The problems of transporting and packaging of fruits and vegetables in Bangladesh

By

Mohammed Golam Al Farooque

DISSERTATION

Completed in partial fulfillment of the requirements for the degree of

PROFESSIONAL DOCTORATE

Central Queensland University (CQU), Australia.

25 September, 2007

Central Queensland
UNIVERSITY

PROFESSIONAL DOCTORATE PORTFOLIO

LIBRARY DECLARATION

This declaration shall be attached to the first of the requisite bound copies of the portfolio.

AUTHOR	**Mohammed Golam Al Farooque**
TITLE OF PORTFOLIO	**The Problems of fresh food packaging and transportation in Bangladesh**

I acknowledge that, following successful examination, a bound hard copy of the portfolio described above, shall be deposited in the University Library and made available in accordance with the University's regulations governing the submission and examination of a research higher degree thesis.

EITHER:

☒ I agree that the portfolio shall be made freely available for the purpose of research or private study.

OR:

☐ I request that access to the portfolio, or parts thereof, be restricted for a specified period, and that release of the portfolio during that period for the purpose of research or private study be contingent upon the approval of the Director of the Division of Library, Information and Media Services (or nominee). I understand, in those cases where I am not reasonably available, such approval may be granted without my having been consulted.

(An author electing this option must also complete the attached page of this declaration.)

Signature of Author

10.10.07
Date

Please complete and return this form to:
Jenny Frazer
Administration Officer (Professional Doctorate)
Faculty of Arts, Humanities and Education
Building 33
Central Queensland University
CQ MAIL CENTRE QLD 4702

The problems of transporting and packaging of fruits and vegetables in Bangladesh

By

Mohammed Golam Al Farooque

DISSERTATION

Completed in partial fulfillment of the requirements for the degree of

PROFESSIONAL DOCTORATE

Central Queensland University (CQU), Australia.

25 September, 2007

Acknowledgement

At first, I must show my gratitude to Almighty Allah for giving me energy & capabilities to preparing this dissertation. Then I would like to express my gratitude to my parents- Md. Arshad Ali & Rawshan Ara Ali and my wife Mrs. Trishna Farooque for their inspiration.

I'd like to thank my daughters & sons - Farzana, Farhana, Autul, Amit & Auvishek for their inspiration while writing this dissertation.

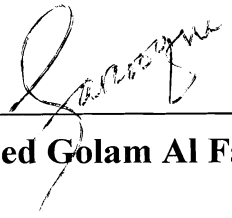
I would like to express my sincere gratitude and thanks to my program supervisor Dr. Tony Fry and industry supervisor Ms. Anne-Marie Willis for their brilliant and excellent guidance and assistance to complete this dissertation.

Research on "the problems of transporting and packaging of fruits and vegetables in Bangladesh" are carried out scientifically and sound packaging system is developed using locally available raw material and where applicable biodegradable agricultural by product are used as a raw materials for developing new and modified packaging containers. It has been influenced by countless discussions with small, medium and large fruit vegetable traders, whole sellers, exporters, and transport companies.

I would convey my sincere gratitude to Md. Mozammel Hoque Bhuiyan & Md. Rana Ur Rahman for their support and help.

I would like to thank all the participants of the workshops, interviews and fact-finding sessions for many thoughtful conversations and their kind cooperation regarding the nature and the goal of transporting and packaging system of fruits and vegetable in Bangladesh. Sincere gratitude to all the wonderful peoples of "The Merchants Ltd." for their support and help.

Once more time all of the teacher in my life, **I** owe more than I can mention...mostly for teaching me to see the silver lining in every dark wood.



Mohammed Golam Al Farooque

TABLE OF CONTENTS

SL No	Description	Page No
	Abstract	5
	Introduction	
	Why I am doing this Project	6-8
	Recognized national need	8-9
	Business Opportunity	9-12
1.	**The context**	
1.1	Agriculture in Bangladesh	13-15
1.2	Socio-economic changes	15-17
1.3	Climate change and its potential impact	17-17
1.4	Packaging fresh produce: advantages and challenges	18-20
1.5	Present status of fruit and vegetable production in Bangladesh	20-21
1.6	Trends in export of fruit and vegetables	21-26
2.	**Packaging: materials and methods**	
2.1	The function of packaging	27-28
2.2	Survey of past practices and types of packaging	28-34
2.3	Current types of packaging containers for fresh produce	35-48
2.4	Modern packaging design	48-56
2.5	Low cost packaging materials available in Bangladesh	56-58
3.	**Transportation from farmyard to market places**	
3.1	Early forms of transportation: river, rail and road	59-60
3.2	Transportation infrastructure of Bangladesh today	60-61
3.3	Past transportation practices for farm produce	61-65
3.4	Current transportation practices for farm produce - survey	66
3.5	Analysis of survey results	66-72
3.6	Current transportation practices: challenges	73-75

