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Marketing and transport

Marketing

Dixie (1989) gave the following two definitions of marketing. 'The series of services involved in moving a product (or commodity) from the point of production to the point of consumption.' 'Marketing involves finding out what your customers want and supplying it to them at a profit.' Marketing of perishable crops becomes increasingly important as the standard of living of consumers increases, because they require higher, more consistent quality as well as fruit and vegetables when they want it, not necessarily when the fruit and vegetables are in season.

In many countries, the production of fresh fruit and vegetables is currently lower than the market requirement. These normally result in a seller's market, where the farmer can sell all the crops that are grown, and there may be little incentive to supply high-quality crops on the market. This happens in less developed countries. In other societies, crop production, or potential crop production, is greater than the demand. The effect of this, in European markets, for example, has not necessarily reduced the price of the crops as might have been expected, but increased the quality of the crops being offered to the consumer. It is not unknown for fruit and vegetables to be destroyed in order to maintain market prices. This can even happen after the crop has been harvested and packed for the market. In industrialised countries, the farmer is increasingly studying the market to determine its requirements. An example of this is organic fruit and vegetables that usually command a premium market price. However, their higher cost of production has resulted in production not always being economic and there are groups lobbying for government subsidies.

Where markets are not well-regulated, this has led to fluctuating supplies of crops such as vegetables. This is because the farmer may see a particular crop is commanding a high price on the market because of undersupply. While the farmer changes his production to this crop, other farmers see the same opportunity and also change resulting in an oversupply. This can lead to low prices and farmers stopping to grow that crop leading to a shortage, and the cycle repeats itself. This has led to the establishment of commodity marketing boards to regulate supply to the perceived demand. There are several cases where these marketing boards have had major effects on produce marketing, for example the New Zealand Apple and Pear Board and Agrexco from Israel, but many others have had limited success in the perishable crop sector.

The flow of fruit and vegetables from the producer to the consumer is not simply governed by the market forces of supply and demand. These forces are tempered, modified and controlled by import duties, quotas and other trade barriers. The General Agreement on Tariffs and Trade (GATT) was first implemented in 1948 as a mechanism to promote free and fair trade between its member states, and

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several rounds of negotiations were carried out in the following years and rules that governed international trade were formulated. The Uruguay round of GATT began in 1986 and was signed in April 1994 in Marrakech. This opened up trade throughout the world, including that in fruit and vegetables. The Uruguay round of GATT led to the creation of the World Trade Organisation (WTO) to reform and police international trade agreements. This put an onus on the more than 100 states that signed the agreement to reform both their internal and external trade policies to open up international trade. However, the rules are complicated and allow for states and trading blocks to subsidise production and impose tariffs on imports to protect their own farmers.

There are many cases where trade is not a 'level playing field' and it is often to the detriment to farmers in developing countries and the benefit of farmers in the more wealthy countries. Such liberalisation of trade can also lead to specific difficulties for some producer countries. There were riots in India against the WTO rules. The banana industry in the French West Indies, the Canary Islands and the African Caribbean and Pacific (ACP) countries has had preferential access to European Union countries. Many of these ACP countries have vulnerable economies, which are dependent on banana exports, and because of factors such as comparatively high labour costs or lower capital investment, they are unable to compete with other countries on price. The WTO ruling against these trade preferences between ACP countries and the European Union has been a potential source of problems in these fragile economies. The WTO ruling in 1997 against trade preferences between ACP countries and the European Union has been a potential problem in these fragile economies. The European Union is the principle importer of bananas in the world and a settlement of the disputed WTO ruling over tariffs on imports into the European Union was achieved in December 2009. The WTO brokered an agreement with the non-ACP banana producers and the United States that ACP suppliers can continue to export to the European Union duty-free and quota-free under the 2008 Economic Partnership Agreements. The European Union will continue to apply a duty on the import of non-ACP bananas called the Most Favoured Nations Duty. There are some provisos with the regulations but, in brief, they are that the non-ACP banana exports to Europe will attract progressively reducing tariffs until 2017.

Marketing systems can be considered on their structure, conduct and performance. Structure relates to their relative size, number of institutions and the various functions of the participants. Conduct is described by the level of control by government and the level of competition of market participants regarding the product, price and promotional strategies. The performance can be measured in several ways, but the most common one is by its efficiency. Profits, turnover, innovation and research and development may measure efficiency. These three factors are interdependent in that each will affect the way the market is structured and the way business is conducted and both in turn will affect its performance.

Many perishable crops are seasonal and their value, or selling price, varies throughout the year. Orderly marketing can be achieved in certain cases by storing the crop from the harvest season to the season of scarcity. Many different marketing systems have been used in many developing and industrial countries. However, the problem remains of getting fresh fruit and vegetables from the producer to the consumer with the minimum of loss in quality or quantity, at the time the consumer desires them and at minimum cost. All marketing systems have some flaw in them, and many have been started and have had to close after periods of operation. All these systems are constantly changing and evolving to suit changing market and political situations.

Marketing systems

Direct marketing

The simplest system is where the farmer sells directly to the consumer. For this, the consumer may call directly at the farm. In many countries, this has led to the development of farm shops where the farmer harvests the crop and offers it for sale. This is often supplemented by purchasing crops from wholesale markets to increase the range of crops offered. 'Pick-your-own' is where the farmer grows the crop and customers harvest it themselves and pay the farmer for the quantity they have harvested.

Middlemen

Middlemen may visit the farm to purchase from the farmer. They will then resell the produce to a wholesaler or retailer. In many situations, the middlemen have their own labour force, which relieve the farmer from having to harvest the crop; he simply sells the crop by area or weight harvested. An example of this is the Kissan Company in Bangalore in India. They are major processors of mangoes, and they have a team of workers whose function is to go from plantation to plantation harvesting fruit that is then sent directly to the factory. In many less developed countries, the farmer harvests the crop, transports it to market and then sells it. In many cases, these sales are at the retail level and can take the farmer a considerable amount of time to sell only a small quantity.

Direct to retailer

In industrial countries, many farmers, particularly those on a large scale, sell directly to supermarkets. This is commonly on a contract basis and can be a very convenient way of marketing for the producer or importer. The supermarkets, however, have stringent quality requirements and times of delivery. Only the best organised and efficient farmers who are forward thinking are consistently successful in these markets. In the United Kingdom, with overproduction of many crops, some supermarket suppliers fail.

Wholesale markets

Specialist wholesale markets have been established in towns and cities throughout the world to assist in marketing fresh fruits and vegetables. Many of these have been in existence for centuries. These consist of groups of middlemen who purchase produce, often from the producer, the producer's cooperative or importer (sometime through brokers) and sell the produce to a retailer. The situation is usually more complicated with wholesalers selling to secondary wholesalers or to exporters (particularly in some developing countries) or directly to the consumer. Fresh produce is mainly highly perishable and has a fragmented production base, which makes it extremely difficult to standardise quality and production specifications (Henderson 1993). Wholesaling of fresh produce should minimise the number of transactions and reduce the stocks required and be involved with price discovery, minimising of wastage as well as assembly, stockholding, financing, standardisation and breaking bulk (Sturgess 1987). The demand for fresh produce is relatively inelastic in that large price fluctuations create only small fluctuations in demand. This can result in prices being unstable and the need for buyers and sellers to have frequent and close contact (Henderson 1993). In United Kingdom, at the Covent Garden market, the average mark-up for wholesaling services was about 18% of the value of primary production at the farm gate or the dockside (Sturgess 1987).

