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THAILAND INSTITUTE OF SCIENTIFIC AND TECHNOLOGICAL RESEARCH
ASEAN SUBCOMMITTEE ON FOOD HANDLING

STRUCTURE AND PROPERTIES OF CONTAINER
FOR FRUITS AND VEGETABLES IN THAILAND

BY

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TISTR, BANGKOK 1984

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โครงสร้างและคุณสมบัติของภาชนะบรรจุผลไม้และผักในประเทศไทย

โดย อมรรัตน์ สวัสดิ์หัต, มยุรี ภาคลำเจียก, ปรีชา โคชู และ นิรันดร์ ศิริพันธ์

บทคัดย่อ

ภาชนะบรรจุผักและผลไม้ที่ใช้ในประเทศไทย ที่นำมาศึกษาโครงสร้างและคุณสมบัติ ได้แก่ เชิงไม้ไผ่แบบต่าง ๆ (เชิงปากบาน, เชิงทรงกระบอก, เชิงผัก), ลังไม้, กล่องวัสดุผสม, กล่องกระดาษลูกฟูก, กล่องพลาสติกชนิดมีฝาปิด, ลังพลาสติกชนิดที่มีลวดรองรับเมื่อเรียงซ้อน, ลังพลาสติกชนิดพับได้, ถุงพลาสติกถัก, ถุงพลาสติก และกระดาษเหนียว.

ภาชนะบรรจุมีขนาด, ความแข็งแรง และราคาแตกต่างกัน. เชิงปากบานเป็นที่นิยมใช้ที่สุด และใช้กันอย่างแพร่หลายทั่วประเทศ. เชิงไม้ไผ่มีความแข็งแรงต่ำ มีค่าการต้านแรงกด 63-220 กิโลกรัมแรง, ส่วนลังไม้และกล่องวัสดุผสมมากกว่า 5 ตัน และกล่องกระดาษลูกฟูก 400-650 กิโลกรัมแรง. การต้านแรงกดของภาชนะบรรจุพลาสติกที่ใช้หมุนเวียนได้อยู่ในเกณฑ์ 700-800 กิโลกรัมแรง แต่มีราคาค่อนข้างสูง.

STRUCTURE AND PROPERTIES OF CONTAINER FOR
FRUITS AND VEGETABLES IN THAILAND

By Amornrat Swatditat*, Mayuree Paklamjeak*

Preecha Tochu* and Niran Sirikan*

ABSTRACT

A study was made by the Packaging Technology Laboratory, Agricultural Products Development Division, TISTR, on the structure and properties of different types of container made in Thailand for packing fruits and vegetables. Many kinds of container are used, which are trapezoidal, cylindrical and vegetable-type bamboo baskets, wooden crates and composite boxes. These also include viz. corrugated fibreboard and sloping-sided plastic boxes, returnable plastic crates with wire stacking device, collapsible plastic crates, woven plastic sacks, plastic bags and kraft papers.

These containers vary in size, strength and cost. Among these, trapezoidal bamboo baskets are the most popular and prevalently used all over the country. The bamboo baskets possess a lower compression strength of 63-220 kgf as against 400-650 kgf of corrugated fibreboard boxes and over 5 tons of wooden crates and composite boxes. The compression strength of returnable plastic containers is good, being 700-800 kgf, but the cost is rather high.

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INTRODUCTION

The traditional containers used for packing fruits and vegetables are mostly bamboo baskets in various shapes. Bamboo basket-making is carried out as a cottage industry. These containers have many draw-backs in packing fragile and highly perishable horticultural produce. Therefore, the loss is rather high.

There are also other types of fruit and vegetable containers, but they are not so popular as basket containers. Thus, it is necessary to study the structure and properties of available containers in order to improve the quality of the container and reduce the loss of produces to a minimum.

This present study started in May 1983, and continued on for a year. It is dealt mainly with the structure and the physical properties of containers used for packing fruits and vegetables in Thailand. It was financed under the ASEAN Subcommittee on Food Handling Project : Fruit and Vegetable Containers.

MATERIALS AND METHODS

The representative samples of different types of container were obtained from original producer or sellers. ISO standards were used for testing most of the properties of the containers except few were by ASTM methods. The details of testing method are listed in Appendix I. The samples were conditioned at $27 \pm 2^{\circ}\text{C}$ and $65 \pm 2\%$ R.H. before testing.

RESULTS AND DISCUSSION

The containers were produced from different materials, e.g. bamboo, wood, paper and plastic. They may vary from region to region depending on the sources of raw material and location of manufacturers. The containers were grouped according to the source of raw material and design of construction into 12 different categories. Their structure and physical properties are as follows:

1. Trapezoidal bamboo baskets

This type of basket is mostly used not only for packing agricultural produces but also for other products as well e.g. fish, poultry, meat and some other consumer goods, etc. The bottom of the basket is square and the top is round with normally two handles (Figure 1). The basket slightly tapers off with a flat bottom, which makes the stacking of the empty containers easier and thus saves space in transportation. The common name is "kheng". There are about 12 different sizes.

The fabrication of the baskets is shown in Table 1. The density of the different strips are as follows:

<u>Strips</u>	<u>Density, g/cc.</u>
Vertical	0.7089
Body weaving	
Outer rind	1.0245
Inner layer	0.8599
Rim weaving	1.0413

The dimension, capacity, weight and price of baskets of different sizes are shown in Table 2. It can be seen that the capacity ranged from 11 to 237 l and weight 250 to 4,650 g. Normally, the commodities at the bottom of large baskets are crushed and damaged. This type of basket may or may not be accompanied by lids, depending on the commodities. Usually, there are many types of lid; some are convex and some are flat with different weaving patterns

People prefer to call the size of basket according to the name of the contents. The most popular size is grapes kheng (2 thung) and sida kheng (3 thung).

