14 years old indicated that 75 g of cooked bean leaves (purchased dried) had a calcium value equivalent to 175 ml of milk (77). The low oxalic acid content of bean and cowpea leaves makes them a superior calcium source compared to true spinach (Spinacia oleracea), Swiss chard (Beta vulgaris) and other leaf vegetables high in calcium-binding oxalic acid.

Legume leaves not only are competitive with the seed on a cooked weight basis but also on a productivity (kg/ha/day) basis (Table 3). Cowpea leaves can produce 9 times the calories, 15 times the protein, 90 times the calcium, 290 times the thiamin, 220 times the riboflavin, 24 times the niacin, and thousands of times the beta carotene and ascorbic acid of cowpea seed, based on the 1975 world average seed yield (22).

Production and Physiological Research

Beans

Research in Brazil has shown that both determinate and indeterminate bean cultivars are most sensitive to 66 percent or greater defoliation at flowering. Plants were uniformly defoliated by removing individual leaflets from all expanded trifoliate leaves. Yield was 77-82 percent of the controls (30). Water stress increased yield reduction by ten percent at all levels and stages of defoliation in an indeterminate type (75). Among determinate bean cultivars, significant genetic variation is present as evidenced by yields 81-107 percent and 63-80 percent of controls following 33 and 66 percent uniform defoliation, respectively (14,75).

In Malawi, the effect of defoliation on bean yield was studied by dividing the plant into three equal zones by height. The mid zone was most important for the seed yield. A determinate cultivar '373', which set most of its pods in the mid zone if defoliated completely in the bottom or top and bottom zones at 21 or 35 days after planting and fertilized with 40 or 80 kg N/ha, had a mean yield of 112 percent of the control (24).

In a separate study, Edje observed that the removal of three randomly chosen, expanded leaves three times at weekly intervals can yield 6.5 T/ha of fresh leaves. Based on a market-seed-to-leaf-price ratio of 7, the combined value of fresh leaves and seed harvest was 140 percent of the control for plants without N fertilizer and 175 percent of control if fertilized with 40 kg N/ha (25). Similar results were observed in a subsequent trial (23). Regardless of the number of leaf harvests or N fertilizer rate, the maximum nitrogen removed by the combined seed and leaf harvests was about 78 kg N/ha compared to 46 kg N/ha for seed harvest alone (25).

Cowpeas

Production research on cowpeas as a leaf vegetable is quite limited but promising. In Uganda, where cowpea leaves are reported to be more popular than the seed, the seed yield of HVS/6/60/14, a large leaf cultivar with high yield potential, was higher following weekly harvests of leaves (51). A thirty-one percent greater seed yield was obtained when fully expanded leaves, three-four nodes beneath the growing apex, were harvested three times at weekly intervals beginning five weeks after planting. Largest leaf yields (68 kg/ha, dry weight basis) were obtained when the harvest began seven weeks after planting. Total defoliation, at 50 and 80 days by cutting whole plants, of a forage type, 'Pusa Barsati', yielded 21T/ha in India (19).

In Nigeria as much as 50 percent defoliation of the cowpea 'Mezea' prior to flowering by removal of every other leaf or parts of expanded leaves reduced seed yield to 85 percent of the control. Removal of all leaves on the main stem at flowering resulted in seed yield 122 percent of the control. It was hypothesized that the defoliation permitted greater light penetration into the canopy and altered the hormonal balance (27). A similar conclusion was reached regarding "rejuvenation" of old leaves by the removal of young leaves (64).

In Tanzania defoliation was compared among peanut, cowpea, soybean, and green gram (V. radiata). Cowpea was least sensitive to 50 percent defoliation, the removal of alternate leaves at flowering. Yield was reduced to only 97 percent of the control (26).

Genetic differences do exist among cowpea cultivars. Seed yield of leafy indeterminate types is reduced less than determinate types following defoliation (81).

Controlled environment research on 'K2809', a determinate cowpea, revealed that cowpea leaves two weeks and older do not effectively contribute to carbon fixation. When grown on 200 ppm nitrate, 50 percent defoliation of whole old leaves or parts of old and young leaves reduced the plant dry weight to 83-87 percent of control. Defoliation by removing of whole young leaves reduced growth to 30 percent of control (37). When inoculated with Rhizobium and defoliated 50 percent (whole or partial old leaves removed at flowering), 'K2809' yielded 71 percent of control. The yield reduction was even more severe if an equal area of young leaves were removed (68).

