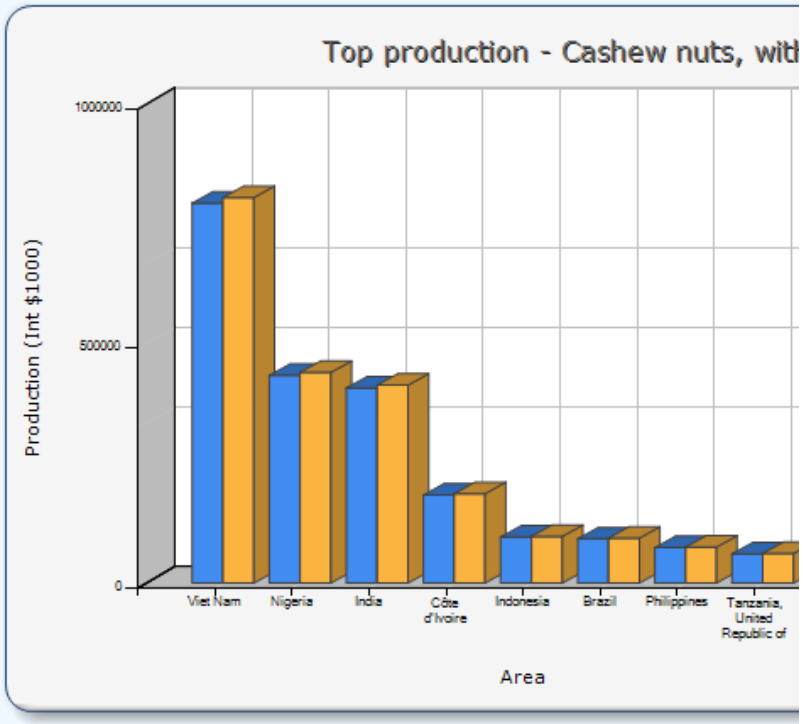
http://faostat.fao.org/site/339/default.aspx

This page presents the 20 highest producing countries of a specific food and agricultural commodity for the year indicated. CASHEW NUT

When applicable International commodity prices are used, to calculate the total value of each commodity produced by each country and subsequently used in the ranking of commodities and countries. They are applied in order to avoid the use of exchange rates for obtaining continental and world aggregates, and also to improve and facilitate international comparative analysis of productivity at the national level.



Rank	Area	Production (Int $1000)	Flag	Production (MT)	Flag
1	Viet Nam	793429		1207600	
2	Nigeria	433639		660000	F
3	India	407358		620000	
4	Côte d'Ivoire	183968		280000	
5	Indonesia	96023		146148	
6	Brazil	92427		140675	
7	Philippines	73953		112558	
8	Tanzania, United Republic of	60840		92600	
9	Guinea-Bissau	53219		81000	F

10	Mozambique	48879	74395	
11	Benin	39421	60000	F
12	Thailand	15768	24000	F
13	Ghana	11169	17000	F
14	Malaysia	8541	13000	*
15	Kenya	6570	10000	F
16	Sri Lanka	4632	7050	
17	Madagascar	4270	6500	F
18	Senegal	3285	5000	F
19	Burkina Faso	2365	3600	F
20	Mexico	1969	2998	

Small-scale cashew nut processing

http://www.fao.org/AG/ags/agsi/Cashew/Cashew.htm

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CHAPTER 1

INTRODUCTION

The cashew tree, native to Brazil, was introduced to Mozambique and then India in the sixteenth century by the Portuguese, as a means of controlling coastal erosion. It was spread within these countries with the aid of elephants that ate the bright cashew fruit along with the attached nut. The nut was too hard to digest and was later expelled with the droppings. It was not until the nineteenth century that plantations were developed and the tree then spread to a number of other countries in Africa, Asia and Latin America.

Cashew processing, using manual techniques, was started in India in the first half of the twentieth century. It was exported from there to the wealthy western markets, particularly the United States. In the 1960s, some of the producing countries in East Africa began to process nuts domestically rather than sending them to India for processing. This allowed them to benefit from the sale of both processed nuts and the extracted cashew nut shell liquid.

1.1 The importance of cashew

Cashew is held with great esteem in many customs and cultures. Its value can be estimated from a question that appeared on the household census in Mozambique that asked whether the house owned any cashew trees.

Cashew is known by many names. In Mozambique, the Maconde tribe refer to it as the "Devil's Nut". It is offered at wedding ceremonies as a token of fertility and is considered by

many to have aphrodisiac properties. The cashew tree and its products are known by the following names in other parts of the world:

Portuguese caju, cajueiro, pe de caju, castanha de caju, maca de caju
French cajou, acajou, ancardier, noix de cajou, pomme de cajou, amande de cajou
English cashew, cashew tree, cashew nut, cashew apple, cashew kernel
Spanish maranon, nuez de maranon
Hindi cadju
Sinhalese cadju
Italian anacardio, noce d'anacardio, mandorlad'anacardio
Dutch acajou, kashu
German acajuban, kashunuss
Swahili mkanju, korosho
Somali bibbo, bibs
Indonesian jambu mente, jambu mete

Source: Andrighetti *et al*, (1989).

The cashew industry ranks third in the world production of edible nuts with world production in 2000 at about 2 million tonnes of nuts-in-shell and an estimated value in excess of US$2 billion. India and Brazil are the major cashew exporters, with 60 percent and 31 percent respectively of world market share. The major importers are the United States (55 percent), the Netherlands (ten percent), Germany (seven percent), Japan (five percent) and the United Kingdom (five percent).

Cashew kernels are ranked as either the second or third most expensive nut traded in the United States. Macadamia nuts are priced higher and pecan nuts can be more costly, if the harvest is poor. Cashew nuts have a well established market in the United States with a great variety of uses. Retail prices range from about US$4 to 11 per pound (US$9 to 23 per kg) depending on the size of nut and the packaging.

The extensive market connections of exporters from Brazil and India make it difficult for the smaller exporters to make gains in the United States market. Importers may appreciate the low prices offered by small suppliers, but the lack of reliability in quality tends to make them favour the larger, more reputable suppliers (The Clipper, 1994).

1.2 Cashew products

Three main cashew products are traded on the international market: raw nuts, cashew kernels and cashew nut shell liquid (CNSL). A fourth product, the cashew apple is generally processed and consumed locally.

The raw cashew nut is the main commercial product of the cashew tree, though yields of the cashew apple are eight to ten times the weight of the raw nuts. Raw nuts are either exported or processed prior to export. Processing of the raw nuts releases the by-product CNSL that has industrial and medicinal applications. The skin of the nut is high in tannins and can be recovered and used in the tanning of hides. The fruit of the cashew tree that surrounds the kernel can be made into a juice with a high vitamin C content and fermented to give a high proof spirit.

1.2.1 Cashew kernels

It is estimated that 60 percent of cashew kernels are consumed in the form of snacks while the remaining 40 percent are included in confectionery. The cashew competes in the same market as other edible nuts including almonds, hazels, walnuts, pecans, macadamias, pistachios and peanuts. There has recently been a considerable rise in demand for edible nuts by consumers interested in quality and health aspects of food. The breakfast cereal, health food, salads and baked goods markets are all expanding markets for cashew nuts.

One major factor that affects the consumption of cashew kernels in world markets is competition from other tree nuts. The major importers in developed countries contract their requirement for the whole year based on the sales from previous years. If prices of a commodity fluctuate over a wide range, they will not want to trade in that item for fear of incurring heavy losses. Since cashew cultivation is not organized on a plantation scale in most producing countries, year to year variation in crop yield is a regular feature resulting in wide price fluctuations for cashew kernels. On the other hand, almonds and pistachios are grown in very large plantations in the United States and thus their prices are steady year after year (Nayar, 1995).

1.2.2 Cashew nut shell liquid

Cashew nut processing allows for the development of an important by-product, which can increase its added value. The liquid inside the shell (CNSL) represents 15 percent of the gross weight and has some attractive possible medicinal and industrial uses. CNSL is one of the few natural resins that is highly heat resistant and is used in braking systems and in paint manufacture. It contains a compound known as *anacardium*, which is used to treat dermatological disorders. The main markets for CNSL are the United States, the European Union (mainly the United Kingdom), Japan and the Republic of Korea. Together these account for over ninety percent of world trade, most of which is supplied by India and Brazil.

1.3 Processing

Traditionally the various processing operations were performed manually by experienced semi-skilled workers. This is still the case in India, which is the world' s largest producer of cashew kernels. Since the 1960s, various mechanized pieces of equipment have been developed and are available in several countries. The processes that have been mechanized are roasting, cashew nut shell liquid extraction and shelling. For the most part, the cleaning of raw materials and sizing and kernel grading have remained labour intensive manual operations.

There are significant differences in investment requirements, labour skills, health requirements and levels of efficiency between the Indian manual technology and the medium to large-scale mechanical and semi-mechanical operations. In general the Indian processing system involves lower investment and variable costs and achieves far greater efficiency in terms of kernel material yield and the proportion of whole kernels extracted. However this

system requires large numbers of experienced workers who work at unhealthy levels of exposure to CNSL. The mechanized systems are more vulnerable to breakdown due to shortage of spare parts, require large volumes of nuts for efficient operation and operate well below manufacture specifications when strict grading and sizing activities are not in place prior to shelling (Jaffee and Morton, 1995).

1.4 Opportunities for small-scale processors

Cashew processing is a very competitive but also a potentially lucrative activity that can and should be exploited by more small-scale processors. African countries that are in the process of re-building their local cashew processing industry would be well advised to follow the Indian example of small scale, mainly manual processing operations.

There are several good reasons why small-scale producers and processors should get involved in cashew processing, including the following:

- Cashew kernels are a high value luxury commodity with sales growing steadily at an annual rate of seven percent, with every expectation that the market will remain strong.
- There is substantial potential to exploit cashew by-products, such as cashew butter, from broken nuts, CNSL for industrial and medicinal purposes and the juice of the cashew apple that can be processed further.
- Cashew is a good crop for smallholder farmers. In Mozambique cashew is considered by smallholder farmers to be one of their most lucrative crops. It requires few inputs and harvesting does not coincide with peak labour demands for other food crops (Hanlon, 2000).

Thus cashew has the potential to increase the incomes of poor producers, to create employment opportunities during harvesting and processing and to increase exports.

However, as with all small-scale processing operations, cashew processing is not without risk or problems. In order for the small-scale processor to succeed, there are certain constraints, which also need to be considered:

- Cashew production is very weather dependent so supply is variable. World prices, although stable on average, are highly volatile in the short term.
- Luxury goods must be of high quality. In order to compete directly in the world market, a high level of standards, branding and marketing are required.
- Exploitation of by-products requires new technology, which may be expensive or difficult to obtain.
- Production volumes must be sufficient to ensure a consistent supply of raw material.

These constraints are not, however, insurmountable. With good committed support from local governments, introduction of policies that favour rather than hinder the small-scale entrepreneur and back-up from relevant development organizations, cashew processing can be an attractive and viable option for the small-scale processor.

1.5 The way ahead

Small-scale producers and processors need to establish more direct relationships with the European food industry, which packs and markets cashew nuts. At the moment, the world purchasing circuits are dominated by middlemen, brokers and wholesalers who control prices, quality requirements and the volumes sold (Partnership, 1995). Development organizations can be instrumental in bridging the gap between the small-scale processor and the buyer, thus helping the former to succeed. They can offer a range of support services, including the following:

- training in quality assurance and control,
- providing information on available equipment and machinery,
- advice on standards and export legislation,
- providing information on packaging,
- providing access to packaging materials and suppliers,
- advice on marketing.

One area that deserves special attention is the development of value-added products for export. Most exports are in the form of plain kernels in bulk, which are imported by large wholesalers in the consuming countries. These are then re-packaged, either as they are, or after roasting and salting and sold to retailers. Opportunities exist for processors to penetrate these markets, however, they are fraught with difficulties, such as pricing and competition from existing products. The key to opening up new markets or expanding the existing ones is to supply the best quality products at competitive and steady prices. Particular attention to providing goods of consistently high quality is vital and cannot be over-stressed. This requires inputs from various stakeholders in the food processing chain and is a service that can be provided by government and non government organizations interested in supporting the small-scale food processor.

This bulletin gives a general overview of cashew production, with a detailed section on cashew processing. It is suitable for smallholder farmers, small-scale processors and development professionals who wish to support development of the cashew processing sector. Considerable emphasis is placed on processing operations, particularly for the small and medium-scale processor. This bulletin also contains a comprehensive list of organizations and resource persons involved in cashew processing and a selection of suppliers and manufacturers of cashew processing equipment. The bibliography section contains an assortment of relevant literature that the reader should find interesting and useful.

CHAPTER 2

CASHEW PRODUCTION

2.1 Botanical characteristics

The cashew tree, *Anacardium occidentale L.*, belongs to the *Anacardiaceae* family of plants, which also includes the mango, the pistachio and the poison ivy. The tree is native to Brazil, but has spread to other parts of tropical South and Central America, Mexico and the West Indies. In the 1600s, Portuguese traders introduced the cashew tree into India and Africa to prevent soil erosion. It is now widely cultivated for its nuts and other products in the coastal regions of South Africa, Madagascar and Tanzania and in South Asia, from Sri Lanka to the Philippines.

The cashew tree is a tropical evergreen, resistant to drought, unexacting as to soil (although it prefers deep, sandy soil), which grows up to 12 metres high and has a symmetrical spread of up to approximately 25 metres. It has leathery oval leaves. Reddish flowers grow in clusters and the pear-shaped fruits, referred to as cashew apples, are red or yellowish in colour. At the end of each fruit is a kidney-shaped ovary, the nut, with a hard double shell (Figure 1). Between the shell and nut is black caustic oil, which is difficult to remove and can be used in varnishes and plastics.

The cashew tree grows with a minimum of attention and is easily cultivated. It is usually found from sea level to an altitude of 1 000 metres (3 000 feet), in regions with annual rainfall as low as 500 mm (20 inches) and as high as 3 750 mm (150 inches). For maximum productivity, good soil and adequate moisture are essential. Optimum conditions include an annual rainfall of at least 889 mm (35 inches) and not more than 3 048 mm (120 inches). The tree has an extensive root system, which helps it to tolerate a wide range of moisture levels and soil types, but commercial production is only advisable in well-drained, sandy loam or red soils. The cashew tree can flourish in the sand of open beaches, but it grows poorly in heavy clay or limestone.

Most cashew trees start bearing fruit in the third or fourth year and are likely to reach their mature yield by the seventh year if conditions are favourable. The average yield of nuts of a mature tree is in the range of 7 to 11 kg per annum. Although the cashew tree is capable of living for 50 to 60 years, most trees produce nuts for about 15 to 20 years.

2.1.1 Varieties

Cashew seedlings present great variation in growth habit, quality of crop and yield. The tree cross-pollinates freely and this has further contributed to high variability although there are as yet very few named varieties of cashew trees. Generally a distinction is made only between those with yellow or red cashew apples. Tests have indicated that very large nuts usually have inferior kernels, low density and slow germination (Caribbean Technological Consultancy Services Network, 1993).

2.2 Agricultural practices, propagation and culture

2.2.3 Sowing

The cashew tree is usually grown from seeds placed directly in the field, since seedlings do not transplant well due to their delicate root system. Seed nuts should be thoroughly dry, clean and free from insect or fungal attack. Seeds should be stored until the next rainy season before

they are planted in the field, unless irrigation facilities are available, or seedlings are raised in polythene bags in a nursery where water is available. After a few months, stored nuts gradually lose their germination capacity.

Seeds should be water tested prior to planting those that sink should be chosen as they have a high success rate and tend to germinate quickly. Seeds should be planted at a depth of about 5 cm. The maximum depth at which a seed should be sown is about 10 cm, depending on the soil conditions. Two or three seeds should be planted together, stem end up, at a slight incline and covered with 5 to 8 cm of soil. Germination usually takes place in 15 to 20 days, although seeds of low density (i.e. those that float in water) may require as long as eight weeks to germinate. Using seeds of high density, from selected trees, considerably increases the chance that some of the seeds at one site will perform well. Two months after sprouting, the two weakest seedlings should be removed from the site, leaving only the strongest one to grow. By planting more than one seed, the occurrence of gaps in a plantation is reduced (Ohler, 1979).

In orchard practice, pits measuring from 30 cm × 30 cm × 30 cm to 60 cm × 60 cm × 60 cm are dug and left to weather for a month or two. They are then filled with soil, which has been mixed with rotting manure about two weeks before seeding. In loose soils of sufficient fertility, the root system of the seedlings develops so quickly that, when growing naturally, root lengths would exceed the size of the planting hole within a few months and therefore in optimum growing conditions planting holes are not essential.

Advantages of sowing

- The plant can develop its root system and especially its root tap quickly.
- It is the cheapest method of planting.
- It is the quickest method of planting as one person can plant 400 to 500 sites each day.

Disadvantages of sowing

- Lower rate of germination.
- Danger of serious damage by animals.
- Less opportunity for selection of seedlings than when planting seedlings that are raised in plastic bags in the nursery.

2.2.4 Seasonal planting

Cashew seeds should be sown or planted during the rainy season in areas that lack irrigation facilities. The best time for planting is during periods of regular rainfall, so that the soil does not dry out again. If the soil dries out before the germinated seeds have become securely rooted, they may die. The advantage of early planting is that it gives the seedlings more time to develop before the onset of the dry season.

In climates with irregular rainfall and short rainy seasons, the risk of germinated seedlings drying out can be reduced by pre-soaking the seeds before planting, deep sowing (5 to 10 cm) and covering the site with mulching material to reduce evaporation. The mulching material should be carefully selected and any weeds with mature seeds should be removed.

2.2.5 Raising seedlings in a nursery

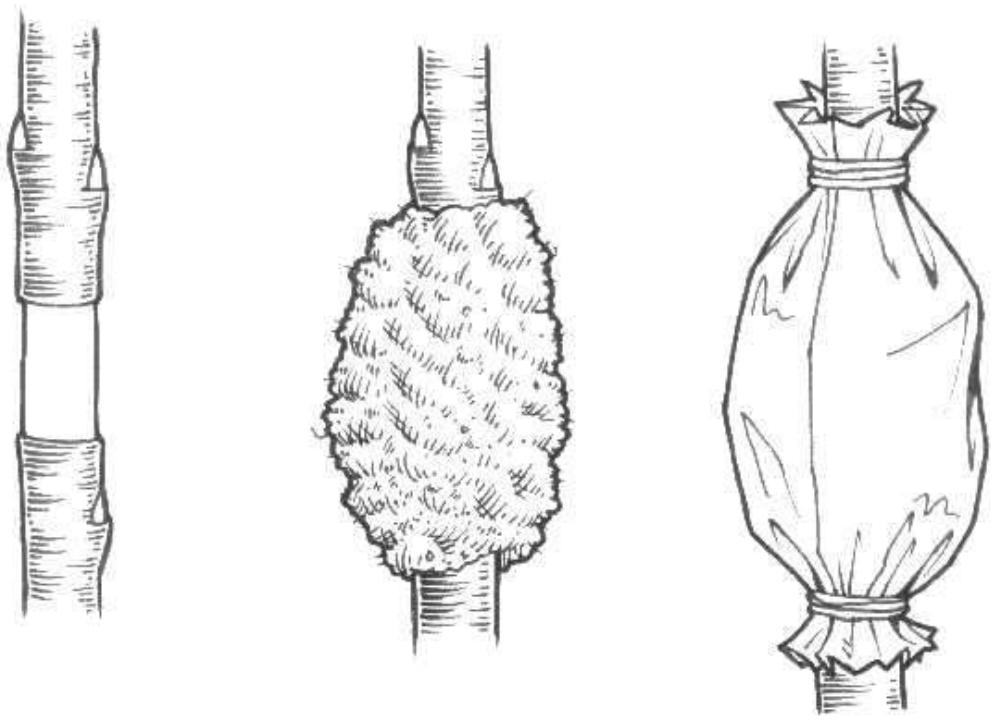
Where it is necessary to raise seedlings in a nursery, the seeds should be sown in containers of a type that can be set in the ground and readily disintegrate. In Cuba, baskets of uva-grass or *cona brava* are used and cut away before setting the plant into the ground. In Jamaica, it has been found that nursery seedlings can be raised in the ground and transplanted with 90 percent success, providing the plant is taken up with a good ball of soil and the top is cut back by one third, when it is put into the field. It is recommended that the seedlings be transplanted within a week of emerging, to ensure that the transplantation is successful (Caribbean Technological Consultancy Services Network, 1993).

Seedlings can also be planted using plastic bags as containers. The seedlings should be lifted into their planting holes in the plastic bags, which are then carefully slit with a sharp knife and removed.

2.2.6 Layering

Ground layering

The lowest branches of the cashew tree tend to trail on the ground at a distance of several metres from the trunk. Where branches touch the ground, spontaneous rooting may occur. Covering such branches with soil and keeping the area moist encourages rooting, a method which has been used in India for a long time. However, such layers cannot be easily transplanted to other places and the shape of the material tends to produce low trees of spreading habit. The number of layers that can be obtained in this way is also rather low.



The stem is girdled to induce root formation above the cut.

The girdled stem is covered with damp moss.

Aluminium foil or plastic sheeting is wrapped around the moss and tied at both ends. This cover is removed 2 to 3 months after tying or when the roots can be seen.

Figure 1: Air-layering.

Air-layering

A strip of bark about 0.5 cm wide is removed from either a year-old branch or a pencil-thick shoot (about 1 cm diameter) of the current season, at about 20 to 30 cm from the growing point. The exposed wood is wrapped with twine to prevent the bark from growing over it during the healing process and covered thickly with moist moss, wood shavings or sand. It is then wrapped securely in a sheet of 100 to 150-gauge plastic and the ends are tied tightly to the branch with twine (Figure 1).

After 20 to 30 days, callus is formed at the foot of the layer and 40 to 50 days later, small roots emerge from the callus tissue. After approximately 75 days, there should be adequate root formation (five or more well formed roots measuring 1.0 to 1.5 cm long) to separate the twig from the tree. The part of the twig below the layer is cut about halfway through. One week later, the cut is deepened and a few days later the layer can be removed and transplanted into plastic bags or other containers and hardened off before planting. If the layer is separated from the tree in one cut, the shock will be too great for it to survive.