The maximum compression load of a basket of 2 thung was 162 kgf (average of 10 baskets) with 20 mm depression. Tongdee (1981) reported the compression load of different sizes to be 80-220 kgf with 6-14 mm depression. If the baskets are placed upward and stacking on top of one another, the space will not be utilized efficiently. The lower basket will usually be

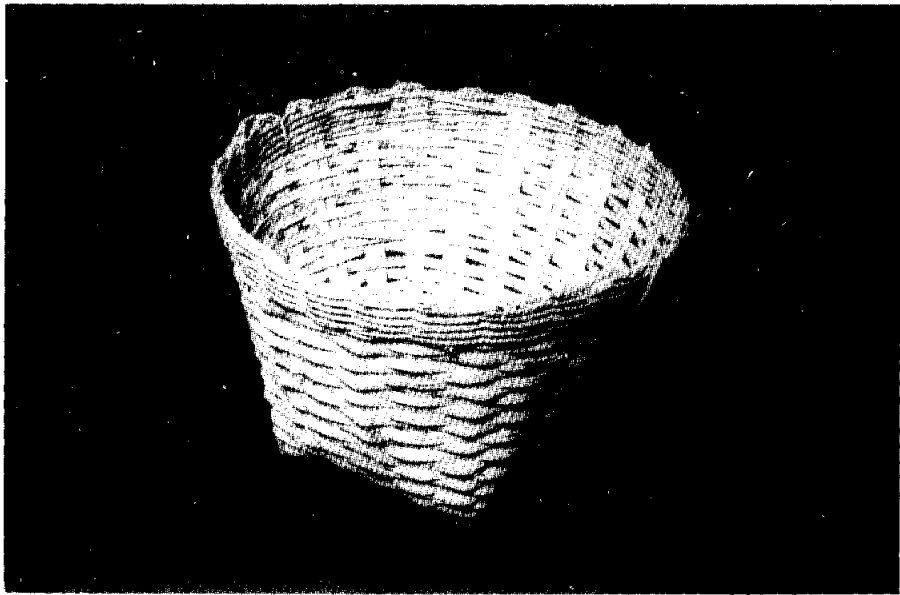


Figure 1. Trapezoidal bamboo basket.

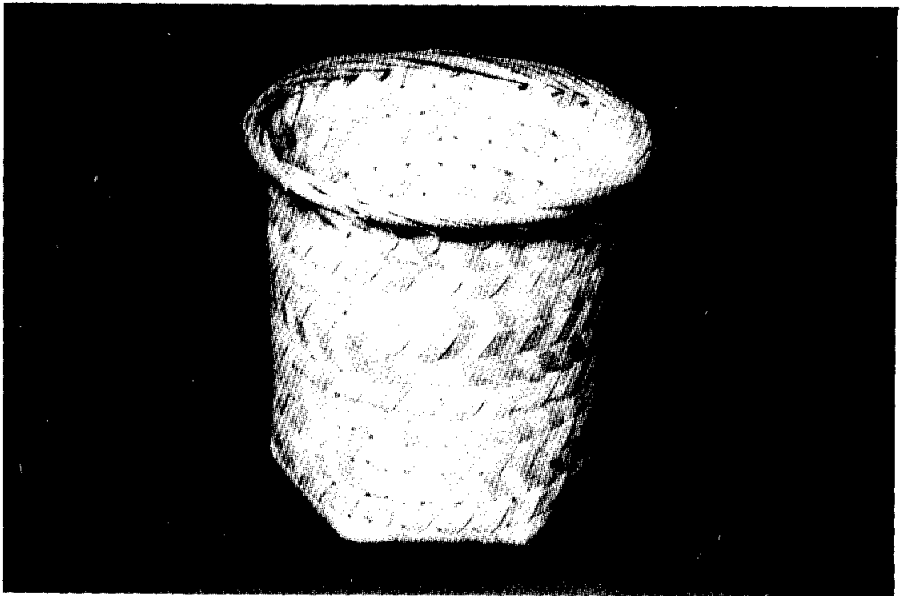


Figure 2. Cylindrical bamboo basket.

TABLE 1. FABRICATION OF TRAPEZOIDAL BAMBOO BASKETS

Local name by size	Vertical strips			Body weaving strips			Rim weaving strips		
	No.	Width (mm)	Thickness (mm)	No.	Width (mm)	Thickness (mm)	No.	Width (mm)	Thickness (mm)
	4 handles	24	40-42	1-2	30	10-20	1-2	14	10-15
No. 1	24	35-40	1-2	26	18-25	1-2	14	10-15	2
No. 2	24	35-40	1-2	28	10-20	1-2	14	10-15	2
No. 3 extra	24	32-35	1-2	27	8-16	1-2	14	10-12	2
No. 3	24	35-40	1-2	25	12-17	1-2	12	8-10	2
No. 4	24	24-30	1-2	30	8-13	1-2	14	4-6	1-2
3 thung, thick rim	20	35-40	1-2	17	12-15	1-2	15	10-13	2-3
3 thung, (sida)	24	28-30	1-2	27	8-13	1-2	12	3-5	1-2
2.5 thung	24	15-25	1-2	12	25	1	10	4-5	1-2
2 thung	24	22-25	1-5	20	8-12	1	8	4-5	2
1.5 thung	20	16-22	1-2	19	7-11	1	12	3-5	2