Retail markets

Retail outlets vary from carts on the streets, through established open markets (Figure 57) and small greengrocer's shops to multiple retailers called supermarkets. Throughout the world, this diversity of retail outlets has been retained, but the multiple retail sector has constantly increased its market share. This is due to various factors including the consistent quality of produce and convenience of purchasing the weekly shop in one place. Retail stores were traditionally supplied by the retailer going to the wholesale market early in the morning and purchasing the items required. With the multiple sector, various systems have been put in place to obtain supplies. These usually involve the produce being delivered to a distribution centre where crops are held and sometimes graded and sent to individual retail outlets. In Britain, there has been considerable debate

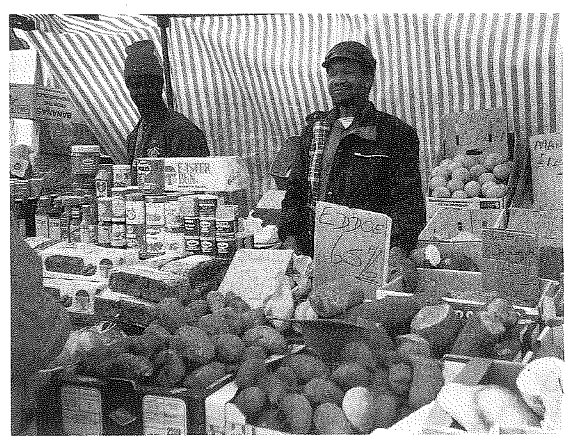

Figure 57 A retail fruit and vegetable market in Bedford, UK. *See colour plate section.*

about supermarkets obtaining locally produced fruit and vegetables. Some progress has been achieved but they often have difficulties in maintaining consistent supplies of sufficient quality.

State marketing

In the past, in some communist countries the state was responsible for the marketing of fruits and vegetables. In the People Democratic Republic of Yemen before unification with the Yeman Arab Republic, this system prevailed. The result was that harvesting and handling systems were very inefficient and delivered poor quality produce to the consumer. In China, the marketing of fresh produce was entirely in the hands of the state until the mid 1980s. After that time, wholesale and retail markets were allowed to evolve. It is interesting to observe that this system involved middlemen with lorries going to the countryside and bringing the produce to places in the towns and cities where the produce were offered for sale. In 1986, the Dazhongsi Farm and Sideline Products Wholesale Market was established in Beijing. This provided a site in which wholesale trade could take place and by 1993 had 10,000 customers and total annual sales of 58 billion kg. It is the largest of the four wholesale markets in Beijing and is operated by the local government and charges 2% on sales to meet its operating costs. They also pay an additional 3% in tax to the Government.

Dutch auctions

The Centraal Bureau van de Tuinbouwveilingen in Nederland operates a special type of wholesaling. These wholesale auctions are owned by growers who produce, harvest, grade, prepare, pack and send the produce to the auction (Hill and Selassie 1993). Auction staff is responsible for quality and assembling the produce into suitable quantities for sale. The lots of produce are offered for sale by the movement of the arm of a clock that moves from a high price to progressively lower prices. Prospective purchasers can stop the clock at any point and then become the owner of that produce at the price on the clock at the time it was stopped. Computerisation has been developed in controlling the auction clock and linking the clock with the auction accounts department and distribution. Clocks from several auctions can be displayed together with information on supply and demand (Crawford and Selassie 1993). The marketing system in Holland often leads to high wastage levels of good quality produce. This is done to keep prices high so that where some lots do not achieve a predetermined minimum price, those lots are taken off the market and destroyed. A mean price is taken for all the produce of that type which has been sold at that time, and the owners of the produce that has been destroyed receive the same proportional share as those whose produce was sold.

Panels

Many organisations market their produce through panels. These are common in the United Kingdom and are fruit and vegetable importing companies who are responsible for marketing and distribution of a product or group of products from one source. For a company to be a panel member, it must reach the standards required by the supplier. An example of this would be the citrus panel that is supplied by Outspan. Outspan would invite a company to join their panel whom they feel have sufficiently high standards, distribution network and contacts within the industry. The panel member then has the responsibility to supply retailers. In most cases, the supermarket sector of the fruit and vegetable retailing industry deals through panellists rather than directly with the marketing board. The supermarket may prefer to work in this way because it provides flexibility so that if the produce does not achieve the required standard, it can easily be returned to the panel member to be retailed elsewhere or otherwise disposed of. The panellists receive a commission for the services that they supply. This system does extend the marketing chain and may change or be modified to meet competition in a changing market situation.

Cooperative marketing associations

Cooperative marketing is where a group of farmers associate to market their produce together. There are many examples of successful marketing cooperatives. East Kent Packers in England was formed by a group of local apple and pear producers owned by the grower members, but it unfortunately went out of business. They provided very sophisticated controlled atmosphere storage facilities and grading and packing equipment. Members grew and harvest their crops and sent them to East Kent Packers where they are graded, packed and sent to market or placed in storage for later marketing. The stores and packhouse were used for other crops on a contract basis when they were not required for members' fruit, which provided additional income for members. Growers' cooperatives have the advantages for small- to medium-sized farmers of increasing the quantity of produce to be marketed, thus improving continuity of supply, bargaining position and the employment of special marketing techniques and staff. In some cases, marketing and related activities are supported by statutory bodies such as marketing boards or export boards.

Fair trade

In spite of the creation of the World Trade Organisation, there is much international trade that exists to the benefit of developed countries at the expense of less developed countries. Twenty percent of the world's population had 82 times the income of the bottom 20%. There are many organisations that have been set up to address this imbalance of trade and income. Fair Trade is a non-government organisation (NGO) that is over 40 years old. It has a charity background but commercial companies are also involved. It publishes a set of values in which trade takes place. Other objectives are to give value for money and good quality so there is something in it for consumers. Its objective is sustainability 'in it for the long term', so that it provides a stable situation for the grower.

The main product with which it is involved is coffee marketed as Café Direct. Fair Trade is a movement not a brand, but becoming a brand is their aim in United Kingdom especially with Café Direct. Café Direct has been in existence for over 10 years and is sixth largest supplier of coffee in Britain. It has suppliers of 1.5 million growers and their families. It comes from a higher cost base; therefore, it charges a premium for its brand. Much of this is passed to the grower who either invests the premium into his or her own cooperative or uses it to improve his or her standard of living. In the United Kingdom and Japan (where the People Tree brand is trendy and cool and good with young people), many people are conscious of it, but in Spain and United States, they are not.

Fair Trade has become increasingly concerned with the marketing of bananas and supports a cooperative in Ghana. A fruit sticker is attached to each cluster of fruit and a premium price is charged to the consumer. Most of this is passed onto the producer, so those small farmers receive a better income than they would if they marketed their fruit in other ways.

Market analysis

There are two basic systems that can be applied to the marketing of fresh fruit and vegetables. The first is simply to market what farmers can produce. This system is very common in developing countries and usually is well founded and has evolved over generations. Supply and demand for the crops are not always in balance and there can be large seasonal fluctuations in both quantities available on the market and the price received for the crop. In extreme situations, it may not be worth harvesting the crop. Many ways of overcoming this situation have been developed including storage to link periods of excess supply and market promotion to increase the demand at that time. This marketing system can be a major problem where new markets are being developed. This is particularly important where export development or a processing industry is planned. The alternative is market analysis. This means looking at the proposed market and producing for that market. This can involve producing specific varieties of specific crops to a defined quality and predetermined schedule. It usually also involves management and postharvest practices which are required by the market. One analytical procedure, which can be used to assess the market potential, is SWOT analysis (strengths, weaknesses, opportunities and threats). The stages are to look first at the planned business to determine what it can do or be developed to do best. When this has been decided, the difficulties that are likely to be encountered in the proposed business must be estimated and ways in which these weaknesses can be overcome must be formulated. The market must be studied in detail to determine current supply and demand factors by studying previous market data and picking up possible trends of what the market might be in the future. This will also include determining any legislation governing standards and which varieties of crop receive the best prices and at what time of the year.

Market situations, especially on export markets, are constantly changing and it is important to know what competitors, or potential competitor, are doing or planning to do. This should be taken into account when planning the business. Crop production is subject to environmental conditions and sometimes pest and disease infestation and in developing countries the supply of materials that are necessary for production and postharvest operations.

Retaining the crop in optimum condition throughout the marketing chain also becomes increasingly important in ensuring that marketing is profitable. A major contributor to this is the means of transporting the crop from the producer to the consumer.

