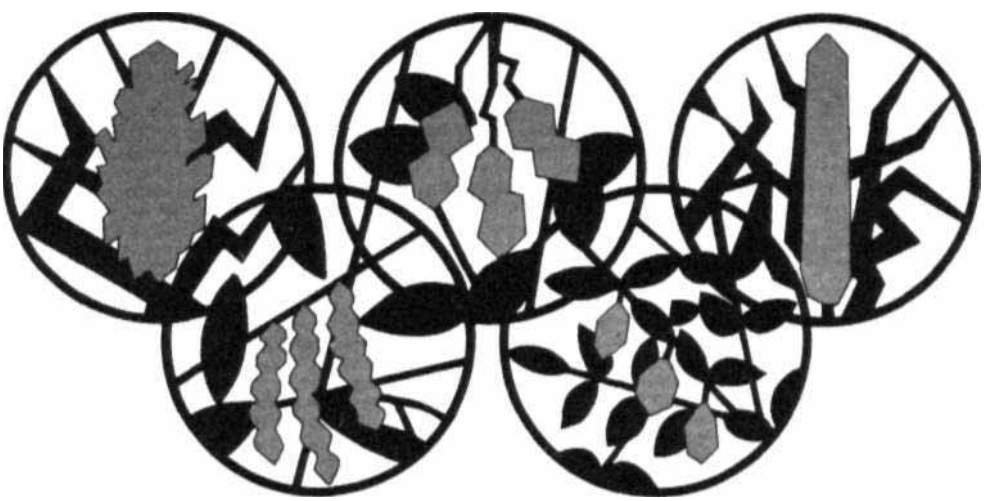
Nutritive Value and Uses of Pigeonpea and Groundnut

Compiled by

Faujdar Singh and B. Diwakar



Skill Development Series no. 14

ICRISAT

Human Resource Development Program

International Crops Research Institute for the Semi-Arid Tropics

Patancheru, Andhra Pradesh 502 324, India

1993

Nutritive Value and Uses of Pigeonpea and Groundnut

Compiled by

Faujdar Singh and B. Diwakar

Skill Development Series no. 14

ICRISAT

Human Resource Development Program

International Crops Research Institute for the Semi-Arid Tropics
Patancheru, Andhra Pradesh 502 324, India

1993

Human Resource Development Program

Publications in this Skill Development Series (SDS) are issued semiformally for limited distribution to program participants, colleagues, and collaborators. Copies may be requested by the SDS number. Constructive criticism from readers is welcomed by the Program Leader, Human Resource Development Program, ICRISAT.

Acknowledgments

Information has been taken from published and unpublished reports. Efforts have been made to indicate the trade names (®) where available. Omissions or inclusions of a trade name does not constitute endorsement or discrimination of a product by ICRISAT or by the compilers. This publication should not be cited as a reference.

Comments and suggestions from Dr Umaid Singh, Ms Santosh Gurtu, and encouragement from Dr Y.L. Nene for compiling this document are gratefully acknowledged. Thanks to Mr S.V. Prasad Rao for computerizing this manuscript.

Contents

Pigeonpea

Pigeonpea is useful in various ways both as human food and animal feed. As human food pigeonpea is used as *'dhal* (split seed without seed coat), whole seed, and green vegetable to supplement cereal-based diets. The seed by-products from the *'dhal* mills are used as animal feed. Pigeonpea leaves are used as dry or green fodder. Stalks of pigeonpea are useful for making baskets, constructing huts, hedges, and binding material (Faris and Singh 1990). Pigeonpea green manure provide nitrogen-rich organic material to improve soil structure (Whiteman and Norton 1981).

Nutritive Value of Pigeonpea

Pigeonpea seed is composed of cotyledons (85%), embryo (1%), and seed coat (14%) (Faris and Singh 1990). The dietary nutrient values in the green seed, dry seed, and *dhal* of pigeonpea are summarized in Table 1.

Table 1. The dietary nutrients of pigeonpea.

Constituents	Green seed	Mature seed	*dhal*
Protein (%)	21.0	18.8	24.6
Protein digestibility (%)	66.8	58.5	60.5
Trypsin inhibitor (units mg^{-1})	2.8	9.9	13.5
Starch (%)	48.4	53.0	57.6
Starch digestibility (%)	53.0	36.2	-
Amylase inhibitor (units mg^{-1})	17.3	26.9	-
Soluble sugars (%)	5.1	3.1	5.2
Flatulence factors (g 100 g^{-1} soluble sugar)	10.3	53.5	-
Crude fiber (%)	8.2	6.6	1.2
Fat (%)	2.3	1.9	1.6
Minerals and trace elements (mg 100^{-1} g dry matter)			
Calcium	94.6	120.8	16.3
Magnesium	113.7	122.0	78.9
Copper	1.4	1.3	1.3
Iron	4.6	3.9	2.9
Zinc	2.5	2.3	3.0
Vitamins (mg 100^{-1} g fresh weight of edible portion)			
Carotene (Vit A 100^{-1} g)	469.0		
Thiamin (Vit B1)	0.3		
Riboflavin (Vit B2)	0.3		
Niacin	3.0		
Ascorbic acid (Vit C)	25.0		

(Source: Faris et al. 1987)

Starch and proteins are the major constituents of pigeonpea. The high digestibility (%) of protein and starch of pigeonpea makes it a staple for millions of people in the semi-arid tropics (SAT).

Pigeonpea significantly contributes to meet the dietary requirements of crude fiber, ash, fat, magnesium, manganese, and copper (Faris and Singh 1990). Pigeonpea contains high amounts of vitamin B, carotene, and ascorbic acid (Miller et al. 1956). These are deficient in cereals; therefore, pigeonpea has a good supplemental value of cereal-based diet. Pigeonpea is a rich source of lysine but deficient in the sulfur-containing amino acids—methionine and cystein. Cereal grains contain sufficient levels of methionine and cystein. Faris and Singh (1990) reported that pigeonpea improves the amino acid score for lysine in rice- and wheat-based diets, and for threonine, leucine, and isoleucine in wheat-based diet when used in a 70:30 cereal: pigeonpea ratio.

Antinutritional Factors

Pigeonpea contains considerable amounts of several antinutritional factors, namely, protein inhibitors, amylase inhibitors, and flab causing sugar and phytic acid. Pigeonpea contains some amount of polyphenolic compounds (tannins) that inhibit the digestive enzymes—trypsin, chymotrypsin, and amylase. These are especially present in dark seed coated pigeonpea. These compounds create problems when pigeonpea is consumed in large quantities. However, the antinutritional factors in pigeonpea are less than they are in soybean, pea, and common bean. Pigeonpea also contains some unavailable carbohydrates that reduce the bioavailability of other nutrients (Kamath and Belavady 1980).

The toxic factors that interact with glycoprotein on the surface of red blood cells, causing them to agglutinate are called phytolectins. These factors are present in pigeonpea, but being highly sensitive to heat treatment, these are of little significance. Legumes cause flatulence when consumed in large amounts. This is due to high level of oligosaccharides; stachyose, raffinose, and verbascose. These sugars constitute about 53% of the total soluble sugars in pigeonpea (Singh 1988).

Pigeonpea as Human Food

Pigeonpea is consumed in various forms some of which are described below.

Whole seed

Pigeonpea seed has a hard seed coat with slightly acrid taste (Rachie and Roberts 1974). The dry pigeonpea seeds are soaked overnight and cooked with salt and spices. The boiled whole seeds are sometimes fried with spices and eaten with cereals, particularly in Africa. Foods such as *Bongko* and *Brubus* made with the whole seed are popular in Central Java. Other dishes and snacks are *rempeyek, serundeng,* and *gandasturi* (Damardjati and Widowati 1985).

Sprouted seed. The seeds are soaked in water and allowed to sprout. The sprouted seeds are eaten raw or cooked (Aykroyd and Doughty 1982; Morton 1976).

- ***Tempeh.*** This is prepared in combination with soybean. Tempeh is prepared by fermenting soaked, denuded, and cooked pigeonpea seed with a *Rhizopus* mould. The seed is spread on a mesh, and the mould is allowed to grow on the surface and through the seed, forming a compact cake. The tempeh cake is cut into pieces and fried before eating.

- **Ketchup (sauce).** This is prepared by fermenting pigeonpea in salt solution with *Aspergillus oryzae, A. niger,* and *Rhizopus* sp. The fermentation is continued in brine solution. Then it is cooked to prepare a sauce.

- **Canned seed.** Sometimes whole seeds are canned. This involves soaking of the dried seed (white seeds are preferred) in water for 24 h followed by pressure-cooking in the brine solution (very salty water) before they are canned.

- Roasted pigeonpea seeds are also consumed particularly in eastern India. The seeds are soaked in water for 1 h and dried. The dried seed is mixed with little oil and water, and again dried. This dried seed can be roasted on heated sand.

Dhal

The cotyledons of dry seeds excluding seed coat is called *dhal.* In India and many Asian countries, pigeonpea is mainly consumed as *dhal* (MP 1). *Dhal* is popular because it takes less time to cook and has acceptable appearance, texture, palatability, digestibility, and overall nutritional quality.

Green Seeds as a Vegetable

The green seeds of pigeonpea are used as a vegetable (MP 3). Green seeds contain more protein, sugar, and fat than mature dry seeds. The protein and starch digestibilities of green seeds are also better than those of mature dry seeds (Table 1). The flatulence causing sugars, trypsin, and amylase inhibitors are lower in green seeds than in mature dry seeds (Singh et al. 1984a). Green pigeonpea is a better source of iron (Singh et al. 1984b) and calcium than *dhal* (Faris and Singh 1990).

Green seed

The green pods are harvested before physiological maturity. The seeds of such pods contain most or all of its dry matter, but the starch is not completely converted to sugar and thus are tender. Vegetable pigeonpea varieties are preferred with large seeds and pods.

Green pods

Immature pods are harvested before the seeds are distinct, and cooked like french beans in curries (Heynes 1919; Morton 1976). Such pods are also used as salads (Faris and Singh 1990).

Animal Feed

The dry leaves and the left over pods at threshing of the crop are used as feed for animals. The by-products of seed coats, broken bits, and powder from the *dhal* mill collectively are called *'Chunl.* It is a valuable food for milch cattle (CSIR 1950; Pathak 1970). Being a perennial crop with large biomass production with a high level of nitrogen under low input conditions there is considerable focus on using pigeonpea as a fodder supplement, particularly in the areas where soybean does not grow well and soybean meal is imported for animal feed (Wallis et al. 1988).

Forage

Pigeonpea has potential to produce high biomass ranging from 40.0 to 57.6 t ha^{-1} (Akinola et al. 1975; Singh and Kush 1981). About 50% of this yield is edible forage and rest is wood (Whiteman and Norton 1981). Plants grown for forage use should be cut 0.15 or 0.3 m above ground level at an interval of 8-12 weeks. The long-duration genotypes were better adapted to cutting as long as lower leaves remained on the stubble (Akinola et al. 1975; Akinola and Whiteman 1975).

Grazing

The grazing of pigeonpea is either by vegetative growth at intervals or by using pigeonpea grown as stand-over forage for dry season when there is deficit of energy and protein for the animals. The pigeonpea forage possesses a high nutritive index (Whiteman and Norton 1981).

Pigeonpea forage is useful as a protein supplement when pasture quality is low. The leaf is a main component in the vegetative phase; however, the nutritive value of forage is improved if pods and seeds are also available (Henke 1943).

Fodder

Dry leaves of pigeonpea provide a good substitute for alfalfa in animal feed. In India it is mixed with wheat straw to feed cattle. Dry leaves were found to be a useful replacement for alfalfa as a source of carotene and other essential nutrients in chicken rations (Squibb et al. 1950).

Pod Shell

Dry matter yield of pigeonpea in pod shells are almost equal to the seed yield. However, pod shells are low in protein and high in fibers. The inclusion of a small amount of high-quality forage improves the nutritive value of pigeonpea pods (Whiteman and Norton 1981).

The pod shell (trash) after removing the seed is a useful feed for ruminant cattle. This contains high levels of digestible crude protein, but low levels of digestible energy and sulfur (Whiteman and Norton 1981).

Dhal mill by-products

When pigeonpea seed is processed to make *dhal* its recovery ranges between 65 and 75%. The remainder by-product (25-35%), known as *'chuni'* is a good source of concentrate ration to cattle (Faris and Singh 1990). This by-product usually consists of 3-8% broken cotyledons, 15% powder, and 10% husk. *'Chunf* is used by dairy owners or feed mills to prepare cattle feeds. The powder and broken cotyledons are valuable sources of protein for cattle and poultry, and are sold at a higher price, when these are aspirated off husk (Kurien and Parpia 1968).

Other Uses of Pigeonpea

Wood

The wood (stem and branches) yield of pigeonpea in northern India is 6-10 t ha^{-1} from short-duration genotypes (ICRISAT 1984) and 3-6 t ha^{-1} from medium-duration genotypes in central and southern India (Jain et al. 1987). The thin branches are used in several ways.

- The heat value of pigeonpea wood is one half of the same weight of coal (Panikkar 1950). It is used as fuel for cooking.
- The straight branches are useful as light construction material for roofing, wattling on carts, tubular wicker-work lining for walls, and baskets (Watt 1908; Pathak 1970). These are also useful for temporary fencing, hut construction, and binding material.
- Small baskets to carry the farm produce are made from the branches of pigeonpea after soaking these in water for 36 h. Medium-sized, thin, and straight main shoots (after removing branches) are used to make big baskets. The big baskets are used as storage bins. The storage bins are plastered using a slurry of soil, dung, and benzene-hexa-chloride.
- Pigeonpea wood was found useful in production of pulp to make good quality writing and printing papers (Akhtaruzzaman et al. 1986).

Host for producing lac and silk

Lac is produced by a scaled insect (*Laccifera lacca* Kerr). This insect inhabits on small tree branches in clusters and produces a hard exudate to protect itself. These clusters are harvested and the hard exudate

is extracted to make shellac and lacquer products (Faris and Singh 1990). Pigeonpea is a suitable host for two lac strains *'Rangeeni'* and *'Kusumi'* (Chowdhary and Bhattacharya 1973).

Pigeonpea plants act as host for scaled insects producing lac in north Bengal and Assam in India, Thailand, Vietnam, and China (Faris and Singh 1990). Pigeonpea has the advantage of a short life cycle in comparison to other lac host plants. However, lac from pigeonpea does not bleach well, therefore it is considered inferior in quality (Macmillan 1946).