TABLE OF CONTENTS

	Description	Page No
4.	**Towards improved packaging practices**	
4.1	Cost barriers to packaging fresh agricultural produce	76-78
4.2	Cost benefit analysis	78-79
4.3	Skill development of producers	79-82
4.4	Pack house operations for fruits & vegetables	82-89
4.5	Plastic as a packaging material: discussion of issues	89-91
4.6	Controlled atmosphere packaging: benefits and costs	92-100
5.	**Towards improved transportation practices**	
5.1	Modes of transport: effect on packaging selection	101-103
5.2	Actions to address transportation problems	104-105
5.3	The Cool Chain	105-107
5.4	Other considerations in transporting fresh produce	107-108
5.5	Towards an effective farm transportation system	108-110
6.	**Summary and Conclusion**	111-113
	Appendixes	
	Appendix -1(a): Fruits grown in Bangladesh	114-116
	Appendix -1(b): Vegetables grown in Bangladesh	117-120
	Appendix -2: Growth rate of different horticultural crops	121-122
	Appendix-3: Selecting produce for case study	122-123
	Appendix-4: Type of Packages and materials	123-124
	Appendix-5: List of unfamiliar word	124-125
	Appendix-6: Questionnaire	125-128
	Appendix-7: Participants at the workshop	128-129
	Appendix-8: Workshop Program	129-132
	Appendix-9: New packages	133-141
11	**Bibliography**	142-148

ABSTRACT

Bangladesh, basically an agricultural country, is gradually emerging into the international market with fresh agricultural produce. In order to compete in the market, standardization of the produce and packages is essential. In the research undertaken, the packaging status of fresh horticultural produce, and past, present and future practices of packaging and transporting fresh fruits and vegetables were reviewed. This investigation covered: methods of maintaining the quality of fresh fruits and vegetables; scientifically developed packaging materials; designing of appropriate methods of storage; sorting, grading and packing techniques – according to the requirements of the customers of developed countries. Following this, cost benefit studies were undertaken for developing various types of packages. Modification of presently available packaging materials and skill development of local work force were also considered and initiated – via interviews, surveys and workshops conducted with agricultural producers and transporters in a number of agricultural regions in Bangladesh. Wherever possible and appropriate, priority was given to the use of agricultural waste as the raw materials for developing internationally acceptable biodegradable forms of packaging. On this basis, some prototypes have been produced.

Why I am doing this Project

This project brings three critical needs together:
The first need is a matter of national concern. The farming sector in Bangladesh urgently needs to reduce the amount of produce that is spoiled by the way it is handled, packaged and transported from harvest to market. This can be as high as 80%. I have been especially concerned about this because no extensive research has been undertaken before to identify the problems of handling, transporting and packaging of fruits and vegetables in Bangladesh, which is far from satisfactory especially to ensure decline in wastage and identification of the problems of prospective produce. Initially, the present status of packaging was identified by field level interviews with the producers and users of packages for fresh agricultural produce. Literature search continued simultaneously in the relevant libraries of Bangladesh Agricultural Research Institute, (BARI); Bangladesh Agricultural Research Council, (BARC); Bangladesh University of Agricultural (BAU); Shere Bangla Agricultural University (SAU); Banga Bandhu Sheikh Muzibur Rahman University of Agriculture (BBSMRU) and Institute of Food Science and Technology (IFST).

The second need goes to wishing to develop the company of which I am Deputy Managing Director. The company is based on converting and flexible packaging in Bangladesh. It is now the largest packaging company in this country. It employs 600 people and was established in 1983. The company has gradually become the major supplier of flexible packaging materials to major local and multinational companies.

From my thirty years of experience in the printing and packaging industry I see that in a country like Bangladesh it is possible and necessary to combine the generation of wealth from a successful business with the creation of employment and the solving of some of the social and economic problems the country faces. From this perspective, I decided that it was desirable to bring my own, and my company's, expertise to the nation's fresh food packaging and transportation problem. To this end I put the idea of carrying out an intensive research to identify the problems of transporting and packaging of fruits and vegetables in Bangladesh.

The third need is bringing more produce to market in prime condition, so that the volume exported can increase. The project was viewed as being able to contribute to this aim and in so doing increase the viability of the farming

sector, which is dominated by the almost ninety million small farmers. These farmers' efforts can be significant for improving the overall status of transporting, packaging and other management efforts. By these farmers increasing their income, the cost of packaging and transportation can become less of a financial burden. More broadly however, by improving the performance of the farming sector, and businesses like mine, the project has the potential to contribute to national development. Bangladesh, it should be remembered is a new country facing a number of major challenges, such as how to improve its marketing, distribution, technology, and management information systems.

During the course of the project I have learnt a great deal about farmers and their systems for transporting and packaging fruits and vegetables. Having placed myself in a position of viewing Bangladesh and the problems I have engaged from perspectives both inside and outside the country, my own perspective has altered. I now view that we have identified the major problem associated with transporting and packaging systems.

Besides the obstacles to the implementation of my recommendations that are addressed in this work, especially designing and development of packaging and transporting system of fresh produce, the general situation in Bangladesh at the start of the C21th cannot be disregarded. The development of farming and the export of fresh produce require a degree of economic and political security, so that the national infrastructure improves along with the wellbeing of the population at large. Political stability is a major factor for improving the condition of the country. So to achieve the most fruitful result of this research, the government of Bangladesh would need to give due regard to the political stability of the country. In addition to political stability, awareness at all levels, about environmental aspects need to be developed. This situation is given special urgency by the threat of climate change due to global warming. A sea level rise of just one meter will reduce the landmass of the country by 40%. This means 40% of the land will be submerged in the sea (Bay of Bengal). If special care is not taken to protect the environment, the whole country will face a grave disaster by the year 2020.