TABLE 2. GENERAL CHARACTERISTICS OF TRAPEZOIDAL BAMBOO BASKETS

Local name by size	Inside dimension (mm)					Capacity (l)	Weight (g)	Price (P)
	Top ^{1/}	x	bottom ^{1/}	x	height			
4 handles	750	x	605	x	655	237	4650	50
No. 1	725	x	545	x	630	201	3500	45
No. 2	685	x	490	x	570	156	2930	35
No. 3, extra	620	x	425	x	560	121	2220	28
No. 3	575	x	405	x	485	92	1630	25
No. 4	510	x	360	x	430	65	1170	20
3 thung, thick rim	510	x	290	x	380	61	1850	40
3 thung, (sida)	515	x	360	x	395	60	1050	18
2.5 thung	450	x	330	x	330	40	550	15
2 thung, (grapes)	445	x	285	x	310	33	600	10
1.5 thung	390	x	265	x	300	26	550	14
1 thung	310	x	205	x	205	11	250	9

^{1/}diameter

pressed by the weight of the upper resulting in damages of the commodities. In order to solve these problems, the normal practice is to place one upward and one downward alternately for the first layer, and then one downward and one upward in such a way that it is top to top and bottom to bottom. At present, trucks are used with horizontal dividers which are made of wooden planks to prevent compression of the baskets and damage on the commodities. Hence the space in the truck could still not be fully utilized.

2. Cylindrical bamboo baskets

This type of baskets are mainly built in the northern part of the country as container for fruits and vegetables grown in these area such as longan, lichi, mango, potato and onion, and then transported to Bangkok or other parts of the country. The capacity of this type of basket ranges from 40 to 188 l (Tongdee 1981). Data on the size and type of the cylindrical bamboo baskets for packing longan is as follows:

Outside dimension

Top diameter	450 mm
Bottom diameter	390 mm
Height	440 mm

Inside dimension

Top diameter	420 mm
Bottom diameter	370 mm
Height	430 mm

Capacity 54 l

Incline strips

No.	60
Thickness	0.5-0.7 mm
Width	15-18 mm
Density	0.8193 g/cc

Weave strips

No.	11
Thickness	0.5-0.7 mm
Width	26-30 mm
Density	0.8262 g/cc

Rim weaving strips

No.	6
Thickness	0.8-1.2 mm
Width	7-8 mm
Density	1.0160 g/cc
Compression strength	67.3 kgf
Depression	25 mm
Price	10 ¢

The other size of basket which is equally important to the size mentioned above is the size of baskets for packing onions and potatoes with the outside top and bottom diameter of 500 mm, 400 mm in height and 68 l in capacity.

The strength of the basket can be vertically reinforced with bamboo clumps and pieces which will raise up its compressive force 2 to 4 times, depending upon the kind and size of bamboo used (Cherdchai et al. 1982).

3. Vegetable-type bamboo baskets

These baskets are made in the northern part of the country as container for any kinds of vegetable produced in the nearby area, e.g. garlic, cabbage and chinese cabbage. There are two main types called "Garlic-type bamboo baskets" (Figure 3) and "Chinese cabbage-type bamboo baskets" (Figure 4). Both of these two types are fabricated from very narrow and thin bamboo strips, approximately 1 mm thick and 5 mm wide. The description of the two types are as follows:

	<u>Garlic</u>	<u>Chinese cabbage</u>
Outside dimension		
Top diameter, mm	520	470
Bottom diameter, mm	365	385
Height, mm	350	300
Inside dimension		
Top diameter, mm	510	460
Bottom diameter, mm	355	375
Height, mm	340	290
Weight, g	250	200
Capacity, l	50	40
Density of bamboo strips, g/cc	0.7354	0.7012
Compression strength, kgf	26.3	4.1
Depression, mm	35	15

The size of the baskets may vary since they are fabricated normally by hand.

The main purpose of the baskets is to contain or hold commodities together and have no protective function. Generally, they are flexible and get out of shape easily and, therefore, have inadequate protection to the contents.

4. Wooden crates

The crates are made of Para rubber wood or recycled wood planks from incoming boxes or pallets (Figure 5). They are nailed sawn wood with horizontal battened ends. The side-boards of any crates are spaced slightly apart to allow ventilation, and the crate may or may not be provided with a top depending upon the type of commodities and the size of the crates. An example of the size of the crate is described as follows:

Outside dimension

Length	520-580 mm
Width	260-305 mm
Height	350-365 mm

Inside dimension

Length	440-480 mm
Width	230-255 mm
Height	340-350 mm

Capacity 40 l

Weight 6-7 kg

Board

Width	30-160 mm
Thickness	12-18 mm

Compression strength 75,000 kgf

Price 20-25 ¢

The capacity of crates may vary from 50 to 85 l. They are often reused for mangoes, mangosteens, langsarts and mandarin oranges.

5. Composite boxes

The boxes are made in the northern part of Thailand as shown in Figure 6. The boards are made from fabricated bamboo strips laminated together and lined with paper, then they are nailed to the rectangular battens. The battens are of square section of 40 mm. The description of the boxes are:

Outside dimension	540 x 345 x 380 mm
Inside dimension	465 x 295 x 360 mm
Capacity	49 l
Weight	3.58 kg
Compression strength	75,000 kgf

The boxes are provided with a top and used for packing longan and lichi.