Medicinal uses

Pigeonpea has several uses as medicine. It is used in Ayurveda as volerant, a medicine that heals wounds and sores, as an astringent, a medicine that stops bleeding by constricting the tissues, and as a medicine that cures diseases of the lungs and chest. It also works as antihelminthic to destroy internal worms (Faris and Singh 1990). Ekeke and Shode (1985) reported that pigeonpea causes reversion of sickled cells in patients suffering from sickle-cell anaemia.

MP 1. Dehulling Operations (*Dhal* Milling)

Pigeonpea seed is split into *dhal* by a milling process called dehulling. *Dhal* yield of pigeonpea varies between 50 and 80% (with a mean of 62%) in small- scale milling operations and between 60 and 85% (with a mean of 71%) in large- scale milling operations (Singh and Jambunathan 1981).

The milling operations include cleaning, grading of seed, conditioning for husk, loosening, dehulling, splitting, and polishing. The *dhal* milling can be both at the domestic and commercial level (Narain et al. 1986).

I. Domestic Milling

This involves cleaning and grading of seed, pretreatment or conditioning of seed and splitting the cotyledons (Fig. 1).

1. **Cleaning and grading of seed.** The dry husk, inert material, and small shrivelled seeds are discarded by using sieves.

2. **Conditioning of seed**

   a) **Dry conditioning.** The cleaned and graded pigeonpea is passed through an energy coated roller for pitting. The pitted seeds are manually mixed with warm oil (about 1% linsed or mustard oil) followed by sun drying for 2-5 days. Before the last day of sun drying, 2-5% water is sprinkled on the seed and it is thoroughly mixed and heaped overnight for tempering.

   b) **Wet conditioning.** This requires alternate wetting and drying of seed for 2 to 4 days. Kurien et al. (1972) recommended uniform adjustment of moisture within the seed by exposing it to hot air (300°C) for several minutes. This provides complete removal of the husk (99%) in a single pass with least scouring of the peripheral layer of the seed when dehusking is done by an abrasive (pearling) action in stone rollers. This method gives 10-15% more *dhal* compared to traditional commercial method and reduces the processing time and cost.

   Saxena et al. (1981) suggested treatment of pigeonpea seed with sodium bicarbonate (0.3 to 1.0%). This resulted in the recovery of 68% *dhal and* 88% dehusking efficiency. Reddy (1981) found 75% *dhal* recovery and a 96% dehusking by pitting the seed followed by treatment with

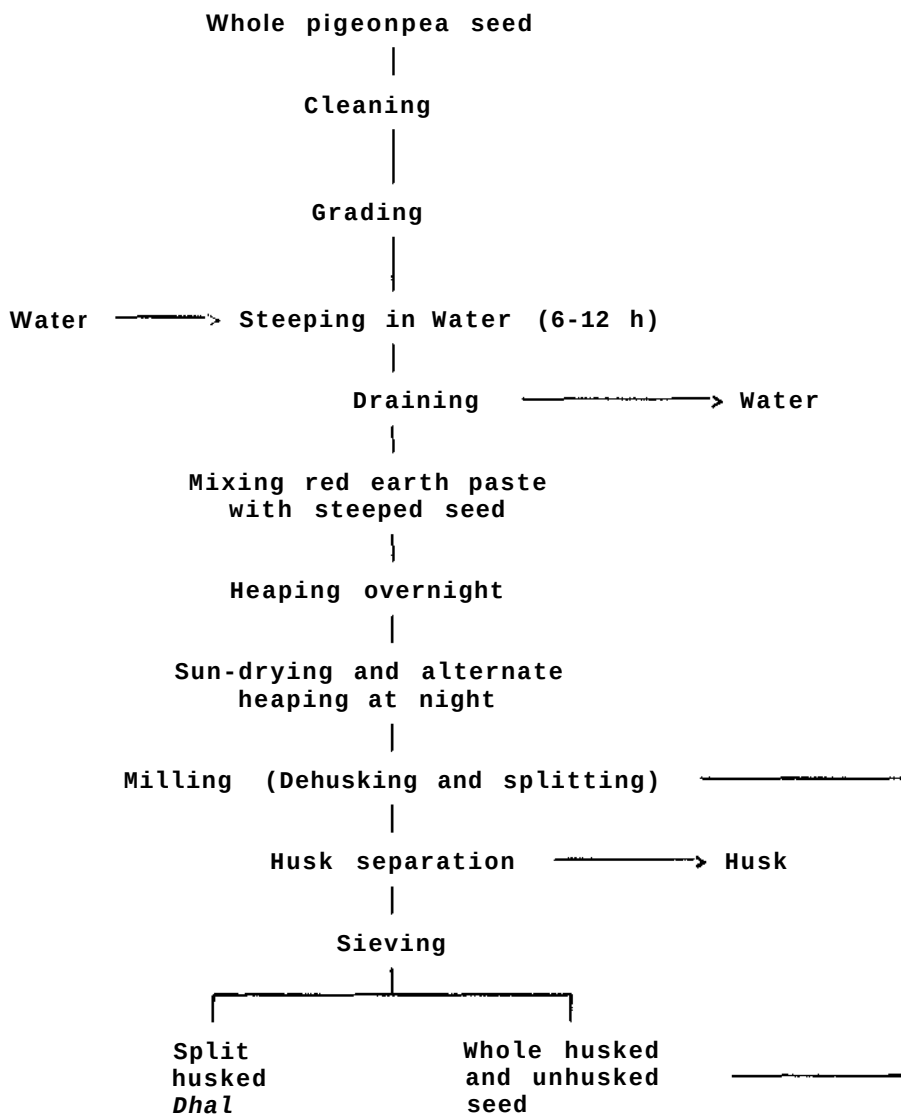


Figure 1. Flow chart for traditional milling of pigeonpea by wet method.

(Source: Narain et al.1986)

a sodium bicarbonate solution, tempering for 12 h, and oil treatment [250 g oil (100 kg seed)$^{-1}$]. This followed by another tempering for 12 h before dehusking in a modern rice pearler. Further, Srivastava et al. (1988b) reported high dehusking efficiency when soaked in sodium bicarbonate (6%) solution. Pigeonpea roasting on dry sand at 100°C for 5 min with an initial moisture content of 12.1% is also recommended.

3. **Dehusking and splitting.** This is done either by using disc shelters or roller machines. A disc shelter used for wet processing works on the principle of attrition and is useful for removing the husk and splitting the cotyledons simultaneously. However, it results in excessive breakage.

   Dry processing is done by a roller machine that works by abrasion. It is only efficient for dehusking. When it is used for dehusking and splitting simultaneously, it rounds off the edges of split cotyledons causing excess powdering and reduction in the commercial value of *dhal* (Kurien 1971).

4. Polishing of *dhal.* The polishing of *dhal* is done by using a cone polisher similar to the one used in the rice mill. Rubber roll machines have been introduced recently to minimize the scouring (Narain et al. 1986).

   A machine similar to a pin mill gives good splitting with less breakage. Usually dehusking and splitting are done simultaneously. Sometimes these operations are conducted in two steps.

II *Dhal* Milling (CFTRI Technology)

A technique was developed at the Central Food Technological Research Institute (CFTRI), Mysore, India, for dehulling pigeonpea. This procedure completes milling in two stages; (i) initial roasting of the seed in a current of heated air, followed by tempering to loosen the seed coat and making it brittle; and (ii) dehusking in an abrasion type roller and splitting.

Loosening of the seed coat involves conditioning of pigeonpea with hot air at 120° to 180°C in a chamber, where the seeds attain a temperature of 79° to 95°C. Using a conditioning chamber where hot air enters the seed mass and moves upward, while the fluidized seed mass moves down by gravity. After equilibration in the chamber, the seed is stored in perforated tempering bins with aeration, allowed to rest for slow cooling and moisture evaporation to a level at which the husk can be easily removed.

The husk is removed in an abrasion type dehusking machine. Most of the husk is pulverized and it falls off through the wire-mesh sieve. Since seed becomes hard from loss of moisture, the peripheral scouring is negligible. Some of the seeds are split (depending on the variety) but dehusking is complete in almost all cases.

The husk and powder are first aspirated, then spirt cotyledons are separated by sieving and polished with water to restore the moisture loss during conditioning. Oil (0.1-0.2%) is added at this stage to impart a glossy appearance to the *dhal.* The recovery of *dhal* by this method ranges from 75 to 82% which is considerably higher than traditional milling. Further, this method is independent of weather as it does not employ sun drying. However, the energy requirement in this process is high (85 kWh t^{-1}).

III *Dhal* Milling (Pantnagar Technology)

Narain et al. (1986) reported a new technology to make *dhal* at Govind Ballabh Pant University of Agriculture and Technolgy, Pantnagar, India (Fig. 2). This involves following steps:

i) **Pretreatment.** This is done by mixing pigeonpea seed with 6.0% sodium bicarbonate solution, followed by tempering for 5-6 h and drying to 10% moisture.

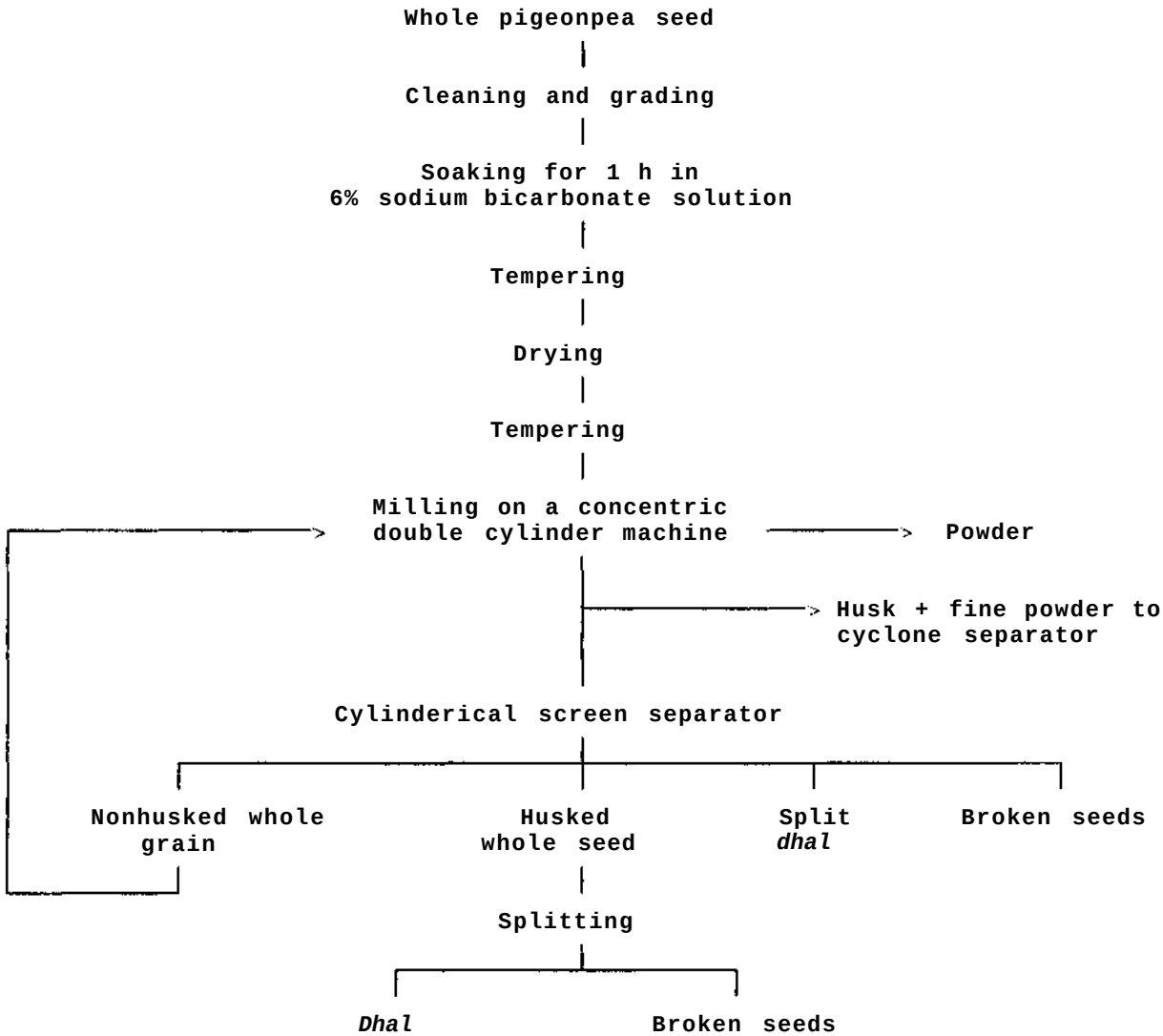


Figure 2. Flow chart of the improved Pantnagar *dhal* milling process.

(Source: Narain et al.1986)

ii) **The machine system.** This consists of a concentric double cylinder auger feeder and discharge machine. The inner cylinder is made of emery to provide a rough surface. The emery cylinder carries flights part of the length towards the outlet so as to provide a constricted passage with its plane normal to the axis of the auger. Residing time of seed in the milling zone is regulated by controlling the discharge opening size through an automatic loading device. An elevator to feed the dehusking roller, a cyclone separator to separate the husk, and a *dhal* grader to separate dehusked seed and broken seeds are attached to the milling unit.

The Pantnagar technology was reported to be on par with the CFTRI technology in *dhal* recovery and dehusking. It is not dependent on weather and has a high dehusking efficiency (over 97%) with a single pass. It requires less energy 45 kWh t^{-1} compared to 85 kWh t^{-1} for the CFTRI process, and 60 kWh t^{-1} as compared to the traditional process (Narain et al. 1986).

Singh and Jambunathan (1990) discussed different modifications of *dhal* milling in India. A survey showed that *dhal* recovery ranges from 60% to 85% depending on the milling procedure and presoaking treatments.

Pretreatment factors affecting *dhal* recovery

Water. Soaking of pigeonpea in water helps loosen the binding action of the gum between seed coat and cotyledons. Increasing the moisture helps soften the seed coat. Soaking time varies from 2 to 14 h in villages. In large *dhal* mills, the seed moisture level is increased by sprinkling water or sometimes alternate wetting and drying (Saxena 1985).

Oil. This treatment allows oil to penetrate the pigeonpea seed through the husk into the cotyledon layer and the cotyledons are released under the mild heat of the sun from the seed coat. Treatment of seed for several days can totally loosen the husk (Singh and Jambunathan 1990).

