

stored as close as possible to their optimum temperatures. In general, fresh vegetables are stored at temperatures below 4°C while temperate fruits such as apples, pears, grapes, strawberries as well as fresh-cut fruits are stored at 4°C. Tubers and most tropical fruits such as mangoes, pineapples, papayas and subtropical fruits such as guavas, tangerines and longans are stored at room temperature, which is generally set around 25°C. It should be noted that while optimum temperatures of many tropical fruits are 12–15°C, they are stored at 25°C. At higher temperatures, fruits deteriorate very rapidly, hence having a shorter shelf-life. Superstore types in Thailand are listed below:⁴



Name	Country of origin	Number of stores (2005)
Tesco Lotus	United Kingdom	140
Casino Big-C	France	43
Makro	The Netherlands	29
Carrefour	France	22

- **Supermarket, grocery store**

Supermarkets or grocery stores in Thailand as of 2002 are listed below:

Name*	Country of origin	Number	Web site
Tops	The Netherlands	48	www.tops.co.th
FoodLion	Belgium	37	tescolotus.com
Jusco	Japan	10	N/A
FoodLand	Thailand	8	www.foodland.co.th
Villa Market	Thailand	8	www.villamarket.com

- **Fresh market vendors**

In years past, fresh produce in Thailand was generally sold in fresh markets located within each community for convenience. Presently, the fresh market is no longer a major retailer of fresh produce for most consumers in Bangkok or larger cities, given that superstores and supermarkets offer a wider range of goods and activities with a greater level of convenience. Some consumers still, however, prefer and remain loyal to the fresh market for reasons such as affordability of fresh produce and the ability to procure smaller more appropriately proportioned quantities than can be procured at the superstore or



⁴ <http://www.siamfuture.com>

supermarket. However, primary concerns at the fresh market include poor hygiene of the premises and safety of the fresh produce. Another important issue of concern at fresh markets is that the fresh produce is commonly maintained under ambient temperature conditions which negatively impacts on its quality and shelf-life.

- **Street vendor**

Another retail outlet for fresh produce is the street vendor. Fresh produce is displayed by street vendors either on a cart, or on a mat spread on the street. The seller is a grower or small retailer who buys fresh produce from a wholesaler or another grower. The sale of produce out of pickup vans has also gained popularity in recent years as fresh produce can be sold at more than one location by the same vendor.



Exporter

Exporters obtain fresh produce from different sources including growers, groups of growers, collectors, wholesalers and distributors. Packaging requirements of exporters are primarily dependent on market requirements. Standards, regulations and certification are increasingly required by exporters to assure the safety of food. Fresh produce exports from Thailand go mainly to wholesale markets in destination countries. It may either be sold in bulk or repacked for retail markets. Some exporters may have direct contacts with retailers.

1.1.1 Processor

Processors obtain fresh produce from various sources such as growers, wholesalers or other processors. Fruits and vegetables are processed in order to preserve them and to increase their shelf-life. Fresh produce can be processed by canning, freezing, drying and juicing. Fresh produce can also be marketed in the form of fresh-cuts.



1.1.2 Consumer

Consumer requirements for fresh produce vary in accordance with location, income grouping and age. The recent past has witnessed a trend of increasing consumer demand for fresh fruits and vegetables in Thailand owing to increased awareness and recognition by consumers of the health benefit of consuming fresh fruit. Consumers in high-end domestic markets and in export markets are very concerned about the safety and quality of the produce they procure. This is not the case for consumers in domestic wholesale or fresh markets, where the quality of the fresh produce and the packaging requirements may be compromised, but the price is affordable to most. Bulk packaging is mainly required at wholesale markets.

1.2 Export markets for fresh produce produced in Thailand

Thailand is recognized among the leading producers and exporters of fresh produce in the world. Approximately 80 percent of fresh produce outputs of Thailand are sold on the domestic market. The remaining 20 percent is sold on the international market. The top ten international export markets for fresh produce outputs from Thailand are presented in Table 4.1.

Table 4.1 Top ten countries by export value for fresh fruits from Thailand (2006–2008)

Rank	Export countries	Export values (million baht)		
		2006	2007	2008
1	United States	13 305	13 781	14 598
2	China	3 894	4 587	5 269
3	Netherlands	3 903	3 163	3 760
4	Japan	2 489	2 504	3 242
5	Hong Kong	1 652	2 397	2 489
6	Germany	1 688	1 844	2 103
7	Canada	1 172	1 309	1 653
8	Russia	1 514	1 753	1 557
9	Indonesia	1 294	1 367	1 319
10	France	1 091	924	1 261
11	Others	14 517	14 857	18 249
	Total	46 518	48 486	55 499

Source: Office of Agricultural Economics, Thailand

Fresh produce is marketed in various forms including as whole fresh fruit, as fresh cuts, and as processed products – canned, bottled and dried. Survey data shows that fresh produce sections in supermarkets in 2009 averaged around 20 percent of total displayed area, when compared to 5 percent in 2004.

Distribution practices in fresh produce supply chains in Thailand

Good supply chain management aims to minimize waste and achieve cost reductions while maximizing overall value.

Produce is transported from a grower/packer/distributor to a wholesaler, retailer or exporter usually by truck. Packed or unpacked produce is loaded onto the truck either with or without pallets. Different truck types are used depending on the target markets and quantities of fresh produce. The most common trucks used in Thailand in transporting produce are two-axel and three-axel trucks. Produce is generally transported under ambient conditions. Large distributors, retailers and exporters, however, generally make use of refrigerated trucks for produce distribution. There are no standardized truck sizes in Thailand.

Fresh produce is distributed in Thailand using varied packaging formats and a range of different packaging systems. These are now described:

- Unpacked produce loaded on to a truck

Fresh fruits such as pineapple, pomelo, durian and rambutan are often loaded in a “loose format” directly onto trucks without any packaging (Plate 4.1). On arrival at the central or wholesale market, they are transferred by purchasers into bulk containers such as plastic crates, bamboo baskets or plastic bags. The selection of produce by purchasers can result in injury from impact or cuts leading to wastage. Damaged produce is sold at a substantially lower price than high quality produce, and is sold in low-end markets.