The whole process takes about two and a half months, although the time varies depending upon the period of the year when the layer is being prepared. Layers that are produced early in

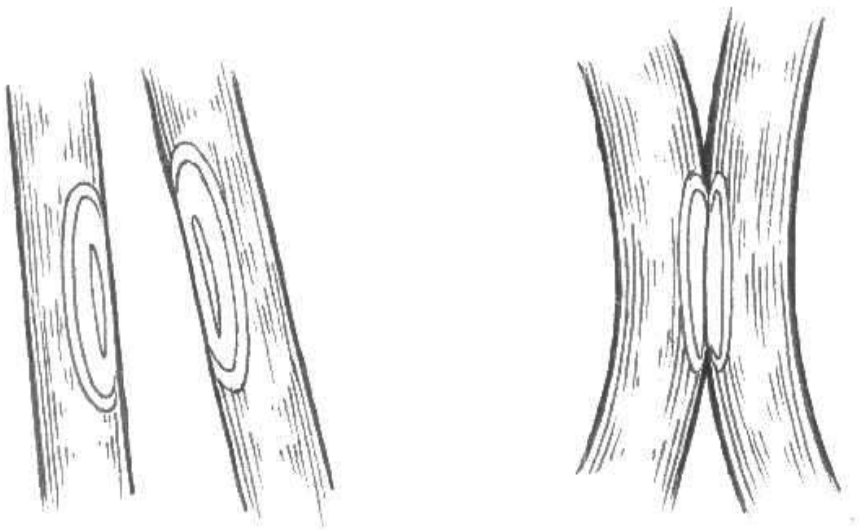
the rainy season have time to establish themselves and develop a large enough root system to survive the dry season.

Air-layering has been one of the most successful methods of vegetative propagation in cashew. The method is rather laborious and the cost is relatively high, but the advantages of obtaining a plantation from high yielding, uniform material make these costs extremely worthwhile. A large disadvantage of this method, as with all methods of layering, is the relatively small number of layers that can be produced by one tree per year. It is estimated that from one tree, 80 to 120 successful layers can be obtained. In order to obtain sufficient material for a fairly large plantation, the first generation of air layers should be grown to maturity and only then, from many trees of the same quality, could sufficient material be obtained for later plantings.

2.2.7 Approach-grafting or inarching

The technique of approach-grafting is relatively easy but labour intensive and like air-layering has to be done in the field. Seedlings to be grown as rootstocks are raised in containers. Once they are 8 to 9 months old, they are cut back to half their height and kept in grass baskets for a month in the shade until new shoots appear. The basket is replaced by a sheet of 100-gauge plastic to retain moisture and the seedling is joined to a year old branch of the same diameter on a selected tree as described below.

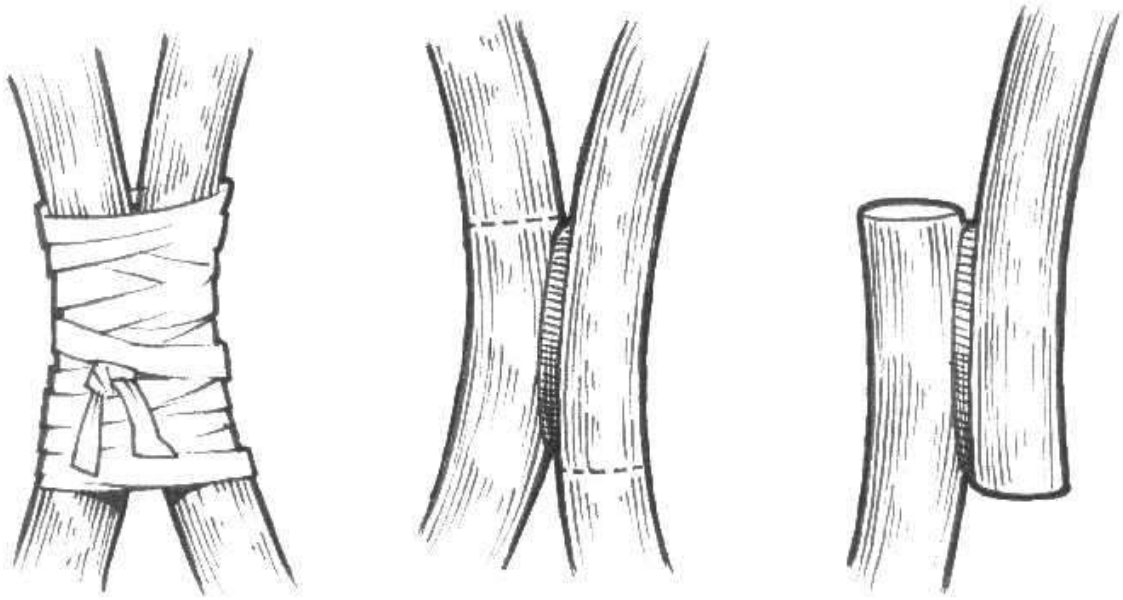
From the stem of the seedling and from the shoot with which it will be united, strips of bark and inner wood, measuring about 5 to 8 cm in length, are removed (Figure 2). Both cut surfaces, which should be of the same size, are bound together with twine and the join is firmly tied with string, binding the seedling stem and the shoot together. In 90 days the union should be complete and the grafted plant is gradually separated from the parent (Figure 3). A "v" cut is made half way through the branch 2 cm below the graft and a similar cut is made in the rootstock 2 cm above the graft. Seven or eight days later the cuts are deepened and after a further period of four days the severing is completed. About 60 percent take is expected.



Two independent plants with stems approximately the same size. For example, seedling plants in containers and established plants.

Identical slices of wood and bark (2.5 to 5 cm long) are cut from both stems. The stems are placed closely together.

Figure 2: Inarching.



The stems are bound tightly together with string, tape or raffia.

After graft union heals, the stock plant is cut above the union and the scion is cut below the union.

Figure 3: Inarching.

2.3 Land preparation

Cashew seedlings are very sensitive to competition with weeds, but in many areas, especially on sloping land, the vegetation should not be removed completely before planting because of the danger of water and wind erosion. In tropical countries with a marked dry season and where the rainy season tends to start with torrential rains, the danger of erosion increases if large areas of land have been cleared.

If the soil is very sandy and subject to strong winds, clearing the land may result in severe wind erosion, which is virtually impossible to stop. In these areas, the land should be cleared in strips, which are perpendicular to the direction of the prevailing winds. Once the cashew trees have developed to such an extent that their rows act as wind breaks, the remaining land

can be cleared. Another important reason for leaving strips of natural vegetation is to ensure that the insect population required for pollinating the cashew flowers is maintained.

The removal of tree stumps is an expensive but essential part of the clearing process. The sprouting stumps need to be slashed each year as they compete with the cashew trees and prevent a good view between the rows.

2.4 Spacing

To promote maximum development and reduce competition for available moisture, it is recommended that the seedlings be planted 10 to 15 metres apart. This is considered to be the most productive spacing for mature trees. The average yield per hectare will be 700 to 1 000 kg but yields outside these limits are encountered. However, cashew trees are normally planted more closely, which results in overcrowding and they are often intermixed with other trees either in small orchards or in the wild.

2.5 Fertilizer use in cashew

Cashew is often grown as a casual crop by smallholder farmers and as a result its fertilizer requirements are overlooked. Also the trees are long standing and are frequently grown in soils that are of poor quality. As each season passes, the soils become more depleted and productivity gradually declines. Yields of trees grown in this way are very much lower than the potential that could be gained if fertilizer was applied.

Experiments have demonstrated that regular application of the major plant nutrients (nitrogen, potassium and phosphorus) is beneficial for healthy trees and increased cashew yields. In addition, application of magnesium to cashew is beneficial (Fernandopulle, 2000). Two separate mixtures of fertilizer, based on the combination of nitrogen (N), phosphorus (P) and potassium (K), have been recommended according to the growth stage of the plant.

Young plant mixture

This mixture is recommended for cashew plants from field planting up to 5 years of age. It contains N:P:K in the ratio of 4:3:2.

For 100 kg of young plant fertilizer, the following is used:

Compound	**weight (kg)**
Urea	38
Rock phosphate	47
Muriate of potash	15

Adult plant mixture

This mixture is recommended for cashew plants from 5 years onwards. It contains N:P:K in the ratio of 4:3:4.

For 100 kg of adult plant fertilizer, the following is used:

Compound	**weight (kg)**
Urea	33.5
Rock phosphate	41
Muriate of potash	25.5

2.5.1 Basal dressing at planting

Each planting hole should be filled with topsoil mixed with young plant mixture and dolomite and if possible with organic matter. In a hole that measures 60 cm × 60 cm × 60 cm, 250 kg young plant mixture and 300 kg Dolomite are required, plus 1 to 2 kg organic manure. The soil is removed from the hole and mixed with the chemical fertilizer. The hole is then re-filled with the mixture of soil and fertilizer. This should take place before the rains to allow the soil and fertilizer time to settle before the seedlings are planted. If the seedlings are planted directly into the fertilizer, the tender roots may be damaged. To avoid damage, the seedlings should be planted at the beginning of the monsoon or four to six days after refilling the hole.

2.5.2 Rate of application of fertilizer

During the early stages of growth, it is better if the amount is split and applied in two separate doses at the end of each season, to avoid the heavy rains.

Time after transplant (years)	**Young plant mixture (g/plant/year)**
1	200
2	350
3	500
4	650
5	800

After five years of age, the rate of application of adult mixture varies with the plant yield.

Average yield/plant (kg/plant/year)	**Adult plant mixture (kg/plant/year)**
<10	1
10 to 15	1.5
15 to 20	2.0

>20	2.5

2.5.3 Method of fertilizer application

Fertilizer should only be applied after weeding and cleaning the base of the individual trees within a 1 to 2 metre radius, to avoid the competition for nutrients from weeds. In the early years (up to 1.5 year), fertilizer should be broadcast close to the plant, covering an entire full circle up to a distance of 0.5 m from the base of the plant. The fertilizer should be lightly mixed with the soil. As the plant grows older, the area should be gradually extended to reach 1.0 m. Mulching the fertilized area is encouraged as it is beneficial. With adult plants, the fertilizer should be broadcast in a circular strip (1 to 1.5 m wide) and about 0.5 to 1.0 m away from the base of the tree. The fertilizer should be lightly mixed with the soil.

2.5.4 Frequency and timing of application

Fertilizer should be applied to young plants twice a year at the end of each monsoon rain. It is applied to adult plants annually at the end of the monsoon rains and before flowering. The fertilizer should be applied when the soil is moist, at the end of the monsoon season so as to avoid the heavy rains. Application of fertilizer during the dry season is not advisable as the nutrients require water to be dissolved and absorbed by the roots.

2.6 Diseases

Cashew seedlings can be affected by a number of different diseases. The fungus, *Colletotrichum glocosporioides,* is one of the most common pathogens in cashew (Ohler, 1979). Initial symptoms show the development of reddish-brown, shiny, water-soaked lesions, followed by resin oozing out onto the affected parts. As the lesions grow, the affected shoots and inflorescences are killed and the leaves become crumpled. The affected nuts and apples decay and shrivel and the flowers turn black and fall off. The trees can be sprayed with various fungicides, including Bordeaux mixture, to control the fungus.

Several diseases that result in the terminal twigs dying off are grouped under the name "die-back" or "pink disease" which is produced by *Glocosporium*. There may be associated pitting of the surface of the nut. This serious disease requires the affected branches to be pruned and sprayed with a 1 percent Bordeaux mixture or other copper-based fungicides.

Characteristic symptoms of other infections which attack cashew include wilting and withering; the yellowing of the lower leaves; the seedlings turning pale and showing water-soaked girdles of darkened tissue around the stems; or the rotting of the underground portion of the stem. Powdery mildew may appear on young leaves and inflorescences during dry weather.

2.7 Pests

Insect pests are a major source of crop loss in all cashew-growing areas of the world. More than 60 species of insects attack the crop during its different stages of growth. These pests include sap-sucking bugs, leaf-chewing caterpillars, beetles, aphids, scales, thrips and some mites. They can cause considerable damage to the tree and the crop by bringing about the death of the floral-flushing shoots, the early abortion of young nuts and loss of yield.

The adult weevil, or borer, is dark grey in colour and about 2 cm long. The larva has a curled whitish body with wrinkled skin and dark brown head. The eggs are laid singly in small holes made by the female in the bark of the trunk or the main branches of the cashew tree. After hatching, the larvae tunnel down just beneath the bark, eating the sapwood. The grubs should be removed as soon as they are detected because they cause gum leakage and will eventually kill the tree. To control the borer, all heavily-infested trees should be cut down and the bark should be cut away in places that show signs of weevil attack. Once the wood has dried out sufficiently, it should be burned, to kill all the remaining larvae and eggs. Alternatively, the base of the tree can be sprayed with Malathion and the bore holes filled with the spray.

The tea mosquito bug (*Helopeltis antonii* Sign.) is a common pest found in Sri Lanka, causing up to 30 percent loss of yield. The adults and nymphs of the species feed on tender shoots and floral branches, as well as on the developing nuts and apples, by piercing and sucking the sap (Ranaweera, 2000). *Helopeltis* populations increase during the rainy season, reaching a maximum at the end of the rainy season and the beginning of the dry season. This coincides with the emergence of a new flush. Insecticide application should be started when the new flush emerges. The damage caused by *Helopeltis* is of two types. Primary damage, which is seen as brown lesions surrounding the feeding punctures, causes affected leaves and young shoots to turn brown, wither and die. Secondary damage occurs when the puncture holes are infected by secondary pathogens and the whole stem or branch dies back or is affected by blight.

Helopeltis can be controlled by chemical spray. Three applications of a 0.1 percent mixture of Carbaryl are recommended at flushing, onset of flowering and the fruiting season. However, Carbaryl is indiscriminate and will kill other beneficial insects. Special attention must be paid to the second spray at the onset of flowering, to minimize the effect of insecticide on pollinators. The optimum time to spray is between 0600 hours and 0800 hours and again between 1600 hours and 1900 hours, when the *Helopeltis* bug is active.

A copper fungicide or Bordeaux mixture (1 percent) can be used to control inflorescence die-back, which may occur. *Helopeltis* damage can be limited by careful cultural practices. The plantation should be kept weed-free to remove alternative hosts of the bug. Removal of non-productive and diseased branches from the trees allows for improved air circulation and solar radiation within the crop canopy and can then reduce the humidity of the canopy. This in turn can reduce the damage caused by the pest.

Thrips are known in many countries to attack cashew leaves, causing a symptom called "silvery leaves". They suck the leaf juices and leave a "scorched" area. Heavy attacks will stunt the growth of young plants but can be controlled by spraying with a 0.05 percent solution of Malathion.

The caterpillar of the leaf miner attacks young plants by tunnelling through new leaf tissues. The first signs are winding trails on the leaves. Later the infestation shows as patches of white

blisters. The adult is a tiny, silvery-grey moth. The larvae appear red when they are fully-grown and are about 6 mm long. Affected trees should be sprayed with a 0.06 percent solution of "Folidol E.605" (30 ml in 50 litres of water).

A sporadic leaf-eating caterpillar, which has poisonous stinging hairs, sometimes occurs in swarms and defoliates the cashew tree. It pupates in silky cocoons and the adult moth is large and reddish-brown in colour.

The mealy bug attacks the cashew inflorescence but can be controlled by spraying with a 0.06 percent solution of "Folidol E.605" (30 ml in 50 litres of water). Among the other pests are leaf webbers, flea beetles, spider mites and scales.

Rodents, such as rats, squirrels and porcupines, may cause serious damage to cashew seedlings, particularly when they emerge above the ground. Cashew apples are sometimes attacked by fruit flies. Monkeys are partial to ripe apples and can cause damage to the cashew trees whilst foraging for the fruit. Bats and parrots also eat cashew apples.

2.8 Harvesting

The harvesting and processing of cashew is very labour intensive. After producing clusters of flowers, cashews produce the edible apple and also a nut encased in a heavy shell, which is the true cashew fruit. The cashew tree flowers for two or three months and fruit mature about two months after the bloom. The cashew nut forms first at the end of the stem. Subsequently, the stem swells to form the "apple" with the nut attached externally.

The cashew nut is 2.5 to 4.0 cm (1.0 to 1.5 inches) long and kidney shaped. Its shell is about 5 mm thick, with a soft leathery outer skin and a thin hard inner skin. When fully ripe, it falls to the ground. Harvesting generally involves collecting the nuts once they have dropped to the ground after maturing. Workers scour the area and detach the nut from the fruit. For the nuts to be easily traced, the surface under the tree has to be free from weeds. In some places, the whole area under the tree is swept free of dry leaves. The nuts are generally collected in baskets or sacks. Cashew fruit are generally left to fall to the ground before being collected, as this is an indication that the kernel is mature. If fruit are picked from the trees, the cashew apple will be ripe, but the kernel will still be immature.

The quantity of nuts, which can be harvested, depends upon the yield of the trees. Where many nuts fall together, much less time is required for walking in search of them. On average, each individual can harvest a maximum of 50 kg per day. A very limited number of nuts fall at the beginning of the production season. A peak in the number of nuts falling is gradually attained and production slowly declines. Although activities are labour intensive and time consuming, they are not heavy and women and children can help.

In very dry climates where the topsoil remains dry overnight, nuts can be left under the trees for several weeks without their quality being affected. However, where humidity of the air or soil causes moisture and dew formation, the nuts should be reaped at least twice a week. This is not very economical, unless it is carried out on smallholdings with relatively high labour intensity, as there will not be adequate numbers of nuts to harvest sufficient quantities to achieve collection levels of 50 kg per day (Ohler, 1979).

Apples to be used for processing into products such as jam or juices should be picked from the tree before they fall naturally. On falling to the ground, apples may become damaged. Once damaged, the apples may ferment and deteriorate quite rapidly. The riper the apple, the sweeter the taste. It is therefore recommended that the apple be picked as it is about to fall. At this stage the nut is fully-grown for about two weeks and is ripe and ready for harvest.

Apples, which are not within reach of the picker's hands, can be harvested using a small basket or sack attached to a ring at the end of a long stick. Fully ripe apples will drop into the sack when the tree is shaken. Apples that have not matured completely should be cut off with a small knife attached to the stick. The nuts must remain attached to the apple, since some juice may be lost on their removal.

The cashew apple will only keep for 24 hours after it has been picked. Transporting large quantities of apples is difficult for this reason. When stacked in layers, apples may burst and lose their juice because of the weight on top of them.

2.8.1 Drying of the raw material

Cashew nuts are dried in the sun for two reasons:

- To reduce the moisture content of the nut,
- To mature the seed in the infrared and ultra-violet rays of the sun.

Cashew nuts should keep for 12 months or more, provided that they are dried to moisture content of eight percent or below, packed in sealed polythene bags and stored under dry conditions. The moisture content of cashew nuts at harvest is dependent on climatic conditions, moisture content of the soil, on which the nuts have fallen, weed growth density under the tree and the time between nut fall and harvest. High moisture content may cause deterioration of the kernel due to mould or bacterial attack or enzyme action. Drying the nuts immediately after harvesting is essential in preserving their quality, but this process is often neglected.

Sun drying of cashew nuts can be done on specially prepared drying floors or mats made of bamboo or palm leaves. The drying areas should be smooth and slightly sloping, so as to allow rainwater to run off. The cashew-nut layer on the drying floor should not be thicker than 10 cm, thus allowing for about 60 kg of nuts per square metre. The nuts should be constantly raked in order to ensure that they all receive the same benefit of the sun's rays and therefore they are dried evenly. The nuts should be heaped together and covered in the evenings. If the nuts are heaped while still warm, they will continue to dry under the cover of a tarpaulin. The nuts should be checked the following morning to ascertain the need for further drying.

Dried nuts should make a rattling sound when falling. Drying may take between one and three days depending upon local climatic conditions. As soon as the nuts are dry, they should be stored and protected from rain.

2.9 Storage

Technical requirements for storage are dependent on weather conditions. As cashew nuts are usually produced in climates with a long dry season, simple buildings with concrete floors and walls and roofs of corrugated metal, should provide adequate storage.

Certain prerequisites must be satisfied to ensure safe storage:

1. a waterproof, dry floor,
2. a firm and secure roof,
3. openings in the wall must be protected in order prevent water from entering the room,
4. headroom must be adequate to allow the bags in a stack to be moved around if large quantities are to be stored,
5. the store should be easily inspected: there must be sufficient clearance between the wall and the bags,to allow individuals to walk around and check the condition of the stack,
6. the stack must be placed on a raised wooden platform, in order to prevent moisture from being drawn from the floor to the nuts.

2.10 Infestation of harvested nuts

Raw cashew nuts, stored in sacks, sometimes in the open awaiting shipment and frequently without protection from rain, are subject to infestation through the stem-end. This may go undetected until damage has progressed to the point of heavy loss. Infestation also occurs in the shelled kernels at various stages of handling.

2.11 Post harvest handling

The nut is encased in a rock hard shell that is virtually impossible to penetrate after harvest. In order to extract the nut, the whole shell is soaked in water, softened by steaming and carefully air-dried to the final moisture content (9 percent). Each nut is hand massaged and cracked via a manual process that entails putting the nut against one sharp blade and bringing another blade, which is on a foot powered lever, through the outer shell. The blade on the foot lever is raised by an enthusiastic stomp allowing the outer shell to separate from the nut. The nut inside is carefully picked out of the outer shell using a nut pick.

CHAPTER 3

USES OF CASHEW

The cashew tree has been cultivated for food and medicine for 400 years. Cashews have served nutritional, medicinal and wartime needs. More recently, they have been used in the

manufacture of adhesives, resins and natural insecticides. During World War II, the cashew tree became highly prized as the source of valuable oil drawn from the shell.