Chemicals. The use of sodium bicarbonate, calcium hydroxide, sodium carbonate, and sodium chloride as a pretreatment have been reported (Saxena et al. 1981). Pretreatment with 6% sodium bicarbonate solution was most effective, resulting in 78% *dhal* recovery.

Heating. It is an efficient way to loosening the seed coat. In India, roasting on sand at 100-125°C for 5-10 min is done (Singh and Jambunathan, 1981). Kurien (1977) suggested conditioning the pigeonpea seed in a chamber with hot air (120-180°C), where the seed is exposed to a temperature of 70-95°C. The heat is transferred through a counter-current flow technique. In the conditioning chamber, hot air enters through the seed mass and moves upwards, while the seeds move down by gravity.

Nutrient losses on denuding

During dehulling outer layers of cotyledons are scarified resulting in 12% yield loss as powder fraction (Singh and Jambunathan 1990). The outer portion of cotyledons is a rich source of protein, sugar, fiber, and ash but poor in starch. Further, considerable amounts of calcium (about 20%) and iron (about 30%) are removed, but it does not affect protein quality and amino acids.

MP 2. Processing of Green Pigeonpea

Processing of green seed requires shelling of pods, preservation (includes cleaning the seed, blanching, and filling cans or polyethylene bags), and freezing.

Shelling

Harvested green pods are either manually or mechanically shelled depending on the quantity of produce handled by the processing unit. Hand shelling requires low capital investment and is helpful in discarding undesirable seeds. However, it may be costly if labor cost is high. The shelling losses are more when done by machine (Singh and Jambunathan 1990).

Cleaning

The damaged seed and foreign matter is rejected during hand-shelling. Cleaning is done by placing the seed in cold water before blanching.

The mechanical sheller has conveyors for cleaning and washing. Small pieces of pods and small and damaged seeds are removed by air blast. Then seeds are sieved with a large mesh screen separating the pieces of seeds and other extraneous material (Mansfield 1981). During cleaning, seeds are washed with running cold water in various combinations and types of flotation washers.

Blanching

Blanching is done to fix color, improve flavor, reduce volume, and improve texture to permit a large mass of pigeonpea to fit into the can. Blanching also removes mucous substance and free starch to obtain a clearer brine, and to remove intercellular gasses from the seeds. This will put a low strain during heating (Sammy 1971). One method to obtain clear brine is to heat seeds at 85°C for 10 min in hot water followed by immediate cooling in cold water at 26.7°C (S'anchez-Nieva et al. 1961). Blanching is also done by steam, and this causes less shrinkage and lower nutrient losses (Melmick et al. 1944), but involves high energy cost.

After blanching and cooling, off-colored seeds and foreign matter, if any, are removed before canning or freezing (Singh and Jambunathan 1990).

Canning

Pigeonpea varieties with large, uniform, bright green seeds are preferred for canning. For canning, harvesting green seeds of similar maturity is important to obtain a high quality product. The mature green seeds are canned better than starchy yellow mature seed (S'anchez-Nieva 1961; S'anchez-Neiva et al. 1963).

After blanching and cooling, cans are filled with seeds and a 2% brine solution at 90.5°C to 93.3°C. For a small can, the brine is maintained almost at boiling point and there is no need to make a mechanical exhaust. However, for a large can, the near-boiling brine does not create sufficient vacuum before the can is closed, therefore, an additional means of creating vacuum is needed. To inhibit the growth of thermophilic bacteria, that spoil the product, it is necessary to process the closed cans as early as possible (Mansfield 1981).

Freezing

There are two methods of freezing: an automatic continuous system, and a batch system. In the automatic system, blanched and cooled seeds are transported by conveyor to a fluidized bed freezer. The procedure operates below freezing point (-23.3°C to -28.9°C), therefore, individual seeds are quickly frozen. The frozen seeds are hand-packed into wax-treated cartons to prevent dehydration of the product and are

stored at -17.8°C (Singh and Jambunathan 1990).

In the batch system, blanched seeds are dropped into a cold water tank directly from the hot water blancher. After cooling, they are hand-packed in polyethylene bags, and placed in trays for freezing in a batch freezer (-23.3°C to -28.9°C) for 4 to 10 h (Mansfield 1981). The frozen bags are then placed in corrugated containers for storage at -17.8°C (Singh and Jambunathan 1990).

MP 3. Uses of Pigeonpea as *Dhal* and Vegetable

Pigeonpea *Dhal*

The *dhal* is cooked in different ways. North Indians prefer pigeonpea *dhal* cooked in water with salt, turmeric, cumin, and dried unripe mango pieces or dried raw mango powder *(amchur).* Whereas in South it is used as *sambar* which is prepared using pigeonpea *dhal,* 2 or 3 types of vegetables such as gourds, brinjal, okra etc., added with salt, tamarind, turmeric, chillies, cumin, and coriander. All these ingredients are put together in water in proportions according to the taste and liking of an individual and cooked in a pressure cooker under high steam.

Preparing *Dhal* in northern India

Ingredients	Quantity
Dhal	250 g
Water	500 mL
Chilli powder	$^1/_2$ tsp
Salt	1 tsp
Turmeric	$^1/_2$ tsp
Dried raw mango pieces	10 g
Cumin seeds	5 g
Ghee/oil	15 g

Method

- Soak the *dhal* in water for 1 h, drain out excess water, and clean the *dhal* well.
- Boil 500 mL water and put the *dhal* in it while boiling.
- Add salt, turmeric, chilli powder, dried raw mango, and allow to cook in a vessel for 35 min by covering with a lid, or put all the ingredients in a pressure cooker and cook for 12 min.
- Now heat the oil and add the cumin seed till cumin seeds turn brown. Then mix this with the cooked *dhal,* or fry fine pieces of onion and tomato in ghee and add to the cooked *dhal.*
- Serve *dhal* hot or cool with rice or bread.

In southern India instead of mango pieces or powder, tamarind water is added to make *dhal* (*sambar*) somewhat acidic. The vegetables are also cooked with dhal.

Vegetarian Preparations

Faris et al. (1987) suggested following dishes form pigeonpea for vegetarian diets.

Green pigeonpea massala

Ingredients	Quantity
Green pigeonpea seed	250 g
Tomatoes (ripe)	200 g
Onions	50 g
Ginger	20 g
Garlic	20 g
Yoghurt (curd)	100 g
Fresh coconut (copra)	20 g
Cumin seeds	5 g
Cinnamon	2 g
Cardamom	3 g
Oil	10 g
Lime (optional)	One
Turmeric	A pinch
Garam massala	A pinch
Coriander leaves (green)	A bunch
Salt	To taste

Method

- Wash the pigeonpea seed, boil for 5 min with a pinch of sodium bicarbonate, drain off excess water, and keep aside.
- Blanch the tomatoes, remove skins and seeds, and chop fine.
- Fry the sliced onions to a golden brown, grind to a paste with curd, ginger, and garlic, and keep separately.
- Grind the coconut to a paste after removing the milk. Save the milk.
- Fry the onion paste, coconut paste, cumin seeds, and turmeric powder over low heat. After 5 min add the blanched tomatoes, and keep frying until the raw smell ceases.
- Add the coconut milk, boiled pigeonpea, and salt; cook tor another 10 min until the gravy thickens. Remove from the heat and mix some lime juice (optional). Sprinkle the *garam massala* and garnish with chopped coriander leaves.
- Serve hot with *chappati, paratha, puns, bhatura,* or rice.

Stuffed *purls* with green pigeonpea and lentil *dhal*

Ingredients	Quantity
Green pigeonpea seed	200 g
Lentil *dhal*	50 g
Onion (minced)	50 g
Green chillies	Two
Cumin powder	$^1/_4$ teaspoon

Salt	To taste
Garam massala	2 pinches
Water	220 mL
Turmeric	A pinch
Asafoetida *(hing)*	A pinch
Covering	
Maida (fine wheat flour)	450 g
Fat	30 g
Salt	1 teaspoon
Water to mix	250 mL
Oil (for deep frying)	250 g

Method

- Shell the green pigeonpea; clean and wash the lentil *dhal.*
- Boil the lentil, pour out all water, and mash.
- Boil the green pigeonpea, pour out water, mash and mix with the mashed lentil.
- Crush the green chillies.
- Put all ingredients for the filling except the salt, and cook over a low heat until water evaporates. Add salt, *garam massala,* and after mixing well, remove the heat.
- For the covering, sieve the flour with salt and add melted fat and water. Make it into a fairly stiff dough.
- Allow the dough to stand for 1 h.
- Divide the dough into about 16 even-sized balls, roll them very thinly into even pieces, shape it round, spread the pigeonpea filling evenly on eight of them, cover the filling with the remaining eight, and then pinch the edges (with a little water) to enclose the filling. A round biscuit cutter can be used to cut the stuffed *puris.*
- Deep fry in hot oil until the *puris* become a light golden brown.
- Serve hot with tomato sauce or dry vegetable curry.

Green pigeonpea with *paneer*

Ingredients	Quantity
Green pigeonpea seed	450 g
Cottage cheese (*paneer*)	150 g
Coriander powder	5 g
Chilli powder (or *paprika)*	$^1/_4$ teaspoon
Onions	50 g
Fat	30 g
Garlic	3 flakes
Ginger	A small piece
Tomatoes	220 g
Cashewnuts	30 g
Yoghurt (curd)	30 g

Salt	To taste
Green coriander leaves	A few sprigs
Garam massala	2 pinches
Turmeric	A pinch

Method

- Grind together the onions, coriander powder, chilli powder, turmeric, ginger, and garlic to make a fine paste.
- Grind the cashewnuts separately.
- Boil the green pigeonpea seed with a little salt and sodium bicarbonate for nearly 5 min, and cool. Retain the water in which the green pigeonpea seed was boiled for making the gravy.
- Blanch the tomatoes in hot water, remove the skin and seeds, and keep aside after chopping.
- Cut small cubes of *paneer.* Heat the fat, fry the *paneer* pieces lightly, and remove. In the same fat, add the ground *massala* and chopped blanched tomatoes. Fry for about 3 min, add the pigeonpea seed and a little water, and continue cooking until the pigeonpea is soft and the ground *massala* is cooked.
- Add the fried *paneer* and a little water. Simmmer for about 4 min.
- Add ground cashewnuts and beaten curd, mix well, and continue to simmer. When the mixture thickens, remove it from the heat and sprinkle in the *garam massala.*
- Serve hot, garnished with chopped coriander leaves.

Prawns with pigeonpeas (nonvegetarian)

Ingredients	**Quantity**
Green pigeonpea seed	250 g
Prawns (shelled)	250 g
Yoghurt (curd)	150 g
Onion	100 g
Oil	100 g
Ginger	20 g
Garlic	20 g
Fresh coconut *(copra)*	30 g
Poppy seeds	30 g
Cinnamon	3 g
Cardamoms	3 g
Bay leaf	2 leaves
Garam massala	A pinch
Coriander leaves	A sprig
Salt	To taste

Method

- Clean, soak, and boil the pigeonpea seed for 5 min with a little sodium bicarbonate, drain the water, and keep aside.
- Slice the onion and fry it to a golden brown.

- Remove the milk from the coconut and keep separately.
- Clean the prawns by removing the vein.
- Grind the onion, curd, ginger, garlic, copra, and poppy seeds to a paste.
- Soak the prawns for 1 h in the ground paste.
- Heat the oil with the cinnamon and cardamoms over a very low heat; fry for 2 min. Add the prawns to the *garam massala* and keep frying. If the mixture becomes dry, keep adding small quantities of coconut milk.
- Cook for 20 min, then add the boiled pigeonpea seed, the remaining coconut milk, and salt; simmer for another 10 min, garnish it with sliced tomatoes and chopped coriander leaves.

ICRISAT Happenings (November 1989 to February 1990) published a series of recipes with green pigeonpea. Some of these recipes are listed here.

Cream of pigeonpea soup (nonvegetarian)

Ingredients	Quantity
Shelled green pigeonpea	1 cup
Pickled meat with dash of green celery	1 slice
Margarine	30 g
Large onion	1
Celery	2 sprigs
Lemon juice	1 tsp
Water	3 cups

Method

- Grind pigeonpea to paste for seasoning finely.
- Cut meat into small pieces. Heat fat, saute seasoning, add meat and saute.
- Add pigeonpea and lemon juice and 3 cups water. Bring it to a boil.
- Simmer for 2 h or until all skins burst and peas become soft.
- Stir.
- Pass through a sieve. Return to heat.
- Add salt if necessary, and a dash of green celery, if desired.
- Serve as an appetizer or first course of a meal.

Pigeonpea *accras*

Ingredients	Quantity
Green pigeonpea	1 cup
Flour	1/2 CUP
Baking powder	1 tsp
Egg	1
A dash of pepper	
Large onion	1
Salt	1 tsp
Vinegar	1 tsp
Celery	1 sprig

Method

- Boil pigeonpeas slowly in 2 cups of water. Drain off extra water.
- Crush the pigeonpea well on a stone, with a rolling pin or bottle on a board, or in a fine mincer.
- Put crushed pigeonpeas into a bowl and add minced onion and celery.
- Add the other ingredients and mix well to a thick paste. Heat oil in a shallow frying pan.
- Fry 3 or 4 spoonsful of the mixture at a time, turn over till it is brown on both sides.
- Drain the content on absorbent paper. Garnish as desired and serve hot.

Stewed pigeonpea (nonvegetarian)

ingredients	Quantity
Fresh shelled pigeonpea	1 cup or 1 can
Meat (pickled)	125 g
Celery	2 sprigs
Salt	1 tsp.
Sugar	1 tbsp.
Large onion (chopped)	1
Clove garlic (crushed)	1 tbsp.
Oil	1 pot spoon
Hot water	3 cups
Pumpkin	125 g

Method

- Wash pigeonpea and mix with pickled meat for seasoning.
- Heat fat and fry meat slightly on all sides.
- Add pigeonpea and fry slightly, turning frequently.
- Add seasoning, stir, then add hot water and pumpkin cut into small pieces.
- Simmer slowly until pigeonpea become soft.

o Crush pumpkin pieces, add sugar, and stir. Check the taste and serve hot.

Note: For curry preparation, add 1 1/2 tbsp. curry powder to the pigeonpea.