Branding

At one time, branding seemed to be just related to tough looking men in leather using a red hot iron on cattle, but the concept has now become a major occupation of clever people putting a logo or name into the mind of people. The subject of branding of fresh fruits was reviewed by Best (1993). In its simplest form, a brand can be defined as 'a name, term, symbol, design or all of these intended to identify and differentiate goods and services one from another' (Kotler 1991). However, according to Davies (1992), brands are more than just a 'label to differentiate' and are in fact 'a complex system that represents a variety of ideas and attributes separate and distinct from the product, each capable of undergoing change independently of each other'. Murphy (1990) defined a brand as 'a trademark which, through careful management, skilful promotion and wide use, comes in the mind of the consumers, to embrace a particular and appealing set of values and attributes, both tangible and intangible. It is therefore much more than the product itself; it is much more than merely a label. To the consumer, it represents a whole host of attributes and a credible guarantee of quality and origin. To the brand owner it is in effect, an annuity, a guarantee of future cash flows'. He identifies the brand as the output of a management process which invests resources to develop assets that are increasingly being recognised on company balance sheets and being assessed for their profit earning capability.

Increasingly, the brand is seen not as a thing that people involved in marketing do to their product but as a relationship that they develop with their customers. de Chernatony and McDonald (1992) suggested that successful brands are 'an identifiable product, service, person or place, augmented in such a way that the buyer or user perceives relevant unique added values which match their needs most closely. Furthermore its success results from being able to sustain these values in the face of competition'. The success of brands stems from the management of the entire marketing mix to create an augmented commodity form of a product that has meaning to the consumer beyond the functional product. Although brands are most commonly associated with products, and in particular fast moving consumer goods, they can be developed for a wide range of market offers including services, countries and people.

These definitions trace the development of the understanding of the brand over time and reflect the changing emphasis of branding from physical products to services such as financial services. Their emphasis on the non-functional aspects of branding appears to be particularly relevant to the fresh fruit industry.

Consumers are aware of brands in the fresh produce industry. In a survey reported by Best (1993), prompt awareness by people in the United Kingdom for brands in the citrus industry were:

Jaffa	95%
Outspan	93%
Sunkist	54%
Morocco	30%
Florida	24%

An understanding of the parts which comprise a brand is paramount to understanding why some 'products get commodity prices, giving them low margins, and other brands get the commodity price plus whatever the brand is worth beyond the product' (King 1984). Levitt (1986) described the brand as having several components, which might be applied to a fresh fruit brand as follows:

- Core attributes that meet the basic needs of the consumer, for example an apple.
- Generic attributes that exist in the commodity form of the product, delivering the functional attributes that meet the basic need of consumers. For example, the Cox's Orange Pippin variety, ripe, blemish free, graded, labelled, available in stores.

- Expected attributes where the generic form is tailored to needs of specific customers. For example, Cox's Orange Pippin grown in England, tasting like English Cox's Orange Pippin, available in stores servicing the targeted consumer segment, labelled English Cox Apples.
- Augmented attributes meeting consumers' non-functional needs. For example, assurances of taste and quality of traditional Cox's Orange Pippin, reassurances that English Cox's Orange Pippin can only be grown in England, and that English Cox's Orange Pippin represent an English way of life.
- Potential attributes that are the limitless enhancements of the brand, often intangible and emotional, which underlie its extended life. For example, upgrading of the cultivar to include new features, extension of the Cox's Orange Pippin image to other products such as jams, and juices. Keeping adjustments in promotions to keep in touch with perceived English self-image of the main consumer segment.

National transport

This is the transfer of produce from the farm to the place where it is to be offered for sale. The system varies in both less developed countries and the industrialised countries from simply packing the produce in some kind of vehicle for transport, to having comprehensive environmental control around the crop. The reasons for selecting a particular type of transport may be related to:

- special characteristics of the crop
- its value
- what is available
- what is most appropriate.

Where crops are moved short distances, quickly from the field to the market or directly to the consumer, it is usually unnecessary for most crops to need any temperature management or other controlled conditions. This simple kind of transport can appear cheap, but it may result in high crop losses due to physical damage. In a study of banana transport in the Sudan, it was shown that bunches packed in lorries padded with banana leaves and transported from the field to the ripening rooms had extremely high levels of damage. Packing the bananas in plastic boxes for transport greatly reduced these losses (Silvis *et al.* 1976).

In a study of sweet potatoes by Tomlins *et al.* (2000) in Tanzania, the handling and transport system resulted in up to 20 and 86% of roots with severe breaks and skinning injury, respectively, and a reductions in market value of up to 13%. The most severe impacts occurred during unloading and loading from road vehicles and ships. However, skinning injury and broken roots were correlated with a large number of minor impacts.

International trade

From the middle ages, small quantities of dried spices, fruits and beverage crops were traded internationally mainly from the East to Europe, but these were relatively small quantities and were expensive. International trade in fresh fruits and vegetables was scarce. In the late 18th century, citrus fruits were traded throughout Europe, but were mainly from orchards in Spain and Portugal. At that time, the human populations in Europe were comparatively small and mainly involved in some aspect of agriculture or the service sector and there was little incentive for international trade. In the 19th century, the industrial revolution stimulated manufacture and the trade in raw materials to service the industry. This was particularly so in Britain, where the population rose from a fairly stable level of some 9 million in 1801 to over 36 million by 1911. This stimulated the demand for food and attracted imports. Initially, these were mainly from other European countries, but with the development of steam ships, they increasingly came from further afield. Dietary habits also changed and the market for fruit and vegetables increased. This demand was supplied by local producers and led to the development of such technologies as producing crops in heated glasshouses, but also to an increasing extent by imports. This was especially stimulated when the British Government abolished the import duty on fruit in 1860. Citrus fruits were the main import, but apples, cherries, grapes, melons, pears and plums were also traded. Pineapples were exported from the West Indies to Britain from 1842 in schooners. In order to supply out-of-season fruit, shipments of apples, grapes and other fruits were being made from South Africa to Britain from 1888 with mixed results. The first export shipment of bananas was from Jamaica and was reported to be 500 stems to Boston in 1866 which took 14 days and the fruit were said to have been sold at a profit (Sealy *et al.* 1984). There was no indication of temperature control during this or subsequent shipments in the latter part of the 19th century. In 1879, steam ships as well as schooners were being used to transport fruit from the Caribbean Islands and Central America to the United States.

International sea transport of perishable foodstuffs using refrigeration began in the latter part of the 19th century. The use of cooling for transport began in 1873 or 1874 using ice through which air was circulated by fans on shipments of meat from the United States to Britain and this developed into a regular trade in 1877 when mechanical refrigeration was used on the ships. The first records of refrigerated shipment of fresh fruits and vegetables were in 1880 from Italy to Britain and included pears and peas. In 1901, the vessel Port Morant carried 23,000 stems of bananas from Jamaica to Britain using mechanical refrigerated holds for the company Elder and Fyffes (Sinclair 1988).

Cold chain

Cold chain transport, where the crop is precooled directly after harvest and kept at a constant temperature throughout the marketing chain, is being increasingly practised in both industrial and non-industrial countries. The system involves a high capital expenditure but ensures a high level of quality maintenance and a reduction in physical losses of crops. In Britain, the major retailers (supermarkets) have distribution centres where growers deliver their crops. The supermarket will have agreed price, quantity and quality with the producer. They will also specify the precise time at which it must be delivered and the temperature of the crop at the time of delivery. A well-run cold chain is therefore essential in order to achieve these requirements.

Transport by sea

For export, fresh fruit and vegetables are largely transported in temperature-controlled cargo space in either 'break bulk' or containers such as 'reefers', porthole or ventilated types. In trial shipments of mangoes from the West Indies to Britain, it was shown that the fruit was in good condition on arrival and was profitably sold (Table 32).

Table 32 Costs (other than labour) and returns in Trinidad and Tobago Dollars of a shipment of mangoes of the cultivar Julie shipped from Trinidad to Britain at 13 °C taking 10 days (source: adapted from Thompson 1971b)

Expenditure		T&T $
Cost of fruit per carton		1.60
Cost of carton		0.71
Refrigerated sea transport		1.34
Total		3.65
Income		
Grade 1	53%	12.24
Grade 1	19%	3.96
Grade 2	19%	3.60
Wastage	9%	0.00
Total		19.80

Refrigerated containers were first introduced in the 1930s, but it was only in the 1950s that large numbers were transported on ships. Their use was on the West Coast of the United States to Hawaii. In the late 1960s, the porthole container was introduced. Different operators developed different specifications and sizes of the various types of container. This was particularly evident in their length, which varied from 17-, 20-, 24-, 35- and 40-feet long. This variation prevented interchange of containers between different operating lines. Currently, only a small part of the world supply of containers deviate from the standard 20- and 40-foot lengths recommended by the International Standards Organisation in 1967. The first purpose-built container ship was completed in 1969 that had a capacity of 1300 twenty foot equivalent units and during succeeding years they have increased in capacity. Numbers have also increased, for example over the period 1970–1988, the world container fleet has increased from 195,000 twenty feet equivalent units to 2,869,000 twenty foot equivalent units.