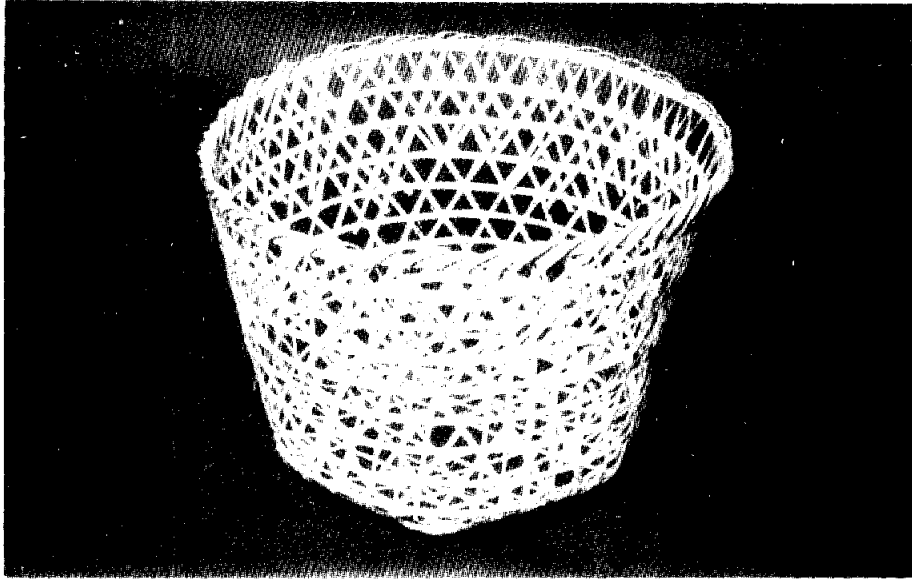


Figure 3. Garlic-type bamboo basket.

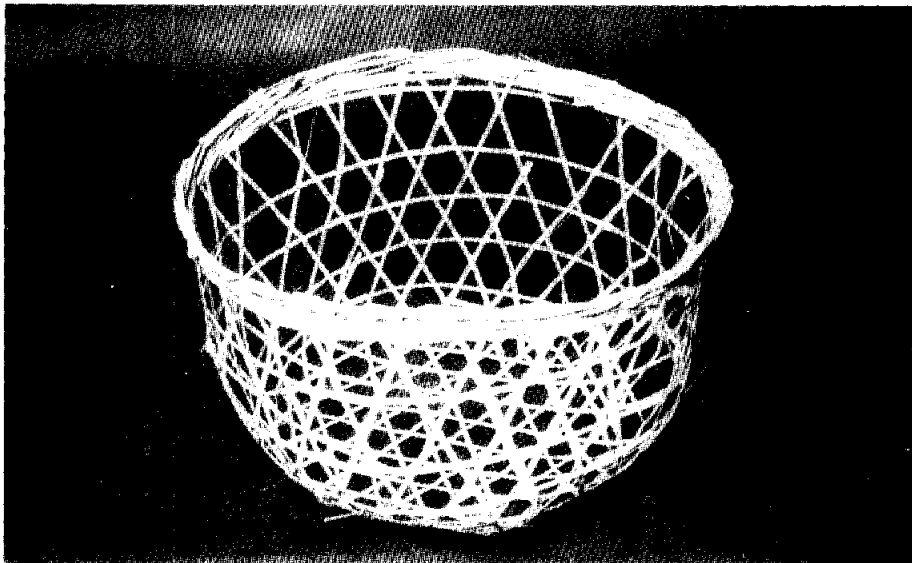


Figure 4. Chinese cabbage-type bamboo basket.

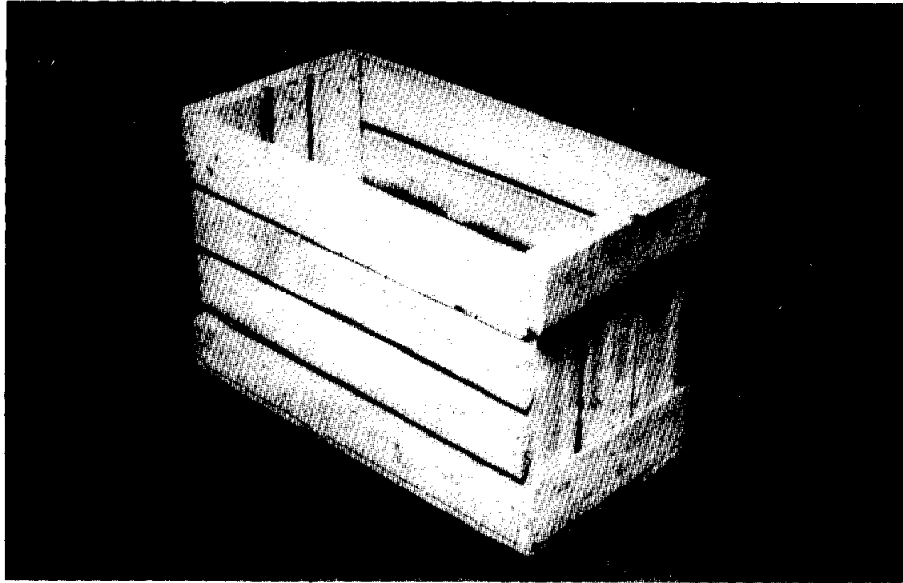


Figure 5. Wooden crate.