Photo 4.1 Loading of unpacked produce onto trucks

- Packed produce loaded on a truck

Produce is packed in various types and sizes of packages prior to loading on to trucks (Plate 4.2). Different packaging systems and truck types are used in accordance with the destination markets. Retail packages of produce are placed in bulk packaging. Fresh produce is generally manually handled. Various types of handling equipment are shown in Plate 4.3.



Photo 4.2 Loading of packaged produce onto trucks



Photo 4.3 Equipment commonly used for fresh produce handling in Thailand

Transportation systems used for fresh produce marketing

Six-wheel trucks are the most commonly used type of vehicle for the transportation for fresh produce in Thailand. A majority of trucks are not refrigerated owing to high cost. Trucks can travel via either fixed or non-fixed routes.

Trucks used for the transportation of fresh produce are owned by different parties in the supply chain as follows:

- *truck transportation companies*, e.g. Nim See Seng, a major shipping and logistics service provider in Thailand which offers truck transportation service for delivering goods, including agricultural commodities within Thailand and neighbouring countries;
- *packers/distributors/retailers*, e.g. The Royal Projects Foundation; large retailers such as Tesco Lotus, Carrefour, Tops Supermarket, etc.;
- *exporters*, e.g. KC Fresh, Siam Export Mart, Swift, etc.;
- *export shippers and freight forwarders*.

In general, small trucks loaded with packaged produce deliver produce to central or wholesale markets. The central market for agricultural goods of Thailand is “Talaad Thai” located in the north of Bangkok. Other main wholesale markets in Bangkok are “Pak Klong Talad” located in the west of Bangkok, “Talad Si Moom Muang” located in the north of Bangkok, and “Talad Mahanak” located in the south of Bangkok. Produce is generally scheduled to arrive at markets in the evening or early morning, depending on the distance between the grower/packer/distributor and the central/wholesale markets. This serves to avoid high temperatures that cause excessive weight loss of produce during the day. Central/wholesale markets operate on a 24-hour basis. Wholesale purchasers often procure their produce in the late evening or early morning.

In situations where produce is packaged (“on-farm packaging”) prior to delivery to wholesale markets, it is unloaded on arrival at the market, stacked and then sold as packaged produce without breaking down into smaller units. This form of produce marketing provides convenience to both sellers and buyers. Pre-packaging reduces waste in the supply chain, owing to reduced handling of produce by purchasers.

Produce from central/wholesale markets is sold to small retail markets such as vendors in fresh markets or in four-wheel pickup trucks who run around or park in residential areas around Bangkok. Produce items that are regularly used as cooking ingredients such as chillies, green beans and lemons may be divided into small units packaged in common polyethylene (PE) or polypropylene (PP) bags in quantities suitable for household usage. Some small grocery-type bags are hung around the pickup truck offering consumers the freedom to select the produce. Some types of produce are weighed in accordance with consumer needs. This “local” style has become one of the popular ways for everyday selling/buying of produce in Thailand.

Large retailers with grocery/supermarket sections set up their own distribution centres in the suburbs of Bangkok to pre-package all fresh and perishable foods for their multidivisions in Bangkok. Produce is packed in reusable plastic crates and is sent from the distribution centre to supermarket consignees. Some types of produce may be packed on sight at the grocery store.

Produce that is destined for export is packed either at a packing houses or distribution centres and is loaded on to trucks for transportation to the shipping port or airport. Produce destined for export can be pre-packaged in retail packaging, before being placed in a shipping container (corrugated or foam box) or packed directly in a shipping container for repacking at the destination market. Trucks used can be of any type and may be either refrigerated or unrefrigerated.

Temperature plays a significant role in maintaining produce quality. Temperature management in supply chains in tropical countries such as Thailand is a key solution to improving quality and prolonging the shelf-life of produce. While maintaining temperature from farm to shelf is costly, efforts must be made to identify efficient systems and to apply good practice in post-harvest management in order to reduce cost.

Factors contributing to losses during transportation in Thai supply chains

Some of the current practices of packaging for fresh produce in a supply chain in Thailand, which contribute to high percentages of produce damage and loss, may be summarized as follows (Plates 4.4 to 4.6):

- Packing too many layers of produce which results in high percentages of damage and reduces produce quality (Plate 4.4).
- Loading different sizes of boxes/crates on to trucks results in poor stacking and reduced logistical efficiency while increasing cost (Plate 4.4).
- Packing without proper cushioning or accessory materials which results in substantial damage (Plate 4.5).
- Use of improper packaging which results in a high percentage of damage and shortens the shelf-life of produce (Plate 4.6).
- Transporting produce in unrefrigerated trucks, or storing produce under unrefrigerated conditions or at too low temperature shortens the shelf-life of produce.



Use of foam boxes for packaging

High compression, high damage due to excessive packaging

Photo 4.4 Some current practices in fresh produce packaging that could cause produce damage



Photo 4.5 Produce damage resulting from improper packaging/cushioning during transportation

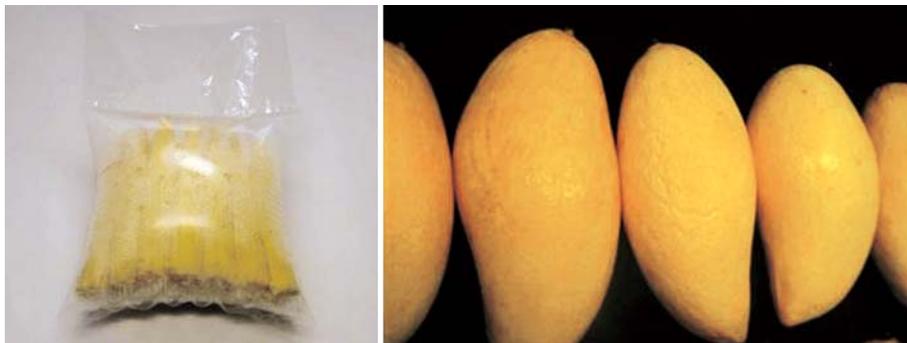


Photo 4.6 Improper packaging of mango resulting in shrinkage due to water loss (right); CO₂ accumulation of baby corn in a commonly available PE bag (left)

Factors that could compromise safety include:

- The use of unclean, non-hygienic reusable plastic crate/basket can transfer contamination to produce, and shorten its shelf-life of produce.
- Packing, storing, selling, handling and distributing produce using unclean equipment, in an unclean environment can compromise safety and shorten shelf-life.