Pigeonpea logs

Ingredients	Quantity
Green pigeonpea	1 cup (1 3/4 cup when cooked) or 1 can
Salt	3/4 tsp
Fat	30 g
Lime juice	1 tsp
Egg	1
Flour paste	1/3 cup
Onion minced	1 large
Bread crumbs	1/2 cup
Minced celery pepper	1 tsp

If desired use extra bread crumbs and oil for frying

Method

o Boil pigeonpea in 2 cups of water till all water evaporates (or drain canned pigeonpeas). Grind pigeonpea with rolling pin or pass through a mincer.

o Saute minced seasoning in the fat, add to pigeonpea with an unbeaten egg, salt, and lime juice, also add 1/2 cup of crumbs. Mix well and divide into six portions and shape into logs about 4 inches long.

o Dip logs one by one into flour paste then roll in bread crumbs, patting them on firmly. Complete other logs with paste and bread crumbs.

o Heat oil in a frying pan. Fry in heavily smoking fat, 1 or 2 at a time. Keep rolling continuously to keep the shape.

o Drain on absorbent paper, arrange on dish, garnish with celery sparsely.
o For a main dish, serve with cheese or other sauce.

For cheese sauce

Ingredients	Quantity
Fat	60 g
Grated cheese	60 g
Salt	1/2 tSp.
Flour	4 tbsp.
Water	1 1/4 cups
Mustard	1 tsp.

Method

o Heat fat slowly.

o Stir in the flour and add the liquid gradually by stirring continuously.

- Add mustard, salt, and grated cheese. Stir till cheese melts.
- Serve hot in a sauce-boat.

Pigeonpea souffle (nonvegetarlan)

Ingredients	Quantity
Pigeonpea green	1 can or 1 3/4 cups
Eggs, separated	3
Onion (minced)	1 small
Minced celery	1 tsp
Salt	1 tsp
Vinegar or lime juice	2 tsp
Milk or liquid from pigeonpea	1/2 cup

Method

- Grind the pigeonpea with rolling pin on a board, or mash with a fork, or pass through a mincer.
- Put it into a bowl, add minced celery for seasoning, salt, acid liquid and egg yolk. Stir well.
- Heat oven to 250°C. Grease a baking dish.
- Beat egg white stiffly and fold it into the mixture with a fork, and put into the dish.
- Bake till brown for about 25 min.
- Serve with a sauce as the main dish, or a second protein dish.

Note: For best results stand the baking dish in a tin of water during baking.

Pigeonpea patties or fingers

Use the same recipe and method as for pigeonpea logs. Add 1 mL fat and a cup of milk or water, and mix as for logs. Turn on oven to 400°C. Put mixture into greased sponge-finger or pattie tins and bake for about 15 min. Serve fingers as an appetizer, and patties with gravy or savory sauce as a main dish.

Green pigeonpea with banana (a recipe from Venezuela)

Ingredients	Quantity
Shelled green pigeonpea	1 cup
Raw banana	1
Onion (sliced)	1
Tomatoes	2
Garlic clove (crushed)	1
Water	1 L
Oil	2 tsp
Coriander leaves	1 bunch
Salt	To taste

Method

- Cook green pigeonpea in 1 L water.
- Clean raw banana and cut into pieces.
- When the pigeonpea is soft, add the banana pieces, and cook on a low flame until they are soft. Keep aside.
- Heat 2 tbsp of oil and fry the onions and garlic until they turn brown.
- Cut the tomatoes and add to onion and garlic.
- Add the pigeonpea, banana and water, cook for 15 min. Add pieces of coriander leaves and salt.

Pigeonpeas au Gratin

Ingredients	**Quantity**
Green pigeonpea	1 cup
Salt	1 tsp
Celery	1 sprig
Pumpkin	125 g
Margarine	30 g
Breadcrumbs	3/4 cup
Onion	1 medium size
Acid (vinegar)	2 tsp
Coconut milk	1 cup
Water	1 cup
Grated cheese	50 g

Method

- Cook pigeonpea in the coconut milk and water.
- Meanwhile, wash, peel, and cut pumpkin into small pieces, chop onion and celery.
- Heat fat, saute pumpkin and seasoning, then add pigeonpea.
- Cook till all liquid is absorbed.
- Heat the oven to 350°C. Grease pie-dish.
- Mix 2/3 of the crumbs into the pigeonpea mixture, and put the mixture into the greased dish. Sprinkle the remainder of the crumbs and cheese. Bake till brown (15-20 min). Garnish with slices of sweet pepper, hard-boiled egg, tomato wedges, etc.

Gardener's pie (nonvegetarlan)

ingredients	**Quantity**
Green pigeonpea	1 1/2 cups or 1 1/2 cans
Onion	1 medium size

Bacon or salted meat	1 slice
Salt	1 tsp
Breadfruit (or yam, or eddoes or other starchy vegetable)	900 g
Celery	1 sprig
Lime juice	1 tsp
Margarine or other fat	60 g
Milk or pigeonpea liquid	1/3 cup
Egg	1

Method

o Boil the pigeonpea and salted meat in 2 1/2 cups of water till it is cooked. Take out liquid separately.

o Meanwhile wash breadfruit, remove core (or wash yam/eddoes) and steam-boil in 1 1/2 cups water.

0 Heat 1/2 of fat, saute the minced onion and 1/2 of the pigeonpea. Pass the rest of the pigeonpea through a mincer and mix both sets adding salt and lime juice.

0 Grease a pie dish with the rest of the fat and add the mixture and 1/3 cup of liquid or milk.

0 Peel and cut the starchy vegetable, mix with egg and a dash of lime juice. Heat the oven to 400°C.

0 Press the breadfruit mixture out into a soft dough-like covering for the pigeonpea in the dish. Decorate with a fork, brush with fat, and brown in oven.

Pigeonpea egg shells (nonvegetarlan)

Ingredients	**Quantity**
Pigeonpea	1 can or 1 3/4 cups
Eggs	3
Dash of pepper	-
Chopped celery	1 tbsp.
Fat	30 g
Bread crumbs	3/4 cup
Onion	1 medium size
Liquid, or	1/4 cup
beaten egg yolk	1
Lemon juice	1 tsp.
Flour paste (or beaten egg white)	1/3 cup
Extra bread crumbs	3/4 cup

Method

0 Hard boil three eggs and cool.

0 Mash or crush pigeonpeas with fork or rolling pin.

0 Saute the minced seasoning, crumbs, salt, citric acid and liquid (which may be beaten egg yolk and pigeonpea liquid).

0 Check the taste and divide into 3 equal portions.

- Remove shells from the eggs and wipe dry. Cover each egg with 1 portion of this mixture, shape to look like large eggs.
- Dip in flour paste, roll in crumbs.
- Roll in crumbs again and pat smoothly.
- Heat the oil in a frying pan and fry one egg at a time in smoking oil until brown, keep rolling constantly to get the oval shape.
- Drain on absorbent paper and allow to cool.
- Cut across the center, either lengthwise or across, to show the cut egg surrounded by the pigeonpea mixture.
- Arrange on a dish, garnish with wedges of tomato and prepared cress.

Pigeonpea chicken *pelau* (nonvegetarian)

Ingredients	Quantity
Chicken (wings or thighs)	400 g
Shelled green pigeonpea	2 cups
Rice	1 cup (200 g)
Coconut milk	1 cup
Pumpkin or carrots (diced)	200 g
Salt	2 tsp
Margarine	30 g
Large onion	1
Celery	2 sprigs
Lime juice	2 tsp
Green hot pepper	1
Burnt sugar coloring	1-2 tbsp
Cooking oil	1 pot spoon

Method

- Clean and cut chicken into 2-3 inch pieces. Season with salt, citric acid, and garlic to taste.
- Mince seasonings, add to chicken, cover it, and leave for 15-20 min.
- Meanwhile, boil pigeonpea in 2 cups of water till it is soft.
- Heat oil in thick saucepan, scrape off seasonings from chicken, and save in the vessel.
- Fry the chicken until brown on both sides.
- Add pigeonpea, seasoning, and caramel coloring to the chicken; fry, turning frequently. Add rice and turn continuously until brown.
- Add pumpkin or carrot to the pot, and coconut milk and enough water to cover the food for about 1" above the level of ingredients. Bring to boil, add the margarine and the green pepper.
- Cover the pot; lower the heat, and simmer slowly until all water is absorbed. With a fork separate the grains. Turn off heat, leave it to cool. Serve warm with avocado, tomato, and/or other raw salad.

Note: 2 table spoons of curry powder may be used instead of caramel coloring.

Abbreviations used:
tsp = tea spoon; tbsp = table spoon.

MP 4. Isolation of Starch and Noodles from Pigeonpea

Isolation of Starch

Singh et al. (1989) indicated that starch can be isolated from whole seed as well as *dhal.* Soak the pigeonpea (seed/*dha/*) in water overnight, wash and grind it in a waring blender at low speed for 2 min. Filter the slurry through a cloth bag (about 80 mesh) and later pass it through a standard sieve (200 mesh). Keep the filtrate aside for 4-6 h for the sedimentation of starch. To increase starch yield it is slurred in water and sedimented 2 to 3 times or until the water is clear. The recovered starch is then heated in a hot-air oven at 50°C.

Preparing Pigeonpea Noodles

To prepare soft noodles dry starch and water (1:7 W/V) are boiled for 5 minutes. This makes starch gel. The gel is extruded into cold water using an extruder with 2-mm diameter holes. This will give soft transparent noodles 15-20 cm long, with a 60-65% moisture. Hard noodles are prepared from dried and cooked starch (95:5 W/W) mixed in the water in the ratio of 1:7 (W/V). This material is then extruded into boiling water; then the noodles are separated and kept in an oven at 50°C overnight; and finally sun-dried (Singh et al. 1989).

MP 5. Miscellaneous Uses of Pigeonpea

Fermented Products

In combination with cereals, fermented pigeonpea products such as *tempeh, dhokla, dhal* patties, *adai,* and *kadaba* are prepared (Salunkhe et al. 1985).

Procedure for *tempeh* preparation

Ingredients: Pigeonpea *dhal* 150 g, inoculum of *Aspergillus oligosporum* $^1/_2$ tsp, vinegar 1 tsp.

Method

0 Soak the *dhal* in water for 6 h. Wash 2-3 times and drain off excess water.

0 Pressure cook the *dhal tor* 15 min @ 1 kg cm^{-2}.

o Mix *Aspergillus oligospormun* inoculum and vinegar.

0 Spread the material thin (1.5 cm) on a sterilized tray and cover it with perforated polyethyetene sheet.

0 Incubate the material at 30°C for 12-16 h.

o A compact white cake (tempeh) is ready. This can be sliced to make cubes for use.

The same can be dehydrated at 70°C for storage (Vaidehi and Rathnamani 1988).

Damardjati and Widowati (1991) noted that in Indonesia soybean *tempeh* is most common. They found no significant difference in organoleptic test between *tempeh* made from soybean-pigeonpea (2:1 w/w) and that made from soybean.

Pigeonpea sauce

There are two kinds of pigeonpea sauces — salted and sweet. The techniques used to prepare sauces are similar, except for the addition of sugar in the case of sweet sauce. To prepare sauce take denuded pigeonpea, soak it in water, and cook it. Add *Aspergillus oryzae* at 30°C and leave for 72 h. Fermentation can continue in 25% brine solution tor 30 days followed by filtering. The filtrate is mixed with spices and coconut, cooked, and refiltered.

Sweet pigeonpea sauce is considered to be of second-grade quality. Salted pigeonpea sauce is accepted by consumers even though its protein content is less than 2% (Vaidehi 1991).

Rice-pigeonpea cookies

To prepare protein-enriched cookies, pigeonpea flour is added to rice flour. The cookies are made by mixing rice flour, pigeonpea flour, and other ingredients. These are mixed into a dough, which is kneaded flat, molded, and then baked (Prasetyo 1988).

Groundnut

Groundnut pods have outer thick woody shell with 2 or 3 seeds embedded inside. The shelling percentage ranges from 60 to 75%. The seed consists of two cotyledons, germ, and thin skin called testa. The seed testa constitute 4-5%, cotyledon 92-94%, and the germ 3-4% of the seed mass. The testa is composed of carbohydrates, cellulose, protein, and phenolic compounds, while cotyledons have mainly oil and protein. The germ contain high proportion of protein, reducing sugar and disaccharides (Nagaraj 1988).

Nutritive Value

Groundnut is a rich source of energy due to its high oil and protein contents (Table 2). It supplies about 5.6 calories grain^{-1} when consumed raw and 5.8 calories grain^{-1} when consumed roasted. It is a rich source of essential amino acids, minerals, and vitamins. Groundnut has good digestibility in both raw and roasted forms (Nagaraj 1988). The main uses of groundnut are discussed in MP 6 to 9.

The quality characters and uses of groundnut vary among the developed and developing countries. In developed countries, groundnut is used for the preparation of peanut butter and confectionery products. In developing countries, it is mainly used for oil extraction and its by-product is utilized for feed and food purposes (Jambunathan 1991).

Table 2. The chemical composition and essential amino acids of groundnut[1].

Content	Percentage	Content	g (100 got protein)$^{-1}$
Protein	25.2	Lysine	4.00
Oil	48.2	Threonine	3.12
Starch	11.5	Valine	4.59
Soluble sugar	4.5	Methionine+ Cystein	2.56
Crude fiber	2.1	Isoleucine	3.69
Moisture	6.0	Leucine	6.95
		Phenylalanine+ Tyrosine	10.12

1. Source: Jambunathan 1991.

The true protein digestibility of groundnut in rat bioassay was comparable to that of casein protein. However, biological values, net protein utilization, and protein efficiency ratio of casein were higher than that of the groundnut (Jambunathan 1991).

The groundnut oil is more stable in shelf because of its fatty acid composition, especially because of the proportion of unsaturated to saturated fatty acid. An Oleic (O) : linoleic (L) ratio (0:L) of 1.6 and above has been recommended by food processing industries for groundnut (G.L. Hildebrand, SADC/ICRSAT Groundnut Project, personal communication with R. Jambunathan, ICRIST Center, 1991).

Antinutritional factors

Some antinutritional factors such as trypsin and enterokinase inhibitors are also reported in groundnut (Lau et al. 1980).

As Human Food

Groundnut produced in different countries are consumed in various ways depending on consumer preferences and food habits. The seed can be consumed raw (nonheated), boiled, and roasted. The oil extracted from it is a very important cooking medium in India and many Asian countries. Bulk of groundnut is used for extraction of oil. In USA, Canada, and Australia groundnut is grown to make peanut butter rather than to extract oil. Groundnut is also used to make confectionery and its flour to make baked products.