Break bulk

Break bulk refers to a system of transport where individual boxes or pallets of produce are stacked directly in the hold of the ship. Bananas account for some 35% of the fresh produce transported in this way. Most produce is palletised before shipping and maintained in this condition throughout the marketing chain; in some cases, this is right up to the retail outlet. Palletisation reduces handling and therefore labour costs and damage to produce. The standard international pallet is 1000×1200 mm on which produce is commonly stacked to some 2100 mm high. The holds of ships are commonly 2200 mm high and reefers the same or higher so that pallet loads can fit in with an adequate clearance to allow for air circulation. Boxes should be secured on the pallet with edging strips so that they do not move during transport. During winter when the seas are rough, there is a considerable increase in the level of damage to boxes and to the fruit they contain. Dunnage or inflatable bags may be placed between pallets to improve air circulation and temperature control.

Reefer containers

A large and increasing amount of fresh fruit and vegetables is transported by sea freight refrigerated (reefer) containers (Thompson and Stenning 1994). Reefers are insulated containers which have their own individual refrigeration units. They are built to International Standards Organisation specification which specifies that they must be sufficiently strong so that they are capable of holding 30 tonnes and withstand a vertical load of up to nine containers stacked above it. These containers have about 70 mm of insulation in the walls, generally polyurathane foam. A new insulated container will have a heat leakage of about 22 W K^{-1}, but some containers designed solely for the carriage of fresh fruit will have thinner insulation with a heat leakage of around 35 W K^{-1} (Heap 1989). The foam almost always contains low conductivity halocarbons to improve performance. Insulation efficiency reduces with time, due to loss of halocarbons and moisture ingress, by about 3–5% per year (Heap 1989). Sizes vary but commonly used international sizes are given in Table 33.

Operating costs of containers is usually much higher than break bulk, but apparently it can also be lower as it depends on the journey (Table 34). Bananas are the most important fruit that is transported by sea freight and almost all international trade in bananas is still carried out using break bulk. The trade from Martinique and Guadeloupe in the Caribbean is heavily subsidised through the EU Common Agricultural Policy and there they use containers for bananas. The relatively new industry from the port of Tema in Ghana uses containers, but this reflects the scale of operation and the difficulty in securing break bulk transport. For the growers in Ghana, it means that the only way the industry can be viable is by obtaining subsidised prices mainly through the Fair Trade Organisation.

Table 33 Sizes and capacities of reefer containers (source: adapted from Seaco Reefers)

Type	External dimensions	Internal dimensions
20 foot (RM2)		
Length	6,096 mm	5,501 mm
Width	2,438 mm	2,264 mm
Height	2,591 mm	2,253 mm
Capacity	28.06 m^2	
Tare	3,068 kg	
Maximum payload	21,932 kg	
ISO payload	17,252 kg	
40 foot (RM4)		
Length	12,192 mm	11,638 mm
Width	2,438 mm	2,264 mm
Height	2,591 mm	2,253 mm
Capacity	59.81 m^2	
Tare	4,510 kg	
Maximum payload	27,990 kg	
ISO payload	25,970 kg	
40 foot (RM5)		
Length	12,192 mm	11,638 mm
Width	2,438 mm	2,264 mm
Height	2,896 mm	2,557 mm
Capacity	68.03 m^2	
Tare	4,620 kg	
Maximum payload	27,880 kg	
ISO payload	25,860 kg	

Table 34 A comparison between the c.i.f. costs of international transport of bananas communicated to UNCTAD in 1981 in US$ per carton (source: adapted from Sinclair 1988)

Journey	Break bulk ($)	Containerised ($)
Central America to North America	5.64	5.95
Central America to Europe	7.63	7.41
French West Indies to France	8.42	8.23

Porthole containers

Porthole containers, which are also called Conair containers, are insulated containers that do not have their own refrigeration unit. Instead they have two 10 cm diameter ports, which can be connected to an external refrigeration system via a flexible hose. They are used in ships where the containers are plugged into the ship's refrigeration system. They may also be plugged into a unit at the port to cool the produce while awaiting transport. The advantages of this type of system are that the rental costs on the containers are lower and the units can be cooled more quickly because of the larger refrigeration capacity from the ship's system. Disadvantages are that special facilities are required both at the port and on the ship. Refrigeration can only be started when the container has reached the port and not at the packhouse where it may be loaded. With reefer containers, a diesel generator may be fitted or attached to the container so that its contents may be cooled directly after it has been loaded.

Ventilated containers

Ventilated containers are standard metal containers that have no insulation or refrigeration unit but have some kind of ventilation system. This may simply be square apertures along each of the long sides with downward pointing fixed louvers. A row is situated near the top and another row near the bottom down each of the long sides of the container. Ventilation is passive using natural convection currents. A more elaborate system has extractor fans installed high up on the doors of the container. These usually have the same ventilation of the passive system but with just one row of apertures towards the bottom of the container on each of the long sides. The attraction of these types of container is their low rental cost compared to reefers. SeaVent used a passively ventilated container filled with 17 1/2 of green coffee in extremes of temperature and humidity in a simulated trial of the conditions that would be encountered during transport from the tropics to Europe. It was found that the coffee was in perfect condition, and this method is now being used on a large commercial scale throughout the world. They are also used for transport of crops such as potatoes and onions even for long distances such as from Australia to the United Kingdom.

Modified atmosphere containers

Modified atmosphere containers have been used for several decades with varying degrees of success. Transfresh of Salinas in California build containers that are designed to be gas-tight and that have an aluminium track fitted around the door to which is fitted a plastic curtain to eliminate leakage through the door. After loading, the container is sealed and the required gaseous atmosphere is injected through purging ports.

Controlled atmosphere containers

Controlling the levels of some of the gases in reefer containers has been used for many years to increase the marketable life of fruits and vegetables during transport. Many commercial systems have been manufacture Champion (1986) reviewed the state of the art of controlled atmosphere transport as it existed at that time. He listed the companies who cooperated in the production of the paper, which gives some indication of the large number of companies who were involved in the commercial application of this technology, as follows:

- AgriTech Corporation, USA
- CA (Container) Systems, UK
- Finsam International, Norway
- Franz Welz, Austria
- Fresh Box Container, West Germany
- Industrial Research, Netherlands
- Synergen, UK
- TEM, USA
- Transfresh Corporation, USA
- Transfresh Pacific, New Zealand.

Many of those companies have since gone out of business and others have been started. Champion (1986) also defined the difference between controlled atmosphere containers and modified atmosphere containers. The latter has the appropriate mixture injected into the sealed container at the beginning of the journey with no subsequent control, which means that in containers being used to transport fresh fruits and vegetables, the atmosphere will constantly change during transport. Controlled atmosphere containers have some mechanism for measuring the changes in gases and adjusting them to a preset level. Dohring (1997) stated that the world fleet has increased fourfold since 1993 and in 1997 consisted of 38,000 reefer containers with only some 1000 providing control of humidity CO_2 and O_2, that is controlled atmosphere containers.

Dohring (1997) claimed that 'avocados, stone fruit, pears, mangoes, asparagus and tangerine made up over 70% of container volumes in recent years. Lower value commodities e.g. lettuce, broccoli, bananas and apples, make up a greater percentage of the overall global produce trade volumes but cannot absorb the added CA costs in most markets.' Previously, Harman (1988) had suggested the use of controlled atmosphere containers for transport and storage for the New Zealand fruit industry, but there has been only limited uptake. Lizana and Figueroa (1997) found that long distance sea transport for 35 days of Hass avocado fruits from Chile to the United States was feasible in refrigerated controlled atmosphere containers. They found that the best controlled atmosphere storage combination for Hass avocado fruits was at 6 °C and 90% r.h. with 5% CO_2 and 2% O_2.