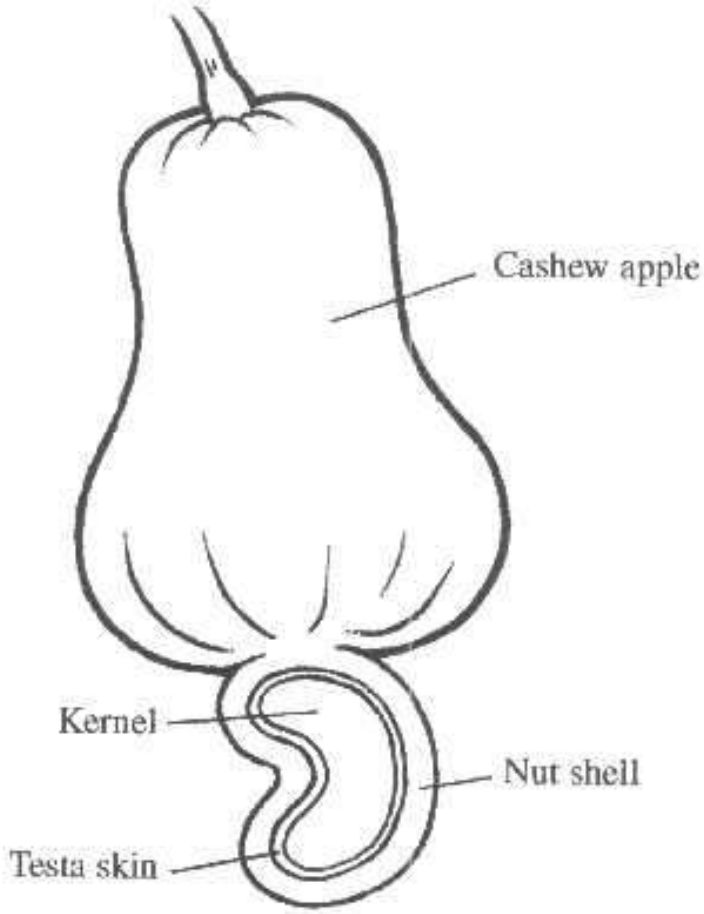


Figure 4: Cross section of a cashew fruit.

The cashew kernel is a rich source of fat (46 percent) and protein (18 percent) and is a good source of calcium, phosphorus and iron. It has a high percentage of polyunsaturated fatty acids, in particular, the essential fatty acid linoleic acid. The tart apple is a source of vitamin C, calcium and iron. The bark, leaves, gum and shell are all used in medicinal applications. The leaves and bark are commonly used to relieve toothache and sore gums and the boiled water extract of the leaf or bark is used as a mouthwash. A paste of bark ground in water is used in topical applications for the cure of ringworm; in this form it can however act as an irritant and should not be applied to sensitive skin or to children. The root has been used as a purgative. Fibres from the leaves can be used to strengthen fishing lines and nets and as folk remedies for calcium deficiency and intestinal colic, as well as a vitamin supplement. The water-resistant wood is used for boats and ferries, while the resin, in addition to having industrial uses, is used as an expectorant, cough remedy and insect repellent.

3.1 Uses of cashew nut

The cashew nut kernel is constituted of three different portions namely the shell, the kernel and the adhering testa (Figure 4). The primary product of cashew nuts is the kernel, which is the edible portion of the nut and is consumed in three ways:

- directly by the consumer,
- as roasted and salted nuts,
- in confectionery and bakery products, for example, finely chopped kernels are used in the production of sweets, ice creams, cakes and chocolates, both at home and industrially and as paste to spread on bread.

The relative importance of these uses varies from year to year and country to country, but it is estimated that at least 60 percent of cashew kernels are consumed as salted nuts. Separately packed cashew nuts are a good selling line, mainly as an appetizer to cocktail drinks. Salted cashews are part of the snack food market. They compete mainly with other nuts, although chips, salted popcorn and other savoury snacks can impinge on the nut market. The price of cashew nuts is much higher than the price of peanuts or other snacks so those sales must be based on a strong taste preference by the consumer. Cashew nuts are generally considered a luxury product and an element of their appeal may lie in this status.

3.2 Uses of cashew nut shell liquid (CNSL)

The cashew nut shell contains a viscous and dark liquid, known as cashew nut shell liquid (CNSL), which is extremely caustic. It is contained in the thin honeycomb structure between the soft outer skin of the nut and the harder inner shell. The CSNL content of the raw nut varies between 20 and 25 percent.

Cashew nut shell liquid (CNSL) is an important and versatile industrial raw material. There are more than 200 patents for its industrial application, in particular, its use as raw material for phenolic resins and friction powder for the automotive industry (brake linings and clutch disks). In drum-brake lining compounds, cashew resins are used as fillers and may also be used as binders. In disc pads, the role of cashew resin is restricted to the use of friction dust as filler. The advantage of the cashew resins compared with synthetic phenolic resins is that they are more economical and produce a softer material, which gives a quieter braking action (CTCS, 1993).

CNSL is also used in mouldings, acid-resistant paints, foundry resins, varnishes, enamels and black lacquers for decorating vases and as insecticides and fungicides. In tropical medicine, CNSL has been used in treating leprosy, elephantiasis, psoriasis, ringworm, warts and corns.

Like cashew nuts, CNSL also has an excellent international market and its imports have reached almost US$10 million annually, corresponding to the sale of the raw liquid. However, the exporting country would earn much more foreign currency if manufactured products were exported.

After extracting the CNSL, the cashew nut shells can be burned to provide heat for the decorticating operation or can be used in the manufacture of agglomerates. Together with the

testa, it may be used either in the manufacture of dyestuff or to provide durability to hammocks and fishing lines.

3.3 Uses of cashew apple

In cashew-producing countries, the nut is only one of the products enjoyed by the local populations. The cashew "apple" or false fruit is an edible food rich in vitamin C. It can be dried, canned as a preserve or eaten fresh from the tree. It can also be squeezed for fresh juice, which can then be fermented into cashew wine, which is a very popular drink in West Africa. In parts of India, it is used to distil cashew liquor referred to as *feni*. In some parts of South America, local inhabitants regard the apple, rather than the nut kernel, as a delicacy. In Brazil, the apple is used to manufacture jams and soft and alcoholic drinks.

The cashew tree bears a false fruit known as the cashew apple from which the nut protrudes. The cashew apple is between three and five inches long and has a smooth, shiny skin that turns from green to bright red, orange or yellow in colour as it matures. It has a pulpy, juicy structure, with a pleasant but strong astringent flavour.

The cashew apple is very rich in vitamin C (262 mg/100 ml of juice) and contains five times more vitamin C than an orange. A glass of cashew apple juice meets an adult individual's daily vitamin C (30 mg) requirement. The cashew apple is also rich in sugars and contains considerable amounts of tannins and minerals, mainly calcium, iron and phosphorous. Furthermore, the fruit has medicinal properties. It is used for curing scurvy and diarrhoea and it is effective in preventing cholera. It is applied for the cure of neurological pain and rheumatism. It is also regarded as a first-class source of energy.

Until recently, the potential of cashew apple had not been investigated due to its highly astringent and acrid taste which is believed to originate in the waxy layer of the skin and which causes tongue and throat irritation after eating. Cashew fruit can be made suitable for consumption by removing the undesirable tannins and processing the apples into value-added products, such as juices, syrups, canned fruits, pickles, jams, chutneys, candy and toffee. The recommended methods for removing the astringent properties of the cashew apple include steaming the fruit for five minutes before washing it in cold water, boiling the fruit in salt water for five minutes or adding gelatin solution to the expressed juice.

The fruit should be picked from the tree by hand to avoid bruising the delicate flesh. They are then carefully washed and the nuts are removed for processing. Cashew apples should be processed within two to three hours of picking, since they undergo rapid deterioration when kept for a longer time.

Currently only six percent of cashew apple production is exploited, since the producer only has a guaranteed market for cashew nuts. It is also extremely difficult to use the whole fruit commercially as the apple ripens prior to the nut. The quality of nuts detached from the green fruit, is unacceptable for commercialization.

The ripe apple can be eaten or used for jam making, for the production of fruit juices or for making alcoholic beverages. The development of processing options for the cashew apple has also been limited by its high degree of perishability and consequent difficulties in transportation from growing areas to distant processing plants.

3.3.1 Using cashew apples in recipes

In gathering the fruits and transporting them to be processed, the prime purpose should be to have the fruit arrive in the very best condition possible. Cashew apples should be sorted and only mature, undamaged cashew apples should be selected for use in recipes. These should be washed in clean water prior to use. Recipes for the use of cashew apple are listed in Annex 2.

Cashew wine

Cashew wine is made in many countries throughout Asia and Latin America. It is a light yellow alcoholic drink, with an alcohol content of 6 to 12 percent.

Processing

Cashew apples are cut into slices in order to ensure a rapid rate of juice extraction when they are crushed in the juice press. The fruit juice is sterilized in stainless steel pans at a temperature of 85°C in order to eliminate any wild yeast. The juice is filtered and treated with either sodium or potassium metabisulphite, to destroy or inhibit the growth of undesirable types of micro-organisms such as acetic acid bacteria, wild yeast and moulds.

Wine yeast (*Saccharomyces cerevisiae* - var ellipsoideus) should be added. Once the yeast has been added, the juice is thoroughly stirred and allowed to ferment for about two weeks. The wine is separated from the sediment and clarified by mixing fining agents, such as gelatin, pectin or casein, with the wine. Filtration is carried out with filter-aids such as fullers earth. The filtered wine is transferred to wooden vats.

The wine is pasteurized at 50 to 60°C. The temperature should be controlled, so that it does not rise exceed 70°C, since alcohol vaporizes at a temperature of 75 to 78°C. The wine is then stored in wooden vats and subjected to ageing. At least six months should be allowed for ageing. If necessary, the wine should be clarified again before bottling. During ageing and subsequent maturing in bottles, many reactions, including oxidation, occur. The formation of traces of esters and aldehydes, together with the tannin and acids already present enhance the taste, aroma and preservative properties of the wine (Wimalsiri *et al*, 1971). The product is packaged in glass bottles with corks and should be kept out of direct sunlight.

Flow diagram

Selection
Mature, sound cashew apples
⇓
Slicing To increase extraction of juice
⇓
Crushing
⇓

Sterilization	At 85°C
⇓	
Filtering	
⇓	
Inoculation	With *S. cerevisiae*
⇓	
Fermentation	Two weeks
⇓	
Filtering	
⇓	
Pasteurization	50 to 60°C
⇓	
Ageing	In wooden vats for 6 months

3.4 Dried cashew fruits

Cashew fruit are not readily consumed in the raw state because of their high content of astringent compounds. If these are removed and the fruit is sweetened, it can be converted into a useful dried product. The fruit must therefore be extensively processed prior to drying.

Fruits are prepared according to the following process:

- Fruits are picked from the tree using special hooked sticks (note that fruits harvested at this stage of maturity contain nuts that are immature). The fruit is washed and boiled in salted water (two percent solution) for five minutes to remove the astringent compounds.
- The skin is pricked with a fork and the fruit pressed in a small hand press to extract the juice. The collected juice is reserved for later use.
- The fruit is boiled for three hours in a solution of cashew juice and raw sugar (2 kg raw sugar in 10 litres of juice). Other sweeteners can also be used, for example: 0.5 kg white sugar in 1.8 litres of cashew juice; 1.2 litres cane juice in 1 litre cashew juice; 250 ml (1 cup) honey in 2 litres cashew juice.
- The boiled, sugared fruit is laid out on screens and placed in a drier. In a simple solar drier, drying time takes about three days.
- The fruit is packaged in airtight moisture-resistant packaging.

Source: Brown, 1992.

CHAPTER 4

TRENDS IN CASHEW NUT PRODUCTION AND TRADE

4.1 Global cashew production

In the early 1970s, the majority of global cashew production (68 percent of total) took place in African countries, in particular, Mozambique and Tanzania. Over the following thirty years, production trends shifted, with Asian countries emerging as the world leaders in cashew production. Today, India commands about 40 percent of the international market in cashew production. Other Asian countries, particularly Vietnam and Indonesia, are beginning to expand their production capacities. Currently, the four main cashew producing regions are India, Brazil, Nigeria and Tanzania. Figure 5 illustrates the global trends in cashew production over the last forty years.

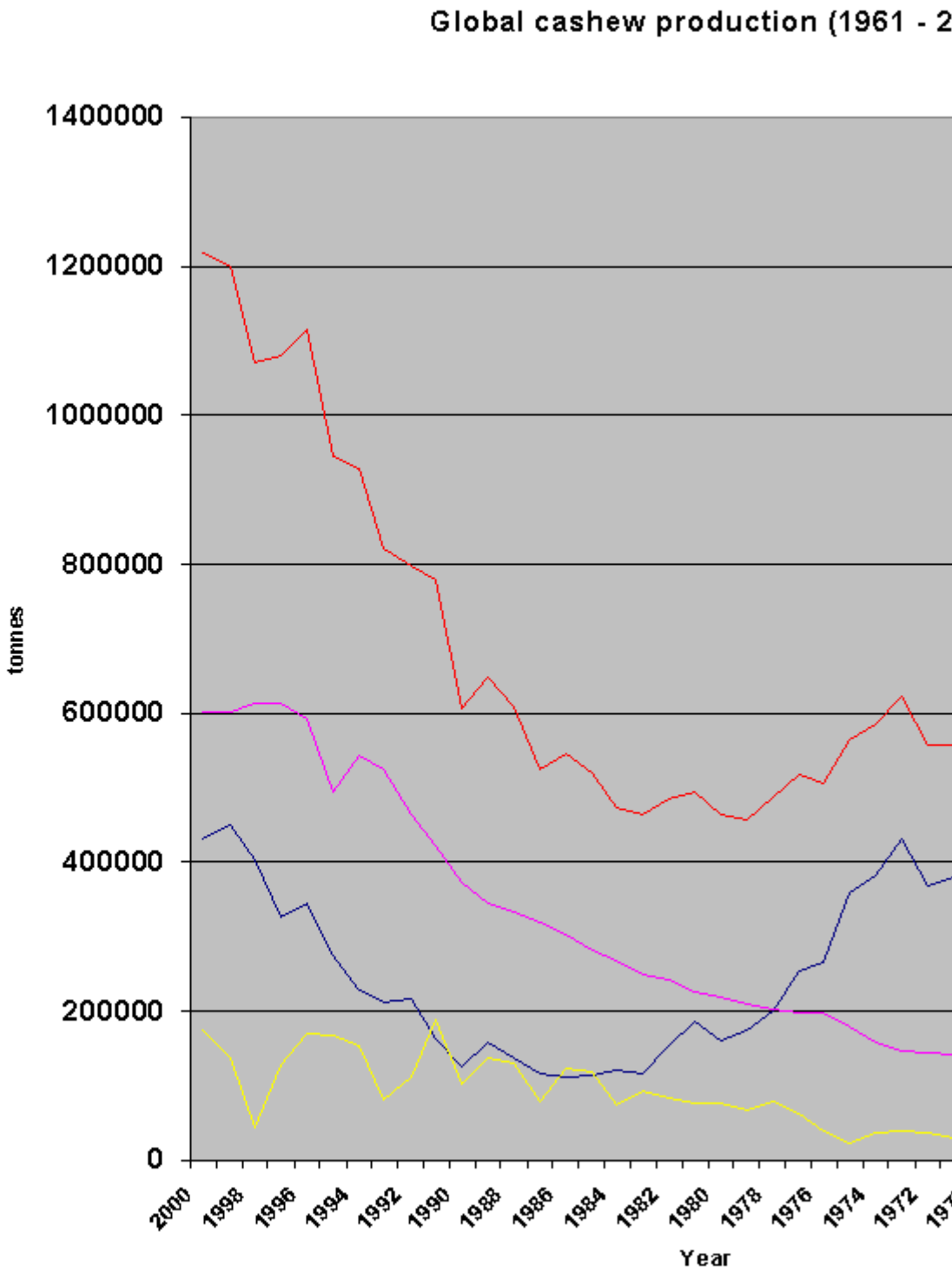


Figure 5: Global cashew production (1961 to 2000) (tonnes).

World production of cashew nuts grew rapidly during the 1950s and 1960s, reaching a peak of 624 000 tonnes of raw nuts in 1973. Three countries, India, Mozambique and Tanzania accounted for the majority of this production, while smaller industries had developed in Brazil, Kenya and several other African countries. In 1975 to 1976, there was a sharp decline in world production, which continued into the 1980s. This decline was largely due to decreased production in Mozambique and Tanzania, since production in India during that period remained static (Jaffee and Morton, 1995). The table showing Trends in global production in Annex 1 summarizes trends in average global cashew production over a forty year period. During the late 1980s and continuing into the 1990s, production picked up and continued to increase gradually. In 2000, world cashew production exceeded 1.2 million tonnes. Asian and African countries produced 0.6 million and 0.4 million tonnes respectively.

4.2 Cashew production in Africa

Overall cashew production in Africa steadily increased during the 1950s and 1960s, until the mid-1970s when that continent was the prime producer of cashew nuts. The year 1975 was the start of a fifteen year period of decline in production throughout the continent due to a combination biological, agronomic and socio-political factors. The decline in prices at the end of the 1970s, combined with lower levels of production, dissuaded many farmers from improving cultivation techniques and replanting their cashew plantations (Andrighetti *et al*, 1998).

Since the early 1990s, production has recovered and has continued to increase steadily over the last decade. Today, Africa accounts for about 36 percent of world cashew production.

Historically, Mozambique and Tanzania were the main cashew-producing countries in Africa, with smaller amounts produced in a number of other countries. During the last five to ten years Nigeria has emerged as a leading producer of cashew nuts in Africa.

Table 4.1: Cashew production (tonnes) in African countries from 1961 to 2000.

Country	2000	1998	1995	1990	1985	1980	1975	1970	1965	1961
Angola	800	1 200	900	1 200	1 200	1 200	1 400	1 300	1 000	1 000
Benin	10 000	10 000	10 000	3 000	1 200	1 086	345	627	50	50
Burkina Faso	1 000	1 000	1 000	1 074	645	200				
Cote d. Ivoire	28 000	28 000	20 000	7 000	3 500	600	450	300	400	400
Ghana	7 500	7 500	1 000	500						
Guinea-Bissau	38 000	38 000	37 000	30 000	13 000	3 500	2 500	2 500	2 000	2 000

Kenya	8 000	9 000	5 000	7 000	8 500	15 000	21 600	22 200	9 000	3 000
Madagascar	7 000	6 500	6 000	5 300	4 000	3 400	2 900	2 400	1 900	1 600
Mozambique	35 000	51 716	33 423	22 524	25 000	71 100	188 000	184 000	136 000	107 000
Nigeria	176 000	152 000	95 000	30 000	25 000	25 000	25 000	25 000	22 000	7 000
Senegal	15 000	7 000	1 500	500						
Tanzania	106 500	93 200	63 400	17 060	32 750	41 416	115 840	107 445	76 000	50 000
Togo	155	155	748	587						
Total Africa	**432 955**	**405 271**	**274 971**	**125 745**	**114 795**	**162 502**	**358 035**	**345 772**	**248 350**	**172 050**

Source: FAO, 2000

Table 4.2: Leading African producers of cashew. Percentage of African and Global production (1961 to 2000).

	2000	**1998**	**1995**	**1990**	**1985**	**1980**	**1975**	**1970**	**1965**	**1961**
Year										
World	**1 217 210**	**1 070 774**	**944 070**	**606 681**	**520 973**	**464 215**	**563 795**	**511 939**	**386 303**	**287 535**
Total Africa	**432 955**	**405 271**	**274 971**	**125 745**	**114 795**	**162 502**	**358 035**	**345 772**	**248 350**	**172 050**
Mozambique	35 000	51 716	33 423	22 524	25 000	71 100	188 000	184 000	136 000	107 000
% of Africa	8.1	12.8	12.2	17.9	21.8	43.8	52.5	53.2	54.8	62.2
% total	2.9	4.8	3.5	3.7	4.8	15.3	33.3	35.9	35.2	37.2
Tanzania	106 500	93 200	63 400	17 060	32 750	41 416	115 840	107 445	76 000	50 000
% Africa	24.6	23.0	23.1	13.6	28.5	25.5	32.4	31.1	30.6	29.1
% total	8.7	8.7	6.7	2.8	6.3	8.9	20.5	21.0	19.7	17.4
Nigeria	176 000	152 000	95 000	30 000	25 000	25 000	25 000	25 000	22 000	7 000
% Africa	40.7	37.5	34.5	23.9	21.8	15.4	7.0	7.2	8.9	4.1
% total	14.5	14.2	10.1	4.9	4.8	5.4	4.4	4.9	5.7	2.4

Source: FAO, 2000

4.2.1 Production in Mozambique

In the 1960s, Mozambique accounted for half of the world's cashew nut production and in the mid 1970s it was the leading world producer with 240 000 tonnes of raw nut production. The civil war from 1982 to 1992 had serious repercussions on the industry, reducing production to merely 23 000 tonnes per annum. With the return of peace to the country, cashew production

has gradually increased again, but is still far below former levels (production in the year 2000 was only 35 000 tonnes).

In Mozambique, cashew nuts are grown entirely by small-scale farmers and subsistent families, mainly in coastal areas. A 1996 to 1997 survey showed that 26 percent of all rural families have cashew trees and 16 percent of rural families have more than ten cashew trees. Even ten percent of urban families have cashew trees. The importance of cashew in Mozambique was shown by a question on the 1997 national census, which asked: "Do you have any cashew trees?"

This huge decline in the cashew industry in Mozambique, coupled with the 1995 intervention by the World Bank that was aimed at rejuvenating the industry, has attracted a lot of interest from economists and development specialists.

From 1972 onwards, there has been a general decline in cashew production in Mozambique. However, during this time there have been good years when exports remained high. For example, in 1976 there were 21 100 tonnes of processed cashew kernels exported worth US$33 million and accounting for 23 percent of export earnings. In 1982 there were 16 700 tonnes exported, worth US$44 million and 19 percent of total export earnings.