The data about consumption patterns of groundnut is available from developed countries only. Narsimham et al. (1987) reported the average (for the years 1981-85) consumption pattern of groundnut (Table 3), and concluded that at the domestic level groundnut consumption was 61% for crushing (oil), 28% for food, and 11% for seed and feed purposes.

Table 3. Groundnut consumption (%) patterns in different parts of the world[1].

Country	Peanut butter	Roasted and salted seed (pod/seed)	Confec-tioneries	Oil	Seed/ other feed
Australia	25.8	44.9	4.8	19.4	5.1
Canada	56.6	25.2	18.2	-	-
France	5.9	29.4	64.7	-	-
The Netherlands	25.8	61.3	12.9	-	-
Spain	2.0	90.0	8.0	-	-
UK	11.1	66.8	20.2	-	1.9
USA	52.6	23.0	20.5	-	-
West Germany	4.9	80.0	15.1	-	-
India[2]	-	2.0	2.0	80.0	16.0

1. Source: Narsimham et al. 1987.
2. Approximate values.

Groundnut oil

Raw groundnut oil is yellow and has a nutty odor and taste. It contains mucilage, albuminous material, and free fatty acids. To obtain a pale-yellow color, the oil is neutralized and refined (Nagaraj 1988). Groundnut oil is extracted by three methods; hydraulic pressing, screw pressing, and solvent extraction. The solvent extraction process gives a higher oil yield (Kadam and Chavan 1991).

The groundnut oil is used as a cooking medium, and it may be processed into a variety of products. It is hydrogenated to give vanaspati or vegetable ghee. It is also used in soap-making and manufacture of margarine.

On a limited scale, groundnut oil is useful for the preparation of cosmetics, candles, leather dressing, furniture, creams, and as a substitute for tallow. It is also useful to extract glycerine and as a substitute to olive oil in medicine. Groundnut oil contains an anti-inflammatory compound. Its emulsion is an useful insecticide. It also works as a suckericide in the control of tobacco sucker insect (Nagaraj 1988).

Factors affecting production and quality of oil

a. Genotypes. The oil content in groundnut varies between 40.8% and 54.4% in Indian cultivars. In USA, Its oil content ranges between 44.8% and 58.3% (Young and Hammons 1978).

The bunch varieties have a high oil content (Sekhon et al. 1972). The linoleic acid of Spanish, Virginia and runner types was 34.2%, 29.6% and 22.8% respectively (Woodroof 1973). The runner types had higher concentration of tocopherol, responsible for auto-oxidative stability of oil (Fore et al. 1953). Hence, oil derived from spreading genotypes has a better quality.

b. Nutrients. Application of N, P, and K has limited influence on oil content but these elements influence productivity. Application of P marginally increases oil content (Patil 1975). Application of sulfur and sulfur containing compounds increased oil content by 3-5% (Singh et al. 1970).

c. Crop maturity. Harvesting the immature pods or delay in harvest reduces oil content. Pods harvested at optimum maturity had higher oleic and linoleic acid ratio, thus leading to a better quality (Nagaraj 1988).

Groundnut Haulm and Hull

Groundnut haulm

Groundnut haulm is a nutritious feed for cattle. It contains protein (8-15%), lipids (1-3%), minerals (9-17%), and carbohydrate (38-45%) at levels higher than cereal fodder. The digestibility of nutrients in groundnut haulm is around 53% and that of crude protein is 88% in animals. Haulms releases an energy upto 2,337 cal kg^{-1} of dry matter. The composition of haulm depends on soil, variety, season, and fertilizer application (Nagaraj 1988).

Groundnut hull

Groundnut hull forms about 25% of the total pod mass produced. The majority of groundnut hull are either burned, dumped, or left to deteriorate naturally. However, there have been some efforts to use groundnut hull in cattle feed, and as a fiber component in human diet (Kerr et al. 1986). Hull contains more than 60% fiber, and therefore, has low digestibility.

MP 6. Use of Pods and Seeds

Fresh harvested seeds

The freshly harvested groundnut is consumed either raw or boiled.

Raw groundnut. The seeds are eaten raw after harvest without any cooking.

Boiled groundnut. The freshly harvested groundnut pods are boiled in 6% salt solution (brine) for about 20 min and shelled, before the seeds are consumed. The varieties suitable for this purpose are those that have 3-4 seeded pods, with good water permeability through pod shell (thin) for the ease of salt uptake while boiling. Boiled groundnut are consumed as a snack.

Dry groundnut

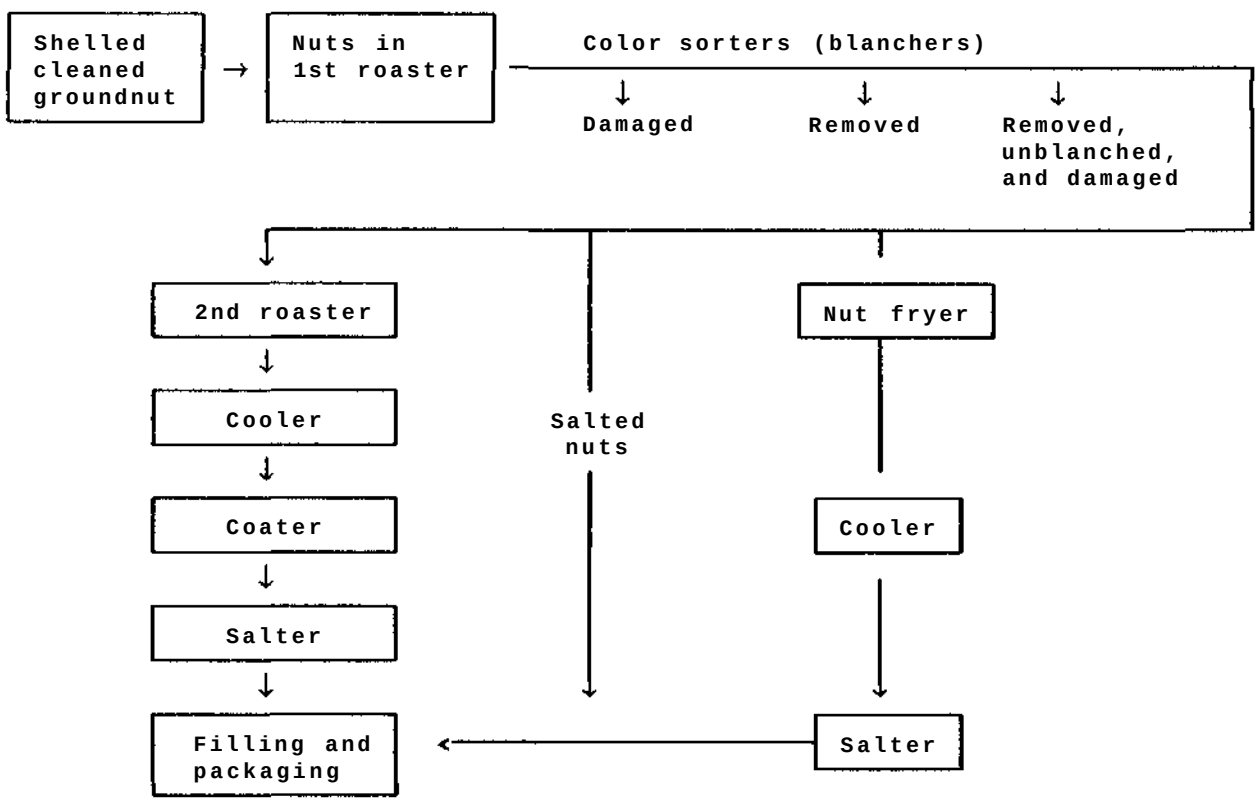
The dry groundnut seeds are eaten either by roasting the pods in heated sand on iron pans. The roasted pods are shelled and seeds are eaten with or without salt.

Roasting of groundnut seeds

Groundnut seeds are roasted using vegetable oil with or without salt (1-4%) by applying dry heat, or on sand for an even distribution of heat. The dry roasted groundnut is useful in preparation of peanut butter, confectionery or bakery products. After roasting, the testa are removed and the dried cotyledons are consumed. Roasting reduces moisture content and develops a pleasant flavor which makes the product more acceptable for consumption. However, excess heating during roasting results in tow nutritional quality of protein (Kadam and Chavan 1991).

The roasted groundnuts are eaten as snack. They are also used in candy preparations.

The seed testa is removed from the seed by blanching before roasting it. The large-scale roasting involves the following steps:



(Source: Young and Heinis 1989)

Sweet preparations

A few sweet preparations of groundnut seeds are popular in India.

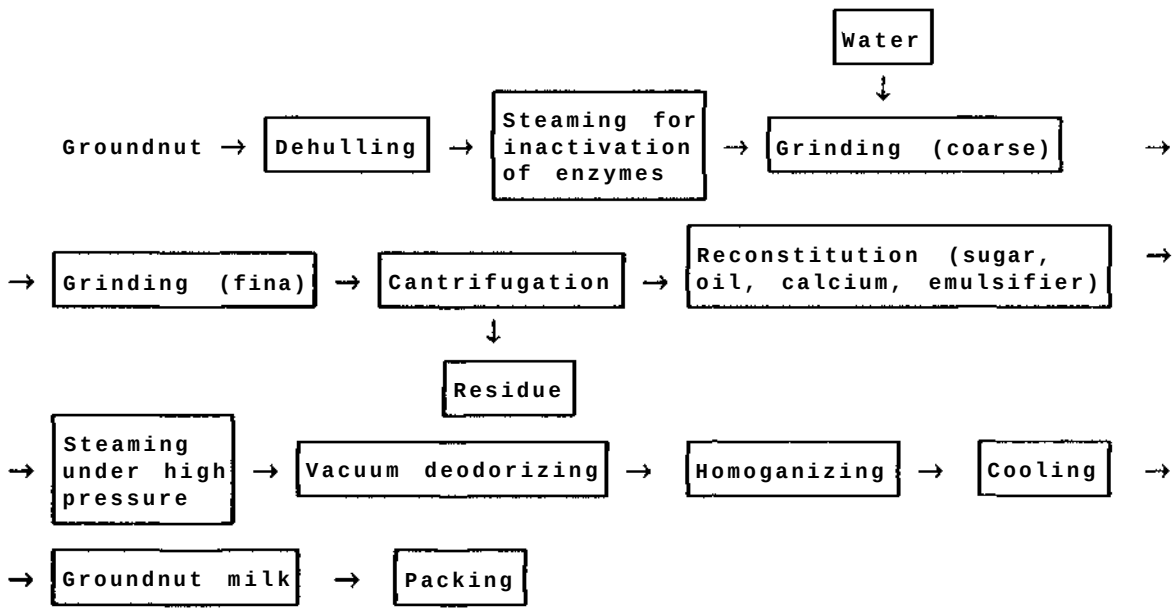
Laddu. This is prepared using roasted groundnut seeds after removing the testa. A thick jaggery syrup is prepared and the split seeds of groundnut are added in the hot jaggery syrup and uniformly mixed. Small portions of the mixture are taken in hand and made into balls or *laddus* of about 3-5 cm diameter. Another way is to coarse grind the roasted and decorticated groundnut seed (1-5 mm diameter). Then this is mixed in jaggery syrup and made into small balls (Kadam and Chavan 1991).

Chikki. It is prepared by mixing roasted and decorticated groundnut seeds in a hot slurry of sugar. The mixture is spread on a flat surface (1.0-1.5 cm thickness). The product is cut into small rectangular pieces after cooling and packed in thin polyethyelene sheets for sale.

MP 7. Groundnut Milk and Butter

Groundnut milk

The groundnut milk is prepared by soaking groundnut seeds in 1% sodium bicarbonate solution for 16-18 h. The excess water is drained off and seeds are ground in an acqueous medium. The wet mash is steeped for 4-5 h, and filtered through cheese cloth. A toned milk 'Miltone®' is available in India. Miltone® consists of groundnut milk extended with buffalo milk. Using a lactic culture from the 'Miltone®', a yogurt-like product is prepared (Swaminathan and Parpia 1967). Fermented groundnut milk can be substituted for butter milk in maize muffin recipes without altering the products sensory characteristics (Beuchat and Nail 1978). It can be substituted up to 20% for whole milk in preparation of ice-cream (Kadam and Chavan 1991). The stepwise procedure for large-scale production of groundnut milk is given below.



(Source: Based on processing of soy milk. Kyoko Saio 1986).

Groundnut butter (peanut butter)

It is most commonly used in USA. Groundnut butter is prepared by grinding roasted and blanched groundnut seeds. Seeds are heated at 160°C for 40-60 min, then cooled, blanched, and fine milled to a paste. While milling some grounded dextrose, salt and stabilizer are added. Some hydrogenated oil, antioxidants, honey, lecithin, and whey are also added. When butter becomes thick it is packed in plastic or metal containers. The butter is used as a spread on bread and in the manufacture of candy, cookies, sandwiches, patties, and bars (Kadam and Chavan 1991). The standard specifications of peanut butter have been published by many countries including India, Taiwan, the USA, Canada, Ghana, South Africa (Young and Heinis 1989). These standards vary according to national standards and local abilities to meet them. In the USA there are three preparations based on uses. These are peanut butter, peanut spread, and imitation peanut butter. Peanut butter must contain at least 90% peanuts and 10% additional ingredients, with a maximum oil content of 55% by weight (Weiss 1983). The additives include vitamins (e.g., A, B, C, D), artificial colors or flavors, nonnutritive sweeteners, and preservatives. Groundnut percentages must be declared in peanut spreads and imitation peanut butter, and additional nongroundnut ingredients (e.g., soy bits to absorb groundnut flavors) can be added. Peanut spreads can be prepared with less than 90% groundnut but it must be nutritionally equivalent to peanut butter with at least 24% protein (Young and Heinis 1989).