2. Materials and formats for fresh produce packaging

Fresh produce in Thailand ranges from the delicate mangoes to the armoured durian. Each item of fresh produce has its own specific characteristics, and thus has specific packaging requirements. A variety of options are available for the packaging of fresh produce.

2.1 Bulk packaging

Design features of bulk packages include strength, stackability, ease of handling and space utilization. Several types of fresh produce bulk packaging are used in Thailand. These include plastic crates, corrugated fibreboard boxes and bamboo baskets. Results of the current survey show that that plastic crates are by far the most widely used form of bulk packaging (Figure 4.2).

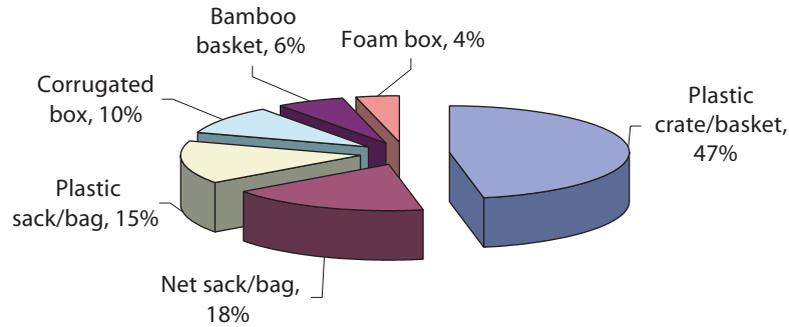


Figure 4.2 Survey data on the use of different types of bulk packaging for fresh produce in wholesale markets in Thailand

Trapezoid plastic crates equipped with steel handles are the most commonly used types of plastic crates in Thailand. Their trapezoid shape allows empty crates to be stored in nested stacks. Large retailers and exporters also make use of round and rectangular nestable plastic crates for the bulk packaging of fresh produce. Solid plastic boxes are used for some produce types but their use is not common. Plastic bags/pouches/sacks are popularly used as packaging for fresh produce, given the convenience they offer in handling and sale. Woven/net plastic sacks are used for produce types that require high levels of ventilation.

Corrugated boxes are commonly used for the packaging of fresh produce destined for export. Solid fibreboard trays and boxes are less popularly used as a bulk packaging option in Thailand when compared to corrugated boxes owing to their comparably higher cost than corrugated boxes. The use of solid fibreboard trays and boxes is generally limited to filling orders from international markets in Europe and North America. Such packing materials are generally imported. Other types of bulk packaging materials used include bamboo baskets and foam boxes, which will be discussed in detail later in this Chapter.

2.1.1 Plastic crates/baskets

Different types of plastic crates are available for use in bulk packaging. Plastics can be formed into rigid, semi-rigid and flexible containers. Although rigid plastic containers are not as strong as wooden boxes or baskets, they are lighter in weight and are less costly. Moreover, plastic packages are resistant to water and moisture, and can be easily cleaned and sanitized which are important criteria for being selected for produce packaging.

Reusable/returnable plastic crates are commonly used for bulk packaging worldwide. Their role has significantly increased in fresh produce distribution in the United States and across Europe. In Thailand and in most countries in the Southeast Asian region, plastic crates have been used in fresh produce packaging for many decades. They are commonly used for delivery from farm to retail. Plastic crates perform a variety of functions ranging from collection, storage, transportation, distribution to display of individual packed produce.

Plastic crates are generally classified as “reusable plastic containers” or “RPC”. Reusability is one of the main advantages of plastic crates over fibreboard containers. Pooling systems have become

a key role in managing efficient supply chains. However, in most cases, management of plastic crates in Thailand is not yet based on a true pooling system as occurs in the United States or in Europe.

Several suppliers of plastic crates for fresh produce exist in Thailand. Users include growers, packers, shippers, distributors, wholesalers and retailers, all of whom generally purchase their own plastic crates. Privately owned plastic containers are generally marked to discourage loss or theft. The use of crate deposit systems is also widespread across Thailand. Deposits are refunded upon safe return of the plastic crates to the supplier. Other agreements can be made between parties in order to help prevent package loss, which is a major problem in the Thai agribusiness.

A closed-loop system is generally used for the management of plastic crates in supply chains in Thailand. These systems generally include no more than three participating parties. The most common arrangement is for a distributor/middleman to provide plastic crates to his growers/shippers. Empty crates are delivered to the farm for packing of harvested produce. Packed crates are transported to a packing-house or storage and distribution facility. Harvested produce packed in plastic crates is then sold domestically at central markets, where small/medium retailers or wholesalers around the area come to purchase fresh produce. The empty crates are then recovered from the market by the crate supplier.

Large retailers generally have their own distribution systems to achieve optimal efficiency and minimize cost. Distribution centres of large retailers are located around the country usually on major routes in order to facilitate efficient logistics. Plastic crates are managed on the basis of a pooling system. A deposit strategy is also applied to promote quick rotation and to prevent loss of the crates. Inventory control of plastic crates is efficiently managed to facilitate the flow of fresh produce in the supply chain. Loose or packed produce is generally delivered, in plastic crates, from a distribution centre to retailers or supermarkets. Some types of fresh produce may be delivered in other types of bulk packaging.

Trapezoid-shaped plastic crates

Trapezoid shaped crates are non-collapsible crates generally made of high density polyethylene (HDPE) or polypropylene (PP) and are equipped with steel handles attached to the crate mouth (Plate 4.7) which facilitates stacking. Packed crates are stacked by placing the steel handles on the slot located at the edge of the crate mouth. Empty crates are stacked by fitting the narrow base into the wide mouth of the crate. Trapezoid-shaped plastic crates are the most widely used bulk packaging containers for shipping produce across Thailand. They are used for packing a range of produce types. While many sizes of trapezoid crates are available, a majority of those used in Thailand have a high depth ratio which allows for the stacking of empty crates. Given their high depth design, trapezoid crates are commonly packed with many layers of produce to fill up the crate, resulting in a high level of damage and loss.