Perishable agricultural produce especially fruits and vegetables require special packaging to transport from farm to store house and to home and overseas market. During this research work, past and present practices in the development of packaging items, particularly for perishable produce, are

reviewed. This research is used to inform proposals for modification of transport systems; and proposals for and trials of modified packaging containers made from locally available raw materials including, where applicable, biodegradable agricultural by-products.

The present project was undertaken in view of my long association in the printing and packaging industry since 1976 and still engaged in this business. During this long 29 years career in packaging industries I had to undertake different assignments at different times and presently holding the position of Deputy Managing Director of "The Merchants Limited" (www.themerchantsltd.com) which is one of the eminent business house in packaging sector of Bangladesh. "The Merchants Limited" is always looking for innovative approaches in this sector of business. During my career in packaging industry I had to undergo training in many national and international workshops and obtained a University degree from the U.S.A in the field of printing and packing. I felt that there is a tremendous business opportunity in commercial production of international standard packaging for agricultural produce. The present project has been undertaken to carry out research in design and development of world-class packaging.

Bangladesh is predominantly an agricultural country that has recently entered the global market with agricultural produce, especially perishable fruits and vegetables. As a result, a rapid growth in the packaging sector of these items can be visualized. My company, Merchants Group, with over thirty years experience in packaging and printing business wants to capture this emerging market sector by designing and developing internationally acceptable packaging containers, using appropriate technology with affordable cost. It has the mission to utilize locally available raw materials of natural origin and to train local manpower to perform the job. Skill development of local young people will enable us to produce world-class packaging to serve the purpose of marketing perishable agriculture products at home and abroad.

Recognized national need

Bangladesh is one of the world's poorest, most densely populated and least developed nations. The agriculture sector plays a very important role in the economy of the country. In the past decade, the agriculture sector

contributed about three percent per annum to the annual economic growth rate. (KM Huq, 2005).

The agriculture sector is the single largest contributor to income and employment generation and a vital element in the country's challenge to reduce rural poverty and foster sustainable economic development. The Government has therefore accorded highest priority to this sector to enable the country to meet these challenges and to make this sector commercially profitable. Value addition of agricultural produce which is very delicate in handling, can be achieved by developing standard packages so that the perishable produce can be marketed with minimum damage and keeping its aroma and freshness (Rashid A. 2002).

Business Opportunity

Currently, fresh fruits and vegetables are among the fastest growing export sectors of Bangladesh, with increasing networks developing between our exporters and foreign buyers. To develop major markets in exporting countries, quality packaging is essential. While developing new packaging and improving existing ones priority was given to use recyclable, biodegradable, low cost agricultural by products as raw materials. Locally available natural products such as bamboo, straw, reeds and other agricultural by products were considered as potential raw materials for developing and designing packaging containers. While making modification to the traditional and existing packaging containers, it was kept in mind to incorporate latest design so that the packaging containers give an excellent exterior look, at the same time serving the purpose for packaging and transporting delicate fresh produce without any post harvest damage. Research and development on traditional and existing packaging containers resulted new products with elegant look and increased customer acceptability and shelf life of the produce.

In Bangladesh, the earliest packages were mostly constructed with plant materials such as woven leaves, reeds and grass stems and were designed to carry by hand. In the past no serious consideration were given in designing packages as result fresh produce were carried to the consumers from the farmers field or house in packages which were made without giving any thought on the suitability of these packages to carry particular produce which resulted in considerable damage, loss of quality and acceptability to the consumer. Non-standardized packages were the major cause of damage of fresh agricultural produce. We have tried to solve this problem in our

present work thereby serving address an acute national need in Bangladesh. We believe the results of our work in this present project will increase the image of our nation and will enhance trade in agricultural produces while serving to address national need we have also opened up a new area of business, which was not looked seriously in the past. New avenues of business opportunity will emerge in near future by utilizing our experience and expertise to manufacture new packaging containers in which locally available naturally grown plant materials will be utilized in economic way which will utilize agricultural by-products, which are biodegradable and environment friendly. Our present endeavor also creates new area of employment among unemployed rural population especially to the rural woman.

During the progress of present work we have traveled extensively in different corners of Bangladesh and identified the hidden potential of the rural people and eagerness to participate in the area of work which were not recognized much in the area of work which were not recognized much in the past. By a little guidance and encouragement this huge group of population can be utilized profitably to develop the economy of the country, particularly in the agricultural sector. By so doing the economic condition of the poverty stricken rural community could be enhanced enormously.

While looking for appropriate literature to get some guideline on this study it was felt that these was scarcity of proper technical journals in this area of research. However, it was possible to get some guideline on this project from some articles published in the Intermediate Technology, Journal of appropriate Technology, Food packaging Journal and some related Journals. I already publish a paper based on this project in the Journal of Socio Economic Research & Development. (Vol 3. issue 1. June 2006). The Board of Editors of the above journal felt the need of publishing this type of research work in future issue of this journal.

The following business opportunities have been identified:

1. The emergence of an agribusiness sector during the 1990s has already contributed to a notable share of GDP and provides rural employment, particularly of women. At the moment, when other previously promising sectors such as Ready Made Garments (RMG) and Energy seem to face structural difficulties, the agribusiness sector promises to fulfill its potential for higher growth and allows to capitalize on

several opportunities for accelerating growth of the sector from an estimated 6 percent annual growth to 10-15 percent are related to five factors (i) population (ii) comparative advantage (iii) policy reforms (iv) entrepreneurship and (v) association.