Whether N_2 was fixed or NO_3 assimilated, about 60 percent of total plant nitrogen was incorporated into 'K2809' cowpea seed (70). This was decreased by cool night temperatures (53). Shading the entire leaves at flowering completely inhibited nitrogen and carbon fixation and reduced seed yield to 32 percent of control. However the percentage of plant nitrogen incorporated into the seeds did not vary significantly from the norm (56). 'Caloona', a forage cowpea, incorporated only 39 percent of total plant nitrogen into the seed (35) and 'C-152', an indeterminate type, incorporated only 13 percent (15). This indicates that additional nitrogen in protein and other fractions is available for leaf harvest.

Legume leaves, especially bean and cowpea, are important and nutritious vegetables for people in less developed countries, particularly in Africa. The tradition of leaf harvesting by peasants, whether in the field or home garden, opposes our modern view of the bean and cowpea as solely seed crops. However, the multipurpose use of staple crops as leaf vegetables is not unusual; both cassava and sweet potato are commonly harvested for leaves and roots (8). In 1983, the Asian Vegetable Research and Development Center released a dual purpose sweet potato cultivar.

At this time there is major breeding and production research by the Centro Internacional de Agricultura Tropical on beans, by the International Institute for Tropical Agriculture on cowpeas and by the Bean/Cowpea Collaborative Research Support Program on both crops. We believe that research to increase seed yield should be supported by a strong collaborative program to increase the utilization of the foliage of these important crops.

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I. Consumption of legumes as leaf vegetables in regions and countries.

Species	Location	Remarks	Source
Abrus precatorius	Pantropical	acdl	49
Acacia albida	Zimbabwe		49
A. arabica	Africa		49
A. concinna	India, Philippines		49
A. farnesiana	S.E. Asia		49
A. drepanolobium	E. Africa		49
A. insuavis	Thailand		49
A. macrothyrsa	Malawi	dl	49,83
A. nilotica	Africa, Arabia, India	bl	22,49
A. socotrana	Somalia		49
A. zygia	Africa		49
Afzelia africana	Africa		49
A. bijugar	Thailand		49
A. quanzensis	Africa	adl	49,83
A. xylocarpa	Thailand		49
Albizzia adianthifolia	Congo		49
A. chevalieri	Nigeria		49
A. gemmifera	Africa		49
A. procera	S.E. Asia, Indonesia	bc	49,58
A. zygia	Africa		49
Arachis hypogaea	Tropics, Brazil, Indonesia, Mali, Senegal	abcdefkm	41,49,54 58,59,65
Astragalus abyssinicus	Africa		49
A. atropilosus	Malawi	dl	82
Bauhinia esculenta	Tropical Africa		49
B. malabarica	Malaysia	acej	48,49,58
B. nonandra	Guiana		49
B. purpurea	India, China		49
B. reticulata	Africa		49
B. thonningii	W. Africa	e	21
B. tomentosa	Tropical Asia	adj	49,58
B. variegata	Tropical Asia	d	48,49
Cajanus cajan	Tropics, W. Africa, Uganda	abdehk	22,41,44, 49,71,72
Calopogonium muconoides	New World Tropics		49
Canavalia ensiformis	West Indies, Africa, Indonesia		48,49,58
C. gladiata	Tropics, Africa	ad	34,48,63
Cassia alata	Pantropical	a	49
C. angustifolia	India		49
C. auriculata	India	l	22,49
C. fistulata	India		49
C. garrettiana	Tropics		49
C. hirsuta	New World Tropics, Indonesia	ad	49,58
C. laevigata	Tropics, Indonesia	abcd	49,58
C. mimosoides	S.E. Asia		49
C. obtusifolia	India, South America	adl	49,62