Cashew remained Mozambique's largest export until 1982, with the majority of the crop going to the United States. The industry involved millions of smallholder farmers and more than 10 000 processors, making it the fourth largest employer after the railways, sugar and textiles. But then cashew production fell sharply and prawns became Mozambique's main export. Today, Mozambique only produces five percent of the world total, fewer than one million small-scale farmers are involved in cashew production and the processing workforce is less than 1 000 (Hanlon, 2000).

Most of Mozambique's cashew processing factories were opened during the colonial era and then abandoned in the late 1970s. Two factories owned by the Anglo-American Corporation of South Africa stayed open until 1981 when *de facto* sanctions were imposed on Mozambique by South Africa. After independence from Portugal in 1975, the factories were run by a state holding company. Great emphasis was put on improving wages and working conditions, particularly for the women who made up half the workforce. The new state managers were able to keep the factories running, but there was no new investment. Inevitably the machinery began to wear out. Many factories are in rural areas, where transport and electricity supplies were affected by the war. In 1989, a serious programme was initiated by the government, to privatize small and medium size businesses. In the early 1990s the World Bank pushed for privatization of larger companies and by 1999 virtually all government-controlled parts of the economy had been privatized. In 1997, there were 15 operational cashew factories, with an installed capacity of 144 000 tonnes of raw nuts but an actual capacity to process 75 000 tonnes of raw nuts per year. This was more than had been commercialized by smallholders in any year since 1981.

Historically, Mozambique was prohibited by law to export raw (unprocessed) cashew nuts until the capacity of the local processing industry had been met. In the 1960s, however, there was some export of raw nuts to India (then the second largest producer of cashew). In 1992, Mozambique replaced its export ban with an export tax on raw (but not processed) nuts. There was an informal agreement with the owners of the newly privatized companies that they would be given a period of protection while they rehabilitated and modernized the factories. In April 1995, the government changed the export tax on raw nuts to 25 percent on sales up to

US$600 per tonne and 70 percent thereafter. But for the 1995 to 1996 season, it set the export duty at a flat 26 percent and further specified that it would fall to 20 percent the next year, followed by annual drops to 16, 12 and 8 percent (by 1999 to 2000) where it would remain. This revised policy was never implemented, however, due to the 1995 intervention of the World Bank (Box 4.1).

There is good reason to believe that cashew has the potential to regain substantial importance for Mozambique and other developing countries because:

1. Cashew kernels are a high value luxury commodity with sales growing at a steady rate of 7 percent per year 1991 to 1996 and with every expectation that the market will remain strong,
2. Northern markets are not controlled, protected or organized into cartels, leaving substantial opportunity for Mozambique and other countries to capture the value added by processing and marketing the kernels,
3. There is substantial potential to exploit cashew by-products such as cashew butter from broken nuts, CNSL and the juice of the cashew apple, which has a good flavour and is high in Vitamin C,
4. The climate in Mozambique is suitable for growing cashews,
5. Cashew is considered by small-scale producers to be one of their most lucrative crops and the work needed comes at times which do not conflict with peak labour times for food crops. Thus it has the potential to increase earnings, create jobs and increase exports.

Certain constraints however need to be overcome:

1. Cashew production is weather dependent, therefore supply is variable. World prices, although stable in the long-term, are highly volatile in the short-term.
2. Luxury goods must be of high quality. Standards, branding and marketing are required in order for the product to compete directly in the world market.
3. New technology is required in order to exploit by-products.
4. Production volume must be dramatically increased.

4.2.2 Production in Tanzania

In terms of global production, Tanzania ranks fourth after India, Nigeria and Brazil. Over the last four decades, Tanzanian cashew production has shown considerable fluctuation (Table 4.2). Between the 1990 to 1991 and 1999 to 2000 seasons, cashew production has increased six-fold from 17 000 tonnes to 106 500 tonnes. It is estimated that this upward trend will continue for the near future, reaching about 130 000 tonnes in the 2000 to 2001 season.

Various factors are responsible for the past decline in cashew production. The 'villagization' policy of the Tanzanian government in the 1970s, aimed at moving people from their original settlements to communal villages, contributed to some extent to the decline in cashew production, since most farms were abandoned as the villagers were moved to new settlements. The low yields of the 1980s were associated with factors such as poor crop husbandry, pests and diseases and low producer prices, which discouraged many farmers from investing in the crop.

At the beginning of the 1990s, trade liberalization policies, combined with improved crop husbandry, improved tree stock and more investment in research activities resulted in an improvement in both cashew production and the cashew industry in Tanzania.

Currently, small-scale farmers carry out the majority of cashew production in Tanzania in mono- or mixed production systems. An estimated 280 000 households, covering an area of 400 000 hectares, are involved in cashew production. The government is actively supporting farmers in upgrading their current farming systems and practices in order to improve the condition of the trees and maximize agronomic potential. Current yields are about 3 kg per tree, but under optimum conditions, yields of 8 kg per tree are expected.

In recognition of the potential importance of cashew nuts in Tanzania, the Cashew Nut Board of Tanzania (CBT) was established by the government in 1993. The main roles of the CBT are to regulate and promote the quality, marketing and export of raw and processed nuts and to advise the government on matters affecting cashew nut production and marketing.

Commercial cashew processing in Tanzania began following the independence of that country. In the early 1960s, a private company known as African Cashew Processors Company Ltd established a simple manual processing plant in Dar es Salaam and in 1965 the first mechanical processing factory, incorporating Italian technology, was installed. This was soon followed in 1968 by a second plant that used Japanese technology. In early 1979, the National Development Corporation (NDC) established seven hand processing factories, two in the Coastal region and two in Southern regions. These manual processing factories were part of the National Cashew Company Ltd. As production from the factories increased, the government was prompted to build five new factories, all with Italian technology. These

twelve factories have a combined processing capacity of 112 000 tonnes. In the 1980s, the rapid decline in production of cashew nuts resulted in the closure of all twelve factories.

All twelve factories require some investment and refurbishment to bring them back into use. The Cashew Nut Board of Tanzania (CBT) is investigating the possibility of initially re-opening four of the factories so that they can be leased or sold to private processors. The government of Tanzania has declared a national policy to encourage the local processing of cashew nuts with the objective of processing the entire crop locally. This policy is in line with similar policies adopted by other major cashew producers. Brazil, Vietnam, Kenya and India (Cashew Nut Board of Tanzania, 2000).

Prior to embarking on a programme of upgrading processing facilities, countries such as Tanzania (and other exporting countries such as Nigeria, Guinea Bissau and Indonesia) might be advised to consider the advantages and disadvantages of processing locally or exporting the raw nuts to India for processing. In making this judgement several factors must be considered. An analysis by Newafrica.com (2000) sets out the parameters. The article considers that the value added by processing easily exceeds that of exporting raw nuts and therefore recommends that nuts are processed locally rather than exported.

4.2.3 Production in Nigeria

During the past decade, the production of cashew nuts in Nigeria has increased almost six-fold from 30 000 tonnes in 1990 to 176 000 tonnes in 2000. Prior to this, production was relatively static at 25 000 tonnes over a 25 year period from 1965. As in the case of other developing countries, Nigeria has recognised the potential economic value of cashew and has made a concerted effort to improve production of the crop.

4.2.4 Production in other African countries

Other African producers of cashew are listed in Table 4.1. During the 1970s, Kenya produced appreciable quantities (over 22 000 tonnes) of cashews, but unlike its neighbours, has never recovered production since the decline in the 1980s. Guinea Bissau, The Ivory Coast and Benin are now emerging as important producers of cashew in Africa (Table 4.1).

4.3 Cashew production in Asia

Cashew production in Asia currently accounts for about 50 percent of global production. It has held this prime position for almost twenty years, reaching over 60 percent in some years. African countries previously dominated the world cashew market, with Asian cashews accounting for about 30 percent of the world total.

India has long been the main cashew producer in Asia, accounting for between 70 and 90 percent of total Asian production (Table 4.3). During the 1970s and 1980s when African production was on the decline, production in India continued to grow at a steady rate. India now accounts for about 40 percent of world cashew production.

During the 1990s, Indonesia and Vietnam emerged as important cashew producing countries within Asia, helping to boost Asia's position as a prime producer. Increased production in these two countries is responsible for reducing India's share of total Asian production from 90 percent at its peak in the early 1970s to just over 70 percent today. Production in Thailand, Malaysia and Sri Lanka has increased steadily over the past forty years.

Table 4.3: Cashew production (tonnes) in Asian countries from 1961 to 2000.

Country	2000	1998	1995	1990	1985	1980	1975	1970	1965	1961
Bangladesh	10	10	20	80	60	20	10			
China	2 000	2 000	923	1 000	6 500	6 000	4 800	3 250	2 400	2 000
India	440 000	440 000	321 640	285 590	221 330	180 266	144 254	123 319	100 000	85 000
Indonesia	69 027	69 027	74 995	29 907	21 114	9 074	9 122			
Malaysia	13 000	13 000	13 000	10 000	6 000	5 200	11 200	4 300	3 600	3 600
Sri Lanka	15 000	15 000	13 000	10 000	9 500	8 260	4 330	2 770	8 800	4 240
Thailand	22 000	21 000	18 000	11 850	9 500	4 500	1 800	1 300	800	500
Vietnam	41 200	54 000	52 800	26 000	9 000	5 600	3 500	2 100	700	700
Total Asia	**602 237**	**614 037**	**494 378**	**374 427**	**283 004**	**218 920**	**179 016**	**137 039**	**116 300**	**96 040**

Source: FAO, 2000

4.3.1 Production in India

For a long time, cashew was not considered to be a serious crop in India. Rather it was grown as a wild crop on land that was unsuitable for other crops. It was frequently grown as a source of fuel or to prevent soil erosion rather than as a cash crop.

In India, cashew is produced in the coastal regions of the states of Kerala, Karnataka, Goa, Maharashtra andhra Pradesh, Orissa and Tamil Nadu. The state of Kerala accounts for approximately 50 per cent of cashew production in India. Kerala has a centralized procurement system and much of the processing is done on an outworker basis by families. Although Kerala only accounts for about 25 percent of the total area under cashew, yields in this state are relatively high when compared to those in other states. Estimated cashew productivity in Kerala is 900 to 950 kg raw cashew nuts per hectare, which is almost double that in the rest of India.

Cashew is predominantly a smallholder crop in India about 70 percent of cashews are grown by small-scale farmers. The remaining 30 percent are grown under re-forestation programmes. Cashew yields in India average around 1.5 kg of nuts per tree. In Kerala average cashew yields are about 5 kg per tree, which is substantially less than the potential yield of 10 to 15

kg per tree under optimum conditions. The poor quality of raw cashews has been a long-term problem for the cashew processing industry in India. The main reasons for poor quality are incorrect harvesting techniques, unsatisfactory drying of raw nuts and inadequate storage of dried nuts.

The number of cashew processing units in India has increased rapidly over the last four decades, from 170 in 1959 to over 700 today. Over two-thirds of the processing units are in the State of Kerala, while the remainder are scattered throughout the other producing states. Together these units have a processing capacity of over 800 000 tonnes per year and provide employment to over 500 000 people, 95 percent of whom are women (Nayar, 1995). The industry is dominated by small-scale, single-owner or family-owned businesses.

Cashew has gained significant economic and social importance in India as a major foreign exchange earner. In 1992 to 1993, India exported 53 436 tonnes of cashew kernels valued at US$160 million. In the same year, a further US $0.8 million was generated through the sale of 4 258 tonnes of cashew nut shell liquid.

In the 1980s and 1990s, India rapidly expanded its cashew production, to become the world's largest producer and now accounts for about 40 percent of global production. Processing capacity increased more rapidly than production, so Indian imports of raw nuts increased rapidly, reaching 203 000 tonnes in 1996 (of which 41 percent originated from Tanzania and 13 percent from Mozambique). In recent years, an increasing number of non-African countries have also supplied raw nuts to India. The decline in African production in the 1970s and 1980s resulted in a rapid decline in imports into India. Alternative supplies of raw nuts were obtained from Vietnam. According to India's 8th National Development Plan, agricultural production should match processing capacity by the year 2000.

The beginnings of India's international trade in cashews date back to after the First World War. This trade expanded rapidly in the 1920s with the introduction of improved packaging materials for long distance transit. By the start of World War II, cashew nuts had become the second most important traded dessert nut after almonds and have remained in this position for the last fifty years (Jaffee and Morton, 1995).

Cashew is the only major plantation crop that is not regulated by an autonomous board. Other plantation crops, such as tea, coffee, cardamom and rubber all have efficient and autonomous boards and as a result have experienced much faster growth in productivity than cashew. Cashew is one of the most neglected plantation crops in India despite its status as a major source of foreign exchange.

The international price of Indian cashew kernels has fluctuated widely over the last decade.

4.3.2 Production in Indonesia

Indonesia has long been the second largest producer of cashew in Asia. Production has picked up over the decade, when it doubled from 30 000 to 60 000 tonnes. Some of the Indonesian production is exported to India for processing.

4.3.3 Production in Vietnam

Cashew production in Vietnam has increased quite rapidly over the last decade. Vietnam now accounts for about 6 percent of total Asian production and is the third largest cashew producer in Asia. Previously, many of the raw nuts were exported to India for processing, to make good the shortfall that India experienced when East African supplies dried up. Now, however, Vietnam has about 60 processing plants, with a capacity of 220 000 tonnes of raw nuts. Annual cashew production is often less than this and Vietnam has become an importer of raw nuts from East and West Africa and South East Asia.

4.3.4 Production in Sri Lanka

Sri Lanka has a very small share (around 2 to 2.5 percent) of the Asian cashew production market. Some of the cashews are processed locally while the remainder are exported to India for processing.

4.3.5 Production in Australia

Cashew is a crop with good potential for the Australian tropics, particularly in the Northern Territory and Queensland, where agro-climatic conditions are suitable for its production. Australia currently produces about 25 tonnes and imports about 5 000 tonnes of cashew a year. There is potential therefore to increase production to meet domestic demand. The cashew industry in Australia is at an infant stage, with three plantations - one in north Queensland and two in the Northern Territory. Expansion of the industry will necessitate a good supply of high yielding plants.

The Australian government is supporting a large cashew research programme (at the Commonwealth Scientific and Industrial Research Organization (CSIRO)) to develop high yielding hybrids adapted to the local conditions.

Australia has no shelling facilities. The raw nut is exported to China for shelling and returned to Australia where it is sold either as raw kernel or further processed into value added goods such as chocolate coated, salted or honey coated nuts (O'Farrell, Blaikie and Chacko, 1998).

4.4 Production in South and Central America

Brazil is the main cashew producing country in the South and Central American continent. A handful of Central American countries also produce minor quantities of cashew nuts (Table 4.4).

Table 4.4: Cashew production (tonnes) in South and Central American countries from 1961 to 2000.

Country	2000	1998	1995	1990	1985	1980	1975	1970	1965	1961
Brazil	167 123	39 836	164 156	99 367	115 000	75 000	20 490	20 309	13 789	9 670
Dominican Republic	930	930	930	930	910	870	810	804	789	775
El Salvador	4 000	4 000	3 000	2 098	2 162	2 208	1 702	1 700	1 600	1 500
Honduras	400	400	400	350						
Mexico	300	300	235	168	1 154	316				
Peru	3 265									
Total South America	**176 018**	**45 466**	**168 721**	**102 913**	**119 226**	**78 394**	**23 002**	**22 813**	**16 178**	**11 945**

Source: FAO 2000

4.4.1 Production in Brazil

Brazil currently holds third place in global production of cashew, after India and Nigeria. Overall, production has tended to increase gradually over the last thirty years, but at times (1988 and 1983 especially) has plummeted (Table 4.4), mainly due to periods of drought.

Brazil recognized the economic value of cashew cultivation at the beginning of the Second World War, when there was a considerable demand for cashew nut shell liquid for the North American war effort. The expansion of cashew areas began at the end of the 1960s through government incentives and funding. This increase in production allowed Brazil to enter the international market, although actual yields of the crop were low. Cashew cultivation, of which 99 percent is in the north of the country, is of great economic importance for the states of Ceara, Piaui and Rio Grande de Norte, which are some of the poorest regions. Interruptions in incentives and financial aid, linked with low internal prices and a stagnation of export demands, were the main factors responsible for the decline in the production of cashew. Over the past twenty years, however, cashew production in Brazil has boomed, with producers making the most of the large US market for the kernels (CDI, 1995).

4.5 Global Trade Trends

Cashews rank third in world production of edible nuts that are traded globally. World trade in edible nuts has experienced relatively rapid growth, averaging about 2.7 per cent per year since the early 1970s and increasing in value from US $1.94 in 1980 to US $2.84 billion in 1990 (United Nations Yearbook of International Trade Statistics).

Worldwide, trade in cashews exceeds US$2 billion and demand is increasing. Of the total world supply, 110 000 tonnes are traded on international markets. India (60 percent) and Brazil (31 percent) are major exporters.

As a major importer of cashew, the USA has a strong influence over the world price, which is fixed in US$ per pound (1 pound = 0.45 kg). The price of W320 grade (320 kernels per pound) over the last 15 years has ranged from US$2.73 to US$3.18. The 1999 price for W320 grade was US$3.30 per lb (US$7.2 per kg) FOB.

International trade in raw cashew nuts has traditionally involved shipments from East Africa to India. India was the first country to build up a processing industry, but domestic production has long been insufficient to meet the requirements of the country's hundreds of small and medium-scale processing outlets. The imports from East Africa generally took place from December to May, which complemented the national harvest from May through to July. Thus, the Indian processors were able to operate over a prolonged period without having to maintain large stores of raw nuts. This trade declined in the early 1980s when East African production reached low levels and Indian importers had problems with access to foreign exchange. Since then, import levels have increased due to greater supply availability, particularly from South East Asia Vietnam and Indonesia and Tanzania (Nayar, 1995). Cashews from Tanzania used to command premium prices over other suppliers, but recent years have seen a growing uncertainty about the quality of Tanzanian shipments, resulting in the loss of premium grade (Jaffee and Morton, 1995).

India has long been the world's largest supplier of cashew kernels with its prices and quality, setting the standards for the industry. In Europe, India has been the preferred supplier, with long standing trading relationships based on confidence in product quality and on fast and regular deliveries. India has more than 150 cashew kernel shippers, many of whom have offices in Europe and the United States (Jaffee and Morton, 1995). Throughout the 1970s, Mozambique was also a major exporter, but its market share has declined. At the same time, Brazilian exports have expanded. The quality of Brazilian cashews does not match that of Indian cashews. Brazilian nuts however have a comparative advantage in the US market, based on lower transportation costs and the unique larger size of the Brazilian cashew nut. Other suppliers, including Tanzania, Kenya and China, are reputed for producing nuts of irregular quality, which contributes to substantial price discounts (up to 30 percent), in international markets.

Most cashew kernels exported form India are plain kernels packed in four gallon prime cans, flushed with carbon dioxide and having a net weight of 11.34 kg (25 lb). These cans are encased in cardboard cartons. Global pricing is generally quoted in US dollars per pound or per kilogram of nuts.

The United States is the largest importer of cashew kernels, accounting for over 50 percent of world imports. Other importers include the Netherlands (ten percent), Germany (seven percent), Japan (five percent) and the United Kingdom (five percent). The former Soviet Union was previously a major importer of cashew kernels, but with recent economic changes trade to this part of the world has diminished. Other emerging markets include the Middle East, South East Asia and Australia (ITC, 1990; O'Farrell, Blaikie and Chacko, 1998).

Cashew kernels are usually the second or third most expensive nuts traded in the United States. Macadamia nuts are more expensive and pecan nuts can cost more in years when there is a poor harvest. Cashew nuts have a well established market in the United States with a great variety of end uses. Retail prices vary from about US$4 to 11 per lb (US$9 to 23 per kg) depending on kernel size and packaging.

The extensive market connections of large exporters from Brazil and India make it difficult for smaller exporters to make gains in the US market. Importers may appreciate the low prices that small suppliers can offer, but the lack of reliability in quality, tends to make them favour the larger, more reputable suppliers (The Clipper, 1994).

Almost all of the world's raw cashew nuts are sent to India for processing, since India has an inexpensive labour force and does not produce adequate quantities of cashews to fulfil its domestic processing capacity. Approximately 25 to 40 percent of nuts processed in India originate in foreign countries. India also has a long tradition and good reputation as a high quality processor of cashew. A number of countries therefore prefer to export their raw nuts to India for processing rather than to process themselves and produce lower quality kernels.

China also has a high processing capacity and benefits from having an inexpensive labour force. Chinese processed cashews were previously considered inferior to Indian nuts, but with improving standards, the import of raw nuts to China is on the increase.

World prices of cashew kernels vary according to the size, class and composition of the product. W320 (320 kernels per pound weight) is the category in highest demand and is the reference point for pricing. International prices for cashew kernels are influenced by the behaviour of market operators. There is no fixed market price and the market is speculative.

Cashew quality is of utmost importance. High quality is a major criterion for success on the world market. India and Brazil have worked hard to ensure high quality of the processed kernels. India's cashew industry was the first to use quality control for improvement of performance. Quality control is administered via the Cashew Export Promotion Council (CEPC).

4.5.1 International Classification

In order to safeguard and guarantee quality, producers and exporters have introduced quality standards, which must be met by cashew exporters. The ISO 6477 standard was introduced in 1988 in order to unite the Brazilian and Indian classifications and to give one single classification scheme for quality control.

Cashew kernels are selected on the basis of the number per unit weight, in accordance with the weight of the kernels. They are also classified either as wholes, chips, splits, butts or baby bits, in accordance with the integrity of the kernel. White or ivory kernels are preferred over brown ones. There is a maximum permitted moisture level (both for raw cashews and cashew kernels) and the product must be free from insects, mould, rancidity and extraneous materials.

The highest price is paid for better quality kernels of the W180 and W210 grades, which are the largest and heaviest grades.