2. A large population base of about 140 million (70 million being less than 18 years of age) provides not only a low cost labor, but also a growing urban middle class with an increasing demand for superior, higher quality and more convenient products. However, keeping in mind the globalization of business and rising labor cost, this scenario may change in the near future. Developing new technology in the packaging sector will be the most economic and sustainable solution. Mainly imported products are currently meeting this demand. However, meeting this demand through domestic production suggests an opportunity for both foreign and domestic investment to develop agro-based industries and value chains linking farmers/producers to markets, including the emerging supermarket chains.

3. Bangladesh agriculture seems to have comparative advantages in a number of commodities including fruits and vegetables. A number of developments would enable Bangladesh to realize the twin potential of meeting domestic demand and expansion of export through agro–processing. There would be need for substantial increases in productivity at the farm level, contributing with a lowering of production costs through economies of scale, value adding processing facilities, packing, clearing, sorting, grading, packaging, pre-cooling, refrigerated storage would also be required. Modern food processing methods would equally need to be introduced. Likewise, substantial improvements would need to be made in the availability of market information, intelligence and in overall marketing systems. To realize the potential of the agribusiness sector would involve a large number of enterprises in supplying production inputs to producers and processors, in providing technical services, in post harvest handling and transportation, in value added processing and in marketing.

4. Policy reform during the last two decades has helped in creating a policy environment that is more conducive to private sector development. The government is committed to playing a facilitative and regulatory role in the agriculture and agribusiness, leaving commercial activities to be carried out by the private sector. This is consistent with the general framework of the Poverty Reduction

Strategy. Effective implementation of government programs in partnership with the private sector will be an essential element in promoting the development and growth if the agribusiness sector of Bangladesh.

5. Many of the associations related to agribusiness have emerged during the 1990s. An opportunity exists for these associations to serve as link between their members and national government. These associations represent a very important resource base for agribusiness enterprise development. Strengthening the capability of the associations to provide services to their members will pave the way to improving the effectiveness of programs oriented towards the promotion of individual enterprises.
6. There appears to be a large pool of Bangladeshi agro-business entrepreneurs, who lack access to information, resources and mechanisms that would make it possible for them to lead successful enterprises. The number of entrepreneurs engaged in expending medium scale enterprises is particularly encouraging.

CHAPTER 1 – THE CONTEXT
1.1 Agriculture in Bangladesh

Bangladesh is bountiful; contrary to common picture of this country it is a "bottomless basket". Mother nature has blessed Bangladesh with highly favorable climate for agriculture. Many different species of plants can be grown here with little or no special efforts. Due to the relentless effort, in past decades by both the government and non-government sectors, especially by dedicated agricultural extension workers, tremendous growth has occurred. From once a food deficient country Bangladesh is now almost self sufficient in food production to feed its 140 million people. Soon Bangladesh will find its place among the food exporting countries of the world (Bhuiyan et. al., 2002). Yet it is still a huge task to meet this challenge.

Eighty five percent of its population is directly dependent on Agriculture. But like other developing countries because of a lack of proper knowledge in packaging and preservation, many perishable agricultural products mainly fruits and vegetables, are wasted in huge quantities. Seasonal fruits and vegetables could be transported to distant places and exported to other countries if proper packaging and presentation techniques using low cost and appropriate technology were to be developed. Bangladesh produces over 1.5 million tons of fruits. In terms of production, bananas, mangos, pineapples, jackfruits, melons, litchis, limes and lemons are the major fruits produced.

In terms of vegetable production, the country produces about 3.4 million tons of potatoes and it is estimated that the production of potatoes increased to 5.3 million tons in 2003-2004. Apart from potatoes the country produces about 1.6 million tons of other vegetables. Other major vegetables are Brinjal (submerging, eggplant), pumpkins, cauliflowers, cabbages, gourds, tomatoes, radishes, peas and beans, (K.M Haque 2005). The country also grows 5.5 thousand tons of pulses and 616 thousand tons of oilseeds of various kinds.

The fruit and vegetable exports of the country have been growing at the rate of 23% per annum in terms of value and almost 19% in terms of volume during the 1992-2003 periods. Very short shelf life is a problem and a serious factor that limits fruit export. During the 1999-2003 period, Bangladesh exported fresh produce of fruits and vegetables to 36 countries but mostly to UK and the Middle East. Currently vegetables are one of the

fastest growing export sectors of the country. During the 1990s the average growth rate of vegetable exports has been about 37% in terms of value and 26% in terms of volume (EPB - Export Promotion Bureau)*.

The Bangladesh Fruit Vegetable and Allied Products Exporters Association (BFVAPEA) placed the value of fruit and vegetable export at US 40 million in 2003. Of this total, about 68% went to the Middle East, with 28% to East Asia. Almost 90% of the EU exports went to the UK. About 50 different types of fresh fruits and vegetables are exported. Exporting of fresh fruits and vegetables to so many countries illustrates the potential of the agribusiness sector. This potential can be increased with networking between exporters and foreign buyers. To develop major export markets, and to break into the international supermarket chains continuous improvements in the quality of packaging is essential.