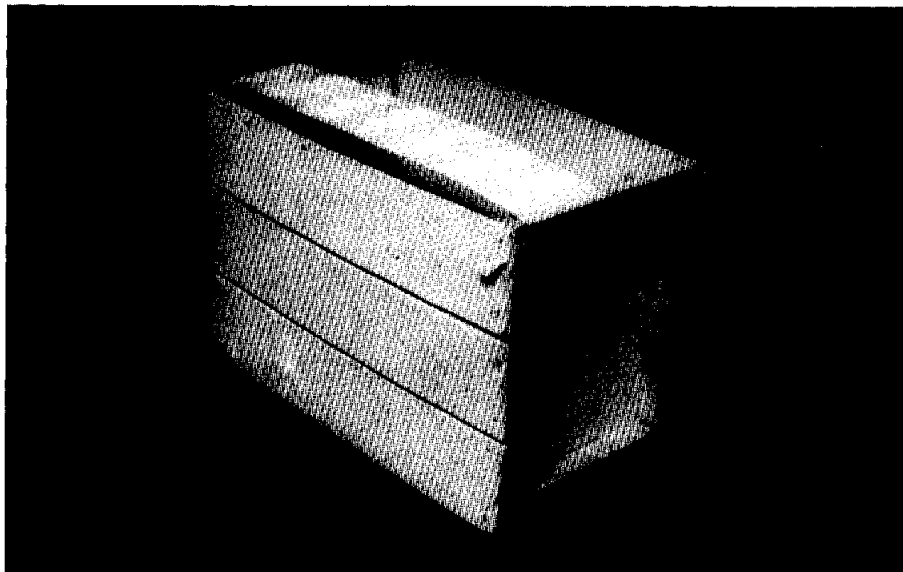


Figure 6. Composite box.

6. Corrugated fibreboard boxes

Corrugated fibreboard boxes are increasingly used as a container for fresh produces locally and for export. Normally, two types of boxes are popularly used, Regular Slotted Container (RSC-IFC 0204) as shown in Figure 7, and Full Telescope Half Slotted Box (FTHS-IFC 0320) as shown in Figure 8.

RSC is a one-piece box which is more generally used than any other styles because they are the most economical to manufacturers and users, and can easily be adjusted to suit the shipment of most commodities. The stacking strength of these boxes depend on the dimension, the combination and flute types of board used. The details of a box used for packing lichi is described as follows:

Type of flutes	C-B
Thickness of board	6.47 mm
Outside dimension	510 x 335 x 306 mm
Inside dimension	500 x 325 x 300 mm
Capacity	48.75 l
Weight	1025 g
Bursting strength	13.2 kgf/cm ²
Compression strength	417 kgf
Depression	41 mm
Price	18 ¥

The size of boxes and the capacity may vary. The capacity may range from 31 to 52 l.

FTHS is a two-piece box, both sections of slotted style full depth cover. The two thickness of fibreboard at the sides and ends of this container afford maximum protection to its contents and give the box superior stacking strength. The FTHS-type box is described as follows (Figure 8):

Type of flutes	B-C
Thickness of board	6.66 mm
Outside dimension	410 x 300 x 223 mm
Inside dimension	383 x 280 x 207 mm
Capacity	22.19 l
Weight	360 g
Bursting strength	13.1 kgf/cm ²
Compression strength	650 kgf
Depression	57 mm
Area of ventilation hole	2.95%
Price	16 ¤

The capacity of the boxes vary from 23-49 l depending on size of the boxes and their contents.

7. Sloping-sided plastic boxes

Sloping-sided plastic boxes have a rectangular horizontal section and injection-molded from polypropylene (Figure 9). Nesting cases occupy approximately 70% less space than the oblong cases in storage and transport when empty. The boxes are described as follows:

Outside dimension	
Top	490 x 350 mm
Bottom	440 x 310 mm
Height	180 mm
Inside dimension	
Top	450 x 320 mm
Bottom	430 x 300 mm
Height	170 mm
Capacity	29 l
Weight	780 g
Compression strength	911 kgf
Depression	5 mm
Price	29 ¤

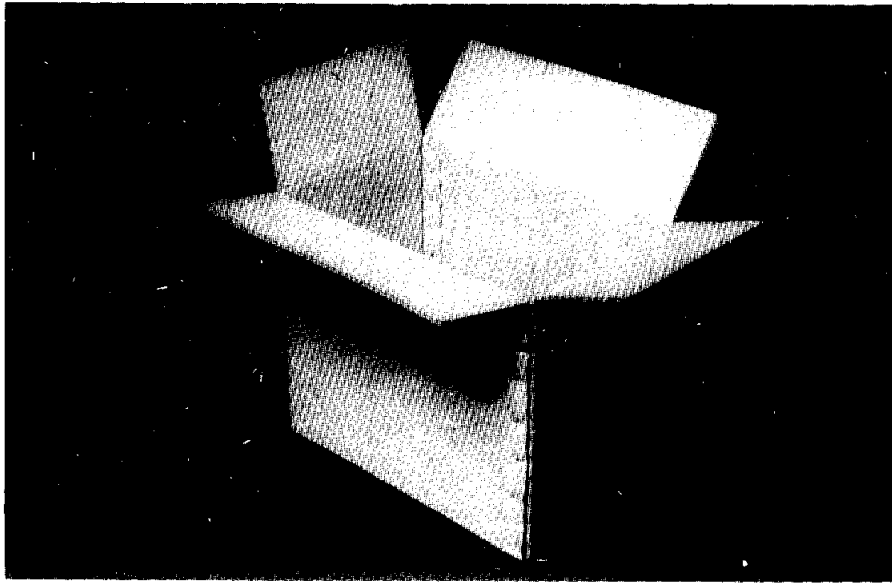


Figure 7. Corrugated fibreboard box : RSC, IFC 0204..