Photo 4.7 Trapezoid-shaped plastic crates commonly used in Thailand

Rectangular plastic crates/boxes

Straight walled rectangular crates (Photo 4.8) are commonly used for the bulk packaging of fresh produce, while solid boxes (Photo 4.9) are used for the packaging of selected produce items. Rectangular crates come in a variety of sizes and designs. Most have handle holes in the body panels. Stacking is done through interlocking tabs with matching receptacles or matching slots along the edges of adjoining crates. Rectangular-shaped plastic crates are gaining popularity as an alternative to trapezoid shaped crates. The key advantage of rectangular plastic crates over trapezoidal plastic crates is greater space efficiency for storage and distribution. Variable depths with fixed length dimensions allow standardization, high produce payload and fewer packing layers, resulting in lower damage and loss. Non-collapsible rectangular-shaped plastic crates are generally used in Thailand, unlike in the United States and European markets.



Photo 4.8 Rectangular plastic crates used in Thailand



Photo 4.9 Rectangular solid boxes used in Thailand

Round plastic crates

Plastic crates made of polypropylene (PP) or high density polyethylene (HDPE) that are round in shape are also used in the bulk packing of fresh produce in Thailand (Photo 4.10). The characteristics and uses of these crates are similar to those of traditional bamboo baskets. The stackability and space utilization of round plastic crates is inferior to that of trapezoid/rectangular plastic baskets. Despite this limitation, they continue to be used by small/medium distributors for the harvesting and shipment of bananas, pomelos, papayas and oranges, especially at wholesale markets.



Photo 4.10 Round plastic crates used in Thailand

Key considerations on the use of plastic crates

Low temperature is a key issue in maintaining the quality of fresh produce. Ventilation of bulk packaging systems is, therefore, an important factor affecting the final quality of fresh produce. Ventilation involves two important post-harvest practices: pre-cooling and storage. Pre-cooling should be done within the shortest time possible after harvest. Pre-cooling is, however, seldom done in Thailand because of the cost involved. Many growers/shippers also do not realize the significant impact of pre-cooling on the keeping quality and marketability of fresh produce.

Plastic crates offer pre-cooling advantages over corrugated boxes. Studies conducted at Kasetsart University, on the rates of pre-cooling mangoes, papayas and pineapples in different shipping containers, showed that reusable plastic containers provided markedly faster pre-cooling rates (7/8) when compared to corrugated boxes of all tropical produce studied. However, air movement over produce during the pre-cooling process could enhance water loss. Ventilation is a trade-off between cooling and heat removal against water loss, which should be considered when selecting bulk containers for packaging and distribution of fresh produce.

Cleaning and sanitizing plays a critical role in assuring the hygiene and safety of reusable containers like plastic crates. After each use, plastic crates are generally cleaned and sanitized at the distribution centres of large retailers. Approved sanitizers such as sodium hypochlorite, chlorine dioxide, various peroxides and ozone are used to reduce the microbial load on plastic crates. Small shippers/distributors may not, however, be aware of the importance of cleaning the crates. Packing of fresh produce in unwashed/unclean reusable plastic poses a risk of cross-contamination. Where single-use containers like corrugated boxes and plastic bags are reused, packers show greater concern for incoming packages that are clean.

2.1.2 Plastic bags/sacks

Plastic bags or sacks are the other form of plastic packaging commonly used for all types of fresh produce. Plastic bags (Photo 4.11) are used for both bulk and retail packaging. They can be made of various sizes and types of films, but the most widely used types for produce packaging are polyethylene (PE) or polypropylene (PP) films. Woven plastic or net sacks are commonly used for produce that requires a high level of ventilation (Photo 4.12). The strength of the woven sacks and net are dependent on the materials used and the spacing of the woven mesh.

Plastic bags/sacks are not reusable and are used as bulk packaging for transporting produce from farms to wholesale markets. They are also used as bulk units for sale. For small produce items such as Thai peppers, e.g. *kheenoo* and *cheefa*, plastic bags/sacks provide convenience in handling. When used for such applications, strength is of minor concern, given that the bags contain only 10–15 kilograms of produce. In some cases, perforation is required in order to dissipate heat, moisture and gas from the package.

Woven sacks are generally used as bulk packaging for limes, potatoes and onions. Commonly packed bags are horizontally stacked on top of each other. Produce packed in plastic bags and in woven sacks should, therefore, have a high level of resistance to mechanical damage.



Photo 4.11 Plastic bags/sacks used as bulk packaging for fruits and vegetable in Thailand



Photo 4.12 Woven or net sacks used for produce requiring high ventilation

2.1.3 Paper cases/boxes/trays

Paper containers are classified as single-use containers, as opposed to plastic crates which are reusable. Paper containers have a number of advantages over plastic crates. Paper containers offer various options of display and can serve as an effective point-of-purchase marketing tool. They can be custom designed to serve specific needs and enhance produce value. Customized designs of paper containers are, therefore, available for produce packaging to perform different functions. These customized designs might, for example, include various holes, handles and designs for convenience and use.

Survey data show that corrugated boxes are the second most commonly used bulk container for in-land packaging and distribution of fresh produce in Thailand and many other countries in the region. They are, however, the most common shipping container for exporting fresh produce much like in several other countries worldwide. Corrugated boxes are probably the most commonly used shipping containers and provide the most economical solution for shipping.

Photo 4.13 shows different types of corrugated containers used in fresh produce packaging in Thailand (domestic, export and import). Boxes used for export usually require certification in compliance with existing standards, specified by freight organizations, industries or standard organizations. The certification systems seek to control and assure the quality specification and performance of the boxes.