Species	Location	Remarks	Source
Cassia occidentalis	Pantropical, Sri Lanka, Indonesia	adkl	22,49,58
C. siamea	S.E. Asia		49
C. singueana	S.E. Asia, Malawi	l	49,83
C. surattensis	India		49
C. tomentosa	Mexico		49
C. tora	Tropical Asia, India, Indonesia, Mali, Cameroon, Nigeria, Tanzania	abcdehlm	22,49,54, 58,62,67, 80
Ceratonia siliqua	N. Africa		49
Cicer arietinum	Mediterranean Region	bdk	22,49
Clitoria ternatea	South America, Puerto Rico, Asia, Indonesia	dlm	49
Crotalaria anthyllopsis	Malawi	dl	82
C. brevidans	Kenya, Uganda		1,39,71
C. cephalotes	Malawi	dl	82
C. falcata	Nigeria		49
C. glauca	Tropical Africa		48,49
C. gutemalensis	Guatemala	abe	48
C. juncea	India		49
C. longirostrata	Mexico, Guatemala	f	17,49,61
C. natalitia	Malawi	dil	82
C. microcarpa	Tanzania		49
C. ochroleuca	Central Africa, Uganda, Malawi	deiklo	49,71,83
C. pumila	Mexico	bdfkl	52
C. retusa	Central Africa, Puerto Rico		49
Cyamopsis psoraloides	India		49
C. senegalensis	Africa, Arabia, India		49
C. tetragonoloba	Africa, India	adk	22,50
Cynometra reniflora	Thailand		49
Daniella olivieri	Africa		49
Delonix alata	India		49
Derris elliptica	Thailand		49
D. heptaphylla	Thailand		49
D. oliginosa	Thailand		49
Desmodium cinereum	Indonesia		49
D. umbellatum	South America		49
Dewevrea bilabiata	Congo		49
Dolichos sp.	Malawi	dl	82
D. bracteatus	India		49
D. lablab (Lablab purpureus)	Tropics, Old World Tropics, India, Indonesia, Kenya, Malawi, New Guinea	acdkl	36,48,49, 50,58,63, 73,83
Dysoxylum euphlebium	Indonesia		49
Entada phaseoloides	Indonesia		49
E. scandens	Congo		49
Eriosema edule	Argentina	e	11
E. glomeratum	Congo		49
Erythrinia berteroana	Tropics and Subtropics	cek	49

Species	Location	Remarks	Source
Erythrinia fusca	China		49
E. herbacea	Florida		49
E. rubrinerva	Central America	ae	48
E. subumbrans	Indonesia		49
E. variegata	India, New Guinea		49,63
Flemingia macrophylla	India		49
Gliricidia maculata	Pantropical		49
G. sepium	Pantropical	k	49
Glycine japonicum	Japan		49
G. laurentii	Pantropical		49
G. max	Pantropical, Indonesia, India	acdk	49,50,58
G. wightii	Malawi	dekl	22,83
Indigofera sp.	Malawi	dl	83
I. arrecta	Pantropical		49
Lathyrus sativus	South Europe, Middle East, India	ek	22,48
Leucaena cephalalates	India		49
L. clarkii	India		49
L. esculenta	Mexico		49
L. lanata	India		49
L. leucocephala (L. glauca)	Tropics, Indonesia, Mexico, Philippines	abcdekl	22,34,49,58
L. martinicensis	India		49
L. mollissima	India		49
Lolium rigidum	Algeria		49
Lotus edulis	India		49
Lupinus sp.	Malawi	dkl	83
Macrotyloma geocarpum (Kerstingiella geocarpum)	India, West Africa	ek	22
Medicago denticulata	India		49
M. polymorpha	Tropics, Subtropics	bdk	22
M. sativa	Temperate Regions, Europe, North America, USSR, China, India, Argentina	abcdko	6,11,22,49 69
Melilotus alba	Temperate Regions	ko	69
M. officinalis	Temperate Regions	eko	69
Millettia sericea	S.E. Asia, Indonesia	bc	49,58
Mucuna aterrima	East Asia		49
M. utilis	Tropics, Subtropics, Indonesia	ad	22,49 58
Neptunia oleracea	Tropical Asia, Thailand, Argentina	ad	11,49
N. prostrata	S.E. Asia, Malaysia, Argentina	adm	11,12,49
Ormocarpum sp.	Malawi	dl	83
O. orientale	China, Thailand, Philippines, Indonesia, New Guinea	dl	63
Parkia speciosa	S.E. Asia		49
Parochetis communis	E. Africa		49