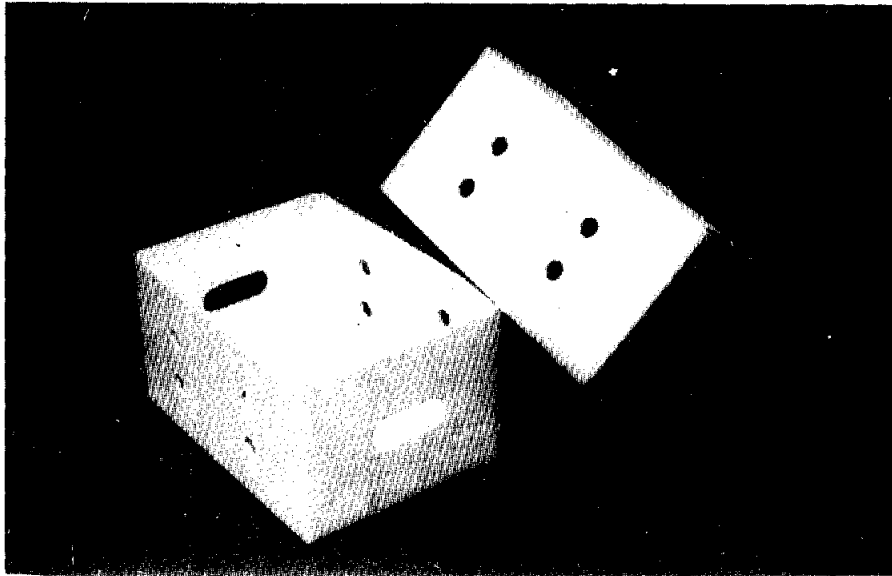


Figure 8. Corrugated fibreboard box : FTHS, IFC 0320..

The boxes have been used tremendously as one-way packing cases for longan to Singapore for the past two years. They are being used increasingly as reusable containers for lichi locally.

8. Returnable plastic crates with wire stacking device

The crates are produced from high density polyethylene as shown in Figure 10. The tapered walls of the crates provide cost-saving in both storing and transporting empty containers. When nesting, the wires are in outward position, and when stacking, their bottoms nest on the wires. The description of crates are as follows:

Outside dimension

Top	570 x 370 mm
Bottom	497 x 297 mm
Height	320 mm

Inside dimension

Top	570 x 330 mm
Bottom	485 x 285 mm
Height	283 mm

Capacity	45 l
Weight	2330 g
Compression strength	846 kgf
Depression	27 mm
Price	120 ¢

9. Collapsible plastic crates

The crates are injection molded from polypropylene as shown in Figure 11. The characterization of the crates are:

Outside dimension	600 x 400 x 320 mm
Inside dimension	565 x 340 x 300 mm
Capacity	63 l
Weight	2460 g
Compression strength	734 kgf
Depression	9 mm
Price	232 ₱

The crates are collapsed by the long panel and the dimension is reduced to 600 x 400 x 66 mm which are about 79% less space than that of the set up one.

There is another size of 41 l crate which cost 190 ₱. This type of crates are not commercially used yet because of the higher price.

10. Woven plastic sacks

The sacks are presently used for packing garlic and shallot (Figure 12). They are open mesh sacks, made up of plastic tape yarn knitting. The sacks are technically suitable only for produce which is not easily damaged. The main advantage is that the product can be seen clearly, so that they are preferable for packing crops such as onion, garlic, shallot etc. It is 520 mm long and 860 mm wide with the opening of approximately 3 x 3 mm.

11. Plastic bags

Polyethylene bags are used to contain different kinds of fruits and vegetables for retailers. There are about 4 different qualities: transparent, recycled light blue, hi-ten translucent and hi-ten light blue. The properties of these plastic bags in similar size are compared in Table 3. It can be seen that the latter two are very high in tensile strength but low in impact resistance.

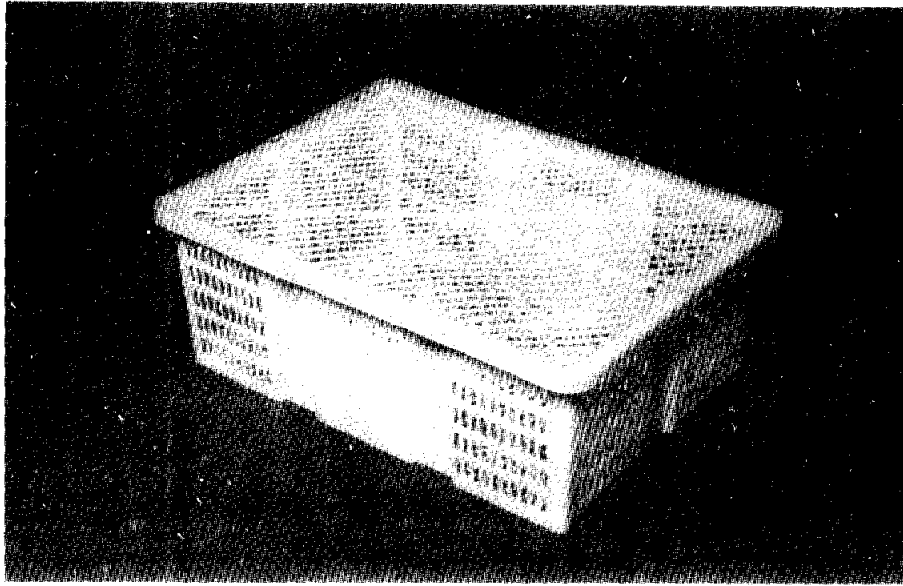


Figure 9. Sloping-sided plastic box.