CHAPTER 5

TRADITIONAL METHODS OF CASHEW PROCESSING

5.1 Cashew processing in Africa

Traditionally, much of the raw Eastern African production has been shipped to India for processing and re-exported as kernels. Manual processing, such as that practised in India, tends to give higher yields of whole kernels than the mechanized methods in use in Africa and Brazil (Errington and Coulter, 1989). This practice decreased toward the end of the 1970s and early 1980s when production in the exporting countries declined.

5.1.1 Cashew processing in Guinea Bissau

Most of cashews produced in Guinea are exported to India for processing. There is, however, a cashew processing centre in Quinhamel at which some local processing takes place. Raw cashew nuts are boiled in a large cauldron for 25 minutes, then sun-dried for 48 hours. This makes it easier to separate the nut from the shell. Shells are removed from individual cashews using a foot-powered shelling machine.

The kernels are spread over special cooling screens and dried for seven hours at 77°C. The thin testa covering the kernel is subsequently manually removed by workers sitting at a row of tables. The cleaned kernels are then graded in accordance with their size and wholeness. The smallest pieces are collected for use in pastries and confectionery. Once separated and classified according to international standards, the cashews are roasted and packed for shipping.

All parts of the cashew are used during processing. The discarded shell is burned to heat the cauldron in which the raw nuts are boiled. The skins can also be burned or mixed with grains for livestock feed and the ovens can be fired from the pruned branches obtained from a well maintained orchard.

Home based cashew processing has very low energy requirements, as fuel is required only for cooking and drying. Workers shell and clean the cashews during daylight hours. The cashew shelling machines, which were originally imported from Brazil, are manually operated. These machines are now made locally. Cashew processing is thus regarded as a low-input activity that is suitable for the small scale or domestic level. Sale of the processed nuts provides year round employment opportunities, unlike the sale of raw nuts for processing abroad which only provides a few months of employment a year.

Those African countries which experienced a decline in their cashew production capacities may now be in a position to revive the industry, particularly at the small-scale. Following the Indian example of small-scale manual processing, rather than continuing with the old concept of large plants that are unable to operate efficiently, will be the most appropriate way forward and will provide opportunities for small-scale processors.

5.2 Cashew processing in Asia

India is the main cashew processing country in Asia. The highly skilled workforce and low labour costs in India allowed it to have a virtual monopoly on the manual processing of cashew for many years. Raw cashew nuts were traditionally shipped from Africa to India for processing, because of the reputation of the high quality of processing in India.

Cashew production and processing provides employment to over 500 000 people in farms and factories. Over 95 percent of these workers are women from the poorer sectors of society. In Mozambique, cashew production and processing used to be the fourth most lucrative business, providing incomes for millions of peasant growers and over 10 000 processors.

5.2.1 Traditional processing in India

The traditional practice in the south Arcot region of India was to spread the nuts out on flat rocks in the sun, to allow them to dry until the shell became brittle. The kernel could then be removed from the shell by striking the nut with a wooden batten to split the shell along the natural line of cleavage. The cashew kernel was removed from the shell without becoming contaminated by the CNSL. Use of this method was made possible by the suitability of humidity and climate condition in that particular region of India. Shells are further processed to obtain the CNSL.

An alternative method of removing the kernel from the shell is to subject the nuts to very low temperatures, thus causing the shell to become brittle. Following this, the nuts are mechanically cut along the natural line of cleavage and the kernels removed. The shells are then further treated to remove the CNSL. This method of kernel removal has been commercially adopted.

Open pan roasting

Open pan roasting is used by traditional cashew processors in India. This roasting technique is very simple with minimal equipment requirements. It however requires skill and judgement in order to prevent the nuts from burning.

The roasting pan is an open circular mild steel dish, measuring 600 to 675 mm (2 to 2.5 feet) in diameter, supported over an open fire. Between 1 and 1.5 kg of raw nuts are placed on to the heated pan at a time. The nuts are heated on the pan, with constant stirring, in order to prevent burning (Figure 6). As the nuts heat up, the CNSL is exuded onto the pan and eventually ignites, producing clouds of thick black smoke. After heating and burning for about two minutes (judged by experience) the pan is dowsed in water and the nuts are thrown off and allowed to cool, during which the shells become brittle and can be readily removed from the nut.

Figure 6: Pan roasting.

5.2.2 Traditional processing in Sri Lanka

Cleaned raw nuts are spread in a single layer on the ground under bright sunlight for six to seven hours a day, over a two to three day period, in order to attain the correct stage of dryness. Partially dried nuts are covered with polythene overnight. A trained processor can determine the correct stage of dryness by shaking together a few dried nuts in the palm of his hands, to give the correct rattling noise.

Processors sit on the ground and shell the nuts by beating with a mallet two or three times on the same spot, until the shell cracks. A hard stone is buried in the ground to serve as a stable platform on which to rest the nut for shell breaking. After the shell is broken the kernel is extracted using a small metal tool resembling a penknife. This method is hazardous to the processor since the CNSL oozes out of the shell onto the hands. The processor wears rubber gloves and uses firewood ash sprinkled onto the floor to neutralise the caustic liquid. The firewood ash also helps to grip the nut. In addition to the danger posed by the CNSL, this method of kernel extraction is very labour intensive and uncomfortable for the women involved in these activities (ITDG Sri Lanka).

Pre-heating and peeling

After extracting the kernel from the shell, the testa, which is a thin reddish coloured skin covering the kernel, must be removed. Removal of the testa is facilitated by drying through slight heating. Care must be taken not to overheat the kernels as they become scorched and discoloured. Traditionally the kernels are heated on either a metal plate or open pan over an open fire. The kernels are tossed over the heat to avoid roasting and burning. An alternative and preferable method is to use a mechanical drier maintained at 55 to 60°C. The kernels are loaded into the drier and dried for three to four hours until the nuts give the appropriate sound when rattled together. Although investment in a mechanical drier is costly, mechanical drying gives a higher quality cashew kernel.

The testa is scraped off the kernel using a small blunt knife. Any burnt or discoloured spots are also scraped off the kernel with the knife. Care must be taken when peeling not to scratch the surface of the kernel as this can trigger off enzymatic browning and reduce the quality of the kernel.

Grading

The peeled kernels are divided into wholes, splits and broken pieces. They are stored in bulk in cardboard cartons or polythene bags.

Drying

Kernels are dried to a final moisture content of five per cent, using either a mechanical drier or oven. It is important to ensure that the drying temperature is not too high as this would cause roasting and discoloration rather than just drying of the kernels. Trained processors examine the kernels for the correct level of dryness by observing the colour and texture and shaking a few nuts together to hear the correct sound.

Grading

The dried kernels are further graded into sizes 180W, 240W and 320W according to the size of the nut. This process is carried out by experienced graders.

Packaging

The type of packaging used is largely dependent on the target market. For the local market, kernels are packed in bulk and sealed in polythene bags. For the export market they are packed and flushed with nitrogen. Regardless of the target market, cashews must be packed in airtight containers so as to avoid the absorption of moisture from the air. They must be stored away from sunlight in order to prevent oxidative rancidity.

5.3 Traditional manual shelling

In the manual shelling process, the nuts are placed on a flat stone and cracked with a wooden mallet. The sheller requires a few basic pieces of equipment, namely cans for shelled kernels and shelled pieces, a shelling mallet, a striking point and a supply of wood ash to dust both the cashews and the fingers of the sheller. The working area should be kept clean to prevent

the ash and spilled CNSL from contaminating the extracted kernels. This is quite easily achieved by organizing the work area and following an accepted routine.

Although this is a labourious routine, efficiency can be improved if attention is paid to ergonomic details, such as the positioning of the pile of nuts in relation to the striking point. The nuts for shelling and the tin for receiving must be correctly positioned so as to avoid wasting effort in reaching from one to the other. The raw and cleaned nuts must also be separated in order to avoid contamination of the extracted kernels. If the sheller is right-handed, the pile of nuts for shelling should be placed on the left hand side. The nut is picked up in the left hand and struck with the mallet on the right hand. The kernel is removed and deposited in the receiving can in the centre or on the right hand side. The shell pieces are brushed aside into a pile. The hands and striking point have to be regularly coated in wood ash to keep the kernels clean.

Shelling is a technique that can be relatively easily learnt. Strength is not required for breakage of the shell. Correct positioning of the nut and the ability to hit the nut in the correct position, so as to allow its breakage is most important. If the nuts have been properly roasted and are correctly positioned on the striking platform, they will easily break down the natural line of cleavage when struck at the broad end. The convex side of the nut should be placed in contact with the striking platform, with the plane of cleavage at right angles to the surface of the striking post. Occasionally, a nut will require more than one strike in order to open the shell, but this technique comes with practice. An average sheller can open one nut in about six seconds or ten nuts per minute. In an eight hour working day, this amounts to about 4 800 nuts or about 5 kg of kernels. At an extraction rate of 24 percent, this quantity corresponds to about 21 kg of raw nuts per day or about 7 tonnes per year. Experienced shellers in India can produce around half as much again, with a quality of 90 percent whole kernels. A good sheller will produce a high percentage of clean, unbroken kernels, whereas a poor sheller will produce a larger quantitiy of dirty broken kernels (FAO, 1969).

For optimum shelling efficiency, the raw roasted nuts should be delivered close to the sheller, such that he does not have to keep moving to fetch them. The nuts should be delivered in small manageable quantities, since large piles of unshelled nuts act as a psychological barrier to the sheller and lower the quality of shelling.

5.3.1 Quality control in shelling

The success of a cashew processing operation is largely dependent on the proportion of whole kernels produced in the shelling operation. Quality control and inspection are therefore critical in ensuring that shellers produce kernels of the highest quality. The critical period for quality control in the shelling operation is the start and the end of the day, but in particular the latter when the sheller may be rushing to complete the day' s work.

Several points must be to monitored:

- The discarded shells must be inspected for completeness of removal. An inspector should aim to inspect approximately one in ten discarded shells for kernels, wholes and pieces that are being discarded with the shell, partially shelled nuts and unshelled nuts.

- The inspector should also inspect the extracted kernels and pieces for cleanliness and to make sure there are no pieces of shell included.
- At the end of the day the quantity of shelled kernels should be weighed to assess the productivity of each sheller. If shellers are paid on a piece-rate basis, then the individual amounts are weighed separately. The percentage extraction, which is the ratio of kernels to raw roasted nuts, is calculated.

Shellers need to be made aware of the quality of their work. They should be rewarded for high standards and penalized for work that is below par. At the end of the day the work place needs to be cleaned and tidied in preparation for next day's work.

Processors may be required either by factory inspectors or health authorities to provide the shellers with gloves. Gloves are not, however, the most suitable form of protection against CNSL, in that they are cumbersome, become dirty and eventually perish from contact with CNSL. Wood ash is much more effective and has been successfully used for over half a century. The new processor may take a little while to get used to applying wood ash to his/her hands. Coconut oil is also used to protect the hands from CNSL.

Shelled kernels have a moisture content of over 6 percent, which makes them susceptible to fungal attack. It is imperative that they be dried immediately after shelling.

5.4 Manual peeling

Manual peeling is performed by gently rubbing with the fingers. Those parts still attached to the kernel are removed with the use of a bamboo knife. One person can peel about 10 to 12 kg of kernels per day.

It is important that the kernels are not cut or damaged during the peeling process. The use of knives increases the likelihood of the kernels becoming damaged, but it is also essential that all of the testa be removed. Gentle scraping of the testa with a blunt knife is the most effective way of removing it.

Peeled kernels can be separated into different grades with the use of a peeler. At the most basic level, the kernels are separated into white wholes, scorched wholes, white pieces, scorched pieces, browns and refuse. However, the more experienced graders are able to separate the kernel into a larger number of categories. It is preferable that grading is carried out at the time of peeling as this cuts down on handling of the brittle kernels. There is, however, the opportunity for further grading subsequent to peeling.

CHAPTER 6

CASHEW PROCESSING OPERATIONS

6.1 General processing

Cashew processing methods have improved considerably over the years. Difficulties in shelling cashew nuts are due to the irregular shape of the nut, the tough leathery outer shell and the CNSL within the shell that must not be allowed to contaminate the kernel during its removal from the shell. An early method used to remove the CNSL in cashew producing countries was to burn the raw nuts for a short period in order to burn the shells and the CNSL without affecting the taste or appearance of the kernel. This was a delicate operation requiring an experienced processor to gauge the length of time required for burning. Kernels produced using this method are only suitable for either home consumption or for the local market.

The most economic features of processing are the ratio of kernels to whole nuts obtained and the percentage of whole kernels obtained. Kernel yields usually vary between 22 and 24 percent of the total weight of raw material processed. The percentage of whole kernels at the end of processing varies between 55 and 85 percent depending upon the processing method and factory management. In general, 65 percent may be considered a satisfactory result.

The main objective of processing is to remove the valuable cashew kernel from the shell with as little damage as possible. Whole kernels command a higher price than do broken pieces. Pale, ivory coloured or white kernels are preferable to coloured or burnt ones. The CNSL has to be removed during the process, without either contaminating the cashew kernels or burning the hand of the processor. The processor must therefore, finely tune the process in order to achieve the best quality kernels.

Extraction of the kernel from the shell of the cashew nut has traditionally been a manual operation. Roasting causes brittleness of the shell and loosening of the kernel from within the shell. Soaking increases the moisture content of the kernel, thereby reducing the risk of it being scorched during roasting and increasing its flexibility so as to make it less likely to crack. The CNSL is released when the nuts are roasted. Collection of this material in sufficient quantities can be economically advantageous. CSNL is unlikely to be collected by very small-scale processors, due to the high cost of the specialised roasting equipment required for its collection.

After the kernels are taken out of the shells, the testa (the thin skin covering the kernel) must be removed, following which the kernels are graded and packaged. The process consists of five main steps:

- Shelling: removal of the outer shell and CNSL
- Peeling: removal of the testa
- Grading: into different sizes and colours in accordance with standard grading
- Drying or humidifying: to a final moisture content of 5 percent
- Packing: into airtight bags or cans, depending upon the scale of operation

Each of these five steps involves a number of operations. The various processing steps differ in accordance with the scale of operation. In some cases, all steps of the process are manually carried out by small-scale processors, while various pieces of equipment are used in commercial scale processing. A general overview of the process and the various processing options is summarized in Figure 7.

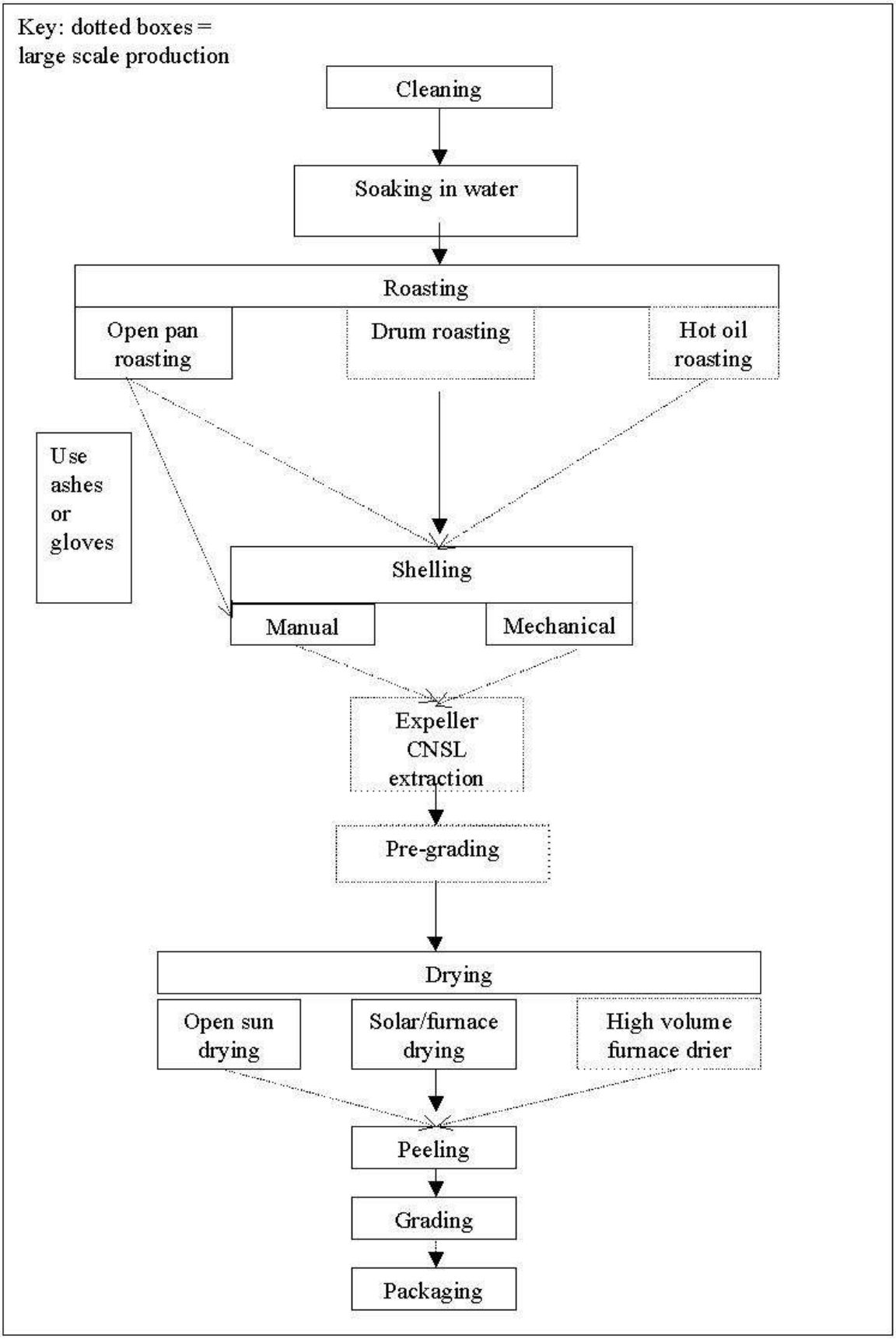

Key: dotted boxes =
large scale production
Cleaning
Soaking in water
Roasting
Open pan roasting
Drum roasting
Hot oil roasting
Use ashes or gloves
Shelling
Manual
Mechanical
Expeller CNSL extraction
Pre-grading
Drying
Open sun drying
Solar/furnace drying
High volume furnace drier
Peeling
Grading
Packaging

Figure 7: Overview of cashew nut processing.

6.2 Cleaning, sizing and conditioning

The first processing operation is the removal of foreign matter and dirt from the nuts. The nuts are collected from the ground after falling from the trees. Apples are removed along with other foreign matter. At the simplest level, the nuts can be sieved by hand using a three-quarter inch (20 mm) mesh sieve to remove dust and dirt (ITDG, 2000).

The cleaned nuts are then conditioned in preparation for removal of the shell. Conditioning increases the brittleness of the shell and thereby facilitates its removal.

6.2.1 Soaking or conditioning

The nuts are soaked in water in order to avoid scorching during the roasting operation. Conditioning is carried out in order to prepare for removal of the CSNL.

In small-scale operations, after cleaning, the nuts are placed in a large open drum (180 to 220 litres/40 to 45 gallons). Water is poured into the drum and the nuts are allowed to stand for ten minutes prior to draining off the water through a hole in the base of the drum. The dampened nuts are then allowed to stand in order to absorb the adhering water. This soaking and conditioning operation is repeated up to three or four times until a moisture content of nine percent is attained.

On a slightly larger scale, in the processing of 2 to 10 tonnes per day for example, a simple cleaning and conditioning system can be set up. This consists of three main parts:

- A platform on which a bag of cashew nuts can be placed and opened.
- A long grill of mild steel rods placed along a length of an enclosed frame across which the nuts are drawn by hand. The sand and dirt pass through the grill and the cleaned nuts fall over the edge into a vat.
- A vat that is large enough to contain the volume of nuts required for one day's processing. There are two vats so that one may be filled while the other is emptied for further processing.

The sacks of harvested nuts on the stand are generally opened by two people, who clean the nuts as they pass over the grill and into one of the vats (Figure 8). Water is then sprayed on to the nuts contained in the vat. The water trickles down through the nuts, while excess water is drained through a hole situated at the bottom of the tank. Spraying is stopped when drainage of excess water begins and the surface water which adheres to the nuts is allowed time to be absorbed by the nuts. The spraying treatment is repeated at three-hourly intervals until the required moisture condition (9 percent) of the raw nuts is met.

All nuts conditioned in this way are further processed in the same batch and the vat is completely emptied prior to the further addition of nuts. If nuts are left in the vat when new ones are added, the moisture content of the remaining nuts will be too high for processing. After the vat is emptied it must be thoroughly cleaned to remove all traces of dirt.

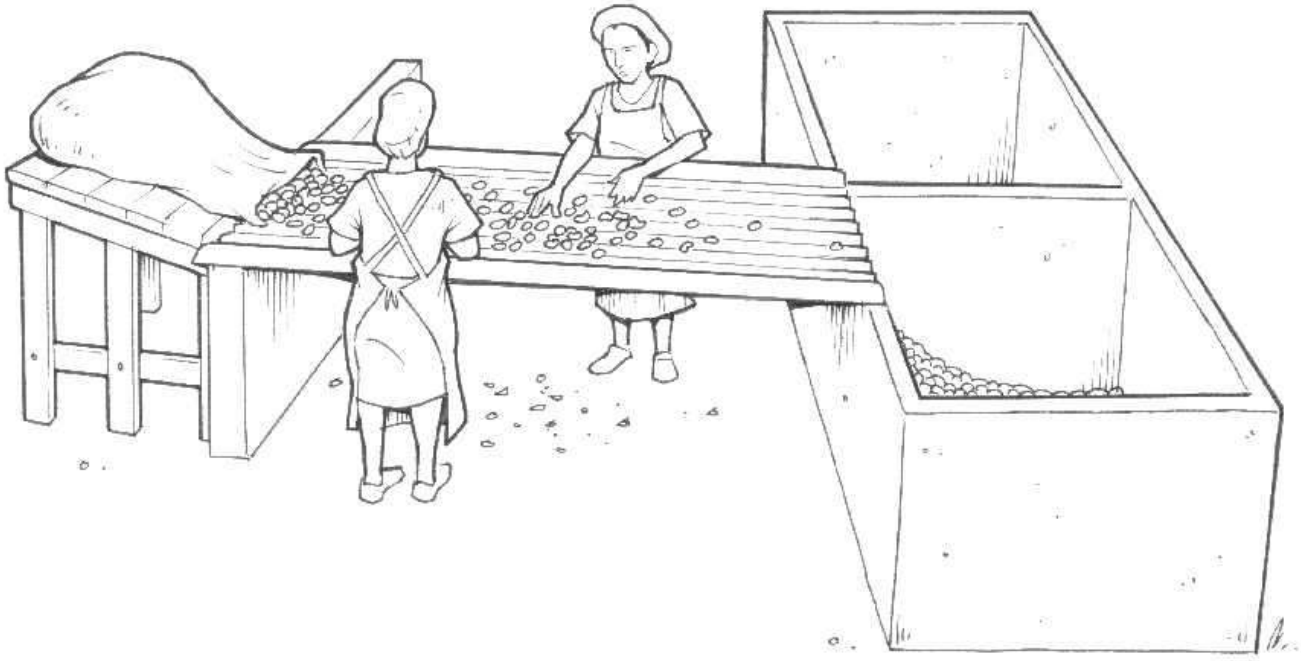


Figure 8: Medium-scale cleaning.