In Bangladesh commercial farming is relatively new venture. Fifty years ago vegetables and fruits were normally just grown around the homestead for the family's consumption only. Excess produce was given to the neighbors free of cost. Only a few farmers sold produce to local markets after meeting their own requirements. As a result the development of packaging for fruits and vegetables remained at a rudimentary stage. Produce was transported to local markets in baskets and many other types of containers made of bamboo, rattan, reeds, straw, date palm leaves, coconut leaves, and jute rope and so on. Many fruits and vegetables were also transported in bags made of knitted jute rope, this so that air can pass through them. During this period (1940-1970) urbanization was not as extensive as it is today.

After the liberation of Bangladesh in 1971 a radical change in the agricultural sector took place. The modernization of the sector resulted in rapid growth with more and more educated and qualified people involved in it. Difference in the sectors of Agriculture, such as horticulture, floriculture and market oriented farming, also developed. Due to revolutionary change many related industries, although small and cottage in scale started to grow rapidly. Keeping in mind the requirements of the present day farming community, entrepreneurs are now stepping into this new area of agro-based industries with a lot of enthusiasm. An agro-products packaging industry is one such venture has tremendous potential for growth. (M.A. Hossain et. Al., 2005)

In developing such an industry we have to be realistic and monitor the purchasing power of the farming community. Initially we have to develop the technology so that it is appropriate to our company's (The Merchants Ltd, Bangladesh) economic environment. At the same time the quality and cost of the packaging and the produce has to be acceptable to the users and producers.

Packaging material should be recyclable, biodegradable, and low cost and preferably should be developed using locally available natural resources such as bamboo, wood and such other materials. Research and development (R&D) on traditional and existing packaging containers will result in new products, which will attract the attention of the customers and encourage them to buy this product. The current trend in packaging manufacturing is to incorporate latest design; this fact should be kept in mind when making modifications to the traditional and existing packaging containers to add value to the produce. Attempts should be taken to process and preserve fruits so they may be marketed and consumed all around the year. Convenient packaging system should also be developed to increase the customer appeal of these processed fruits. (Story et. Al., 1997).

1.2 Socio economic changes

As mentioned earlier the majority population (80%) of Bangladesh is dependent on agriculture, the key to development of this country lies in the development of this sector of the economy. This activity will cause a radical change in the socio economic conditions of these people. Changes are gradually becoming visible, as can be seen in the changing lifestyles of our rural population. The changes that have actually taken place during last three decades have been enormous. Almost all of the sixty four thousand villages of the country have a considerable number of university-educated young people; this was very rare three decades ago. Job creation at a rural level has had a positive impact in retaining these educated young people in their villages, where they are employed in different and rewarding agricultural occupation. Many of these youngsters prefer self-employment instead of working for others. The rate of unemployment has drastically fallen in villages and young people are trying to be more innovative and enterprising in improving the present practices in agriculture. Applying their own knowledge, and with assistance from local agriculture extension officers, these young farmers are leading the process of agricultural modernization.

The availability of properly preserved and packaged foods, combined with higher disposable incomes, suggests the home market for such produce in rural areas as well as towns and cities will significantly grow in the coming years, and contribute to the socio economic scenario of Bangladesh (Shamsuddin et. al., 2005).

Due to globalization it is now possible to market fresh fruits and vegetables worldwide. Twenty years ago shoppers at grocery stores worldwide contented themselves with a few locally produced items. As a result of improved packaging and transportation system more varieties of fruits and vegetables are available in super markets of Asia, Europe and America and are within easy economic reach of middle class consumers. Now papayas, avocado, kiwifruit, and more are available on produce shelves throughout the year. This phenomenon is due to rapid growth, especially rapid advances in fruit handling and transport technology, trade agreements and changing consumer preferences have all played a strong role.

The trend toward trade liberalization, combined with rising incomes, has created a middle class that demands quality products off season and is willing to pay the price. Improvements in transportation technology have reduced delivery time and shipping costs, so that perishable products can travel thousands of miles without substantial loss in freshness and quality. The marketing reach of perishable products has been further extended by packaging innovations, new advances in refrigeration and atmosphere control, fruit and vegetable coatings, and other techniques that slow deterioration of food products. Satellite technologies, particularly global positioning systems, enable shippers to track their cargo round the world, monitor quality, reduce the risk (and costs) of claims, and shorten cargo delivery time (Hardenberg et. al., 1986).

The introduction of agro business in the 1990's has already contributed to a notable share of GDP and of rural employment particularly of women. The opportunities for accelerating growth of the sector from an estimated 6 percent annual growth to 15 percent relates to five factors (i) population growth (ii) Comparative advantage internationally (iii) National Policy reforms (iv) increased Entrepreneurship and (v) trade associations. A large population of about 140 million provides not only a low cost labor due to unemployment and lack of jobs opportunity. However, a growing urban middle class with an increasing demand for superior, highest quality and

more convenient products is expected because consumer expectation on quality of packing and produce is increasing with the increase if income and quality consciousness. (Ahmed et. al., 2005).

For the purpose of present study forty different fruits and vegetable items were short-listed which are commonly grown in Bangladesh. These are all very popular, nourishing and rich in vitamins and other nutrients. Common English name, scientific name, planting season and harvesting time for these selected items are given in the Appendix 1.

1.3 Climate change and its potential impact

Consumers are also becoming more environmentally aware. They are starting to look for the biodegradable packaging and listen to the arguments regarding landfill, recycling and incineration. More and more local authorities are giving out recycling boxes, and people are using them. It is therefore the retail sector's responsibility to assist the local authorities by using packaging materials that are, as far as possible, recyclable or compostable.