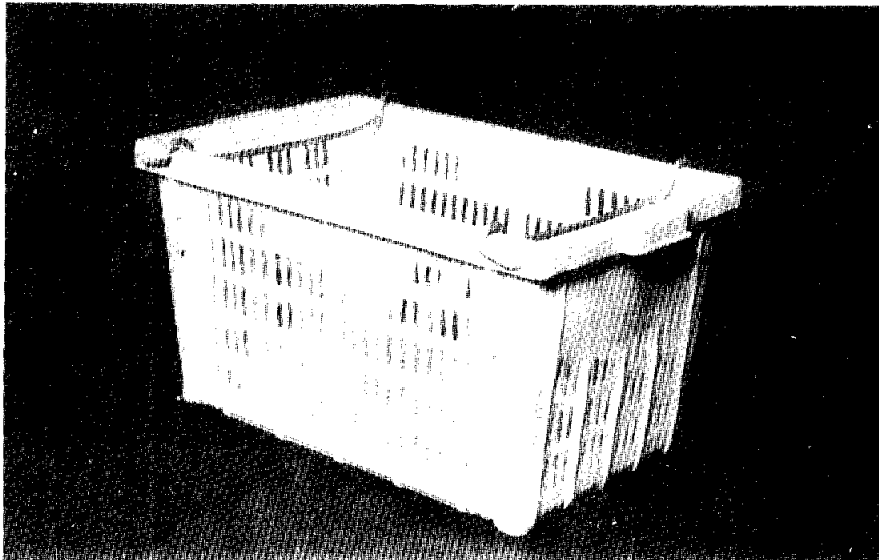


Figure 10. Returnable plastic crate with wire stacking device.

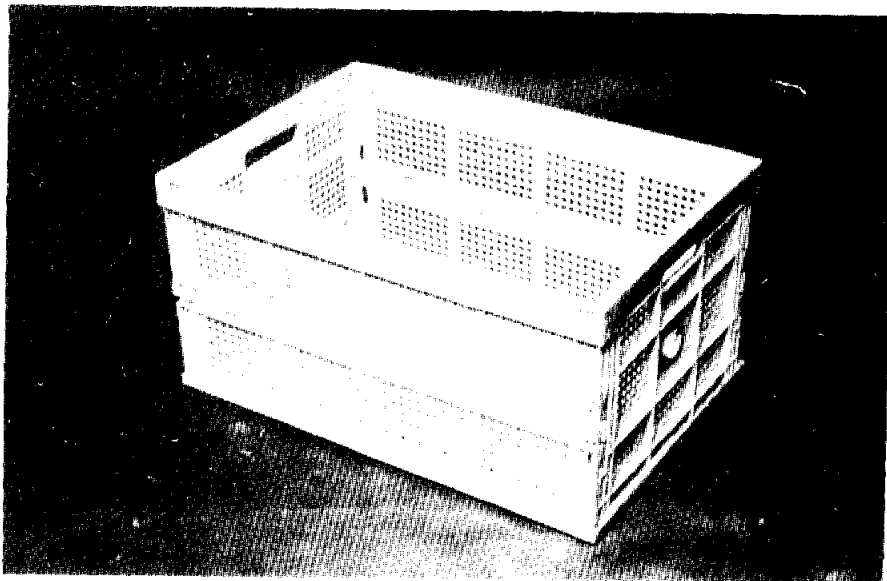


Figure 11. Collapsible plastic crate.

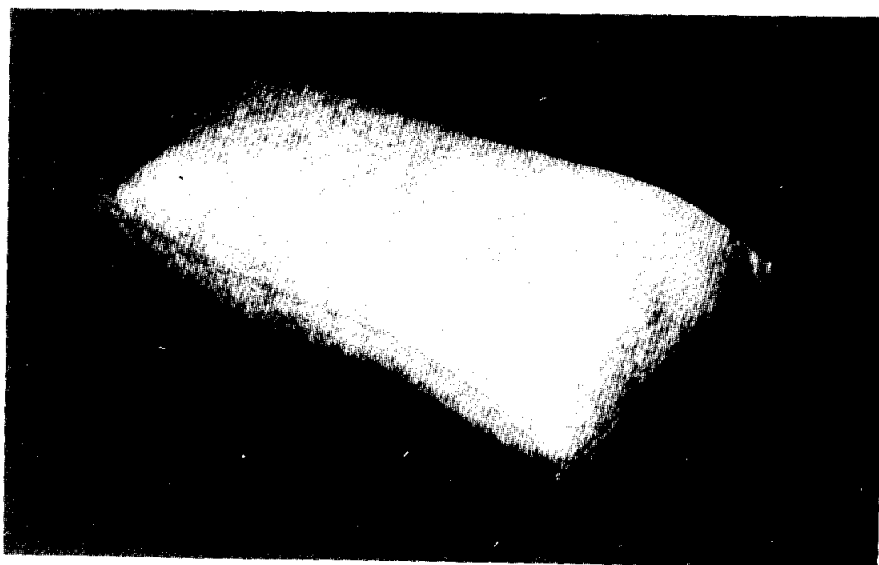


Figure 12. Woven plastic sack.