Standardized containers have been developed for efficient logistics. Corrugated common footprints have been developed in the United States by The Fiberboard Box Association. Similarly, the European Federation of Corrugated Board Manufacturers (FEFCO) has developed the common footprint standard and common footprint (CF) stamps for identifying trays that meet FEFCO specifications. With their uniform dimensions and tab and receptacle system, standardized common footprint containers have efficient and safe stacking as well as inter-stacking features which are absent from conventional corrugated containers. Standardized common footprint containers also protect produce located in the bottom layers of a pallet from top load



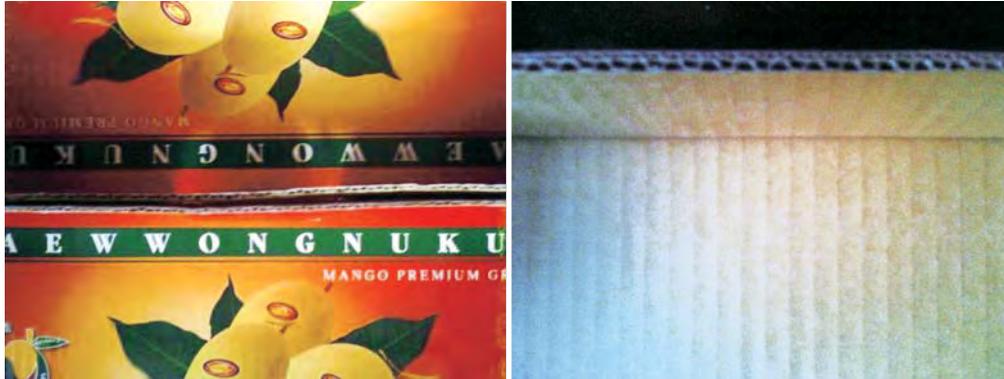
Regular slotted container (RSC) (top) and telescope boxes (bottom)

Photo 4.13 Various types and designs of corrugated boxes and trays

compression, which otherwise occurs with the use of conventional corrugated systems. Common footprint is a global standard, which allows containers from various growers/shippers worldwide to stack safely and efficiently. In addition, it can save space during storage and distribution. These standards offer mixed load shipments for efficient global logistics.

Conventional corrugated containers are widely used in Thailand for exporting fresh produce. The most commonly used type is the regular slotted container (RSC), which is generally used for a range of produce items. Full telescope design (FTD) and full telescope half slotted (FTHS) boxes are also used for fresh produce packaging. The FTD is made from two scored and slotted blank containers, while FTHS boxes are made from two half-slotted containers. The corrugated fibreboard or combined board consists of a linerboard and a medium sheet, which varies in flute profiles. The most common flute configuration used for fresh produce packaging in Thailand is the C-flute and BC-flute for single-wall and double-wall corrugated boards, respectively (Photo 4.14). Standardized produce trays or common footprint containers are often used for international shipping. In most cases, boxes or trays for shipping the produce are provided by the customer.

Another type of paper container commonly used for fresh produce packaging is the solid fibreboard box. Various designs and sizes of fibreboard boxes are shown in Photo 4.15. These boxes are formed by gluing or laminating two or more plies of paperboard sheets together. The solid fibreboard box has a higher manufacturing cost when compared to a similar corrugated box.



Single wall (C flute)

Double wall (BC flute)

Photo 4.14 Common corrugated flutes in fresh produce boxes

Typically, solid fibreboard boxes are more durable than are corrugated boxes, and are thus reused in some cases. International companies have recently introduced solid fibreboard containers for produce packaging in Thailand. They have, however, received relatively little attention from growers/shippers/distributors/retailers. This lack of attention is mainly due to a significant initial cost difference between solid fibreboard and corrugated containers.



Smurfit Kappa solid fibreboard tray

Custom-designed tray

Photo 4.15 Solid fibreboard trays

Key considerations on the use of paper boxes

Ventilation is a drawback with the use of paper boxes as compared to plastic crates. Trays outfitted with an open top can, however, be used to overcome this problem. Corrugated and solid fibreboard boxes for fresh produce incorporate holes or slots in their design for enhanced ventilation and pre-cooling benefits.

Paper containers are well suited for the packaging of produce, given their strength and cushioning properties. They are lightweight and rectangular in shape, thereby allowing stable stacking and efficient space utilization during shipment. They are superior to other containers in the communication function of packaging by having the area of 4–5 panels of the box readily available

for printing produce information. Empty cases are collapsible and are bundled in flat forms which save inventory space. Side panels may be perforated to form handles and to create holes for transfer of moisture and heat.

Uncoated paper containers are, however, moisture sensitive and may lose their strength if wet. They therefore require extra care against moisture and water during use. Corrugated boxes are designed to be single-use containers given that the integrity of the box is greatly reduced during shipment. The moisture barrier properties of paper containers can be improved by coating, waxing, and laminating of the paper surface with polymers. Coated paper, however, produces waste that is not environmentally friendly.

While produce distributors in Thailand are aware of the advantages of using paper-based packaging in transportation, not everyone can afford to purchase paper-based packaging materials. A number of case types are, therefore, currently being used in Thailand for the packaging of fresh produce.

Made-to-order boxes

These boxes are tailor-made for the shipment of high-value fruits and vegetables such as fresh ginger, bell peppers and mushrooms. Graphics on the boxes are specifically designed for each type of produce. The boxes are often made of double-walled corrugated board to enhance protection of produce.

Out-of-specification boxes

These boxes are rejected from the manufacturing plant owing to their failure to conform to specifications. The mechanical strength of these boxes is comparable to that of new, made-to-order boxes. Nevertheless, the graphic designs of these boxes do not always correspond to their contents. They may be used on the domestic market for direct shipment from a producer to known consignees. Their use is prohibited for export shipments, owing to incorrect labelling information.

Used boxes

Corrugated boxes obtained from supermarkets, e.g. boxes used to contain other products such as detergent, toiletries, canned foods or fresh produce are also widely used for the bulk packaging of fresh produce for domestic wholesale markets.

A number of rules, regulations and guidelines have been developed by relevant organizations for the use of paper-based materials in packaging. The main rules and regulations applied to shipping containers are:

- Pictorial markings

Pictorial markings are recommended particularly when shipping abroad. Handling instructions are presented in the form of pictures to avoid language barriers. Pictorial markings commonly recognized include "*fragile/handle with care*", "*this side up*" and "*keep dry*". References pertinent to pictorial markings can be found in International Standard Organisation (ISO 780), American Society for Testing and Materials (ASTM

D 5445), and National Motor Freight Classification (NMFC Item 682-A). Standards and regulations related to the packaging of fresh produce are described later in this report.