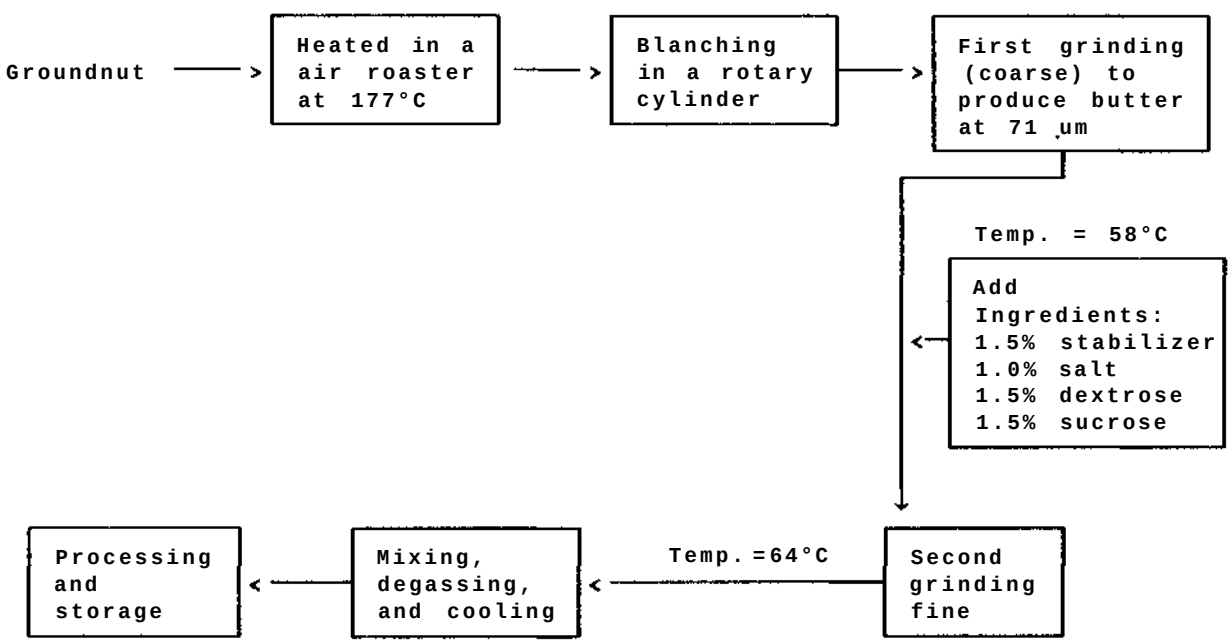
Ingredients In peanut butter

To prepare peanut butter, roasted groundnut seeds are split to remove the germ which otherwise gives a bitter, rancid taste, and a gray color. The other ingredients include stabilizers to prevent oil separation. The glycerine and nonglycerides prepared from vegetable and peanut oils are useful. The choice of a stabilizer depends on the process and desired flavor. A 50:50 soybean-rape seed fats that blend at a 1-2% level is often being preferred (Brekke 1982). The choice of a stabilizer also depends on the packing season, filling, and storage temperature.

The choice of a sweetener depends on processing choice. It can be a combination of corn syrup solids (28-48%), dextrose, and sucrose-honey (Weiss 1983).

Butter processing, formulation, and packaging

In the first stage, the roasted groundnut is ground. Immediately after the first grinding, other ingredients are added and then ground again. This is followed by mixing, degassing, and cooling before packing. The steps for commercial scale of production are as follows.



MP 8. Groundnut Protein Isolates

The protein isolate extraction procedure requires presoaking of split groundnut seeds in a sodium chloride solution (brine) overnight. This is washed with hot water later. This helps to wash out the water-soluble components and flavor components.

The protein can easily be extracted from the cake with dilute alkali. and is later precipitated by lowering the pH. The other way is to use water, 70% alcohol, 10% NaCI, 0.25% KOH. The isolated protein contains 16.2% N, 0.74% ash, and 0.06% lipid. Groundnut protein consists of two globulins namely arachin (93% of defatted seed protein) and conarachin. When a salt extract (0.1% NaCI buffered with 0.01 M sodium sulfate at pH 7.9) is treated with saturated $(NH_4)_2\ SO_4$, arachin gets precipitated first at 40% saturation followed by conarachin between 40 and 85% saturation. Since globulins contain 18.3% N the conversion factor for protein should be 5.46 (Jones 1931; Nagaraj 1988).

The protein isolates of groundnut have high solubility, they are white, and are free from nutty flavors. These protein isolates and oil could be used in the manufacture of cheese analogs. Replacement levels of 40% and 50% were found to be optimal in producing cheese analogs (Chen et al. 1979). The groundnut protein isolates are used in various food products. These isolates can replace about 80% of milk solids without changing the texture, and about 60% without loss of flavor, color, or overall acceptability in the preparation of frozen desserts (Lawhon et al. 1980).

Bakery products

Groundnut cake meal or defatted meal, can be used for preparing biscuits, breads, and cookies. Cookies are prepared from composite meal containing 5% cake meal. To prepare cookies, ingredients include refined wheat flour (250 g), hydrogenated fat (150 g), grounded sugar (125 g), liquid glucose (50 g), cow milk (50 mL), maize flour (12.5 g), liquid ammonia (2 mL), sodium bicarbonate (1 g), and orange color. Refined wheat flour and cake meal could be mixed (90:10 w/w) with these ingredients without affecting the color, appearance, texture, flavor, and taste of the cookies (Kadam and Chavan 1991).

Groundnut biscuits

Ingredients	Quantity
Wheat or sorghum flour	250 g
Sugar (powdered)	150 g
Fat	150 g
Groundnuts	100 g
Baking powder	1 tsp
Essence	Few drops

Method

- Roast groundnuts, allow them to cool, and pound coarsely.
- Sieve flour with baking powder. Add crushed groundnuts.
- Cream sugar and fat together till light and fluffy.
- Fold in the flour lightly and make a biscuit dough.
- Roll into uniform thickness. Cut with a biscuit cutter.
- Place on a greased tray and bake at 176°C for 15 to 20 min.

Precooked full-fat groundnut flakes

Blanched cotyledons (without germs) are dried to a 2-4% moisture level and are then ground to a fine paste. Water is added while heating and the slurry is dried to get flakes. The flakes have good keeping quality and are useful in preparation of formulated foods with high fat and protein value (Nagaraj 1988).

MP 9. Fermented Products of Groundnut

Groundnut cake is fit for human consumption after partial hydrolysis of its component protein by fermentation. This is done using certain molds such as *Neurospora intermedia.* During fermentation sucrose, raffinose and stachyose are eliminated (Worthington and Beuchat 1974). However, fermentation does not change any fatty acid composition, or protein content of groundnut (van Veen et al. 1968). Fermented products are easily digestible, tasty, and nutritious. The Indonesian preparation called *oncom* is a fermented groundnut press cake (Kadam and Chavan 1991).

Procedure for making *oncom* and curd

Oncom and *tempeh* can be easily distinguished by the use of the fungus. All the fermented foods utilizing *Rhizopus oligosporus* as starter are grouped as *tempeh,* while products utilizing *Neurospora* sp are called *oncom.* However, some *oncom* are also prepared using *Rhizophus oligosporus.*

Oncom

This is quite popular in Indonesia. *Oncom* is generally prepared from groundnut pressed cake. It is generally served as a fried snack or in vegetable soup and other Indonesia cuisine (Winarno 1986). There are two types of *oncom,* when fermentation is carried out by *Neurospora* sp it is red *oncom* and when fermentation is carried out using *Rhizopus oligosporus* it is called black *oncom. Oncom* is rich in vitamin B_{12} (31±7 μ g^{-1}). Black *oncom* is rich in iron [55.7 mg (100 g)$^{-1}$]. The average *oncom* consumption in West Java, Indonesia is 0.69 g person^{-1} day^{-1} (Winarno 1986).

Groundnut cake after removing oil is used for preparation of *oncom.* To make *oncom* use the following directions. Soak the cake in water for 24 h. Drain out the excess water and add starch (cassava powder or residue of soybean milk). Steam the material, incubate it with fungus *Neurospora intermedia.* Allow 1-2 days for fermentation at 25-30°C after wrapping in banana leaves. The material is then fried in oil or margarine and consumed (Kadam and Chavan 1991).

Curd (*tofu*)

The groundnut curd is a popular dish in China and Japan. To prepare the curd, groundnut seeds are soaked overnight and ground to an emulsion. This fine emulsion is boiled or steamed and filtered through a fine cloth. A small quantity of calcium or magnesium sulfate is added to precipitate and the material is allowed to settle. Now transfer the material into boxes lined with cloth filters or is spread on trays. The curd is served as a soup or can be deep fried in oil for table purpose (Kadam and Chavan 1991).

MP 10. Groundnut Flour-based Sorghum *Kisra*

Kisra is a thin pancake-like leaven bread. It is generally made from the whole sorghum flour. It is a staple in Sudan. *Kisra* is prepared using sorghum flour (90 g) which is mixed in water (120 mL) and the starter (30 g) in a stainless steel utensil. After thorough mixing, the mass is fermented for 18-20 h at 27°C. After fermentation it attains a 3.9-4.0 pH. Now add 60 mL water and bake the batter for 1.5-2.0 m on hot plate at 150-160°C to a tin-sheet. The *kisra* can also be prepared using about 30% defatted flour of colorless groundnut and 70% sorghum flour without affecting color, texture, and taste. However, fortification reduces keeping quality after 24 h and decreases viscosity. The in vitro digestibility of *kisra* is increased by the addition of defatted groundnut flour (Singh 1991).

MP 11. Groundnut Candies

Groundnut is used in the production of chocolate bars. In India, groundnut candy contains groundnut seed, sugar, liquid glucose, spices (cinnamon, cardamom, cloves, and nutmeg) and vanaspati (hydrogenated fat made from vegetable oil used as butter substitute). The groundnut content is more than 50% while sucrose content is 40% or less in this preparation.

Procedures

There are wide variations in the production procedure and formulations of candies. In some cases, groundnut is used as a topping or molded chocolate block component in nut rolls and clusters. It may also be used as coated nuts that are brittle to provide texture reducing chocolate and sweetness added. Groundnut used for candy bars are slightly over roasted (Brekke 1980).

In nut roll candies, groundnut form a part of the *nougat* formula. *Nougats* are prepared by whipping a sugar-corn syrup blend and enrolling the extruded product (Trevor 1964). Chewiness can be controlled either by using a whipping blend of low sugar corn syrup with high protein, e.g., egg white or one containing higher levels of sugars (Alikonis 1979).

Peanut butter cups are made by using chocolate shells that are spun in molds, filled with peanut butter type fillings, and covered with liquid chocolate. Then the product is passed over a vibrating table for an even coating and is defrayed before packing.

In dragee's or hand-coated groundnuts, a sugar:com syrup:water blend (30:20:7) is boiled and raw groundnut is added until the syrup reaches 154-157°C. Sodium bicarbonate is often added to aerate the brittle. The material is spread on to a cooling slab and cooled to 30°C before packaging (Young and Heinis 1989).

MP 12. Groundnut Butter, Sauce, and Soup

Groundnut Butter Sauce

Also known as *Nagatie-Taoh,* it is a local speciality and delicacy in C6te de Ivoire (Ahmed, 1989).

Ingredients	Quantity[1]
Onion (crushed)	50 g
Meat/chicken/fish	100 g
Spices	As per taste
Salt	1 tsp
Water	300 mL
Peanut butter	100 g
Vegetables (cabbage, cauliflower, tomatoes, etc.)	200 g (mix)
Oil (peanut)	50 mL

1. Approximate quantity is suggested.

Method

- Fry onion and meat in oil.
- Add spices, water, and salt.
- When boiling starts add peanut butter and let the material boil at medium heat for about 30 min.
- Add cut pieces of vegetables and continue boiling until the foam disappears. Then leave it to boil to the consistency desired in the sauce.

Note: The sauce can be prepared with meat, chicken, fish, or sea food alone, or a combintion of these ingredients. It takes 60 min to 90 min of cooking to obtain right peanut butter sauce. The sauce is served with rice dishes or with mashed plantain for lunch or dinner.

Groundnut Soup

ingredients	Quantity
Groundnut fresh, boiled, or roasted	200 g
Dry fish or beef	225 g
Crayfish	50 g
Onion (medium size)	1
Pepper	To taste
Salt	To taste
Water	1000 mL

Method

- To make groundnut soup, the seed testa is removed. The decorticated seeds are pounded in a mortar or ground on a stone to a smooth paste (Abbey et al. 1989).
- All the above ingredients except the paste are added into a pot and allowed to simmer for 10 min.
- A little water is added to the groundnut paste, mixed thoroughly and added to the other ingredients in the pot.
- The soup is allowed to simmer for about 20 min or until the beef is tender.
- Soup is served as a gravy with rice.

Fried Groundnut Press Cake

The groundnut press cake is fried in the oil and eaten. This snack is called *'Kulikali'* (*Hausa*) in Africa. To make this, the following ingredients are required (Abbey et al. 1989).

ingredients	Quantity
Groundnut press cake	200 g
Groundnut oil	400 mL
Salt and pepper	Optional

Method

- Mix the groundnut press cake with salt and a little dash of pepper.
- Squeeze the cake by hand into an obolong shape.
- Deep fry until brown.
- The fried cake is a snack by itself.

References

Abbey, B.W., Phillips, R.D., and McWatters, K.H. 1989. Preparation and uses of legumes and oilseeds in Africa. Pages 281-304 *in* Food uses of whole oil and protein seeds (Lusas, E.W., Erickson, D.R., and Nip Waikit, eds.). Illinois, USA: American Oil Chemists Society.

Ahmed, E.M. 1989. World native uses of peanuts. Pages 159-170 *in* Food uses of whole oil and protein seeds (Lusas, E.W., Erickson, D.R., and Nip Waikit, eds.). Illinois, USA: American Oil Chemists Society.

Akhtaruzzaman, A.F.M., Siddique, A.B., and Chaudhary, A.R. 1986. Potentiality of pigeonpea (arhar) plant for pulping. Bano Biggyan Patrika 15(1-2):31-36.

Akinola, J.O., and Whlteman, P.C. 1975. Agronomic studies on pigeonpea (*Cajanus cajan* (L.) Millsp). 3. Responses to defoliation. Australian Journal of Agricultural Research 26:67-79.

Akinola, J.O., Whlteman, P.C., and Wallis, E.S. 1975. The agronomy of pigeonpea (*Cajanus cajan).* Review Series no. 1/1975, CAB International, UK. 57 pp.

Alikonis, J.J. 1979. Candy technology. West Port CT, USA: AVI Publishing Company.

Aykroyd, W.R., and Doughty, J. 1982. Legumes in human nutrition. FAO Food and Nutrition Paper 20. Rome, Italy. Food and Agriculture Organization of the United Nations. 152 pp.