Species	Location	Remarks	Source
Phaseolus aureus	Pantropical		49
P. calcaratus	India, Burma, China, Indonesia, Fiji	adik	48,49,58
P. coccineus	Pantropical		49
P. limensis	Pantropical		49
P. lunatus	Tropics, W. Africa, Uganda, Indonesia, New Guinea	abdeik	41,48,49, 58,63,71,73
P. mungo	India	abk	48
P. radiatus	Indonesia	adk	58
P. vulgaris	Tropics	edk	22,34,48,49
	Indonesia	cdk	22,58
	South Africa	kmo	77
	Zimbabwe	kst	13
	Zambia	dks	60
	Malawi	adikmqst	23,25,55,83
	Tanzania		67
	Kenya	dk	31,32,36
	Uganda	adkt	42,71
Piliostigma malabaricum	Thailand		49
Pisum arvense	Worldwide		49
P. sativum	Temperate Zone, Tropics Africa, Burma, Indonesia, Malawi	abdek	22,34,48, 49,58,83
Pithecolobium kurstleri	Sumatra		49
P. lobatum	S.E. Asia, Indonesia		48,58
Psophocarpus grandifloris	Ethiopia	adk	43
P. palustris	Zaire	abk	43,49
P. tetragonolobus	S.E. Asia, India, Sri Lanka, Indonesia, New Guinea	abcdekmp	22,34,38,43, 48,49,58,60, 73
Pterocarpus angolensis	Angola		49
P. erinaceus	Africa		49
P. indicus	India		49
P. lucens	Africa		49
P. santaloides	Africa		49
Pueraria thunbergiana	Tropics, China, Japan	bdko	22,48,49
Saraca indica	Thailand		49
Sarothamnus scoparius (Cytisus scoparius)	Europe, Germany	kl	48,69
Sesbania aegyptica	Old World Tropics		49
S. bispinosa	Old World Tropics	k	22
S. grandiflora	Africa, India, Thailand, Malaysia, Indonesia, New Guinea, Pacific	acdekgm	7,12,23,34, 48,49,58,60, 63,73
S. roxburghii	India		49
S. tetraptera	Tropical Africa, Sudan	e	48,49
Sesuvium portulacastrum	Tropical Africa		49
Smithia elliotti	Africa, Malawi	dl	49,83
S. sensitiva	Old World Tropics, Malaysia		49
Sphenostylis briarti	Africa		49
S. erecta	Africa		49

Species	Location	Remarks	Source
Sphenostylis marginate	Malawi	del	82
S. schweinfurthii	Africa		49
S. stenocarpa	Tropics, Africa		49,63
Tamarindus indica	Tropics, Subtropics India, Indonesia	abcdefjk	7,22,48, 49,58
Tephrosia elegans	Africa		49
T. linearis	Pantropical		49
T. purpurea	Pantropical		49
T. vogelii	Africa		49
Teramnus labialis	S.E. Asia		49
Tetrapleura tetraptera	Africa		49
Trifolium pratense	Argentina, Europe	adk	11
Trigonella corniculata	Africa		49
T. foenum-graecum	Middle East, India, Kenya, Malawi	bdegk	7,22,31,32, 49,60,66, 69,83
T. occulata	Africa		49
T. polycerata	Africa		49
Tylosoma fassogiensis	Africa		49
Uraria crinita	Malaysia, Indonesia		49
Vicia abyssinica	Malawi		49
V. faba	Temperate Zone, High Elevation Tropics	ak	34,49
Vigna sp.	Malawi	dl	83
V. marina	Tropical Seashores		49
V. marginata	Pantropical		49
V. mungo	Madagascar		49
V. phaseoloides	Africa, Asia		49
V. reticulata	Tropics, Malawi	dkl	49,83
V. schimperi	Kenya	l	39
V. triloba	Tropics		49
V. umbellata	Asia, Pacific, New Guinea, Indonesia, India	abdek	4,22,63
V. unguiculata	Tropics	dek	22,49
(V. sinensis)	Asia, Pacific	k	60
	Indonesia	adk	58,59
	Africa	abdko	26,44,47,48
	West and Central Africa	akmo	34,41,60
	East Africa	dgkp	2,60
	Transvaal	adekmqst	29,76
	Zimbabwe	adkst	13
	Botswana	dkst	33
	Zambia	degkr	60
	Malawi	abdeikmqst	83
	Ethiopia	em	79
	Tanzania	dk	26,67
	Kenya	dfkmno	16,30,31, 36,39,40,60
	Uganda	degklmpst	42,51,71,72