- Box manufacturer's certificates

Box Manufacturer's Certificates (BMCs) are recommended markings which indicate that box manufacturing meets the requirements stated by carrier rules for shipping products as defined in Item 222 of the NMFC and in Rule 41 of the Unified Facilities Criteria (UFC).

- Quality and safety certification

Markings may also indicate quality or safety certifications. In Thailand, the "Q Mark" (Plate 3.20) or "Q Premium" is accredited by the National Bureau of Agricultural Commodity and Food Standards (ACFS). The "Q Mark" certifies produce at 2 levels: (1) produce level, which indicates that the produce meets quality and safety standards under Good Agricultural Practice (GAP) and the Code of Conduct (COC); and (2) system level – GAP, Good Manufacturing Practice (GMP), Hazard Analysis and Critical Control Point (HACCP) and COC. "Q Mark" product certification may be included on the label, the container, the package or on the produce itself.

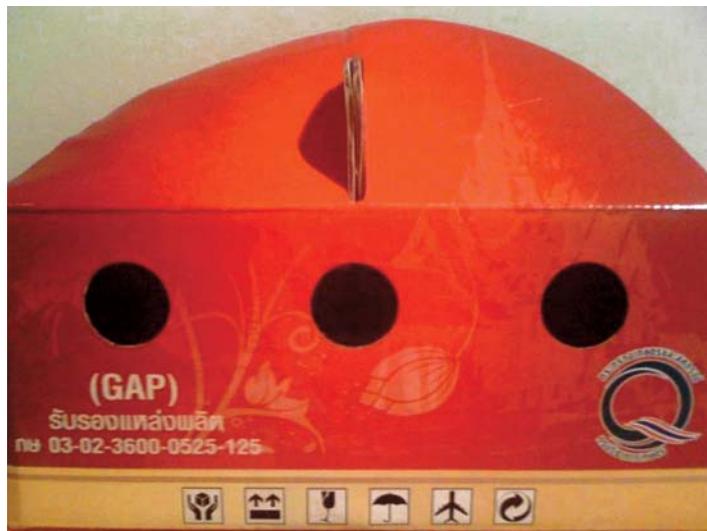


Photo 4.16 Pictorial markings and the "Q Mark" on mango boxes destined for export from Thailand

2.1.4 Wooden containers and bamboo baskets

Wooden containers are very rarely used for the packaging of fresh produce in Thailand. Traditional bamboo baskets are, however, very widely used for the packaging of fresh produce. The use of bamboo baskets for the bulk packaging of fresh produce is a tradition in Thai society. Bamboo baskets are produced in numerous forms, each with its own name and tailored for a specific use. Many patterns are incorporated during weaving to allow for the packaging of specific produce items. The density of the weaving pattern – loose vs dense – can vary according to produce type.

These baskets are considered traditional handicraft products of Thailand and of many other countries in Asia. They can also be categorized in accordance with their shapes and forms as described below.

Bamboo baskets are referred to in Thailand as "*khengs*". They are of two main types: wide-mouth trapezoid baskets (Photo 4.17) and rectangular and cylindrical (Photo 4.18) forms. The wide-mouth *kheng* equipped with two handles is the most popular form of bamboo basket used for the packaging of fresh produce in Thailand and in Asia. It is currently widely used for the transportation of produce from growers to wholesale markets or fresh markets by small and medium growers, shippers, distributors, and for fresh produce items that are not highly susceptible to mechanical damage or which are inexpensive. Rectangular shaped bamboo baskets are traditionally used for the packaging of leafy vegetables, longan and garlic. These *khengs* are generally referred to as "vegetable *khengs*", "longan *khengs*" and "garlic *khengs*" respectively.



Photo 4.17 Wide-mouth trapezoid shaped bamboo basket (*kheng*) commonly used in Thailand and in Asia

Khengs vary in size as shown in Photos 4.17 and 4.18. Empty baskets weigh approximately 250–4,650 grams (11–240 m³) and are nested for convenience and use in storage and shipment. They have a capacity of 10–100 kilograms of produce.

Thick bamboo strips with unpeeled outer rinds are used to supply extra strength to the baskets. The baskets are equipped with two handles at the mouth made of either wood or plastic rope. Bamboo covers tied to the body of the basket are often used to cover the top of the basket. In some cases, bamboo baskets are covered with the leaves of packed produce. *Khengs* are generally used as reusable shipping containers between farms and wholesale markets.



Photo 4.18 Rectangular cylinder shaped bamboo basket

“*Chaloms*” are loosely woven cylindrical bamboo baskets (Photo 4.19), and are in some cases referred to as *khengs*. Various weaving patterns are used in the production of *chaloms*. Tightly woven or dense *chalom* baskets are used for the packaging of fruits and vegetables of small size such as longans and litchis. Loosely woven *chalom* baskets, on the other hand, are used for the packaging of many vegetables including leafy vegetables, vegetable heads such as cabbage, and tubers such as onions.

Chaloms can be covered using range of different options:

- bamboo strips bunched together at the top of the basket;
- bamboo handles made to merge bamboo strips at the top of the basket together;
- use of rope to nest open-top of the baskets;
- use of bamboo lids to cover the open top of the basket.



Photo 4.19 Loosely woven bamboo basket (*chalom*)

Studies conducted at Kasetsart University show that fresh produce packaged in bamboo baskets typically suffers greater physical damage when compared to produce packaged in plastic crates of similar packing volume. Cuts or abrasions are often caused by bamboo strips. Moreover, bamboo baskets are not stackable. A wooden shaft can be used to facilitate the stacking of bamboo baskets for loading (Photo 4.20). Nevertheless, in some cases bamboo baskets are stacked directly on top of each other, with no separator in between, which results in bruising.