Beuchat, I.R., and Nail, B.J. 1978. Fermentation of peanut milk with *Lactobacillus bulgaricus* and *L. idophillus.* Journal of Food Science 43:1109-1112.

Brekke, O. 1980. A Handbook of soy oil processing and utilization (Erickson, D.R., Pryde, E.H., Brekke, O.L., Mound, T.L., and Falb, R.A., eds.). St. Locus, MO, and Washington, USA: American Soybean Association and American Oil Chemists' Society.

Chen, S., Wan, P.J, Lucas, E.W., and Rhee, K.C. 1979. Utilization of peanut protein and oil in cheese analogs. Food Technology 33:88-93.

Chowdhary, M.K., and Bhattacharya, A. 1973. Survival of lac insects on different hosts. Page 21 *in* Abstracts of the seminar on lac productions, 9-10 Nov 1973, Namkum, Ranchi, Bihar, India: Indian Lac Research Institute.

CSIR (Council of Scientific and Industrial Research). 1950. The wealth of India, raw materials. Vol. II. New Delhi, India: Council of Scientific and Industrial Research.

Damardjatl, D.S., and Widowati, S. 1985. Prospects on development of pigeonpea in Indonesia. (In Indonesian) Journal Penelitian Dan Pengenbangan Pertanian 3:53-59

Damardjati, D.S., and Widowati, S. 1991. Utilization of pigeonpea and other grain legumes in Indonesia. Pages 145-152 *in* Uses of tropical grain legumes: Proceedings of a Consultants Meeting, 27-30 Mar 1989, ICRISAT Center, India. Patancheru, A.P. 502 324, India: International Crops Research Institute for the Semi-Arid Tropics.

Ekeke, G.I., and Shode, F.O. 1985. A reversion of sickled cells by *Cajanus cajan.* Planta Medica Dec, 1985:504-507.

Faris, D.G., Saxena, K.B., Mazumdar, S., and Singh, U. 1987. Vegetable pigeonpea: a promising crop in India. ICRISAT, Patancheru, A.P. 502 324, India: International Crops Research Institute for the Semi-Arid Tropics.

Faris, D.G., and Singh, U. 1990. Pigeonpea: nutrition and products. Pages 401-434 *in* The Pigeonpea (Nene, Y.L., Hall, S.D., and Sheila, V.K., eds.). Wallingford, Oxon, UK: CAB International.

Fore, S.P., Morris, N.J., Freeman, A.F., and Brickford, W.G. 1953. Factors affecting the stability of crude oils of 16 varieties of peanuts. Journal American Oilseeds Chemist Society 30:298-301.

Henke, L.A. 1943. Roughages for dairy cattle in Hawaii. Hawaii Agricultural Experiment Station Bulletin 92. HI, USA: University of Hawaii.

Heynes, K. 1919. Food and fodder plants (redgram). Kew Bulletin 15, Kew, UK.

ICRISAT (International Crops Research Institute for the Semi-Arid Tropics). 1984. Annual report 1983. Patancheru, A.P. 502 324, India: ICRISAT.

Jain, K.C., Farls, D.G., and Chechi Reddy, M. 1987. Performance of medium-duration pigeonpea genotypes for wood and grain yield in pigeonpea. International Pigeonpea Newsletter 6:34-35.

Jambunathan, R. 1991. Groundnut quality characteristics. Pages 267-275 *in* Uses of tropical grain legumes: Proceedings of a Consultants Meeting, 27-30 Mar 1989, ICRISAT Center, India. Patancheru, A.P. 502 324, India: International Crops Research Institute for the Semi-Arid Tropics.

Jones, D.B. 1931. Factors for converting percentage of nitrogen in foods and feeds into percentage of proteins. USDA Circular no. 193, Washington D.C., USA: United States Department of Agriculture.

Kadam, S.S., and Chavan, J.K. 1991. Utilization of groundnut in India and scope for novel and alternative uses. Pages 277-285 *in* Uses of tropical grain legumes: Proceedings of a Consultants Meeting, 27-30 Mar 1989, ICRISAT, India. Patancheru, A.P. 502 324, India: International Crops Research Institute for the Semi-Arid Tropics.

Kamath, M.V., and Belavady, B. 1980. Unavailable carbohydrates of commonly consumed Indian foods. Journal of the Science of Food and Agriculture 31:194-202.

Kerr, T.J., Wirdham, W.R., Woodward, J.H., and Banner, R. 1986. Chemical composition and *in vitro* digestibility of thermo-chemically treated peanut hulls. Journal of Science of Food and Agriculture 37:632-636.

Kurien, P.P. 1971. Traditional and improved method of milling of *dhal. In* Proceedings of *dhal* milling conference. Mysore, Karnataka, India: Central Food Technological Research Institute.

Kurien, P.P. 1977. Grain legume milling technology. *In* Proceedings, FAO Expert Consultation on Grain Legume Processing, Rome, Italy.

Kurien, P.P., Deslkachar, H.S.R., and Parpia, H.A.B. 1972. Some developments in pigeonpea milling technology. Paper presented at the pigeonpea scientists meeting, 24-26 Nov 1986, ICRISAT, India. Patancheru, A.P. 502 324, India: International Crops Research Institute for the Semi-Arid Tropics.

Kurien, P.P., and Parpia, H.A.B. 1968. Pulse milling in India. I. Processing and milling of tur (*Cajanus cajan* Linn.). Journal of Food Science and Technology 5:203-207.

Kyoko Saio. 1986. Interaction among traditional and emerging food processing technologies observed in Japanese food industries. Pages 209-216 *in* Traditional Foods - Some Products and Technologies. Mysore, Karnataka, India: Central Food Technological Research Institute.

Lau, A., Ako, H., and Washburne, W. 1980. Survey of plants for enterokinase activity. Biochemical and Biophysical Research Communications 92:1243.

Lawhon, J.T., Golightly, N.H., and Lucas, E.W. 1980. Utilization of membrane produced oilseed isolates in soft-serve frozen desserts. Journal of American Oil Chemists Society 57:302-306.

Macmillan, H.F. 1946. Tropical planting and gardening. London, UK: Macmillan and Company Ltd.

Mansfield, G.R. 1981. Processing and marketing of pigeonpeas: the case of Dominican Republic. Pages 344-350 *in* Proceedings of International Workshop on Pigeonpea, 15-19 Dec 1980, ICRISAT, India. Vol. 1. Patancheru, A.P. 502 324, India: International Crops Research Institute for the Semi-Arid Tropics.

Melmick, D., Hachberg, M., and Oser, B.L. 1944. Comparative study of steam and hot water blanching. Food Research 9:148-153.

Miller, C.D., Branthoover, B., Seklguchi, N., Deming, H., and Bauer, A. 1956. Vitamin value of foods used in Hawaii. Hawaii Agriculture Experiment Station Technical Bulletin 30:303-313.

Morton, J.F. 1976. The pigeonpea (*Cajanus cajan* Millsp.), a high protein, tropical bush legume. Horticultural Science 11:11-19.

Nagaraj, G. 1988. Chemistry and utilization. Pages 554-565 *in* Groundnut (Reddy, PS., ed.). New Delhi, India: Indian Council of Agricultural Research.

Narain, M., Singh, B.P.N., and Saxena, R.P. 1986. Some developments in pigeonpea milling technology. Paper presented at Pigeonpea Scientists Meet, 24-26 Nov 1986, ICRISAT, Patancheru, A.P. 502 324, India: International Crops Research Institute for the Semi-Arid Tropics.

Narsimham, N.V., von Oppen, M., and Parthasarathy Rao, P. 1987. World markets for hand picked and selected (HPS) groundnuts. Resource Management Program, Economics Group, Progress Report 82. ICRISAT, Patancheru, A.P. 502 324, India: International Crops Research Institute for the Semi-Arid Tropics. (Limited circulation.)

Panikkar, M.R. 1950. Alternate fuel-arhar stalk. Indian Farming 11:496.

Pathak, G.N. 1970. Redgram. Pages 14-53 *in* Pulse Crops of India. New Delhi, India: Indian Council of Agricultural Research.

Patil, V.C. 1975. Effect of zinc, iron, and calcium under varying levels of phosphorus on growth, yield, and quality of groundnut. Ph.D. thesis submitted to University of Agricultural Sciences, Bangalore, Karnataka, India.

Prasetyo, B.E. 1988. Study on supplementation of rice flour with pigeonpea for making cookies. (In Indonesian). Thesis, Gajah Mada University, Yogyakarta, Indonesia.

Rachie, K.O., and Roberts, L.M. 1974. Grain legumes of the low-land tropics. Advances in Agronomy 26:1-132.

Reddy, V.P.R. 1981. Dehusking of arhar grains (*Cajanus cajan*). M.Tech. Thesis, Govind Ballabh Pant University of Agriculture and Technology, Uttar Pradesh, India.

Salunkhe, D.K., Kadam, S.S., and Chavan, J.K. 1985. Chemical composition. Pages 29-52 *in* Post-harvest biotechnology of food legumes. Boca Raton, Florida, USA: CRC Press.

Sammy, G.M. 1971. Canning potential of pigeonpea cultivar G1 26/2. Food Technology Series no. 4. Faculty of Engineering, University of West Indies, Trinidad, West Indies. 4 pp.

S'anchez-Nteva, N.F. 1961. The influence of degree of maturity on the quality of canned pigeonpeas. Journal of Agriculture of University of Puerto Rico 45217-231.

S'anchez-Nieva, N.F., Gouzalez, M.A., Benero, J.R., and Hernandez, I. 1963. The brine-grading of pigeonepas. Journal of Agriculture of University of Puerto Rico 47:14-23.

S'anchez-Nieva, N.F., Rodriguez, A.J., and Benero, J.R. 1961. Improved methods of canning pigeonpeas. University of Puerto Rico Agricultural Experiment Station Bulletin 157:1-26.

Saxena, R.P. 1985. Mitling of pigeonpea grain (*Cajanus cajan* L.) and associated aspects. Ph.D. thesis, Govind Ballabh Pant University of Agriculture and Technology, Pantnagar, Uttar Pradesh, India.

Saxena, R.P., Singh, B.P.N., Singh, A.K., and Singh, J.K. 1981. Effect of chemical treatment on husk removal of arhar (*Cajanus cajan*) grain. ISAE Paper no. 81-PAS-156, New Delhi, India: Indian Society of Agricultural Engineers.

Sekhon, K.S., Ahuja, K.L., Sandu, R.S., and Bhatia, T.S. 1972. Variability in fatty acid composition in peanut I. Bunch group. Journal of the Science of Food and Agriculture 23:919-924.

Singh, B. 1991. Cereal-based foods using groundnut and other legumes. Pages 293-301 *in* Uses of tropical grain legumes: Proceedings of a Consultants Meeting, 27-30 Mar 1989, ICRISAT Center, India. Patancheru, A.P. 502 324, India: International Crops Research Institute for the Semi-Arid Tropics.

Singh, D.N., and Kush, A.K. 1981. Effect of population density on growth pattern and yielding ability of pigeonpea. Pages 165-175 *in* Proceedings of the International Workshop on Pigeonpeas, 15-19 Dec 1980, ICRISAT, India. Vol. 1. Patancheru, A.P. 502 324, India: International Crops Research Institute for the Semi-Arid Tropics.

Singh, N., Subbiah, B.V., and Gupta, V.P. 1970. Effect of sulphur fertilization on chemical composition of groundnut and mustard. Indian Journal of Agronomy 15:24-28.

Singh, U. 1988. Antinutritional factors of chickpea and pigeonpea and their removal byprocessing. Plant Foods for Human Nutrition 38:251-261.

Singh, U., Jain, K.C., Jambunathan, R., and Faris, D.G. 1984a. Nutritional quality of vegetable pigeonpeas *(Cajanus cajan* L.): dry matter accumulation, carbohydrates and proteins. Journal of Food Science 49:799-802.

Singh, U., Jain, K.C., Jambunathan, R., and Faris, D.G. 1984b. Nutritional quality of vegetable pigeonpeas *(Cajanus cajan* L.): minerals and trace elements. Journal of Food Science 49:645-646.

Singh, U., and Jambunathan, R. 1981. A survey of methods of milling and consumer acceptance of pigeonpeas in India. Pages 419-425 *in* Proceedings of International Workshop.on Pigeonpeas, 15-19 Dec 1980, ICRISAT, India. Vol. 2. Patancheru, A.P. 502 324, India: International Crops Research Institute for the Semi-Arid Tropics.

Singh, U., and Jambunathan, R. 1990. Pigeonpea: post-harvest technology. Pages 435-455 *in* The Pigeonpea (Nene, Y.L., Hall, S.D., and Sheila, V.K., eds.). Wallingford, Oxon, UK: CAB International.

Singh, U., Rao, P.V., Seetha, R., and Jambunathan, R. 1989. Nutrient losses due to scarification of pigeonpea (*Cajanus cajan* L.): cotyledons. Journal Food Science 54(4):974-976.

Squibb, R.L., Faila, A., Fuentes, J.A., and Love, H.T. 1950. Value of *Desmodium,* pigeonpea food, Guatemalan and United States alfalfa meals in rations for baby chicks. Poultry Science 29:482-485.

Srivastava, V., Mishra, D.P., and Khare, B.P. 1988a. Effect of insect infestation on biochemical composition of pigeonpea *(Cajanus cajan* (L.) Millsp.) seeds stored in mudbin. Bulletin of Grain Technology 26:120-125.

Srivastava, V., Mishre, D.P., Laxmi Chand, Gupta, R.K., and Singh, B.P.N. 1988b. Influence of soaking on various biochemical changes and dehulling efficiency in pigeonpea *(Cajanus cajan* L.) seeds. Journal of Food Science and Technology 21:54-62.

Swaminathan, M., and Parpia, H.A.B. 1967. Milk substitutes based on oilseeds and nuts. World Review of Nutrition and Dietetics 8:14.

Trevor, W.C. 1964. Chocolate and confectionary. London, UK: Leonard Hill.

Vaidehi, M.P. 1991. Utilization of pigeonpea in India and scope for novel and alternate uses. Pages 137-144 *in* Uses of tropical grain legumes: Proceedings of Consultants Meeting, 27-30 Mar 1989, ICRISAT, India. Patancheru, A.P. 502 324, India: International Crops Research Institute for the Semi-Arid Tropics.