Gas sealing

The degree of control over the gases in a container is affected by how gas-tight the container is; some early systems had a leakage rate of 5 m^3 h^{-1} or more, but current systems can be below 1 m^3 (Garrett 1992). Much of the air leakage is through the door and fitting plastic curtains inside the door could reduce the leakage, but they were difficult to fit and maintain in practice. A system introduced in 1993 have a single door instead of the double doors of reefers containers, which are easier to make gas-tight. Other controlled atmosphere containers are fitted with a rail from which a plastic curtain is fitted to make the container more gas-tight.

Gas generation

Controlled atmosphere containers are gas-tight, so the respiration rate of the fruit will eventually produce lower O_2 and higher CO_2 levels. Ilinski *et al.* (2000) found that for the apple cultivars Antonovka, Martovskoe, Severni Sinap and Renet Chernenko, the CO_2 concentration in controlled atmosphere containers reached 15–19% and O_2 was reduced to 0.4–0.8% within 3–3.5 days. This may be too slow and therefore the systems used to generate the atmosphere in the containers falls into three categories (Garrett 1992):

- The gases that are required to control the atmosphere are carried with the container in either a liquid or solid form.
- Membrane technology is used to generate the gases by separation.
- The gases are generated in the container and recycled with pressure absorption technology and swing absorption technology.

The first method involves injecting nitrogen into the container to reduce the level of O_2 with often some enhancement of CO_2 (Anonymous 1987). It was claimed that such a system could carry certain cooled produce for 21 days compared with an earlier model, using nitrogen injection only, which could be used only on journeys not exceeding 1 week. The gases were carried in the compressed liquid form in steel cylinders at the front of the container, with access from the outside. O_2 levels were maintained by injection of nitrogen if the leakage into the container was greater than the utilisation of O_2 through respiration by the stored crop. If the respiration of the crop was high, the O_2 could be replenished by ventilation.

In containers, which use membrane technology, the CO_2 is generated by the respiration of the crop and nitrogen is injected to reduce the O_2 level. The nitrogen is produced by passing the air through fine porous tubes, made from polysulphones or polyamides, at a pressure of about 5–6 bar. These will divert most of the oxygen through the tube walls, leaving mainly nitrogen which is injected into the store (Sharples 1989).

A controlled atmosphere reefer container, which has controls that can give a more precise control over the gaseous atmosphere, was introduced in 1993. The containers use ventilation to control O_2 levels and a patented molecular sieve to control CO_2. The molecular sieve will also absorb ethylene and has two distinct circuits that are switched at predetermined intervals so that while one circuit is absorbing, the other is being regenerated. The regeneration of the molecular sieve beds can be achieved when they are warmed to 100 °C to drive off the CO_2 and ethylene. This system of regeneration is referred to as *temperature swing*, where the gases are absorbed at low temperature and released at high temperature. Regeneration can also be achieved by reducing the

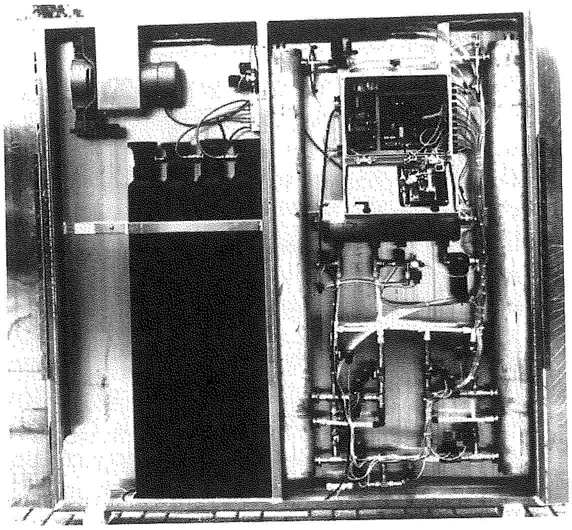

Figure 58 Control panel for CA container. (Source: T. Bach.)

pressure around the molecular sieve, which is called pressure swing. During the regeneration cycle, the trapped gases are usually ventilated to the outside, but they can be directed back into the container if this is required. The levels of gas, temperature and humidity within the container are all controlled by a computer which is an integral part of the container. It monitors the levels of oxygen from a paramagnetic analyser and the CO_2 from an infrared gas analyser and adjusts the levels to those which have been preset in the computer (Figure 58).

Lallu *et al.* (1997) described experiments on the transport of kiwi fruit in containers where the atmosphere was controlled by either nitrogen flushing or 'Purafil' to absorb ethylene or lime and 'Purafil'. The former maintained CO_2 levels of approximately 1% and O_2 at 2–2.5%, whereas in the latter, the CO_2 levels were 3–4% and O_2 levels increased steadily to 10%. A control container was included in the shipments, and on arrival, the ethylene levels in the three containers were less than 0.02 μl L^{-1}.

Champion (1986) mentions the 'Tectrol' gas sealing specifications. Simulated commercial export of mangoes using the 'Transfresh' system of controlled atmosphere container technology was described in Ferrar (1988). Avocados and bananas were stored in two 'Freshtainer' controlled atmosphere containers, 40-feet long and controlled by microprocessors. The set conditions for avocados were 7.4 ± 0.5 °C for 8 days followed by 5.5 ± 0.5 °C for 7 days, with 2 ± 0.5% O_2 and a maximum of 10 ± 0.5% CO_2. Those for bananas were 12.7 ± 0.5 °C for 8 days followed by 13.5 ± 0.5 °C for 11 days, with 2.0 ± 0.5% O_2 and a maximum of 7 ± 0.5% CO_2. Temperatures and container atmospheres were continually monitored and fruit quality was assessed after the predetermined storage period. The results confirmed that the containers were capable of very accurate control within the specified conditions. Also, the fruit quality was better than that for controls which were avocados held in a cold store for 2 weeks at 5.5 °C in normal atmosphere and bananas held at 13.5 ± 0.5 °C in an insulated container (Eksteen and Truter 1989).

Peacock (1988) described a controlled atmosphere transport experiment. Mango fruits were harvested from three commercial sites in Queensland when the content of TSS was judged to be 13–15%. Fruit were de-stalked in two of the three sources and washed, dipped for 5 min in 500 μl L^{-1} benomyl at 52 °C, cooled and sprayed with prochloraz (200 μl L^{-1}), dried and sorted and finally size graded and packed in waxed fibreboard cartons. Some cartons contained polypropylene inserts, which cupped the fruits, other fruits were packed on an absorbent pad, but the majority was packed on expanded polystyrene netting. After packing, fruits were transported by road to a precooling room overnight (11 °C). Pulp temperatures were 18–19 °C the following morning; after 36 h of transport to Brisbane and overnight holding in a conventional cool room, the fruits were placed in a controlled atmosphere shipping container. At loading, the pulp temperature was 12 °C. Fruits were stored in the container at 13 °C with 5% O_2 and 1% CO_2 for 18 days.