Photo 4.20 Stacking of bamboo baskets using wooden shafts

With the many advantages of plastic crates and paperboard boxes over bamboo baskets in terms of strength, stacking, ease of handling and space efficiency, the use of bamboo baskets for fresh produce packaging in Thailand has declined tremendously. Bamboo baskets are still used for the bulk packaging of some root, tuber and bulb crops such as garlic, red onions and onions, which are lightweight and require a high level of ventilation during storage. Surveys conducted within the framework of this study at wholesale markets reveal that bamboo baskets account for 6 percent of fresh produce packaging. Plastic crates offer several advantages over bamboo baskets and, as a result, the use of bamboo baskets has declined substantially during the past decade.

2.1.5 Foam containers

Another type of bulk container commonly used in the packaging of fresh produce in Thailand for both domestic and export markets is the foam box (Photo 4.21). Foam boxes used in fresh produce packaging are typically made from polystyrene (PS). According to data obtained during this survey, a number of shippers/distributors in Thailand make use of foam boxes for the export of fresh produce because of their superior thermal insulation and the physical protection they offer. Foam boxes are the best insulators among bulk containers. They are generally packed with gel ice to keep produce temperatures low during long-distance flights. Experience at Kasetsart University has shown comparably less produce damage with foam box packing as compared to corrugated box packing.



Photo 4.21 Foam boxes closed with the use of tape

They are generally packed with gel ice to keep produce temperatures low during long-distance flights. Experience at Kasetsart University has shown comparably less produce damage with foam box packing as compared to corrugated box packing.

Surprisingly, survey findings confirmed by further communications, reveal that several produce packers do not make appropriate use of foam boxes. While produce should be cooled to its optimum temperature prior to packing, several distributors pack warm produce in foam boxes and then transfer the boxes to cold room storage. In addition, several foam boxes contain holes resulting in the loss of insulation. From the standpoint of protection, technical data do not show that foam boxes are stronger or more durable than corrugated boxes.

2.1.6 Bundling of produce

Bundling is a simple method of holding produce items together by tying them with rope, tape or rubber bands. Asparagus and leafy vegetables are commonly wrapped with kraft or newsprint, plastic or banana leaf before tying. Bundled produce can either be packed in plastic crates for shipping or sold as individual bulk units (Photo 4.22).



Photo 4.22 Vegetable bundling with twine and with and without wrapping at wholesale markets

While the bundling of vegetables for retail packaging is a widespread practice, bundling can also be used for the bulk packaging of produce. Vegetable bundling is more common than is fruit bundling. Nevertheless, the bundling of fruit stalks has recently become popular with consumers owing to its visual appeal in retail.

2.1.7 Accessories and cushioning materials

Packaging accessories can help in protecting fresh produce from physical damage during shipping and storage. These include foam nets (Photo 4.23), moulded pulp or plastic trays (Photo 4.24), paperboard partitions (Photo 4.25), bubble wrap sheets or bags (Photo 4.26), individual plastic wrapping bags (Photo 4.27), shredded paper or newsprint liners (Photo 4.28), and sponge (Photo 4.29). Foam nets are the most commonly used packaging accessory in Thailand. Studies conducted at Kasetsart University show that foam netting significantly reduces mechanical damage by 20–60 percent for selected tropical produce items. Some of these cushioning materials, e.g. foam nets may also be used during the retail display and sale of produce.

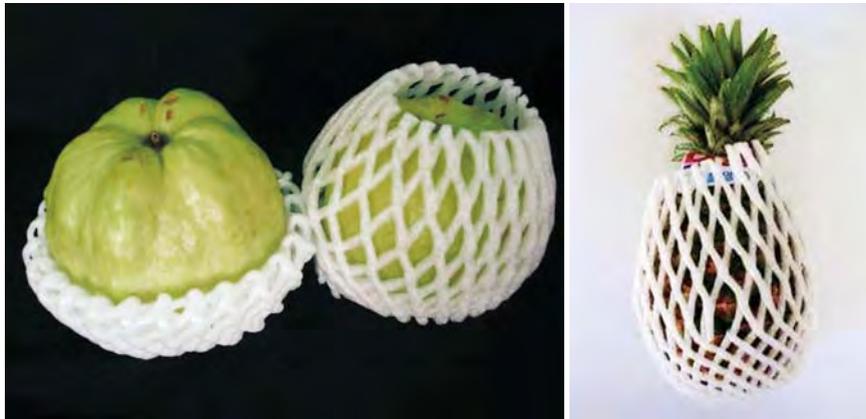


Photo 4.23 Foam net cushions



Photo 4.24 Moulded pulp and plastic trays



Photo 4.25 Paperboard partitions



Photo 4.26 Bubble wrap



Photo 4.27 Individual plastic wrapping bag



Photo 4.28 Shredded paper and newsprint liners



Photo 4.29 Use of sponge as a cover and a liner in boxes

Single-layer packing in a container significantly reduces the percentage of bruised fruits. The packing of more than one layer of fruits into plastic crates is one of the major causes of produce damage in fresh produce supply chains in Thailand. Growers/shippers/distributors, however, generally follow recommended container standards or customers' orders for international markets, which usually require only 1–2 layers to be packed.

2.1.8 Comparison of types of bulk packaging

Table 4.2 summarizes the relative advantages and disadvantages of the various types of bulk packaging used for fresh produce in Thailand. The user must identify major factors and then rank their importance in order to design a suitable packaging system. Primary factors to be considered include produce type, distribution environment, packaging characteristics and marketing requirements. Several important characteristics of bulk packaging must be considered in making decisions on the selection of the package type for fresh produce. These characteristics serve different functions and purposes such as strength for protection, stackability for proper handling and distribution, ventilation for maintaining quality and shelf-life and printability for information

and branding, etc. Proper design should also take account of ergonomics and the environment as well as the cost involved at all steps. All of these are important factors in the decision-making process.