Clearly, government assistance is needed to deal with some of these issues. It is vital to create guidelines for acceptable biodegradability of packaging and a recognised logo to go onto the packaging. Help is also required from a central source on the issue of packaging incineration.

Much of the packaging we use is not recyclable, or would cost too much to recycle. Consumers are constantly asking retailers why so many different types of plastic are used and why materials cannot be recycled. On the other hand, the government is reducing the number of landfill sites it is licensing, and incineration and energy reclamation is a big no-no with all of the green organisations, so the retail sector itself needs to look at green packaging materials.

To this end, the author has been working with a couple of years to introduce more biodegradable and compostable packaging made from sustainable crops. The Merchants ltd. has a large portfolio of biodegradable, compostable packaging made from sustainable source material that are being used more often, not just in produce packaging, but for all foods and non-foods, which is what some retailers are looking for. There is every reason for non-foods to be packed in environmentally friendly packaging.

1.4 Packaging fresh produce: advantages and challenges

Developing appropriate methods for proper packaging of perishable fruits and vegetables could save the farmers from substantial damage in transit losses. Seasonal fruits and vegetables are plentiful during peak harvest time; however, due to their perishable nature their presence in the market place is very short lived. Almost all vegetables and fruits are initially very cheap during peak harvesting season, but thereafter prices increase rapidly, causing problems for producer and consumer alike.

Packaging fresh fruits and vegetables is one of the important steps in the long and complicated journey from grower to consumer. Bags, crates, hampers, cartons, bulk bins and palletized containers are just some of the convenient containers for handling, transporting, and marketing fresh produce. More than 1,500 different types of packages are used for produce in the U.S. and the number continues to increase as the industry introduces new packaging materials and concepts. Although the industry generally agrees that container standardization is one way to reduce cost, the trend in recent years has moved towards a wider range of package sizes to accommodate the diverse needs of wholesalers, consumers, food service buyers, and processing operations. (Peleg et. Al., 1985)

Packing and packaging materials contribute a significant cost to the producer industry; therefore it is important that packers, shippers and buyers have a clear understanding of the wide range of packaging options available.

From time immemorial packaging of fresh fruits and vegetables was practiced to transport produce from one location to other. In early days in the region fresh vegetables and fruits after harvesting were packed in bamboo baskets and many other containers made of bamboo, wood and other natural products such as long tree leaves and various types of grasses which were converted into suitable containers for packaging perishable produce.

In the middle of last century synthetic materials were developed and gradually they occupied a major share of packaging materials. Almost all produce became packed using synthetic polymers such as polyethylene, polypropylene, polystyrene. These packaging materials gained high acceptability by the packers and consumers because of their elegance, light weight, convenience in carrying and printability. Until recently synthetic polymers were the most convenient and cost effective packaging material.

However, the adverse effect they produce on the environment, because of their non-biodegradability, meant they became unacceptable to the consumers in many countries. As a result of increasing awareness about environment pollution by the consumers some countries have already non-listed synthetic polymers as packaging material and regulatory authorities in many countries banned these materials for packaging. Environmentalists all over the world are also pressurizing their respective governments and international bodies to ban the synthetic polymers as packaging material. (Schewfelt et. Al., 1993).

Recent trends focus on the development of alternative biodegradable materials for packaging. Due to this changed situation every country is considering to go back to nature and develop new packaging materials, which are biodegradable and environment friendly. Cellulose materials such as jute, cotton, bamboo, wood and such other items are being considered for the purpose. (Champ et. Al., 1994).

Research on appropriate packaging is going on in many parts of the world with the aim of retaining freshness, texture and nutritional quality for longer period so that these produce is more acceptable to consumers. In Bangladesh, although most of the packaging is still done following traditional methods such as bamboo baskets, jute woven bags, and packing baskets made of straw and reeds, there are trends to develop suitable packaging containers to enhance the quality and increase the shelf life of perishable produce. (Holt et. Al., 1984).

An intensive literature search showed that attention is being given to design and develop appropriate packages for transporting to different markets, so that quality of the produce does not deteriorate. Benchmarking is also being undertaken to develop better quality and lower cost packing materials. Value adding via these materials increases the competitive edge of produce in the marketplace. Traditional methods of packaging and transportation of these produce are rapidly disappearing in Bangladesh.

The challenge then, is to be able to design and develop new kinds of packaging containers using traditional low impact materials and methods, packages that can effectively protect and maintain the freshness of perishable produce. Traditional packaging materials such as bamboo branches, coconut leaves, date palm leaves, rice and wheat straw, palm leaves, banana leaves and reeds are all readily available in Bangladesh.

To develop proper, appropriate and affordable packaging that reduces waste and damage in transit while increasing the marketability of the produce, it is necessary:

— **To know which fruit and vegetables are being grown in what quantities, what their physicochemical characteristics are, which ones are being exported or have export potential.** *The next section will deal with these questions, with particular emphasis on the expanding export market for agricultural produce.*

— **To survey past and present packaging practices, locally and internationally, including developing a typology of different types of packages and their characteristics.** *This is the subject of Chapter 2.*

— **To gather information about past and present methods of transport of perishable produce, and to analyses well and bad practice as well as opportunities for improvement.** *This is the subject of Chapter 3.*

1.5 Present status of fruits and vegetables production in Bangladesh

The total amount of land available for agricultural production in Bangladesh is about 8.3 million hectors. More than 75% of the available land is used for rice cultivation. Rice and wheat together make up more than 80% of the land available for cultivation. About 20% of the available cultivable land is used for all other crops including fruits and vegetables. Vegetables are cultivated in 1.8% and potatoes in 1.7% of this cultivated area. Growing fruit constitutes about 1.34% of the 20%.