The platform grill and vat can be locally made from a variety of materials. The platform must however be sturdy enough to withstand the impact of the many bags of nuts being dumped on to it. The grill must also be sturdy since the full weight of the nuts resting on it at any one time may increase to as much as 100 to 150 kg. The vat can be constructed from either concrete blocks or from bricks, rendered on the inside with cement to give a smooth finish. Drains contained within the vat should be small enough to prevent the nuts from flowing out with the water. The drains should be kept free so as to allow the water to drain away freely. The vat can be fitted with a small closure that can be lifted to allow the nuts to flow out for subsequent processing.

A vat with internal dimensions of 3.0 × 2.4 × 2.1 metres will hold about 10 tonnes of cashew nuts.

6.2.2 Large-scale cleaning and conditioning

Specially designed equipment for cleaning and conditioning operations has been developed for large scale cleaning operations. The equipment basically consists of a feed hopper into which the raw cashew nuts are delivered. The nuts flow out of the hopper through a cylindrical cleaning trommel. The cleaning trommel consists of two concentric cylinders made of mild steel rods built on rings of flats. The inner cylinder is made of 13 mm (0.5

inches) rods spaced at 33 mm (1.25 inch) centres, about 260 mm (10 inches) in diameter and 2 metres (6 feet) long, mounted on a central shaft. The outer cylinder consists of 7 mm (0.25 inches) rods spaced at 13 mm (0.5 inches) centres, about 75 mm (30 inches) in diameter and mounted on the same shaft. The cylinders are lined up at the feed end and the inner cylinder projects 375 mm (15 inches) beyond the discharge end.

The cylinders rotate and the shaft is mounted at a slight angle in order to ensure that the material passes through it during rotation. The cashew nuts are fed into the inner cylinder. Large pieces of foreign matter are retained in the inner cylinder and removed later at the discharge end. The nuts and small pieces of foreign matter pass through the inner cylinder to the outer cylinder where the nuts are retained and the dirt and debris falls through, on to the floor below. The clean nuts are discharged into a chain bucket elevator hopper.

The buckets on the chain elevator are drilled with drain holes. They pass through a water bath at the bottom of the chain. The nuts fall into the bucket elevator while it is on the downward leg of travel, passing through the water bath and then draining as they are taken on the upward leg of the chain.

At the top of the elevator they are discharged into a mild steel silo with a conical bottom. They are discharged from the silo via a hole in the apex of the inverted cone. Excess water drains through this hole. The capacity of the silo is sufficient for one day's processing in the roasting plant. There is a second silo into which the nuts from the first silo can be transferred by a belt bucket elevator.

Additional water can be added to the silos as required. The quantity of water to be added is determined from experience. Conditioned nuts leave the second silo for the roasting plant. When this happens, nuts from the first silo are transferred to the second. When silo one is empty, more nuts are loaded onto the receiving hopper to re-fill the first silo.

An alternative method of cleaning and conditioning employs the use of a shaking sieve whilst blowing air to remove all lightweight debris. The nuts are washed and then pass over sizing grills, which separate them into three different grades. The nuts fall into the relevant bins where they can be further conditioned if necessary (FAO, 1969).

All the conditioning operations must be done in a closed environment. They all require a certain amount of time and an experienced operator.

6.3 Roasting and centrifuging

Following conditioning, the nuts must be prepared for the removal of shells. The application of heat to the nut releases the CNSL and makes the shell brittle, thus facilitating extraction of the kernel when breaking the shell open. Three methods of roasting are used: open pan roasting (as described in Chapter 5), drum roasting and roasting via the hot oil method. The latter is best suited to medium-scale operations because of the associated higher equipment costs and viability of CNSL collection. The roasted cashew nuts may be centrifuged to remove any adhering surface liquid from the nut.

At the start of the cashew industry in India, open pan roasting was the method used by all processors. The only advantage of the method was its low cost. The fumes and large amounts

of black smoke given off during this process made it a very unpleasant operation. Particular care and attention were required in order to ensure that the kernels were not lost or ruined. The process also suffered from the disadvantage that the by-product CNSL was lost.

Other cleaner methods of roasting were therefore developed.

6.3.1 Drum roasting

An improvement on the open pan roaster was the development of a drum roaster, within which the cashew nuts are roasted. The drum is tilted at an angle over the fire and rotated during heating to prevent the nuts from burning (Figure 9). During rotation, nuts pass through the cylinder and out of the opposite end of the drum. The duration of the roasting process can be regulated by changing the speed of rotation of the drum. The cylinder is covered in a hood connected to a chimney which draws the black smoke upward into the atmosphere and makes it less unpleasant for the operator (FAO, 1969).

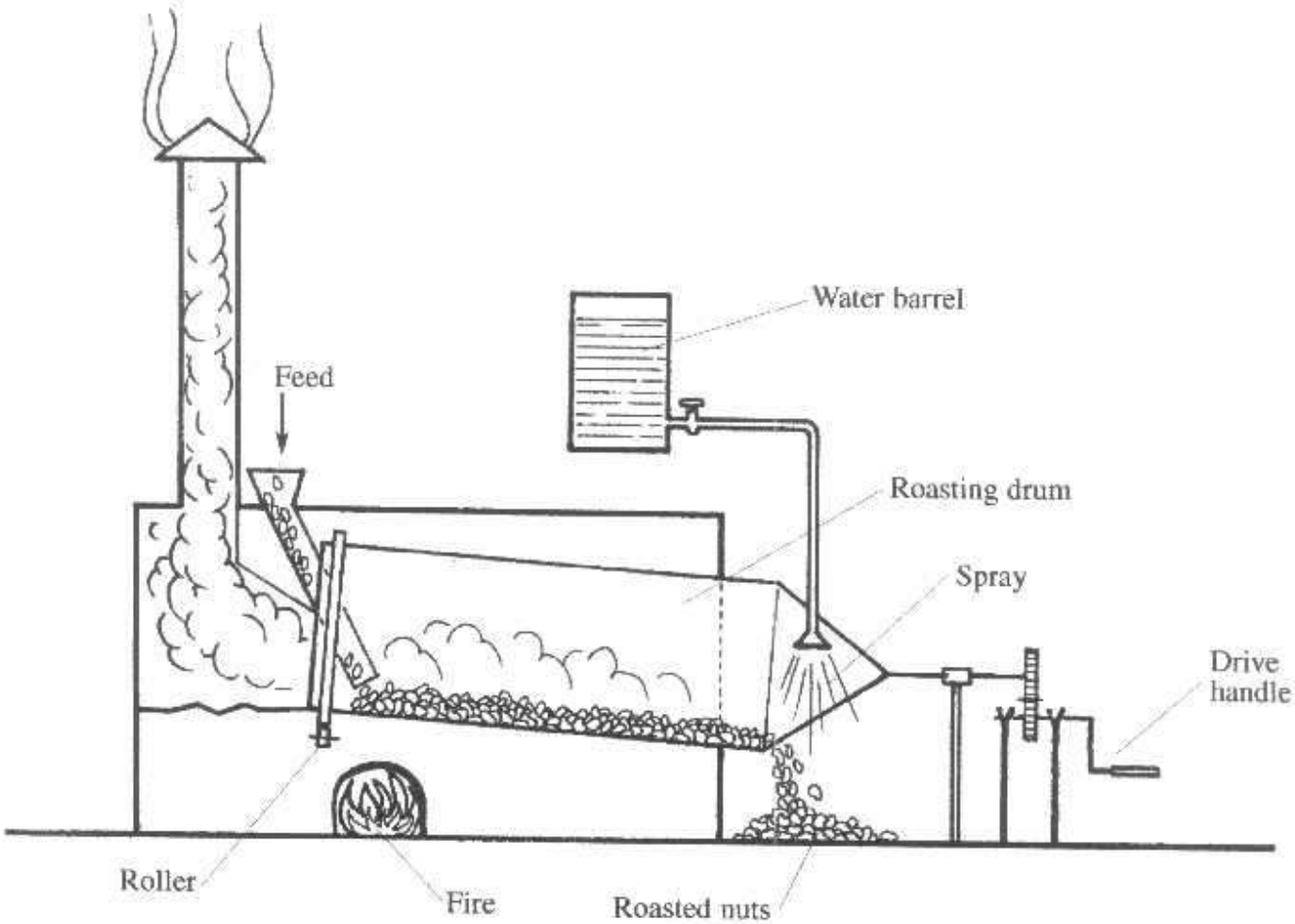


Figure 9: Diagram of a drum roaster fired from a furnace below.

Many of the drums were originally manually rotated, but were later fitted with a power drive. Although this method was an improvement over the original method, it was imperfect in that kernels were lost due to overheating and burning and the CNSL was lost.

6.3.2 The hot oil method

An increased demand for CNSL in the mid 1930s, led to a major change in cashew nut processing. The 'hot oil' method was developed and was widely adopted.

The principle of this method is that oil bearing substances, when treated in the same or similar oil at a high temperature, give up their oil constituents to the bulk, thereby increasing the volume of the bulk. When cashew nuts are submerged in a bath of hot CNSL, the CNSL within the shell is therefore extracted, resulting in an increase in the volume of the bath liquid.

Conditions for successful operation of the 'hot oil' method are described in Box 6.1.

Simple hot oil process

The simplest hot oil process is one that consists of a tank in which CNSL is heated and a wire basket that contains the nuts to be roasted. The nuts are placed in the basket and weighted down with a piece of mild steel plate (1 mm thick). A thermometer is inserted in the side well below the liquid level. Trays on either side of the tank act as draining areas, allowing excess oil to run back into the tank. The tank is heated from below by a built-in furnace. The nuts are held in the hot oil for 1.5 minutes at a temperature of 185°C. The entire process is manually operated. After roasting, the nuts are placed on a wire mesh screen over a tank for further draining and cooling prior to shelling.

A slight modification of this simple method allows larger quantities to be processed in one day. The equipment involves three circular baths situated in close proximity, each with a separate furnace. The baths are approximately 900 mm wide by 900 mm deep and are fitted

with wire mesh baskets, which hold the raw nuts. The baskets are successively dipped into the three oil baths.

The *Pierce Lesley* 'hot oil' method was the first of many to be patented. All subsequent methods are copies or modifications of this method and the equipment used by it. Equipment used varies in its degree of sophistication, throughput and price. The *Oltremare* hot oil plant is one such modified version that operates on the same principles. One advantage of this equipment is that it grades the nuts prior to roasting, thus allowing the nuts to be roasted for different lengths of time in accordance with their relative sizes.

Clean, conditioned cashew nuts are packed in a feed hopper, from which they are discharged at a controlled rate on to a conveyor that carries them through a hot oil bath maintained at 190°C. The equipment is designed such that the residence time within the oil bath is 1.5 minutes. The roasted nuts are subsequently discharged from the conveyor. The liquid level in the bath is maintained by an overflow pipe.

The bath is heated to a constant temperature by a furnace that runs along its length. Two thermometers are mounted within the bath to monitor the temperature. The oil bath is cleaned on a daily basis by a device that scrapes the bottom of the tank, gathering all the sludge and debris that has built up during the day.

The liquid overflow is channelled into drums in which it is filtered and allowed to settle in order to remove pieces of shell and other debris. Excess oil is filtered into drums for shipment.

Decarboxylation of the oil is inevitable throughout the process. The oil begins to froth as soon as new material is fed into the system and frothing continues until a steady state is attained. The oil bath design allows adequate space to accommodate frothing. Soon after roasting, the froth is broken and surplus liquid formed overflows into the settling drums.

Raw conditioned nuts, having a moisture content ranging between 15 and 17 percent are fed into the hot oil bath and heated until moisture is given off as steam. This produces some frothing. The production of steam within the nutshell assists with the extraction of CNSL, thus causing the shell to become brittle. There is a direct correlation between the amount of oil removed from the shell, its degree of brittleness and hence ease of cracking.

Large quantities of water vapour are produced in the oil bath due to the production of steam and the decarboxylation and evaporation of the lower fractions of the CNSL. Water vapour production can however be minimized by covering the bath and drawing off the vapour.

Fuel from a range of sources can be used to heat the furnace. The use of spent cashew shells, which also contain some excess CNSL provides one of the most economical methods of heating the furnace. Problems caused by fumes must however be addressed.

The bottom plate of the tank must be made of steel (20 mm thick) that is reinforced with chromium. Mild steel will pit and distort under the constant heat and the action of the hot CNSL.

The nuts are discharged from the bath on to a cooling conveyor. Scorching of the kernels occurs if the heated nuts are allowed to remain in a pile. It is essential that the kernels be cooled quickly on emerging from the hot oil bath. The conveyor is designed to draw off the

liquid from the nut and allow air to circulate around it in order to facilitate its cooling. Excess liquid is collected in a tank situated below.

The nuts are discharged from the end of the cooling conveyor into a centrifuge, which removes much or the remainder of the adhering surface oil. They are then either manually or mechanically shelled.

The hot oil method is preferred by larger scale processors. A power driven plant, however, requires capital investment and is less flexible than a less sophisticated drum roaster.

It has been shown that hot oil plants are successful when used for processing large quantities of nuts. This is due to the fact that the constant heating and cooling of the CNSL causes polymerization, which changes the characteristics of the oil and seriously affect the efficiency of the roasting process. When large quantities are roasted in a single batch, new liquid added to the bath keeps the liquid fresh while displacing some of the liquid which has been heated and cooled a number of times.

It is advantageous to cool the oil bath as quickly as possible subsequent to roasting. This is done by removing the heat source and allowing air to circulate freely. Cold CNSL can be added to the bath to assist in the cooling process (FAO, 1969).

6.4 Shelling

The objective of shelling is to produce clean, whole kernels, which are free of cracks. Shelling has always been manually performed in India. Other countries have difficulty in competing with the great skill and the low wages of Indian workers. India has therefore enjoyed a virtual monopoly of cashew processing for a long time. Manual shelling (described in Chapter 5) is still relevant to the small-scale processor, although a close look at mechanical options is recommended in all cases.

6.4.1 Mechanical shelling

Several pieces of equipment are designed to remove shells from cashew nuts. The main challenge with mechanical shelling is to remove the kernel without damage or contamination from the CNSL. This challenge is exacerbated by the irregular shape of the nut and the wide variation in the size of the nut. The most successful mechanized decorticators work on nuts that have been conditioned by the hot oil process, which makes the shell brittle and easier to break.

A semi-mechanized process that has been predominantly utilized in Brazil incorporates the use of a pair of knives, each shaped in the contour of half a nut. When the knives come together by means of a foot operated lever, they cut through the shell all around the nut, leaving the kernel untouched. Two people work at each table; the first cuts the nuts while the second opens them and separates the kernel from the shell. About 15 kg of shelled nuts are produced on a daily basis by this team.

The first mechanized shelling system, *Oltremare*, is also based on two nut-shaped knives. The nuts are brought to the knives on a chain, each nut aligned to fit between the knives. The nuts are pushed between the knives and cut. The chain itself has to be fed manually. After coming together, the knives make a twisting movement, thus separating the shell halves. The disadvantages of this method are that nuts smaller than 18 mm cannot be processed and output is reduced since not all the spaces on the chain can be filled. This can count for as much as ten percent of the production volume.

The shelling machines of the *Cashco* system are also chain fed but the nuts are automatically aligned. The shelling device has two knives that cut the sides of the nut and a pin that is wedged into the stalk end of the nut separates the shell halves. This system is advantageous in that it is a fully mechanized operation with an output of about 75 percent whole kernel quality. Nuts smaller than 15 mm cannot however be processed using this system.

Centrifugal shellers use a system, which is simple and enables a continuous flow. A rotary paddle projects the shells against the solid casing of the machine and the impact cracks open the shell without breaking the kernel. All sizes of nuts can be processed by this method. It is however, necessary to grade the nuts into about four sizes, since a different rotary speed is used for each of the various size groups. The percentage of whole kernels produced is around 75 percent. By weakening the shells with grooves before the operation begins, the percentage can be increased. The speed of the rotor can be reduced and the risk of damaging the kernels is minimized.

Development of a cashew nut sheller in India

A mechanical sheller was designed in India by researchers at the Post Harvest Technology Centre, Indian Institute of Technology in Kharagpur. The sheller uses principles of compression and shear, taking into account the physical and mechanical properties of cashew nuts. The machine consists of four compartments power supply, transmission, feeding, shelling and discharging (Figure 10).

The feeding section consists of a hopper and horizontal screw conveyor for positive feed of the roasted nuts to the shelling section. The design criteria for the hopper and screw conveyor use size, bulk density, coefficient of friction and angle of repose of roasted cashew nuts. A flat plate sliding gate is used to control the feed rate of cashews into the sheller.

Figure 10: Cashew shelling machine.

Shelling of roasted nuts takes place between two wooden discs, one of which is stationary (fixed to the machine casing) while the other is mounted on to a shaft. The rotating disc is spring loaded in order to compress and shear the roasted cashew nut against the stationary disc. Sufficient pressure is exerted by the spring in order to compress the nuts between the two discs. The compression and differential speed of the discs causes the shells to be broken and removed. Initial designs of the sheller resulted in either a high percentage of broken kernels or a large number of unshelled nuts. Further to several re-design attempts, a sheller has been developed with a shelling rate of about 70 percent and minimal breakage (Jain and Kumar, 1997).

The entire disc assembly is encased in an 18 gauge mild steel cage. At the bottom is a square opening (150 × 150 mm) for discharging the kernels and shells. A conduit is provided (120 mm diameter and 250 mm long) to prevent the kernels from being damaged by falling onto the collecting tray.

The machine is powered by a 1.5 kW DC motor (1500 rpm), equipped with a belt and pulley arrangement to transmit power from the motor to the shaft.

The performance of the sheller is optimal at 320 rpm. Performance statistics are as follows:

Capacity	18 kg/h
Shelling efficiency	70 %
Whole kernel yield	50 %
Half split yield	22 %
Broken yield	28 %

Die BM kann nicht angezeigt werden. Diese Ursachen verhegt möglicherweise eine zu wenig Arbeitsspeicher, an das BM zu öffnen, oder das BM ist beschädigt. Versuchen Sie den Computer neu, und öffnet Sie dann erneut die Datei. Wenn wollarfer das nicht n angezeigt wird, müssen Sie das Möglichkeiten Wechel und dann erneut einfügen.

Case study: Small-scale cashew processing centre, Kurunegala, Sri Lanka

Processors at a small-scale centre in Kurunegala, Sri Lanka have invested in a mechanical cashew sheller that was designed by the Sri Lanka Cashew Corporation, based on an Indian model. The sheller is operated by two workers . one who places the raw nuts into the machine and the other who removes the kernels from the split shells. The workers carry out these two tasks in turn, alternating about every hour. The raw cashews are placed into a receiving receptacle situated on a chain driven belt. The chain belt is operated via a foot pedal. On depression of the food pedal, the chain belt rotates and a raw nut is placed in the free hole. As the chain rotates, the nut is taken to a pair of knives that split the shell. The split shell is discarded into a collecting bucket. Kernels are removed from the split shells by a second worker.

In order to reduce the quantity of CNSL, the nuts must be conditioned prior to being inserted into the sheller. Operators coat their hands with coconut oil in order to protect themselves against CNSL leaking from the shells. Use of this sheller at the processing unit has increased the efficiency of shelling and in turn the daily output of the unit.

Comparison of performance and labour requirements before and after the introduction of a mechanical sheller in Sri Lanka:

	With a shelling machine	Before the shelling machine
Raw nuts per day (kg)	110	100
Kernel output (kg)	24.4	22.20
Wholes (kg)	20.74 (85%)	15.54 (70%)
Splits (kg)	3.66 (15%)	6.66 (30%)
Labour requirement		
Shelling	2	4

Peeling	4	4
Oven/grading/packing	1	1
Over all supervision	1	1
Total	8	10

6.5 Separation

After shelling, shell pieces and kernels are separated and the unshelled nuts are returned to the shelling operation. Blowers and shakers are generally used to separate the lighter shell pieces from the kernels. Recovery of small pieces of kernel sticking to the shell poses the greatest problem. This is usually done manually from a conveyor belt used to carry all the sorted semi-shelled nuts.

6.5.1 Pre-grading

Pre-grading can be done before or after drying the kernels and may greatly reduce the work involved in final grading. Pre-grading can be done mechanically for large-scale processes, separating mainly the whole from the broken kernels and sometimes separating the different size groups of whole kernels.

6.6 Drying

The shelled kernel is covered with the testa, the removal of which is facilitated by drying the shelled kernel, to produce the blanched kernel. Drying causes shrinkage of the kernel, thereby allowing the testa to be easily removed either mechanically or by hand with a knife. Drying also protects the kernel from pest and fungal attack at this vulnerable stage. All processors dry the shelled kernels prior to peeling.