Table 4.2 A qualitative comparative analysis among primary shipping containers used for fresh produce packaging in Thailand (bulk packaging)

Relative factor	Plastic crate	Corrugated box	Bamboo basket	Foam box	Plastic bag
Raw material	Petroleum-based	Natural source	Renewable source	Petroleum-based	Petroleum-based
Reusability	Excellent	Poor	Good	Good	Poor
Strength	Excellent	Good	Moderate	Good	Poor
Stackability	Excellent	Moderate-excellent	Poor	Good	Poor
Handling	Good-excellent	Good-excellent	Poor	Good	Poor
Space utilization	Moderate-excellent	Good-excellent	Poor	Good-excellent	Moderate
Weight	Heavy	Moderate	Moderate	Light	Light
Moisture resistance	Excellent	Poor-moderate	Moderate	Excellent	Excellent
Ventilation	Good-excellent	Poor-good (hole)	Moderate-good	Poor	Poor-good (hole)
Graphic design	N/A	Excellent	N/A	N/A	Good
Cost of package	High	Moderate	Low	Moderate	Low

2.2 Retail packaging

Retail packaging for fresh produce is available in a range of formats. The selection and use of retail packaging in fresh produce supply chains involves consideration of consumer behaviour and social marketing. The selection of a particular type of retail packaging varies according to the target market for the produce. Individual units of packaging are designed to suit specific portions for consumption – usually for an individual household – before the produce deteriorates. Commonly used retail packaging formats for fresh produce in Thailand can be categorized as: bags or pouches, trays, boxes, cases, cartons and netting or banding.

2.2.1 Bags, pouches and film wrap

Bags or pouches are generally produced from plastic and paper. The most commonly used form of retail packaging for fresh produce in Thailand is the plastic bag or pouch. Plastic bags and pouches can be used for almost all types of produce and for almost all purposes. In most cases, clear films are used for retail packaging in order to allow consumers to see the produce inside the package, given that appearance is a key quality criterion for the selection of produce by consumers.

Bags used for fresh produce packaging in Thailand are commonly made from polyethylene (PE), polypropylene (PP) or polyvinyl chloride (PVC). PE and PP bags (Photo 4.30) can be easily manufactured at low cost, but lack clarity. Polyvinyl chloride bags (Photo 4.31) are clear but are not considered to be environmentally friendly. Some bags are made from bubble wrapping materials to protect produce from physical damage.



Bags closed with plastic tape



Bag with self adhesive seal

Heat-sealed package

Photo 4.30 Produce packed in polyethylene (PE) and polypropylene (PP) bags that are sealed using different methods

Fresh produce continues to respire after harvest and therefore has a limited shelf-life. Modified atmosphere packaging (MAP) is a commercially successful technique for prolonging the shelf-life of many fruits and vegetables. Flexible pouches are commonly used to establish modified atmospheres in packaged produce. The main factors that govern MAP design include produce respiration, film permeability and temperature. Commonly available plastics such as PE and PP are not suitable for the creation of optimum modified atmospheres for most produce items. Many supermarkets have recently adopted the use of PVC bags for the retail packaging of fresh produce. In addition to its clarity, PVC has high gas permeability, which is well suited for MAP of many fruits.



Photo 4.31 Fruits in polyvinyl chloride (PVC) bags

Materials of high gas permeability or breathable materials have continually been researched, and are used globally in the fresh produce industry. The use of MAP for the packaging of fresh-cut lettuce is shown in Photo 4.32. Gas-permeable films are generally imported into Thailand for use in the packaging of produce for export. They are also used in the packaging of produce for high-end local markets owing to their high cost.



Photo 4.32 Leafy vegetables packaged in high gas-permeable or "breathable" bags

Films of high permeability, developed by Thai researchers at the National Metal and Materials Technology Center (MTEC) and Kasetsart University's Department of Packaging and Materials Technology, have now been commercialized in Thailand. The films are suitable for various types of fresh produce including tropical produce. The low cost of these films has broadened their use in packaging for both domestic and export markets.

A wide range of films with varied gas transmission rates have successfully been developed for use in the packaging of a variety of produce items. Many companies have adopted the use of these films for fresh produce packaging for domestic consumption and for export. Films of high gas permeability can extend the shelf-life of many fruits and vegetables by a factor of two to five, when compared to commonly available films. Table 4.3 shows the survey results for oxygen transmission rates (OTR) of the packaging films used in fresh produce packaging in Thailand.

Table 4.3 Oxygen transmission rates of various packaging films used in fresh produce bags/pouches in Thailand

Film	Oxygen transmission rate (cm ³ m ⁻¹ day ⁻¹)
Low density polyethylene (PE)	3 000–4 000
Polypropylene (PP)	3 000–5 000
Polyvinyl chloride (PVC)	12 000–14 000
High gas-permeable film (MTEC-1)	6 000–8 000
High gas-permeable film (MTEC-2)	10 000–15 000
High gas-permeable film (MTEC-3)	18 000–20 000
Imported breathable film	8 000–15 000

Wrapping of fresh produce in plastic films is another form of retail packaging commonly used in Thailand (Photo 4.33). Film wrapping is a convenient and simple method of packaging, usually done by hand. It is widely used for the packaging of fruits and vegetable heads. Film wrapping improves produce appearance, hence promoting retail sale. Commonly available film wraps include PE, LLDPE (linear low density polyethylene) and PVC.



Photo 4.33 Film wrapped produce with and without foam net

Individual wrapping of produce items prevents produce contamination. In addition, because of the low level of film thickness, film wrapping allows for high gas transmission rates thus preventing the anaerobic respiration of produce that occurs in common PP and PE bags which generally require holes to facilitate respiration. Film wraps may be used along with foam net cushions for improved protection during handling and distribution.

2.2.2 Trays

The semi rigidity of trays offers key benefits including protection and convenience for ready-to-eat or ready-to-serve purposes. Trays are usually made from plastic, plastic foam, pulp or paper by a thermoforming process. Plastic trays that are commonly used for fresh produce packaging are made from PE, PP, PET and PS. While popular in the North American and European markets owing to its clarity, PET it is not widely used in Thailand owing to its high cost.

Trays can be custom designed for specific applications into a variety of sizes and shapes: rectangular, square and round. Different methods can be used for closure of the packages, such as overwrapping with film (Photo 4.34), heat-sealed film lids or heat-sealed bags (Photo 4.35). In the past, trays were closed with wire staples or tape. Wire staples, however, pose a risk to consumers and are no longer used as large retailers are now aware of the risks. The use of tape for sealing is still common in retail markets.



Black contrast background versus clear tray (PS or PET)
Photo 4.34 Plastic tray overwrapped with film