Production of Fruits and Vegetables

Fruits: Bangladesh produces over 1.5 million tons of fruits. In terms of production, bananas, mangoes, pineapples, jackfruits, melons, guavas, litchi, limes and lemons are the major ones grown.

Table-1: Production of Fruits (2002-2003)
(In 'ooo M.Tons)

Fruits	Production
Bananas	650
Jackfruits	276
Mangoes	243

Pineapples	154
Melons	85
Guavas	77
Papayas	48
Citrus	11
Others	20
Total	1,564

Vegetables: In terms of vegetables, the country produced about 3 million tons of potatoes in 2003-2004. Apart from potatoes the country produced about 1.6 million tons of other vegetables. Other major vegetables are brinjal (aubergine), pumpkins, cauliflowers, cabbages, tomatoes, radishes and beans.

Table-2: Production of Vegetables (2002-2003)

(In '000 M.Tons)

Vegetables	Production
Potatoes	3386
Brinjals	370
Radishes	199
Arums	139
Pumpkins	118
Cabbages	118
Tomatoes	102
Water Gourds	95
Cauliflowers	84

Vegetables	Production
Beans	50
Point Gourds	40
Ridge Gourds	30
Cucumbers	23
Ladies Fingers	22
Bitter Gourds	21
Indian Spinaches	19
Snake Gourds	12
Others	31
Total	4859

The country also grows 5.5 thousand tons of pulses and 616 thousand tons of oil seeds of various kinds.

1.6 Trends in export of fruit and vegetables.

The export of fruits has been growing at the rate of 23% per annum. In terms of value the increase has been almost 19%, and in term of volume this was during 1992-2003 periods. Very short shelf life is a problem and a serious factor that limits fruits export (Table-3). During the 1999-2003 periods Bangladesh exported fresh fruits and vegetables to 36 countries, mostly to

UK and the Middle East. Out of 252 listed exporters mainly about 25 are active in Business. (Hortex Foundation).

Table-3: Trend of Export of Fruits (1992 to 2003)

Financial Year	Value in '000' US$	Growth (%)	Quantity (MT)	Growth (%)
1992-1993	1,310	77.03	1,249	93.64
1993-1994	1,320	0.76	1,007	(-) 19.38
1994-1995	1,960	48.48	1,365	35.55
1995-1996	9,410	73.98	2,278	66.89
1996-1997	570	(-) 83.28	385	(-) 83.90
1997-1998	10	(-) 98.25	7	(-) 98.20
1998-1999	20	100.00	13	85.71
1999-2000*	5	-	-	-
2000-2001*	-	-	-	-
2001-2002*	-	-	-	-
2002-2003*	3	-	-	-

Note: **** Not shown separately***

Currently, vegetables are one of the fastest growing export sectors. During the 1990s average growth rate of vegetables exports were about 37% in terms of value and 26% in terms of volume (EPB).

Table-4: Trend of Vegetables Export (1992 to 2003)

Financial Year	Value in '000' US$	Growth (%)	Quantity (MT)	Growth (%)
1992-1993	8,060	47.62	8,142	56.46
1993-1994	8,120	0.74	7,415	(-) 8.93
1994-1995	8,690	7.02	8,270	11.53
1995-1996	14,510	66.97	12,931	56.36
1996-1997	24,910	71.67	20,449	58.04
1997-1998	32,470	38.38	23,597	15.39
1998-1999	17,680	45.55	13,106	(-) 44.46
1999-2000	14,000	20.82	10,270	(-) 21.64
2000-2001	12,787	8.66	9,509	(-) 7.41
2001-2002	15,320	19.81	12,761	34.20
2002-2003	13,240	13.58	9,792	(-) 23.27

Exports could grow even faster if it were possible to expand the cargo space much beyond what is available now. The Bangladesh Fruit, Vegetable and

Allied Product Exporters Association (BFVAPEA) place the value of fruit and vegetable export at $40 million in 2003. Of this total, about 68% went to the Middle East, 28% to the European Union and less then 3% to East Asia. Almost 90% of the EU exports went to the UK.

Table-5: Ranking of 7 Top Market Outlets of fruits and Vegetables (1999-2003)

FY	Rank	1	2	3	4	5	6	7	8	Total
1998-1999 (July-June)	Country	UK	KSA	Bahrain	Kuwait	UAE	Qatar	Oman	Others (18)	
	Amount	6.04	3.14	2.72	1.86	1.38	0.97	0.51	1.06	17.68
	%	34	18	15	11	8	5	4	6	100
1999-2000	Country	UK	KSA	Bahrain	Kuwait	UAE	Qatar	Oman	Others (18)	Total
	Amount	3.66	2.73	1.79	1.75	1.40	1.12	0.51	1.04	14.00
	%	26	20	30	30	10	8	4	7	100
2000-2001	Country	UK	KSA	Bahrain	Kuwait	UAE	Qatar	Oman	Others (18)	Total
	Amount	3.23	2.43	2.07	1.86	0.79	0.73	0.60	1.08	1
	%	25	19	16	15	6	6	5	8	100
2001-2002	Country	UK	KSA	Bahrain	Kuwait	UAE	Qatar	Oman	Others (18)	Total
	Amount	3.73	3.21	2.71	1.64	1.04	0.92	0.83	1.23	15.31
	%	24	21	18	11	7	6	5	8	100
2002-2003	Country	UK	KSA	Bahrain	Kuwait	UAE	Qatar	Oman	Others (18)	Total
	Amount	3.76	3.03	1.85	1.68	0.85	0.76	0.68	0.60	13.21
	%	28	23	14	13	6	6	5	5	100

About 50 different types of fresh fruits and vegetables are exported. Exports of fruits and vegetables to so many countries illustrate the potential of the agribusiness sector with increasing network between our exporters and foreign buyers.