TABLE 3. PROPERTIES OF PLASTIC BAGS

Properties	Transparent	Recycled light blue	Hi-ten	
			Translucent	Light blue
Length, mm	652	645	650	650
Width, mm	462	485	460	460
Thickness, μ	43.75	62.5	30.7	26.3
Tensile strength, kgf/cm^2	146.36	107.50	594.85	650.68
Elongation, %				
- Machine direction	155	240	35.3	62
- Cross direction	487	590	69	62
Impact resistance, g	55	55	30	30
Quantity /kg	40	40	67	67
Price, ₹/kg	35	35	44	44

There are about five different sizes of transparent polyethylene bag provided for different types and weights of commodities, and also four sizes for recycled light blue. The properties of each sizes of transparent polyethylene bag and recycled light blue are shown separately in Tables 4 and 5.

12. Kraft paper

Kraft paper is used for wrapping vegetables in a bundle, e.g. swamp cabbage and water mimosa. It is normally a paper from used multiwall paper sacks. Its properties are as follows:

	<u>Sample 1</u>	<u>Sample 2</u>
Thickness, μ	117.8	129.8
Basis weight, g/m^2	80.94	69.64
Tensile strength, kgf		
- Machine direction	6.1	3.5
- Cross direction	4.6	2.6
Elongation, %		
- Machine direction	6.2	1.6
- Cross direction	7.2	4.2
Tear resistance, gf	94.0	88.0
Water absorption, g/m^2	60.18	64.67

Among the containers used locally, trapezoidal bamboo baskets seem to be accepted popularly and are widely distributed throughout the country. The quality of the baskets nowadays is decreasing, however they are still used for both fruits and vegetables. Comparing baskets and wooden boxes at the same price, people still prefer baskets to wooden boxes. Even though the strength and the protection of boxes is better than baskets, but the capacity of the box is lesser than the baskets. The boxes are used only for fruits not for the vegetables.

Since the baskets contain a large quantity of commodities, therefore the produces are then transferred to plastic bags which contains 5 to 15 kg, especially vegetables, to sell to the retailer.

All the containers, except the one used for export, plastic bag and paper are returnable and a retailer have to deposit for the price of the container to a wholesaler. They may be reusable many times and still are valuable as long as they are needed.

TABLE 4. PROPERTIES OF TRANSPARENT POLYETHYLENE BAG OF DIFFERENT SIZES

Properties	1	2	3	4	5
Length, mm	460	550	657	540	900
Width, mm	309	390	462	378	566
Thickness, μ	43.75	43.75	43.75	43.75	62.50
Tensile strength, kgf/cm^2	146.36	146.36	146.36	146.36	115.31
Elongation, %					
- Machine direction	155	155	155	155	152
- Cross direction	487	487	487	487	600
Impact resistance, g	55	55	55	55	100
Quantity /kg	76	52	40	42	15
Weight of content, kg	3	3-4	7-8	12-13	20

TABLE 5. PROPERTIES OF RECYCLED, LIGHT BLUE POLYETHYLENE BAG OF DIFFERENT SIZES

Properties	1	2	3	4
Length, mm	448	557	645	740
Width, mm	309	392	485	509
Thickness, μ	56.3	56.3	62.5	62.5
Tensile strength, kgf/cm^2	101.43	101.43	107.50	107.50
Elongation, %				
- Machine direction	155	152	240	360
- Cross direction	487	600	590	62
Impact resistance, g	20	20	55	55
Quantity /kg	76	52	40	42
Weight of content, kg	2-3	5-6	10	10

CONCLUSION

There are different types of container used for fruits and vegetables in Thailand. The containers are made of bamboo, wood or plastic. The containers may be called trapezoidal, cylindrical and vegetable-type bamboo baskets, wooden crates, composite boxes, corrugated fibreboard boxes, sloping-sided plastic boxes, returnable plastic crates with wire stacking device, collapsible plastic crates and woven plastic sacks, plastic bags and kraft papers are used for small quantities by retailers.

These containers vary in size, strength and cost. Trapezoidal bamboo basket are the most popular and prevalently used throughout the country. Cylindrical and bamboo baskets for vegetables are produced in the northern part of the country. These baskets possess lower strength approximately 63-220 kgf depending on the size. The compressive strength of wooden crates and composite boxes is over 5 tons. Corrugated fibreboard boxes are increasingly used and possess the compressive strength of 400-650 kgf. Containers of plastic group possess good compressive strength (700-900 kgf) but the cost is rather high.

Trapezoidal and cylindrical baskets, wooden crates, corrugated fibreboard boxes and sloping-sided plastic boxes are used also as containers for exporting certain commodities.

This report describes mainly the structure and physical properties of the containers for fruits and vegetables. The contents including type and weight of commodities of these containers reported above will be mentioned in Report No. 2 of this project "Existing Containers Used for Fruits and Vegetables in Thailand".

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APPENDIX I

METHOD FOR TESTING MATERIALS AND CONTAINERS

Paper

- Basis weight of paper ISO 536
- Tensile strength ISO 1924
- Tear resistance ASTM D 689
- Water absorption ISO 536

Corrugated fibreboard box

- Bursting strength ISO 2759
- Water absorption ISO 536

Plastic bag

- Tensile strength ISO R 1184
- Impact resistance ASTM D 1709, Method A

Density, bamboo strips

ASTM D 792

Performance testing

- Compression strength ISO 2872