A UK company, Cronos Containers, supply inserts, called the Cronos Controlled Atmosphere System (manufactured under licence from B.O.C.), which can convert a standard reefer container to a controlled atmosphere container. The installation may be permanent or temporary and is self-contained taking some 3 h the first time. If the equipment has already been installed in a container and subsequently dismantles, then reinstallation can be achieved in about an hour. The complete units measure 2 × 2 × 0.2 m, which means that 50 of them can be fitted into a 40-foot dry container for transport. This facilitates management of the system. It also means that they take up little of the cargo space when fitted into the container, only 0.8 m^3. The unit operates alongside the container's refrigeration system and is capable of controlling, maintaining and recording the levels of O_2, CO_2 and humidity to the levels and tolerances preset into a programmable controller. Ethylene can also be removed from the container by scrubbing. This level of control is greater than any comparable controlled atmosphere storage system, increasing shipping range and enhancing the quality of fresh fruit, vegetables, flowers, fish, meat, poultry and similar products. The system is easily attached to the container floor and bulkhead and takes power from the existing reefer equipment with minimal alteration to the reefer container. The design and manufacture is robust to allow operation in the marine environments that will be encountered in typical use. The system fits most modern reefers and is easy to install, set up, use and maintain. A menu-driven programmable controller provides the interface to the operator who simply has to preset the required percentages of each gas to levels appropriate for the product in transit. The controls are located on the front external wall of the container, and once set up, a display will indicate the measured levels of O_2, CO_2 and relative humidity. The system consists of a rectangular aluminium mainframe onto which the various sub-components are mounted. The compressor is located at the top left of the mainframe and is driven by an integral electric motor supplied from the control box. Air is extracted from the container and pressurised (up to 4 bar) before passing through the remainder of the system. A pressure relief valve is incorporated in the compressor along with inlet filters. Note also that a bleed supply of external air is ducted to the compressor and is taken via the manifold with a filter mounted external to the container. The compressed air is cooled before passing through the remainder of the system. A series of coils wound around the outside of the air cooler radiated heat back into the container. The compressed air then passes into this component which removes the pressure pulses produced by the compressor and provides a stable air supply. The water trap passing into the controlled atmosphere storage system then removes moisture. Water from this component is ducted into the water reservoir and used to increase the humidity when required. Two activated alumina drier beds are used in this equipment, each located beneath one of the nitrogen and CO_2 beds. Control valves are used to route the air through parts of the system as required by the conditioning process. Mesh filters are fitted to the outlet that vents nitrogen and CO_2 back into the container and to the outlet that vents oxygen to the exterior of the container. Nitrogen and CO_2 beds are located above the drier sieve beds and contain zeolite for the absorption of nitrogen and CO_2.

Another type of reefer container that has controls that can give a more precise control over the gaseous atmosphere was introduced in 1993. The specifications are given in Table 35. The containers use ventilation to control oxygen levels and a patented molecular sieve to control CO_2. The molecular sieve

Table 35 Specifications for a refrigerated controlled atmosphere container (source: adapted from Freshtainer INTAC 401)

	External dimensions	Internal dimensions	Door
Length	12,192 mm	11,400 mm	–
Width	2,438 mm	2,280 mm	2,262
Height	2,895 mm	2,562 mm	2,519
Capacity		66.6 m^3	
Tare		5,446 kg	
Maximum payload		24,554 kg	

Temperature range at 38 °C ambient is −25 to +29°C ± 0.2 °C
Oxygen down to 1% (+1 or −0.5%) up to 20 L h^{-1} removal
Carbon dioxide 0–80% (+ 0.5 or −1%) up to 180 L h^{-1} removal
Humidity 60–98% (±5%)
Ethylene removal rate 120 L h^{-1} (11.25 mg h^{-1})
Water recycled to maintain high humidity

Table 36 Fruits given special entry permits by the Japanese Government (source: adapted from Kitagawa 1993)

Country	Fruit	Designated pest	Disinfestation method
Australia	Orange	Mediterranean fruit fly, Queensland fruit fly	Cold treatment (1 °C 16 days)
Australia	Lemon	Mediterranean fruit fly, Queensland fruit fly	Cold treatment (1 °C 14 days)
Canada	Cherry	Codling moth	Methyl bromide fumigation
Chile	Grape	Mediterranean fruit fly	Cold treatment (0 °C 12 days)
Israel	Orange	Mediterranean fruit fly	Cold treatment (1/2 °C 14 days)
Israel	Grapefruit	Mediterranean fruit fly	Cold treatment (1/2 °C 13 days)
Israel	Sweety	Mediterranean fruit fly	Cold treatment (1 1/2 °C 16 days)
New Zealand	Cherry	Codling moth	Methyl bromide fumigation
New Zealand	Nectarine	Codling moth	Methyl bromide fumigation
New Zealand	Apple	Codling moth	Methyl bromide fumigation + cold treatment (1/2 °C 25 days)
Philippines	Mango – Carabao	Oriental fruit fly, Melon fly	Vapour heat treatment (46 °C, 10 min)
Spain	Lemon	Mediterranean fruit fly	Cold treatment (2 °C, 16 days)
South Africa	Orange	Mediterranean fruit fly	Cold treatment (–0.6 °C, 12 days)
South Africa	Lemon	Mediterranean fruit fly	Cold treatment (–0.6 °C, 12 days)
South Africa	Grapefruit	Mediterranean fruit fly	Cold treatment (–0.6 °C, 12 days)
Swaziland	Orange	Mediterranean fruit fly	Cold treatment (–0.6 °C, 12 days)
Swaziland	Lemon	Mediterranean fruit fly	Cold treatment (–0.6 °C, 12 days)
Swaziland	Grapefruit	Mediterranean fruit fly	Cold treatment (–0.6 °C, 12 days)
Taiwan	Orange	Oriental fruit fly	Cold treatment (1 °C, 14 days)
Taiwan	Mango – Irwin, Haden	Oriental fruit fly, Melon fly	Vapour heat treatment (46.5 °C, 30 min)
Taiwan	Litchi	Oriental fruit fly	Vapour heat treatment (46.2 °C, 20 min) + cold treatment (2 °C, 42 h)
Thailand	Mango – Nang Klarngwun	Oriental fruit fly, melon fly	Vapour heat treatment (46.5 °C, 10 min)
Thailand	Mango – Nam Dorkmai, Pimsen dang, Rad	Oriental fruit fly, melon fly	Vapour heat treatment (47 °C, 20 min)
USA	Nectarine	Codling moth	Methyl bromide fumigation
USA	Walnut	Codling moth	Methyl bromide fumigation
Hawaii	Papaya – Solo	Mediterranean fruit fly or Melon fly	Vapour heat treatment (47.2 °C)
Washington	Cherry	Codling moth	Methyl bromide fumigation
Oregon	Cherry	Codling moth	Methyl bromide fumigation
California	Cherry	Codling moth	Methyl bromide fumigation

will also absorb ethylene and has two distinct circuits that are switched at predetermined intervals so that while one circuit is absorbing, the other is being regenerated. The regeneration of the molecular sieve beds can be achieved when they are warmed to 100 °C to drive off the carbon dioxide and ethylene. This system of regeneration is referred to as *temperature swing* where the gases are absorbed at low temperature and released at high temperature. Regeneration can also be achieved by reducing the pressure around the molecular sieve, which is called pressure swing. During the regeneration cycle, the trapped gases are usually ventilated to the outside, but they can be directed back into the container if this is required. The levels of gas, temperature and humidity within the container are all controlled by a computer that is an integral part of the container. It monitors the levels of oxygen from a paramagnetic analyser and the carbon dioxide from an infrared gas analyser and adjusts the levels to those which have been preset in the computer.

Quarantine

Fruits that are susceptible to insect attack are allowed into Japan from certain specified countries, provided a specified disinfestation treatment is applied, for example see Table 36. For example, the Japanese market for Solo papaya from the United States was opened for fruit in 1969 but only from the Hawaiian Islands. They were required to be treated with vapour heat treatment against Mediterranean fruit fly, Oriental fruit fly complex and melon fly.

There are a range of physical treatments, which can contribute further to pest management including heat treatments, biological control and controlled atmospheres. UV irradiation has been demonstrated to increase the natural resistance of some commodities and has been studied as a direct method for decay control. Radiation of fresh fruits and vegetables has been approved since 1989 at the 1 kGy dose and shows promise as an insect control treatment, but its benefits for decay control are limited.