The moisture content of the kernel is reduced from approximately six percent to three percent by drying. It is important that the drying capacity exceeds the shelling capacity, should there be periods of heavy rainfall. Under such circumstances, the drying operation is increased, since the kernels absorb moisture very quickly.

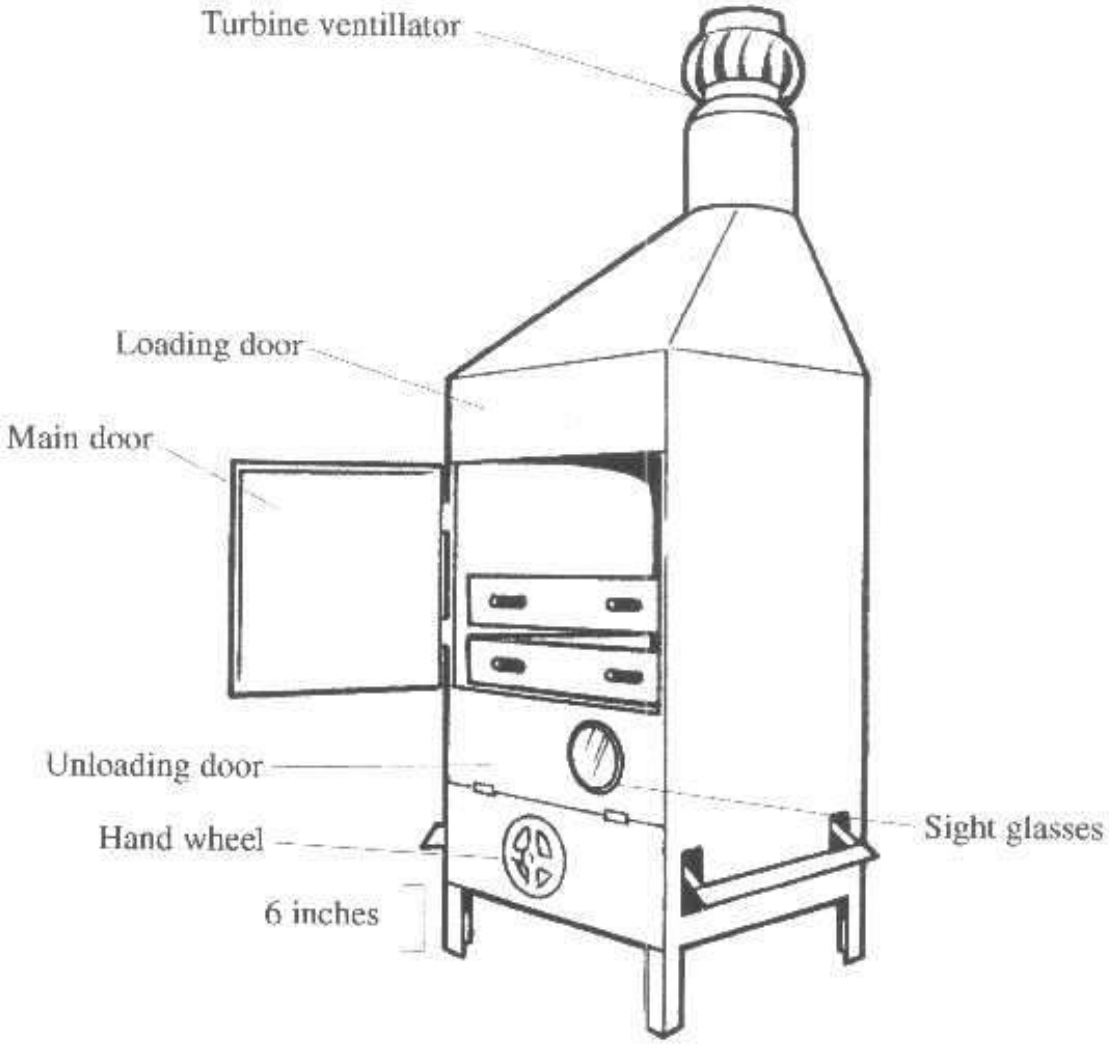


Figure 11: Diagram of as tray dryer.

Sun drying, where the kernels are spread out in the sun in thin layers is possible. It is however heavily reliant on a constant supply of sunshine. Although sun-drying does not pose any risk of scorching the kernels, it may be prolonged under conditions of bad weather, which can lead to mould development.

Artificial drying is more reliable and is required in medium or large-scale operations. Drying usually takes six hours, at a temperature of around 70°C. A uniform temperature throughout the drier is essential to avoid under-drying or scorching. Various drier designs are available. Figure 11 shows a tray dryer, designed by ITDG, for drying cashew kernels. The dryer contains a series of mesh-bottom trays that are slotted into the drying cabinet. The trays should be of a size that can be lifted when full. A lever mechanism automatically moves the trays down when dried trays are removed and when new ones are entered into the cabinet. Hot air circulates over the trays and is exhausted through the chimney. The heat source can either be a gas or electric powered heater. Burning cashew shells or other sources of fuel (ITDG, 2000) can also be used to provide a heat source.

Drying programmes are generally organized so that the kernels from one day' s shelling go directly into the oven for overnight drying. Kernels in the dried state are most vulnerable, since they are brittle and break very easily. It is essential that the kernels are carefully handled in order to minimize damage.

6.7 Peeling

At this stage, the testa is loosely attached to the kernel, although a few kernels may have already lost the testa during prior operations. Manual peeling is performed by gently rubbing with the fingers. Those parts still attached to the kernel are removed with the use of a bamboo knife. Approximately 10 to 12 kg of kernels can be peeled by one individual per day.

It is important that the kernels are neither cut nor damaged during the peeling process. The use of knives increases the likelihood of the kernels becoming damaged. It is also essential that the entire testa be removed. Gentle scraping of the testa with a blunt knife is the most effective way of removing it.

The peeled kernels can be separated into different grades by the peeler. At the most basic level, the kernels are separated into white wholes, scorched wholes, white pieces, scorched pieces, browns and refuse. More experienced graders are able to separate the kernels into more categories. It is preferable that grading is carried out at the time of peeling since this cuts down on handling of the brittle kernels. There is however an opportunity for further grading subsequent to peeling.

It is essential that the peelers work under well-lit conditions in order to enable them to remove the entire testa. At the end of the day, the removed testa is winnowed and all cashew pieces removed. The dust and very fine pieces that cannot be peeled, together with the diseased pieces, are classified as refuse and are thrown away. The browns, which are kernels that are badly diseased and which have not been separated out during the shelling operation, must also be removed and discarded (FAO, 1969).

Strict cleanliness in the peeling operation is essential, not only in the peeling room and its facilities, but must be observed by all personnel. All workers must follow basic codes of hygiene and wash their hands prior to handling the kernels.

The mechanized processes of peeling vary widely. They include air-blasting, suction, a freezing operation and a system of rubber rollers. These systems are of low efficiency due to the difficulty of removing the testa. The level of breakage can be as high as 30 percent. Currently research and development is taking place to improve the viability of the mechanization of this operation.

After peeling, the kernels are weighed in order to record daily production. The peeled kernels are vulnerable to insect infestation and mould growth. They are also prone to rodent attack and should be stored in rodent-proof containers or rooms.

6.8 Grading

The grading operation is important since it is the last opportunity for quality control of the kernels. After the kernels are extracted from the shells, dried and peeled, they are graded for export according to size and condition. The grading system is known as the American Standard, which is also incorporated in the Indian Government export criteria. Kernels are categorized on the basis of colour and condition.

Peeled cashew nuts can be classified into between 11 and 24 grades. These are roughly divided into three groups: white whole, white pieces and scorched grades. The three groups are further broken down as follows:

White wholes	
W180 (super large)	Between 120 and 180 kernels per lb (266 to 395 per kg)
W210 (large)	Between 200 and 210 kernels per lb (395 to 465 per kg)
W240	Between 230 and 240 kernels per lb (485 to 530 per kg)
W280	Between 270 and 280 kernels per lb (575 to 620 per kg)
W320	Between 300 and 320 kernels per lb (660 to 706 per kg)
W450	Between 400 and 450 kernels per lb (880 to 990 per kg)
White pieces	
Butts	A kernel broken cleanly across the section of the nut.
Splits	A kernel which has broken down the natural line of cleavage to form a cotyledon
Pieces	A kernel which has broken across the section but does not qualify for a butt and above a specific size.
Small pieces	As above but smaller.
Baby bits	Very small pieces of kernel which are white in colour.
Scorched grades	
Wholes	Whole kernels that have been slightly scorched during the process but are otherwise sound. These are not graded according to size.
Butts	Butts that have been scorched.
Splits	Splits that have been scorched.

Pieces	As for pieces, but which have been scorched during processing and contain all b the very small pieces.

White, whole kernels are graded according to their size on the basis of the number of kernels per pound (equivalent to 454 g). The most common count for Indian and African kernels is 300 to 320 per pound (W320) followed by 400 to 450 (W450), 220 to 240 (W240) and 200 to 210 (W210) per pound. In Brazil where the crop has a proportion of large kernels not found in other countries, another grade of 160 to 180 (W180) is available. Whole kernels of scorched and dessert types are not graded according to their count. but are sorted according to the colour of the kernel. White kernels, which are not whole, are graded according to the way in which they are broken. Splits are kernels that have divided naturally lengthways, while butts are kernels broken crosswise. Other pieces of kernels that have broken into more than two pieces are graded according to size i.e. large white pieces, small white pieces and baby bits (Errington and Coulter, 1989).

There are other grades that do not fall into the above classification, but which are used for local consumption or are shipped to countries that have an outlet to the cheaper trade. These are the dessert grades and are classified as follows:

- scorched wholes, grade 2: a whole kernel that is discoloured but otherwise sound,
- dessert wholes: a whole kernel with a black spot or comparably more scorched than the above,
- dessert pieces: pieces that are discoloured as above.

In practice, most processors do not produce all of the different grades. They produce such small quantities of certain grades that it is uneconomical to produce them all.

With the exception of a few grading aids, all grading is done by hand. Graders sit on high stools or stand at tables that are covered in blankets to provide a soft surface and reduce breakage. The blankets also hold any dust that is removed from the kernel. It is essential that the room be well lit as colour is an important grading criterion. With experience, graders become accustomed to picking out kernels of one particular size. A proven procedure is to have one or two workers picking out the 210 and 240 count grades, then have one or two more workers picking out the 450 count. The majority of the remaining kernels (and usually the largest quantity) will be the 320 count. In addition, all graders also pick out scorched kernels and broken pieces. It is important that care is taken to avoid breakage of the kernels during grading.

Throughout the grading of white whole kernels, the weight must be constantly checked. This is done with the use of a small counter scale with 250 g (½lb) of graded kernels accurately weighed out and counted. From this, the count per kg (or per pound) can be calculated.

With the scorched grades, the degree of scorching must be evaluated by the grader, who must judge between scorching and discoloration due to disease. This applies to both wholes and pieces and to scorched butts and splits. Kernels that are discarded from the scorched category go into categories of either scorched wholes grade 2, dessert wholes or dessert pieces.

Several attempts have been made to mechanize the grading of kernels, with limited success. Power driven rotary sieves are one mechanical method, another being the use of two outwardly rotating rubber rollers aligned at a diverging angle. For large operations looking towards export markets, it is necessary to grade the kernels to an international level.

In all classes, there are certain minimum requirements to which operators must adhere:

1. Kernels should be free from any deterioration likely to affect the natural keeping quality of the nuts and make them unfit for human consumption. They should be:

- Sufficiently developed and ripe,
- Clean, practically free from any visible foreign matter,
- Free from living or dead insects, whatever their stage of development,
- Free from visible insect damage, mites or other parasites,
- Free from mould or rancidity,
- Free from adhering shell liquid or testa,
- Free of any foreign smell or taste.

2. Cashew kernels should have a moisture content no greater than five percent.

Quality has emerged, ahead of price, as the most vital criterion for any item if it is seeking entry into the global market. Quality aspects include safety, reliability, durability and acceptability of the product to the consumer (Nayar, 1995). Small-scale processors have to match the standards set by importers, consumers and standards agencies. Details of the minimum requirements for export will be available from the Ministry for Export or the Chamber of Commerce. Quality assurance procedures are an essential element of any processing operation to ensure product consistency between different batches. Simple HACCP (Hazard Analysis Critical Control Point) procedures suitable for small-scale operators to follow, can and should be applied to the process (Dillon and Griffith, 1995).

6.9 Rehumidification

Prior to packing the kernels, it is necessary to ensure that their moisture content is increased from three percent up to around five percent. This makes the kernels less fragile, thus lessening the risk of breakage during transport. In humid climates, the kernels may absorb enough moisture during peeling and grading to make a further rehumidification process unnecessary.

The final moisture content is critical since, moisture contents in excess of six percent, favour mould growth. Moisture content of five percent is optimal. Many processors have facilities for adjusting the moisture content.

The moisture content of the cashews can be increased by transferring them to conditioning rooms which are completely closed rooms, in which trays of cashew kernels are placed overnight to absorb moisture from the surrounding air. Under low humidity conditions, the floor is sprayed with water prior to closing the door. Under high relative humidity conditions, it may not be necessary to add water to the floor. Steam is sometimes used for humidifying the kernels. Saturated steam is allowed into the conditioning room. The amount of steam to be injected is determined on basis of personal experience.

Determination of the moisture content is extremely important at this stage of the process. Two methods that are recommended for the determination of moisture content: use of the *Steinlite* Moisture Meter and the *Dean and Stark* apparatus (Box 6.9).

6.10 Packing

The normal packaging used for the export of kernels is airtight cans of 11.34 kg (25 lbs) weight capacity. The packaging material needs to be impermeable, since cashew kernels are subject to rancidity and go stale very quickly. The can will be familiar to most tropical countries as it is a replica of the four gallon kerosene or paraffin oil can. Cans can be locally made in order to reduce costs. Parts purchased overseas can be locally fabricated. This may be done by arrangement with can manufacturers. The output of a can manufacturing line is usually too large for a single consumer, but some cashew nut processors have installed their own can manufacturing plants and supply other processors.

After filling and weighing, the cap should be soldered in preparation for the *vita pack* process. This consists of removing all the air from the can and substituting it with carbon dioxide (CO_2). The advantages of packing cashew kernels in carbon dioxide are two-fold. Firstly, carbon dioxide will not support life so any infestation that may have been present is therefore arrested. Secondly, carbon dioxide is soluble in cashew oil and goes into solution as soon as the can is sealed. Within a short period of time, a decrease in pressure takes place as the carbon dioxide goes into solution and the sides, top and bottom of the can are drawn inwards. The kernels are therefore tightly sealed in the can, thus preventing movement and breakage during transport. Carbon dioxide, being a heavy gas, causes the upward displacement of air and will remain in the cans after filling. Some large-scale machines will operate on six cans at a time, creating a vacuum in each and subsequently filling it with carbon dioxide.

Some processors do not have vacuum pumps and displace the air in the can by feeding in carbon dioxide through a small hole in the bottom of a side of the can. The carbon dioxide valve is turned off when all the air has been replaced. Holes in the can are then sealed, with the hole at the bottom of the side of the can being sealed first and the one at the top last.

6.11 Infestation

Far too little attention is paid to the infestation hazards to cashew kernels. These hazards are more prevalent at some times of the year than others. A good processor will be vigilant all the times. The main insect pests are:

- ants
- grain weevils
- meal moths

The most important defence against infestation of any type is cleanliness and is essential in the rooms used for drying, peeling, grading, conditioning and packaging. Floors and walls must be sound and free from cracks. They should be white-washed on a regular basis. Some processors fill the corners and areas at which the wall meets the floor with a curved filling in order to eliminate all corners, so that the room can be properly swept.

The speed of operations between drying and packaging must be stressed as this reduces the critical period when attacks may occur, to a minimum. The equipment used must also be thoroughly cleaned on a regular basis as insects may breed in hidden crevices and gaps.

The kernels are most vulnerable when dry, being both brittle and susceptible to insect infestation. Therefore, at this stage, they must be handled with care and moved to the next stage of peeling as quickly as possible.

6.12 Hygiene and safety

Successful business activity is dependent upon adequate food safety and hygienic practices. The main ways in which a producer can harm consumers are by selling food that:

- contains poisonous materials,
- contains bacteria or moulds or the poisons they produce,
- contains glass or other contaminants that could cause harm if eaten.

Safe food can be produced by careful attention to hygiene and by the use of proper quality control.

Proper hygiene means careful attention to the cleanliness of the processing equipment and the personal hygiene of food handlers.

Proper quality control means careful attention to the selection of good quality raw materials; correct processing conditions, such as the temperature and time of heating; preventing contaminating materials, such as dirt, metal and stones, from becoming mixed with the food; and the use of suitable packaging materials to protect the food after processing. These factors will ensure that only wholesome food is produced without contaminants. Any bacteria in the raw materials will be destroyed or controlled at a safe level and prevented from growing and multiplying (Fellows, Hidellage and Judge, 1999).

6.12.1 Food hygiene and the law

In most countries, laws on food processing are designed to protect consumers against poisoning and injury. Nuts are prone to becoming contaminated by the mould aflatoxin. Readers are advised to contact their local Bureau of Standards, Ministry of Health or other relevant government Departments in order to obtain full details of the specific laws of their country.

Although food laws can be enforced, in the end, the customer is the most effective food inspector. If customers become ill from eating a food, they will not buy food from that processor again. It is therefore in the processor' s interest to prepare safe wholesome foods.

6.12.2 Food poisoning and its causes

The main cause of food poisoning is microbial activity. Microbes live almost everywhere: on animals and plants (hence on all fresh foods), in and on humans, in the soil, water, air and on all surfaces. There are many different types, but the most important for food hygiene are bacteria, yeast, moulds and viruses.

Agents that cause disease (pathogens) can be transmitted to humans by a number of routes - soil, air, water, direct person-person contact and food. Some can be transmitted to food by animals or by an item of equipment. Cross contamination occurs when contaminants are transferred from one food to another via a non-food surface, for example, utensils, equipment or human hands.

Illness is caused by eating food containing a significant amount of harmful bacteria. Poisoning bacteria can cause illness, either by producing poison in food before it is eaten or by continuing to multiply inside the body after eating. The symptoms of an attack of food poisoning can include stomach pains, diarrhoea, vomiting, headache, fever and aching limbs. Sometimes the illness lasts for days, weeks or months and in some cases, it can cause death.

6.12.3 Personal hygiene

The main problems arise from contaminating food while preparing it, with microbes from the processors own hands or mouth, from dirty tools, work surfaces or from other food. All persons handling food should pay strict attention to good hygiene practices. This includes wearing clean, suitable clothing, including aprons, gloves and footwear and covering the hair to prevent contamination of foods. Aprons, gloves or any other clothing that could touch the food should be thoroughly cleaned everyday if necessary.

All cuts or wounds should be covered by a waterproof dressing and kept clean, even if they are not on the hands. Processors should not handle foods if they have a stomach upset or a skin disease or if they are looking after someone else with these illnesses.

The processor should not smoke, eat or chew anything while preparing food. They should never spit near the food being prepared or cough or sneeze over foods as this spreads bacteria and can contaminate the food.

Everyone who touches food should wash his/her hands properly, using soap and clean water, especially after every visit to the toilet and between handling raw meat or poultry and any other food stuff, to avoid cross contamination.

After the basic preparation of ingredients has been completed, direct handling of the food can be avoided if appropriate care is taken. Food can be moved about with tongs or similar utensils. If the food is to be sold in bags, a good technique is to use the bag as a glove so that direct hand contact is prevented.

6.12.4 Cleanliness of equipment and the working area

Just as invisible harmful organisms live on the body, they can also be present on the utensils and surfaces with which food comes into contact. All surfaces and equipment must be clean before work, during production and after the process is finished. Cloths and sponges used to wipe down surfaces and towels used for hand drying should be washed and sterilized regularly by boiling in water.

There should be a supply of clean water for washing equipment as soon as it has been used and for use in food processing. If the water is not clean, it will contaminate the food. If the water comes from a stagnant pool or dirty source, it should be boiled for at least ten minutes to destroy bacteria, before it is used for washing food or utensils or processing.

All the equipment must be in good condition and be properly repaired. Rusty, dirty or broken equipment must not be used to process foods as these can cause accidents as well as contaminate the food.

Equipment and utensils should be stored where they can be kept clean when not in use. Hang brushes and cloths up to dry after use. Store the cleaning equipment in a separate cupboard from the food and processing equipment. Keep all chemicals, pesticides, poisons and detergents away from food in a separate storage area.

Make sure that there is good lighting to help stop accidents and make working easier and safer.

6.12.5 Other sources of contamination

Food should always be kept covered and above ground level to protect it from contamination by insects, rodents and birds and the bacteria they carry. Flies, bluebottles, rats, mice and other vermin contaminate food with bacteria from their droppings or their bodies. All cupboard doors and lids of tins and jars should fit tightly. Table legs can be put in pots of water or kerosene to stop ants crawling up them.

All spills should be cleaned up as soon as they are formed. Wastes should not be left to accumulate on floors, in drains or on work surfaces. Lids should be kept firmly on bins and waste sacks should be securely fastened before putting them out for collection.

6.12.6 Packaging and preservation

Food poisoning bacteria multiply very quickly in moderate temperatures (between 20 to 40°C) so all foods should be stored in the shade and out of the sunlight. Storage areas and surfaces should be kept dry so microbes do not have the moist environment they need to breed.

Die BM kann nicht angezeigt werden. Diese Computer verfügt möglicherweise über zu wenig Arbeitsspeicher, um die BM zu öffnen, oder die BM ist beschädigt. Versuchen Sie den Computer neu, und öffnen Sie dann erneut die Datei. Wenn weiterhin das Problem auftritt, müssen Sie die BM möglicherweise löschen und dann erneut einfügen.