Vaidehi, M.P., and Ratnamani, A. 1988. Pigeonpea *dhals* for tempeh preparation. International Pigeonpea Newsletter 7:36-37.

van Veen, A.G., Graham, D.C.W., and Streinkrans, K.H. 1968. Fermented peanut press cake. Cereal Science Today 13(3):96-99.

Wallis, E.S., Woolcock, R.F., and Byth, D.E. 1988. Potential for pigeonpea in Thailand, Indonesia, and Burma. CGPRT no. 15. Bogor, Indonesia: CGPRT Center. 74 pp.

Watt, Sir, G. 1908 (reprinted in 1966). The pigeonpea *Cajanus indicus* arhar. Pages 196-200 *in* The Commercial Products of India. New Delhi, India: Today and Tommorrow Printers and Publishers.

Weiss, T.J. 1983. Food oils and their uses. Westport, CT, USA: AVI Publishing Company.

Whiteman, P.C., and Norton, B.W. 1981. Alternative uses of pigeonpea. Pages 365-378 *in* Proceedings of International Workshop on Pigeonpeas, 15-19 Dec 1980, ICRISAT, India. Vol. 1. Patancheru, A.P. 502 324, India: International Crops Research Institute for the Semi-Arid Tropics.

Winarno, F.G. 1986. Traditional technologies of Indonesia with special attention to fermented foods. Pages 136-147 *in* Traditional Foods - Some Products and Technologies. Mysore, Karnataka, India: Central Food Technological Research Institute.

Woodroof, J.G. 1973. Peanuts, production, processing products. West Port, USA: AVI Publishing Company Inc.

Worthlngton, R.E., and Beuchat, L.R. 1974. Alpha-galactosidase activity of fungi on intestinal gas-forming peanut oligosaccharides. Journal of Agricultural and Food Chemistry 22:1063-1066.

Young, C.T., and Hammons, R.O. 1978. The amino acid content of U.S. commercial peanut varieties. Proceedings of the American Peanut Research and Education Association 10:75.

Young, C.T., and Heinls, J.J. 1989. Manufactured peanut products and confections. Pages 171-190 *in* Food uses of whole oil and protein seeds (Lusas, E.W., Erickson, D.R., and Nip Wai-Kit, eds.). Champaign, IL, USA: American Oil Chemists' Society.

Evaluation

Select the most appropriate answer and check the correct answer at the end of the booklet.

Pigeonpea

1. The maximum consumption of pigeonepa as human diet is in the form of
   a) whole dry seed. b) green seed.
   c) *dhal.* d) none of the above.

2. The foliage of pigeonpea is commonly used as
   a) green manure. b) fuel.
   c) hedge. d) animal feed.

3. The byproducts of pigeonpea *dhal* mill are mainly used as a
   a) human food. b) animal feed.
   c) organic manure. d) none of the above.

4. The percentage composition of cotyledons, embryo, and seed coat in pigeonpea seeds are _____ respectively.
   a) 50, 45, and 5. b) 60, 30, and 10.
   d) 80, 15, and 5. d) 85, 1, and 14.

5. The protein digestibility of pigeonpea *dhal* is
   a) 60.5%. b) 66.8%.
   c) 58.5%. d) 45.5%.

6. Pigeonpea *dhal* contains _____ % protein.
   a) 21.0. b) 18.8.
   c) 24.6. d) 35.0.

7. Among the mineral elements, pigeonpea has the maximum amount of
   a) calcium. b) magnesium.
   c) zinc. d) copper.

8. Green pigeonpea has maximum amount of _____.
   a) A vitamin b) B_1 and B_2 vitamins
   c) C vitamin d) Niacin

9. Pigeonpea is nutritionally deficient in
   a) protein. b) lysine.
   c) methionine and cystein. d) threonine.

10. The factors that inhibit the digestive enzymes such as trypsin, chemotrypsin, and amylose are
    a) high proteins. b) high starch.
    c) polyphenols compounds. d) fiber.

11. The toxic factors that interact with glycoproteins on the surface of red blood cells causing them to agglutinate are
    a) proteins. b) enzymes.
    c) phytolectins. d) lectins.

12. Consumption of food legumes in large quantities causes flatulence because of the high content of
    a) proteins. b) starch.
    c) fat. d) oligosaccharides.

13. Sugars, trypsin, and amylose inhibitors in pigeonpea are lower in
    a) dry pods.
    b) green seed.
    c) *dhal.*
    d) immature pods.

14. The pigeonpea green seeds have more _____ than dry seeds.
    a) calcium and magnesium
    b) proteins and trypsin
    c) starch
    d) zinc

15. Pigeonpea *dhal* is more popular than seed as dehulling improves the
    a) appearance and texture.
    b) payability and digestibility.
    c) nutritional quality of grain.
    d) all the three above.

16. Fermented, soaked, dehulled, and cooked pigeonpea on spread mesh is allowed to grow *Rhizopus* mold to form a compact cake, and cut into pieces and fried before being eaten. This preparation is called
    a) *tempeh.*
    b) *oncom.*
    c) canned seed.
    d) *kisra.*

17. Soaking of dry pigeonpea in water for 24 h followed by pressure cooking in brine is necessary for
    a) sprouting seed.
    b) canning.
    c) roasting.
    d) sauce preparation.

18. For green seed consumption, pigeonpea is harvested at
    a) full maturity.
    b) 75% maturity.
    c) physiological maturity of pod.
    d) none of the above.

19. The potential biomass of pigeonpea ranges from
    a) 3 to 4 t ha^{-1}.
    b) 10 to 15 t ha^{-1},
    c) 20 to 30 t ha^{-1}
    d) 40 to 57.6 t ha^{-1}.

20. It is necessary to cut pigeonpea plants _____ above ground level for forage purpose.
    a) 0.15-0.30 m
    b) 0.8-1.0 m
    c) 1.5-2.0 m
    d) 2.5-3 m

21. The recovery of pigeonpea *dhal* from whole seed ranges between
    a) 50 and 60%.
    b) 65 and 75%.
    b) 80 and 85%.
    d) above 85%.

22. The heat value of pigeonpea wood compared to that of coal is
    a) 1:3.
    b) 1:4.
    c) 1:2.
    d) 3:4.

23. Pigeonpea is a suitable host for two lac scale insect strains. These are
    a) red and *gulabi.*
    b) *peeli* and *kali.*
    c) *rangeeni* and *kushumi.*
    d) not known.

24. Pigeonpea has _____ effects to heal the wounds and sores.
    a) stringent
    b) volerant
    c) pectrat
    d) antihelminthic

25. When dry pigeonpea seed is cleaned, graded, and passed through an energy coated roller machine for pitting followed by mixing in 1% warm oil and 2-5 days sun-drying is called
    a) wet conditioning.
    b) dry conditioning.
    c) conditioning.
    d) cleaning.

26. To impart glossy appearance to *dhal* _____ is added while polishing.
    a) water (1-2%)
    b) oil (0.1-0.2%)
    c) milk (1-2%)
    d) all the above

27. Soaking of pigeonpea in water helps in
    a) reducing antinufritional factors.
    b) increasing digestibility.
    c) loosening binding action of gum between seed coat and cotyledons.
    d) none of the above.

28. To penetrate the pigeonpea seed through husk into cotyledon layer and release its binding under the mild heat of sun, it is necessary to treat the seed with
    a) water.
    b) sodium bicarbonate.
    c) oil.
    d) calcium hydroxide.

29. For dry seed, pigeonpea is harvested at
    a) 50% maturity.
    b) physiological maturity.
    c) 75% maturity when pods are yellow.
    d) when all pods are mature.

30. The products prepared from fermented cereals and pigeonpea are
    a) starch and noodles.
    b) *tempeh* and sauce.
    c) stuffed paries and pelau.
    d) soup and vegetables.

31. The green pigeonpea processing includes
    a) shelling and cleaning.
    b) blanching and canning.
    c) freezing.
    d) all the above.

32. It is important to do____ to fix color, improve flavor, reduce volume, and improve texture of pigeonpea.
    a) cleaning
    b) blanching
    c) canning
    d) freezing

33. After blanching and cooling of pigeonpea, cans are filled with seeds at 90.5°C to 93.3°C along with
    a) 1% oil.
    b) 2% brine solution.
    c) alcohol.
    d) vinegar.

34. The starch from pigeonpea can be isolated from the
    a) whole dry seed only.
    b) green seed only.
    c) *dhal* only.
    d) both *dhal* and whole seed.

35. The overnight soaked pigeonpea (seed/*dhal*) are ground in a blender at low speed for 2 min and the slurry is filtered through cloth bag (80 mesh) followed by sieve (200 mesh). The filtrate is kept 4-6 h. The resultant sediment is
    a) protein.
    b) fat.
    c) starch.
    d) slurry.

36. To prepare noodles, starch and water is boiled for 5 min in the ratio of _____ (W/V).
    a) 1:2
    b) 1:7
    c) 1:5
    d) 1:10

Groundnut

37. The normal shelling percentage in groundnut ranges from
    a) 40 to 50. b) 50 to 60.
    c) 60 to 75. d) above 80.

38. in groundnut, seed cotyledons constitute
    a) 50-60%. b) 60-70%.
    c) 80-30%. d) 92-94%.

39. In groundnut, seed testa constitute
    a) 1-2%. b) 2-3%.
    c) 4-5%. d) 8-10%.

40. Groundnut cotyledons mainly contain
    a) carbohydrates. b) cellulose.
    c) phenolic compounds. d) oil and proteins.

41. Raw and roasted groundnut supply energy equivalent to _____ calories grain^{-1} respectively.
    a) 2 and 4. b) 5.6 and 5.8.
    c) 3.5 and 4.5. d) 6.5 and 8.5.

42. In developing countries groundnut is mainly used as
    a) roasted seed. b) butter.
    c) oil. d) bakery products.

43. The mean protein content in groundnut seed is about
    a) 10%. b) 45%.
    c) 20%. d) 70%.

44. The mean oil content in groundnut is about
    a) 35%. b) 45%.
    c) 60%. d) 25%.

45. For oil extraction purposes preferred groundnut varieties are with an oleic (0):linoleic (L) ratio of
    a) 1.6. b)2.0.
    c) 2.2. d) 2.6.

46. Groundnut contains antinutritional factors such as
    a) tannins. b) high fat.
    c) trypsin and enterokinase. d) linoleic acid.

47. Groundnut oil is extracted by
    a) hydraulic pressing. b) screw pressing.
    c) solvent extraction. d) all the above.

48. The maximum use of groundnut oil is
    a) as a cooking medium. b) as peanut butter.
    c) as vegetable ghee. d) in soap making.

49. The groundnut oil productivity can be enhanced by the application of
    a) N and K. b) P and S.
    c) N, P, and K. d) N and Fe.

50. High oleic and linoleic acid ratio can be obtained in groundnut oil when is harvested at
    a) prematurity stage.
    b) physiological maturity.
    c) optimum maturity (above 75%).
    d) 100% maturity.

51. On roasting, groundnut develops
    a) a pleasant flavor.
    b) loss in moisture.
    c) high acceptability to consumers.
    d) all the above.

52. For consuming as boiled pods, groundnut pods are harvested at
    a) prematurity stage.
    b) an optimum maturity.
    c) physiological maturity.
    d) over mature types.

53. Consumers generally prefer boiled groundnut pods with
    a) 1-2 seeds.
    b) 2-3 seeds.
    c) 3-4 seeds.
    d) 5-6 seeds.

54. Excessive heating of groundnut seeds during roasting
    a) lowers nutritional protein quality.
    b) increases nutritional protein quality.
    c) decreases digestibility.
    d) affects all the above quality characters.

55. For extraction of protein isolates, it is important to soak groundnut overnight in
    a) water.
    b) 4% sodium chloride solution.
    c) alcohol.
    d) 10% sodium chloride solution.

56. The groundnut protein contains two globulins. They are
    a) arachin and conarachin.
    b) methionin and tryptophan.
    c) threonine and valine.
    d) cystein and leucine.

57. The fermented groundnut cake is used in the preparation of
    a) cake.
    b) *oncom.*
    c) biscuit.
    d) bread.

58. The fermented groundnut products are
    a) less digestible and poor in quality.
    b) easily digestible and nutritious.
    c) hard to digest and produce flatulence.
    d) all the above.

59. In ice-cream preparations, groundnut milk can substitute for whole milk to an extent of
    a) 10%.
    b) 20%.
    c) 30%.
    d) 40%.

60. For preparing biscuits, breads, and cookies groundnut
    a) seed is used.
    b) oil is used.
    c) cake meal is used.
    d) none of the above.

61. All the fermented foods prepared by utilizing *Rhizopus oligosporus* starter are grouped as
    a) *oncom.*
    b) *tempeh.*
    c) *kisra.*
    d) *tofu.*

62. *Oncom is* generally prepared using the fungus
    a) *Rhizopus oligosporus.*
    b) *Neurospora intermedia.*
    c) *Aspergillus niger.*
    d) none of the above.

63. The *oncom* is a favourite dish in
    a) USA.
    b) Indonesia.
    c) India.
    d) Malawi.

64. The groundnut *tofu* (curd) is popular in
    a) India.
    b) Malawi.
    c) China and Japan.
    d) USA.

65. The addition of defatted groundnut flour to *kisra* increases the
    a) keeping quality.
    b) in vitro digestibility.
    c) flavor.
    d) taste.

66. The protein content in groundnut hull ranges from
    a) 8-15%.
    b) 1-3%.
    c) 9-17%.
    d) 15-20%.

67. The fiber content in groundnut hull is about
    a) 10%.
    b) 20%.
    c) 50%.
    d) 60%.

Correct responses to the questions.

1.d); 2.d); 3. b); 4. d); 5. a); 6. c); 7.b); 8. a); 9. c); 10. c); 11. c); 12. d); 13. b); 14. a); 15. d); 16. a); 17. b); 18. c); 19. d); 20. a); 21. b); 22. c); 23. c); 24. b); 25. b); 26. b); 27. c); 28. c); 29. c); 30. b); 31. d); 32. b); 33. b); 34. d); 35. c); 36. b); 37. c); 38. d); 39. c); 40. d); 41. b); 42. c); 43. d); 44. b); 45. a); 46. c); 47. d); 48. a); 49. b); 50. c); 51. d); 52. c); 53. c); 54. a); 55. b); 56. a); 57. b); 58. b); 59. b); 60. c); 61. b); 62. b); 63. b); 64. c); 65. b); 66. a); 67. d).