Species	Location	Remarks	Source
	Cameroon	kmo	79
	Nigeria	adeko	18,21
	Mali	dkm	20,54
	Benin	kmn	84
	Ghana	kmrt	78
Virecta procumbens	Congo		49
Voandzeia subterranea	Africa		49
Whitfordiodendron atropurpureum	Thailand, Burma		49

a Young leaves specified
b Young shoots or stem tips or seedlings specified
c Consumed raw or in salad
d Consumed alone, cooked, steamed, or boiled, as cooked greens
e Consumed mixed in soup, stew, sauce, as a potherb
f Consumed mixed into a starchy food
g Consumed fried
h Foul smell noted
i Bitter taste noted
j Sour taste noted
k Cultivated plant
l Wild plant
m Leaves sold in markets
n Relative low price noted
o Stored in dry state, no other details on dried leaves
p Stored as dried powder
q Stored as dried pellets
r Raw leaves dried in sun
s Cooked leaves dried in sun
t Dried leaves consumed in dry season

II. Nutritive value of leaves, pods and mature seed of cowpea, bean and winged bean (100 g edible portion).

Part	Species	H2O %	Calories	Protein g	Fat g	CHO g	Ca mg	P mg	Fe mg	B Carotene mg	Thiamin mg	Riboflavin mg	Niacin mg	Ascorbic Acid mg	Source
	Cowpea														
Leaf raw		85.0	44	4.7	.3	8.3	256	63	5.7	2.4	.20	.37	2.1	56	A
Leaf dried		10.6	277	22.6	3.2	54.6	1556	348	12.0	27.0				86	A
Leaf cooked		89.3		3.3			132	42	4.6	6.53				6	D
Pod raw		86.0	44	3.3	.3	9.5	65	65	1.0	.96	.15	.14	1.2	33	B
Pod cooked		89.5	34	2.6	.83	7.0	55	49	.7	.84	.09	.09	.8	17	B
Seed raw		10.5	343	22.8	1.5	61.7	74	426	5.8	.02	1.05	.21	2.2	---	B
Seed cooked		80.0	138	5.1	.3	13.8	17	95	1.3	.01	.16	.04	.4	---	B
	Bean														
Leaf raw		86.8	36	3.6	.4	6.6	274	75	9.2	3.24	.18	.06	1.3	110	A
Pod raw		90.1	32	1.9	.2	7.1	56	44	.8	.36	.08	.10	.5	14	B
Pod cooked		92.4	25	1.6	.2	5.4	50	37	.6	.33	.07	.09	.5	12	B
Seed raw		12.3	336	21.7	1.5	60.9	120	323	8.2	.10	.37	.16	2.4	1	A
Seed cooked		69.0	118	7.8	.5	21.2	38	140	2.4	---	.11	.06	.7	---	B
	Winged Bean														
Leaf raw		85.0	47	5.0	.5	8.5	134	81	6.2	3.10	.28	---	---	29	C
Pod raw		89.5	34	1.9	.1	7.9	53	48	.2	.34	.19	.08	1.0	21	C
Pod cooked		92.2	25	1.4	.1	5.9	39	36	.1	.39	.19	.9	.7	0	E
Seed raw		9.7	405	32.8	17.0	36.5	80	200	2.0	---	---	---	---	---	C

[A]Leung, W.W. 1968.
[B]Adams, D.F. 1975
[C]Duke, J.A. 1981.
[D]Imungi, J.K. 1983.
[E]Leung, W.W. 1972.
[F]Gomez, M.E. 1981.

III. Nutritive productivity of Cowpea, bean, and winged bean leaves and mature seeds.

Crop and part	Yield (kg/ha)	Duration (days)	Yield (Kg/ha/d)	Calories (ha/d)	Protein (Kg/ha/d)	Ca (g/ha/day)	Fe (g/ha/day)	B-Carotene (ha/day)	Thiamine (mg/ha/day)	Riboflavin (mg/ha/day)	Niacin (mg/ha/day)	Ascorbic Acid (mg/ha/day)
Bean												
Seed	535[A]	90	6	20,600[B]	1.35	5.2	.43	6	30.6	11.4	126	180
Winged Bean												
Leaf	8,000[C]	60[C]	135	63,500[B]	6.75	108.0	2.70	4,130	378	---	---	39,150
Seed	1,000[B]	180[B]	6	24,300[B]	1.97	4.8	.12	0	---	---	---	---
Cowpea												
Leaf	10,000[D]	60[D]	165	56,100[B]	6.93	178.2	7.75	4,000	462	396	1980	57,750
Seed	212[A]	90[B]	2	6,800[B]	.45	2.1	.12	0	1.6	1.8	80	40

[A]Duke, J.A. 1981, World Average, 1975.
[B]Duke, J.A. 1981.
[C]Oomen, H.A.P., Grubben, G.J.H. 1977.
[D]Grubben, G.J.H. 1977.