Irradiation has been used postharvest on fruit and vegetables for many decades. It had become increasingly important as a quarantine treatment because of the phasing out of methyl bromide that was used to prevent the transfer of insect species between countries. Irradiation breaks the DNA bonds in insects, resulting in them being unable to develop, unable to reproduce or being killed depending on species and dose. Irradiation leaves no residues in the fruit or vegetable. Irradiation doses that are needed to kill the insect may be higher than those tolerated by fruits, and therefore, the other unique feature of irradiation treatments is that they are generally designed to sterilise insects, not to kill them. In the case of fruit flies, APHIS (2002) has established the criterion for a successful dose as the non-emergence of adults to prevent sterile adults from triggering control strategies if detected in traps within areas free of established fruit fly populations. The USDA approved the use of irradiation to treat fruit for importation into the United States in 2002 (APHIS 2002). According to the USDA Fresh Fruits and Vegetables Import Manual, irradiation as an optional treatment is available only after an exporting country has entered into a framework equivalency work plan agreement and met other specified requirements. The facility used for irradiation must be certified by the national nuclear regulatory authority of the country where the facility is located before involvement with USDA. This can represent challenges related to the location of the facility to the production sites. APHIS of the USDA in 'Irradiation treatment of imported plant pests, Part 305.2' Authority: 7 U.S.C. 7701-7772; 21 U.S.C. 136 and 136a; 7 CFR 2.22, 2.80, and 371.3. supplied comprehensive regulations related to quarantine for importing in fresh fruit and vegetables (Table 37). The New Zealand Ministry of Agriculture and Forestry

Table 37 Irradiation for certain plant pests in imported regulated articles into the United States (source: reproduced with permission from the Legal Information Institute, Cornell University Law School)

Scientific name	Common name	Dose (Gy)
Anastrepha ludens	Mexican fruit fly	70
Anastrepha obliqua	West Indian fruit fly	70
Anastrepha serpentina	Sapote fruit fly	100
Anastrepha suspensa	Caribbean fruit fly	70
Bactrocera jarvisi	Jarvis fruit fly	100
Bactrocera tryoni	Queensland fruit fly	100
Brevipalpus chilensis	False red spider mite	300
Conotrachelus nenuphar	Plum curculio	92
Croptophlebia ombrodelta	Litchi fruit moth	250
Cryptophlebia illepida	Koa seedworm	250
Cylas formicarius elegantulus	Sweetpotato weevil	150
Cydia pomonella	Codling moth	200
Euscepes postfasciatus	West Indian sweetpotato weevil	150
Grapholita molesta	Oriental fruit moth	200
Omphisa anastomosalis	Sweetpotato vine borer	150
Rhagoletis pomonella	Apple maggot	60
Sternochetus mangiferae (Fabricus)	Mango seed weevil	300
Fruit flies of the family Tephritidae not listed above		150
Plant pests of the class Insecta not listed above, except pupae and adults of the order Lepidoptera		400

approved access to the New Zealand market for Australian mangoes in 2004, papaya in 2006 and litchi in 2008. Irradiation is the approved treatment for insects of concern to New Zealand, and the minimum dose required by New Zealand for the insect pests is 250 Gy. Irradiation has been used for purposes other insect control. Mansour and Mohamad (2004) tested irradiation on the control of codling moth (*Cydia pomonella*) and found that the radio sensitivity of codling moth eggs decreased with increasing age. However, a dose of 60 Gy completely prevented adult emergence, and at 100 Gy, all larvae died before pupation.

Considerable work has been done on the effects of irradiation on the quality of the fruit. The effect of γ irradiation at 0.3, 0.6 or 1.0 kGy on ripening of Kluai Khai bananas was investigated. During subsequent storage at room temperature of approximately 30 °C, irradiated fruit lost weight, became softer and ripened more quickly than non-irradiated fruit (Chanloy *et al.* 2005). Fenfen Kang *et al.* (2012) found that X-ray irradiation at 0.2 and 0.4 kGy could reduce the respiration rate of grapes and extended their shelf life. They found that there were no significant other physical or chemical effects of irradiation, and the irradiation fruit had a better appearance than the non-irradiation fruit after 14 days storage at 1.5 ± 0.5 °C and $75 \pm 5\%$ r.h.

In order to prevent the transmission of crop pests and diseases between countries, safeguards and restrictions are placed on the international movement of fresh produce. National laws may prevent the import of fresh produce from designated areas or require that they be treated in such a way as to eliminate certain pests or diseases.

Since the establishment of the single market in the European Community in January 1993, health requirements for plant material entering the Community have been harmonised. The general rule is that all plant material intended for planting from third countries (countries outside the EC) except seeds and aquarium plants need a phytosanitary certificate. In addition, a certificate is required for certain fruit entering the EU (Table 38), but these are constantly being revised and the local EU office should be consulted before shipments are made.

In the EC, general requirements are that a phytosanitary certificate must accompany fruit and vegetable in order to be permitted to entry from non-EC countries (Table 39). In broad terms, this includes all major fruit, other than bananas and grapes, some leafy vegetables and potatoes from a limited number of countries. A phytosanitary certificate is essentially a statement that the plants or plant produce or products to which it relates have been officially inspected in the country of origin or country of despatch, comply with statutory requirements for entry into the EC, are free from certain serious pests and diseases, and are substantially free from other harmful organisms.

Table 38 Fruit that require a phytosanitary certificate to enter the European Union in 1993 (source: Defra 2006)

Scientific name	Common name	Origin
Anona	Custard apple	Third countries
Citrus and hybrids	Orange, lemon, lime, etc.	Third countries
Cydonia Mill	Quince	Non-European countries
Diospyros	Persimmon, date plum	Non-European countries
Fortunella and hybrids	Kumquat	Third countries
Malus	Apple	Non-European countries
Mangifera	Mango	Non-European countries
Passiflora	Passion fruit	Non-European countries
Poncirus and hybrids	Ornamental citrus	Third countries
Psidium	Guava	Non-European countries
Pyrus	Pear	Non-European countries
Ribes	Gooseberry, redcurrant, blackcurrant	Non-European countries
Rubus	Blackberry, raspberry, dewberry, loganberry	Third countries
Syzygium	Clove, jambolan, rose apple	Non-European countries
Vaccinium	Cranberry, blueberry	Non-European countries
Zea mays	Maize (seeds)	Third countries

Table 39 Phytosanitary requirements for fruit imported into the EC. Fruit of *Fortunella*, *Poncirus*, *Citrus* spp. and hybrids must be free from leaves and peduncles. (source: Defra 2006)

Botanical name	Common name	Origin	Requirement
Annona	Custard apple	Non-European countries	Phytosanitary certificate
		Non-EC European countries	None
Citrus and hybrids	Orange, lemon, lime, etc.	All non-EC countries	Phytosanitary certificate
Cydonia	Quince	Non-European countries	Phytosanitary certificate
		Non-EC European countries	None
Diospyros	Persimmon, date plum	Non-European countries	Phytosanitary certificate
		Non-EC European countries	None
Fortunella and hybrids	Kumquat	All non-EC countries	Phytosanitary certificate
Malus	Apple	Non-European countries	Phytosanitary certificate
		Non-EC European countries	None
Mangifera	Mango	Non-European countries	Phytosanitary certificate
		Non-EC European countries	None
Momordica	Bitter melon	All non-EC countries	Phytosanitary certificate
Passiflora	Passion fruit	Non-European countries	Phytosanitary certificate
		Non-EC European countries	None
Poncirus and hybrids	Ornamental citrus	All non-EC countries	Phytosanitary certificate
Prunus	Includes cherry, plum, peach, apricot	Non-European countries	Phytosanitary certificate
		Non-EC European countries	None
Psidium	Guava	Non-European countries	Phytosanitary certificate
		Non-EC European countries	None
Pyrus	Pear	Non-European countries	Phytosanitary certificate
		Non-EC European countries	None
Ribes	Gooseberry, blackcurrant, redcurrant	Non-European countries	Phytosanitary certificate
		Non-EC European countries	None
Solanum melongena	Aubergine, egg plant	All non-EC countries	Phytosanitary certificate
Syzygium	Jambolan and rose apple	Non-European countries	Phytosanitary certificate
		Non-EC European countries	None
Vaccinium	Cranberry, blueberry	Non-European countries	Phytosanitary certificate
		Non-EC European countries	None
All other fruit		All non-EC countries	Phytosanitary certificate

Chemical pesticide residues in fruits and vegetables are restricted and controlled by legislation. The work of DG VI (Agriculture) of the EC has the responsibility of harmonising chemical pesticide residues in food. With the introduction of Single Market on 1 January 1993, a first list of 55 chemicals was produced which contained their maximum residue level (MRL). The European Union provides directives for MRL and these are communicated in directives issued in the Official Journal of the European Communities. For example, Council Directive 93/58/EEC of 29 June 1993.

In 2008, the Japan inspection services inspected 287,244 kg of mangoes from the United States and rejected only 1 kg, and 926,530 kg of papaya were imported of which 21 kg were rejected. For Table grapes, 1,923,643 kg were imported from the United States and 282 kg were rejected and 101,483 kg were fumigated on entry to Japan.