FOOD HYGIENE SUMMARY

Transferring bacteria from outside sources

- Using dirty implements
- Cutting food up on a dirty board or surface
- Infecting cooked food with bacteria from raw food
- Preparing food with unwashed hands
- Using food that has fallen onto the floor
- Biting fingernails and licking fingers
- Serving food on dirty plates
- Washing up with dirty cloths

Creating ideal growth conditions for microbes

- Not heating food to a high enough temperature
- Cooking food too soon and letting it cool for too long and too slowly before
- Reheating food slowly or insufficiently

CHAPTER 7

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CHAPTER 8

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General information on cashew

http://www.pavich.com/products/cashew.htm
Cashew Background Information

http://www.palmerint.com/overview.htm
A site focussing on Cashew Nutshell Liquid

http://www.newafrica.com/directory/agriculture.htm
Contact details of organizations involved in cashew

http://www.cashews-driedfruits.com/cashewsfactory.htm
A range of information on cashew grades, production, whole kernels

http://www.rirdc.gov.au/pub/spring98.htm
Links to a handbook on cashew production

http://apps.fao.org/pagr/collections?subset=agriculture
Database of annual production statistics

http://www.vedamsbooks.com/no7104.htm
Information on publications

http://www.amberwoodtrading.com/
Includes a cashew market report

http://www.financialexpress.com/fe/daily/20001129/fco29028.html
Current market information

http://www.marketag.com/markets/uk/imports/080130.stm
Market prices

http://www.cashewindiaonline.com/register.html
Up-to-date information from India on the following:
1. Information on cashew producers and products.
2. Cashew trade news.
3. Information on all segments related to cashew-planters, factories, exports, imports, traders, transports machineries etc.
4. Information on new projects.
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Cashew processing in Guinea

Equipment manufacturers and suppliers

Cashew nut decorticators

Capacity: 5 to 10 kg/man/day
Power Source: Manual
Kunasin Machinery
107-108 Srisatchanalai Road
Amphoe Sawankaloke
Sukhothai
Thailand
Tel: +66 (0) 55 642119 / 641653

Capacity: 16 kg/hour
Power Source: Manual
Rajan Universal Exports (Manufacturers) PVT. Limited
Post Bag No. 250
162, Linghi Chetty Street
Chennai - 600 001
India
Tel: +91 44 5341711 / 5340731 / 5340751 / 5340356
Fax: +91 44 5342323

Cashew shellers

Power Source: Manual

Kaddai Engineering
PO Box 2268
Kumasi
Ghana

Sri Lanka Cashew Corporation
349 Galle Road

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Tel: +94 01 576054
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The Bombay Engineering Works
1 Navyug Industrial Estate
185 Tokersey Jivraj Road
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Sewree (W)
Bombay
India
Tel: +91 22 413 7094/413 5959
Fax: +91 22 413 5828
Email: bomeng@bom3.vsnl.net.in

Sri Venkateswara Industries
C-37, Industrial Estate
Yadavagiri
Mysore - 570 020
India
Premium Engineers PVT Ltd
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42, rue Scheffer
75116 Paris
France
http://www.cirad.fr

CSIRO
Australia
E-mail: Enquiries@csiro.au
http://www.csiro.au

FAO
Information Network on Post Harvest Operations
via delle Terme di Caracalla
00100 Rome
Italy
http://www.fao.org/inpho/index-e.htm

GRET
211-213 Rue Lafayette
Paris
France
http://www.gret.org/

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HR3 5HP
UK

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ME4 4TB
UK
http://www.nri.org/

Rural Industries Research & Development Corporation
Australia
http://www.rirdc.gov.au

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Kandy
Sri Lanka
E-mail: techaction@mail.ewisl.net

Technoserve Inc
Av 25 de Septembre No 63
Nampula
Mozambique

ANNEX 1

TRENDS IN GLOBAL PRODUCTION (1961 to 2000)

Country

2000	1999	1998	1997	1996	1995	1994	1993	1992	1991
Africa									
Tanzania	106 500	106 500	93 200	63 000	82 000	63 400	46 500	42 300	41 3
Mozambique	35 000	51 894	51 716	43 325	65 000	33 423	23 000	23 935	54 2
Nigeria	176 000	176 000	152 000	125 000	110 000	95 000	85 000	75 000	55 0
Others	115 455	115 455	108 355	97 006	87 338	83 148	73 924	70 009	67 0
Total	**432 955**	**449 849**	**405 271**	**328 331**	**344 338**	**274 971**	**228 424**	**211 244**	**217 5**
% of world	35.6	37.6	37.8	30.4	30.9	29.1	24.6	25.7	27
Asia									
India	440 000	440 000	440 000	430 000	417 830	321 640	350 000	350 000	305 3
Indonesia	69 027	69 027	69 027	66 878	67 676	74 995	72 077	69 751	62 2
Vietnam	41 200	41 200	54 000	66 900	59 100	52 800	78 000	65 000	58 0
Others	52 010	52 010	51 010	49 575	49 210	44 943	42 920	39 050	38 2
Total	**602 237**	**602 237**	**614 037**	**613 353**	**593 816**	**494 378**	**542 997**	**523 801**	**463 7**
% of world	49.5	50.3	57.3	56.8	53.4	52.4	58.4	63.8	58
South America									
Brazil	167 123	130 841	39 836	125 397	167 211	164 156	149 804	77 098	107 9
Others	8 895	8 895	5 630	5 131	4 692	4 565	4 224	4 250	3 6
Total	**176 018**	**139 736**	**45 466**	**130 528**	**171 903**	**168 721**	**154 028**	**81 348**	**111 6**
% of world	14.5	11.7	4.2	12.1	15.4	17.9	16.6	9.9	14
World Total	**1 217 210**	**1 197 822**	**1 070 774**	**1 080 212**	**1 113 057**	**944 070**	**929 449**	**820 393**	**796 9**

Country	1990	1989	1988	1987	1986	1985	1984	1983	19
Africa									
Tanzania	17 060	19 260	22 470	18 490	19 200	32 750	38 100	33 070	43 2
Mozambique	22 524	50 225	45 000	35 000	30 000	25 000	20 300	35 600	61 0
Nigeria	30 000	25 000	25 000	25 000	25 000	25 000	25 000	25 000	25 0
Others	56 161	63 901	44 823	39 927	38 794	32 045	39 600	21 800	25 5
Total	**125 745**	**158 386**	**137 293**	**118 417**	**112 994**	**114 795**	**123 000**	**115 470**	**154 7**
% of world	20.7	24.5	22.6	22.6	20.7	22.0	26.0	25.0	31

Asia									
India	285 590	274 330	260 260	245 580	234 480	221 330	210 870	201 440	195 7
Indonesia	29 907	27 990	23 305	24 042	22 515	21 114	19 411	18 047	16 8
Vietnam	26 000	8 500	8 000	12 000	10 000	9 000	8 500	7 700	7 0
Others	32 930	34 897	41 302	39210	36 156	31 560	30 640	22 970	23 8
Total	**374 427**	**345 717**	**332 867**	**320 832**	**303 151**	**283 004**	**269 421**	**250 157**	**243 4**
% of world	61.7	53.4	54.7	61.2	55.6	54.3	56.9	54.1	50
South America									
Brazil	99 367	136 130	128 080	75 000	120 000	115 000	74 000	90 000	80 0
Others	3 546	3 655	4 179	4 202	4 339	4 226	3 105	3 520	3 1
Total	**102 913**	**139 785**	**132 259**	**79 202**	**124 339**	**119 226**	**77 105**	**93 520**	**83 1**
% of world	17.0	21.6	21.7	15.1	22.8	22.9	16.3	20.2	17
World Total	**606 681**	**647 665**	**608 533**	**523 874**	**544 866**	**520 973**	**473 435**	**462 719**	**485 3**

Country	**1980**	**1979**	**1978**	**1977**	**1976**	**1975**	**1974**	**1973**	**1972**
Africa									
Tanzania	41 416	57 128	68 478	93 285	83 637	115 840	121 704	145 080	125 5
Mozambique	71 100	66 000	61 000	91 500	122 000	188 000	213 400	240 000	200 0
Nigeria	25 000	25 000	25 000	25 000	25 000	25 000	25 000	25 000	25 0
Others	24 986	27 560	45 500	44 160	35 660	29 195	23 747	22 658	19 3
Total	**162 502**	**175 688**	**199 978**	**253 945**	**266 297**	**358 035**	**383 851**	**432 738**	**369 9**
% of world	35.0	38.4	40.9	48.9	52.5	63.5	65.6	69.3	66
Asia									
India	180 266	171 817	165 323	162 457	161 536	144 254	135 451	129 766	130 0
Indonesia	9 074	9 764	8 799	7 370	7 176	9 122			
Vietnam	5 600	4 900	4 900	4 900	4 900	3 500	3 500	3 500	3 5
Others	23 980	23 665	25 525	23 650	23 860	22 140	21 170	14 060	11 7
Total	**218 920**	**210 146**	**204 547**	**198 377**	**197 472**	**179 016**	**160 121**	**147 326**	**145 2**
% of world	47.2	45.9	41.9	38.2	38.9	31.8	27.4	23.6	26
South America									
Brazil	75 000	65 000	77 000	60 000	36 800	20 490	34 901	36 936	35 0
Others	3 394	3 068	2 892	2 552	2 522	2 512	2 650	2 587	2 5
Total	**78 394**	**68 068**	**79 892**	**62 552**	**39 322**	**23 002**	**37 551**	**39 523**	**37 5**
% of world	16.9	14.9	16.3	12.0	7.7	4.1	6.4	6.3	6
World Total	**464 215**	**457 696**	**488 657**	**519 629**	**507 544**	**563 795**	**585 246**	**624 348**	**558 1**

Country	1970	1969	1968	1967	1966	1965	1964	1963	1962
Africa									
Tanzania	107 445	95 700	92 500	83 800	83 200	76 000	71 000	50 000	70 0
Mozambique	184 000	154 200	185 900	101 000	119 600	136 000	156 000	149 000	108 0
Nigeria	25 000	25 000	25 000	24 000	23 000	22 000	19 000	15 000	14 0
Others	29 327	13 510	14 605	17 582	15 460	14 350	14 650	12 250	12 1
Total	**345 772**	**288 410**	**318 005**	**226 382**	**241 260**	**248 350**	**260 650**	**226 250**	**204 1**
% of world	67.5	63.7	65.8	58.4	63.3	64.3	68.0	64.8	62
Asia									
India	123 319	120 438	118 542	114 182	103 818	100 000	95 000	92 000	88 0
Indonesia									
Vietnam	2 100	2 100	2 100	2 100	2 100	700	700	700	7
Others	11 620	10 440	13 180	12 950	13 870	15 600	9 610	7 690	9 8
Total	**137 039**	**132 978**	**133 822**	**129 232**	**119 788**	**116 300**	**105 310**	**100 390**	**98 5**
% of world	26.8	29.4	27.7	33.3	31.4	30.1	27.5	28.8	30
South America									
Brazil	20 309	23 443	23 683	24 181	13 677	13 789	9 643	13 621	11 9
Others	2 504	2 510	2 466	2 471	2 427	2 389	2 334	2 327	2 2
Total	**22 813**	**25 953**	**26 149**	**26 652**	**16 104**	**16 178**	**11 977**	**15 948**	**14 2**
% of world	4.5	5.7	5.4	6.9	4.2	4.2	3.1	4.6	4
World Total	**511 939**	**452 676**	**483 538**	**387 776**	**381 318**	**386 303**	**383 437**	**349 088**	**324 8**

ANNEX 2

PRODUCTS CONTAINING CASHEW APPLE AND CASHEW NUT

Cashew apple fruit chutney

Ingredients

3 kg cashew apple slices
3 kg sugar
168 g salt

84 g onion (peeled and finely chopped)
21 g cumin powder
21 g black pepper
21 g cardamom powder
42 g green ginger (peeled and grated)
7 g cinnamon (coarsely powdered)
7 g coriander
42 ml acetic acid glacial (vinegar)

Method

Type 1

The cashew apples are immersed in a two percent brine solution (common salt solution) for three days. After washing free of salt, the apples are steamed for five to seven minutes at 10lb pressure. The steamed apples are then cooled and washed in water. Any bad portions are trimmed off before the apples are sliced into segments. The apple slices are cooked with the addition of salt, sugar, spices and the acetic acid. The ginger, cinnamon and coriander are tied loosely in a cloth bag and added to the mixture. This bag is removed when the chutney is cooked.

Type 2

Soak cashew apple slices in a two percent brine solution for three days, remove from the brine and wash in clean water. Remove any undesirable portions and then slice the apples. Chutney is prepared as usual, using 1 kg sugar, 1 onion (large size), 30 g ginger, 1 teaspoon of cumin seed, pepper, cardamom, cinnamon and coriander powder, salt to taste and 20ml glacial acetic acid for every 1 kg of fruit slice.

Tie all the powdered spices in a clean thin piece of cloth, (such as muslin). Prepare a sugar syrup by adding an equal quantity of water to the sugar. Add the sliced apples, chopped onion, grated ginger, vinegar and salt to the sugar syrup. Drop the spice bag in when the mixture begins to boil. Boil the mixture until it is sufficiently thickened and hot-fill into clean, sterilized jars.

Cashew apple pickle

Ingredients

65 g cashew apple pieces
12 g salt
5 g chilli powder
5g coriander
2 g fenugreek seeds
5g mustard powder (fried and ground)
1 g turmeric
1 g acetic acid
1.5 to 2 g citric acid

5g jaggery
5 g ginger oil

Method

Soak cashew apple pieces for 10 days in a 12 percent brine solution and then wash thoroughly in water. Heat the oil and add the spices. Pour the oil and spice mixture over the brined apple pieces, mix well and allow to cool. Add preservatives (acetic acid and citric acid) to the apple mixture, cover with the remaining oil and store in a sterile container.

Sweet cashew pickle in oil

Ingredients

1 kg cashew apples
63 g salt
20 g chilli powder
1.5 g ginger paste
30 g chopped onion
3 g mustard seeds
3 g cumin
3 g cloves
1.5 g cardamom
3g cinnamon
3 g garlic paste
125 ml vinegar
125 g sugar
edible oil (enough to immerse the pickles in the container)

Method

Soak cashew apple cubes in a 12 percent brine solution for 10 days and then thoroughly wash in clean water. Heat a small quantity of oil until it is bubbling and add the mustard seeds, onion, garlic and ginger. When the mustard seeds stop popping, add the remaining spices and the fruit cubes and heat for a few minutes. Cool the mixture to room temperature, then leave to stand in the sun for three or four days. After this time, add the sugar and vinegar and stir into the mixture. Heat sufficient oil to immerse the pickle in the container, cool it and pour over the pickle mixture. Seal the container and store at room temperature.

Recipes using dried cashew apple powder.

Cashew apples are highly perishable as they cannot be stored for more than 24 hours. To resolve this problem, the pulp can be dried and ground into a powder that can be used in a range of products.

Preparation of cashew apple powder

Cashew apple pieces are dried (either with or without cashew apple juice) for 12 hours (with juice) or 4.5 hours (without juice) at 70°C. The dried pieces are ground and stored in airtight containers for use in a range of recipes.

Cashew apple sweet cookies

Ingredients

72 g wheat flour
8 to 16 g cashew apple powder
50 g ghee (clarified butter)
40 g sugar
5 g baking powder

Method

Cream the ghee or butter and sugar to form a light and fluffy cream. Sieve the wheat flour, cashew apple powder and baking powder into the mixture and mix to form a stiff dough. Roll out the dough into a layer an eighth of an inch thick (3 to 4 mm) and cut out small biscuits. Bake at 180°C for 20 minutes until golden brown.

Cashew apple masala cookies

Ingredients

135 g wheat flour
15 to 30 g cashew apple powder
75 g ghee or butter
l0 g sugar
5 g salt
5 g baking powder
45 g curds
20 g green masala
(made from a mixture of coriander leaves, green chillies, curry leaves and ginger in equal quantities)

Method

Sieve the wheat flour with the cashew apple powder, baking powder and salt twice to ensure that it is well mixed. Rub the ghee or butter into the flour until the mixture resembles breadcrumbs, then add the sugar and stir well. Add the green masala and curds and knead the mixture into a soft dough. Roll out to form a thin sheet of one eighth of an inch thickness (3 to 4 mm)and cut with a fancy biscuit cutter. Bake in an oven at 180°C for 20 minutes until golden brown in colour.

Cashew apple porridge mix

Ingredients

70 g malted wheat flour
30 to 40 g cashew apple powder
15 g powdered sugar

Method

Sieve all the ingredients thoroughly to form a uniform mixture. Add 100 g porridge mix to 600 ml of water and cook, stirring continuously for about 5 to 10 minutes.

Cashew apple sweet doughnuts

Ingredients

90g wheat flour
10 g cashew apple powder
1.5 g baking powder
3 g yeast
15 ml + 35 ml water
4 g milk powder
20 g sugar
20 g ghee or butter
1.5 g salt
half an egg
a few drops of vanilla essence
oil for frying

Method

Sieve the flour, salt, cashew apple powder and baking powder together twice. Gently rub the ghee or butter into the sieved powder mix. Mix the yeast with 15 ml water and 1 tsp of the sugar and leave to stand for about 10 minutes until it froths. Add the rest of the water (warmed to about 35° C) to the yeast and mix. Add the sugar, lightly beaten egg and milk and beat until a soft dough is formed. Knead lightly until smooth and rest for 30 minutes. Roll out to about one quarter of an inch (6 to 8 mm) thick and cut with a doughnut cutter. Rest for 10 minutes. Fry the doughnuts in oil until golden brown in colour, then roll in sugar powder.

Cashew apple masala doughnuts

Ingredients

90 g wheat flour
10g cashew apple powder
½ teaspoon yeast

15+35 ml water
5 g (1 teaspoon) milk powder
5 g sugar
½ teaspoon salt
half an egg
10 g ghee or butter
40 g onion (chopped)
6 green chillies
4 g curry leaves (chopped)
10 g coriander leaves
Oil for frying

Method

Sieve the flour, baking powder, cashew apple powder, milk powder and salt together twice. Dissolve the yeast in 15 ml of lukewarm water with a pinch of sugar. Chop the onion, green chillies, curry leaves and coriander leaves. Dry them a little by keeping in an oven or frying for a short time in a pan. Cream the butter or ghee and the sugar together until smooth and then fold in the flour mixture. Add the yeast, the egg and the masala (mixed leaves and chilli) and leave to ferment for about 1 hour. Knead to a smooth dough add a little water and rest for 30 minutes. Roll out to a quarter inch (6 to 8 mm) in thickness. Cut with a doughnut cutter and rest for 10 minutes. Deep fry in oil until golden brown.

Cashew apple sponge cake

Ingredients

90 g wheat flour
10 g cashew apple powder
¼ teaspoon baking powder
50 g ghee or butter
100 g powdered sugar
1 egg
½ teaspoon vanilla essence
½ teaspoon salt
milk to mix

Method

Sieve the flour and cashew apple powder along with a pinch of salt and baking powder. Cream the ghee or butter and sugar until the texture is light and fluffy. Beat the egg thoroughly and add to the creamed mixture a little at a time. Mix well, then gently fold in the flour. Add the milk to bring the mixture to a dropping consistency, spoon into a lined tin and bake at 150°C for 35 to 40 minutes.

Cashew nut vegetable kurma

Ingredients

100 g cashew nuts
100 g carrot (chopped)
100 g peas
100 g French beans
100g paneer (cottage cheese)
2 tomatoes
2 onions sliced
¼ teaspoon turmeric powder
1 teaspoon red chilli powder
1 teaspoon coriander-cumin powder
1 teaspoon ginger-garlic paste
1 clove cardamom
pinch of powdered cinnamon
1 lemon
salt to taste
1 bunch coriander leaves (chopped)
ghee or oil for frying

Method

Boil the carrots, peas and French beans for two to three minutes. Slice the onions and fry in ghee or oil. Add the ginger and garlic paste and fry. Add tomatoes, tumeric, chilli powder, coriander-cumin powder and salt and stir together. Add the paneer pieces, boiled vegetables and cashew nuts. Mix all the ingredients and cook for five minutes. Remove from the heat, add the juice of a lemon to taste and coriander leaves to garnish. Serve with hot chapattis.

Green mango with cashew nuts and raisins

Ingredien

100 g cashew nuts
3 mangoes (green, medium size)
100g raisins
6g garlic flakes
2.5 cm (1 inch) ginger piece
vinegar
8 chillies (red)
sugar
salt to taste

Method

Peel the mangoes and grate them. Grind the garlic, ginger and red chillies to a fine paste with a little vinegar. Melt the sugar, salt and vinegar over a low heat. Add the chilli paste and heat until it dissolves. Add the grated mango, raisins and nuts and cook over a medium flame until thickened. Hot-fill into clean sterile jars.

Cashew nut mushroom curry

Ingredients

75 g cashew nuts (green, tender)
100 g mushrooms
2 chillies (red)
turmeric
1 teaspoon coriander
1 g (a pinch) cumin
½ lime
2 onions
2 chillies (green)
l0 g ginger
4 cloves garlic
½ coconut
1 teaspoon oil
1 sprig curry leaves
1 pinch mustard seeds
salt to taste

Method

Clean the mushrooms and cashew nuts in hot water. Grate the coconut and extract the coconut milk from three-quarters of the coconut. Boil the cashew nuts and mushrooms. Grind the remaining coconut, red chillies, coriander, turmeric and cumin into a fine paste. Slice the onion, ginger, garlic and slit the green chillies. Heat the oil and add the mustard and curry leaves. When the seeds start to pop, add the ground spices and sliced ingredients. Cook until the onions are soft. Add the cooked cashew nuts and mushrooms, lime juice and salt. Simmer for 10 minutes. Add the coconut milk and simmer for 5 minutes. Season and remove from the heat.

Cashew nut banana cake

Ingredients

1 cup cashew nuts (grated or milled)
1¾ cup flour
11 cups sugar
1 mashed ripe banana
¼ cup butter
4 teaspoons sour milk
2 eggs
1 teaspoon soda
1 teaspoon baking powder
½ teaspoon salt

Method

Cream the butter and sugar together, add the banana and beat well. Add the soda, dissolved in the sour milk and beat the eggs well before adding to the mixture. Mix in the flour, baking powder and salt. Add cashew nuts and bake in a moderate oven for about 40 minutes.

Source: Vaidehi, 2000.