In the United States, the Animal Plant Health Inspection Service developed the FAVIR (fruits and vegetables import requirement) database in July 2007 known as Quarantine 56. This established a streamlined approach for the importation of certain fruits and vegetables without specific prior rule making. The database allows customers to search for authorised fruits and vegetables by commodity or country and determine the general requirements for their importation into the United States. This database can be accessed online at: http://www.aphis.usda.gov/import_export/plants/plant_imports/quarantine_56/favir.shtml.

Figure 59 Metal container used for airfreight of fresh produce. Note the boxes are badly stacked as the bottom six layers are stacked on their sides and boxes are designed to be stacked upright to protect the produce inside.

International transport by airfreight

International transport of fresh fruits and vegetables is constantly being questioned in the news media, especially in relation to airfreight transport. This is mainly in terms of the high environmental costs of using fossil fuels for aeroplanes to provide consumers with crops all the year round, which in the past were seasonal. Most of this export trade is from less developed countries to industrialised countries and can be a major source of income for producing countries. This is a very involved subject and not one for a technical work such as this.

For export, fruit and vegetables are usually packed into cartons which in turn are packed into closed containers, igloos or net covered pallets that are specially designed to fit into a specific type of aircraft. The pallets or containers are loaded with the produce and then taken to the aircraft for loading to speed the process. Containers come in various shapes and sizes (Figures 59 and 60), which are designed to maximize the use of the interior of the aircraft.

Akinaga and Kohda (1993) measured the conditions that airfreight cargo was exposed to during transport. They showed that most aircraft have pressurised cargo compartments that are maintained at low humidity (20–40% r.h.) and the same temperature as the passenger compartment. Okras loaded into a freight container without precooling showed a progressive decrease in temperature and increase in humidity during the flight. The increase in humidity inside the container was considered to be due to the poor ventilation characteristics of the container. In another shipment observed by Akinaga and Kohda (1993), the carbon dioxide and ethylene concentration inside a unit load device lined with PVC film for waterproofing containing chrysanthemum flowers was shown to increase. However, the maximum level of CO_2 was only about 0.5% and ethylene at 0.23 $\mu l\ L^{-1}$ and was unlikely to have any effect on the flowers.

Containers that are used on aircraft can have facilities that provide some control over temperature and gases. Reid (2001) recommended a cold chain including refrigerated air containers to reduce losses that occur during shipping and handling of cut flowers. One company which produces and has patented such equipment is Envirotainer Worldwide from the

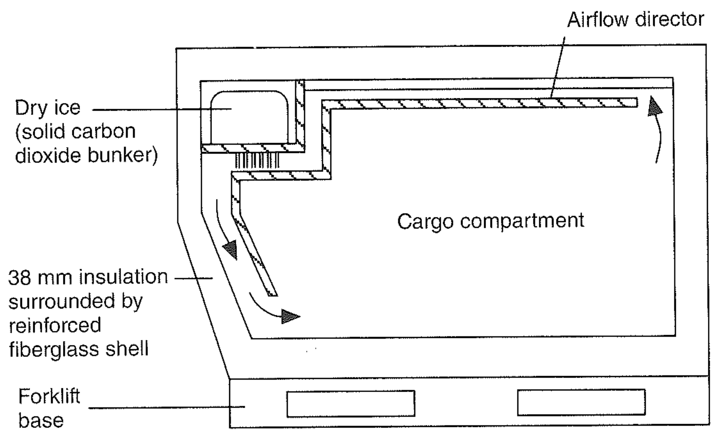

Figure 60 Diagram of a vertical section through a controlled atmosphere airfreight container.

Table 40 Controlled atmosphere containers used for airfreight (source: adapted from Envirotainer Worldwide)

Type	Internal capacity (m^2)	Tare weight (kg)	Maximum gross weight (kg)	Dry ice capacity (kg)
LD3	3.5	190	1,591	56
LD7/9	8.6	499	6,033	56
LD5/11	6.0	408	3,175	90

United States (Sinco 1985). They produce three sizes of insulated containers which are cooled by a fan circulating air across dry ice (solid CO_2) and then through the product in the container. The container has up to 57 kg of dry ice in a compartment that is separated from the cargo compartment. There are no moving parts in the container and air circulation is by convection. Temperature in the cargo compartment is regulated by airflow controls. The sizes are given in Table 40.

Sinclair (1988) reported that Lufthansa had the LD3 airfreight container with a pay load of 1350 kg and LD7 with a payload of 4755 kg. They are insulated with Alu-foam panels affixed to a pallet and air is passed over the dry ice by means of a battery-operated fan which can maintain the temperature within the container at the selected range for the entire transport time.

Air cargo is charged by weight. However, if the volume is greater than 366 cubic inches per kilogram (6 L kg^{-1}), a formula may be applied by the airline to increase the basic charge. The transport cost is a major item in marketing of fresh produce. Examples of costs for beans and cut flowers exported from Kenya to United Kingdom and Holland, respectively, were given by Jaffee (1993) (Table 41) and for limes from Sudan to United Kingdom by Thompson *et al.* (1974) (Table 42). The limes used in the Sudan were the local cultivar which is called Baladi. It had a good strong flavour but was generally smaller than the market requirement, which was greater than 42 mm diameter. In studies, it was found that the distribution of fruit sizes in a commercial harvest was:

- >42 mm diameter: 7.5% with a mean weight of 43.8 g
- 38–42 mm diameter: 25.2% with a mean weight of 33.7 g
- <38 mm diameter: 67.3% with a mean weight of 22.6 g.

Airfreight charges are normally considerably higher than sea freight (Table 43).

Table 41 Distribution of sales revenue, expressed as a percentage of the total, between Kenya and United Kingdom for French beans in April 1985 and Kenya and Holland for cut flowers (source: adapted from Jaffee 1993)

	Fresh French beans (%)	Cut flowers (%)
F.O.B. Kenya	25.6	19.2
Freight and handling	21.3	12.8
Importer's costs and profits	12.7	6.4
Wholesaler's costs and profits	10.4	10.6
Retailer's costs and profits	30.0	50.0

Table 42 Costs and returns (in £ sterling) for an airfreight shipment of limes based on one carton containing 153 fruits weighing 4.13 kg (source: adapted from Thompson *et al.* 1974)

	Expense	Total
Purchase of fruit	£0.38	–
Carton	£0.12	–
Airfreight from Khartoum to London	£0.84	–
Customs and agents charges	£0.45	–
Total expenditure (excluding labour)	–	£1.79
Receipts	–	£2.69

Table 43 Comparison of the variable costs of transporting avocados or mangoes from the Kenyan highlands to Germany either by airfreight or by 20-foot reefer container by sea freight

	Airfreight 2 tonnes	Sea freight 9 tonnes
Transport: field to packhouse	9	41
Transport: packhouse to airport	7	–
Transport: packhouse to seaport	–	260
Stowing in container	–	33
Export clearance at airport	500	
Export clearance at seaport	–	33
Handling at seaport	–	24
Export fees	13	59
Airfreight	1374	–
Sea freight	–	3000
Total	1903	3417
Costs c.i.f. per kilogram	$0.95	$0.38

All figures have been converted to US$ and the study was made in June 1986.

Temperature monitoring

Monitoring the storage conditions of the crop during transport is very important. Reefer containers are fitted with chart recorders that monitor the temperature on the air before and after it passes over the cooling coils. In modern containers, an integral computer often carries out this function. In addition, portable recorders are often placed in the boxes of produce in order to monitor the actual condition close to the produce. These are often contained in sealed units, which are sometimes used as evidence where there is a dispute as to the temperature the crop has been exposed to. Several companies make these recorders, perhaps the best known is Ryan Instruments Incorporated. The recorders have a temperature sensor based on a bimetallic strip attached to a pressure sensitive roll of paper which passes below a pointer attached to the bimetallic strip and records a trace of the temperature over time. A British company called Green PC developed a smaller device (about 55 mm long × 30 mm diameter) called Tiny Talk. The temperature is monitored and recorded on a chip and can be downloaded onto a computer to give a graph of the temperature over time (Robinson 1993). This type of design of recorder has now completely replaced Ryan recorders. They have become reasonably cheap and flexible with the provision of downloading the data onto a computer.