Table-6: List of Major Horticulture Produce Exported from Bangladesh with their English Name, Bangla Name, Botanical Name and Period of Availability.

A. Fruits:

Serial	English Name	Bangla Name	Botanical Name	Usuable harvesting period
1	Indian Gooseberry	Amlaki, Aonla	*Phyllanthus emblica*	August- December
2	Ber, Jujubee	Boroi, Kul	*Zizyphus Mauritania*	December-February
3	Golden Apple	Amra	*Spondias Pinnate*	August October
4	Indian Olive	Jalpie	*Elaeocarpus robustus*	October- November
5	Jackfruit	Kathal	*Artocarpus heterophyllus*	May-July
6	lemon	Elachi Lebu	*Citrus Limon*	July- October
7	Litchi, Lychee	Lichu	*Litchi Sinesis*	May-June
8	Lime	Kagazi Lebu	*Citrus Aurantifolia*	June-September; varieties year round
9	Mango	Aam	*Mangifera Indica*	May-July
10	Jamun	Jam	*Syzygium cuminii*	May-June
11	Wax Apple	Zamrul	*Eugenia javanica*	June-July
12	Wood apple	Bel	*Aegle marmelos*	October- December
13	Pineapple	Anarosh	*Annas Comosus*	Year round, peak season June-August
14	Star Fruit Carambola	Camranga	*Averhoa Carambola*	November-february
15	No English Name	Satkara	*Citrus maroptera*	July- October
16	No English Name	Jhoikar	*Gardenia Pedunculata*	November-December
17	Elephant's Foot Apple	Kot Bel	*Feronia limonia*	October- December

B. Vegetables:

Serial	Vegetables	Synonym	Botanical Name	Usuable harvesting period
1	Amaranths	Danta	*Amaranthus sp.*	Year round
2	Bitter Gourd	korola	*Momordica*	February - October
3	Broccoli	No Bangla Name	*Brassica oleracea var, botrytis*	December –Feruary
4	Bottle Gourd	Lau, Kodu	*Lagenaria Sicerania*	November-April
5	Banana Flower	Kolar Thur or Mucha	*Musa sp.*	Year Round
6	Cucumber	Shosha, Khirai	*Cucumis sativus*	April- September
7	Cauliflower	Fulkopi	*Brassica olerasea var, botrylis, sub-*	November- February

			var, cauliflora	
8	Drumstick	Shajna, Shojina	*Moringa oleifera*	March- August
9	Taro, Dasheen	Mukhi Kachu	*Colocasia esculenta*	July- November
10	Brinjal,Eggplant Aubergin	Bagun	*Solanum Melongena*	Year round
11	French Bean	Farashi Shim, Forash un	*Phaselous vulgaris*	November- March
12	Green Hot chilli	Kancha Morich	*Capsicum Frutescens*	Year round
13	Green Papaya	Pepe	*Carica Papaya*	Year round
14	Hychinth Bean	Deshi Shim	*Lablab nigar*	Novenber- February
15	Indian spinach	Pui Shak	*Basella alba/rabra*	March- Septenber
16	Jackfruit seeds	Kathal Bichi	*Aetocarpus Heterophyllus*	May- July
17	Okra	Dherosh	*Abelmschus*	March- November
18	Pointed Gourd	Potol	*Trichosanthes*	April –November
19	Potato	Alu	*Solanum tubersum*	January- March
20	Plantain	Kacha Kola	*Musa Paradisiaca*	Year round
21	Radish	Mula	*Raphanus Sativus*	October- March
22	Rhizome of taro	Pani Kachu	*Colocasia esculenta*	July- October
23	Ribbed Gourd/ Ridge Gourd	Jhinga	*Luffa Acutangula*	April October
24	Snake Gourd	Chichinga	*Trichosanthes*	March- October
25	Stolon of taro	Kachur Latu	*Colocasia Esculenta*	July- October
26	Sweet Potato	Misti Alu	*Ipomoea batatas*	March- May
27	Sponge Gourd	Dhundul	*Luffa Cylindrica*	March- October
28	Teasel Gourd	Kakral	*Momordica Dioica*	May- October
29	Tomato	Tomato, Bilati Begun	*Lycopersicon Esculentum*	December- April
30	Wax Gourd/ Ash Gourd	Chal Kumra	*Benincasa hispida*	April- October
31	Yard long Bean	Barboti	*Vigna Sesquipedalis*	Year round

C. Others:

Serial	Vegetables	Synonym	Botanical Name	Usuable harvesting period
1	Betel Leaf	Pan	*Piper betel*	Year round
2	Coriander leaves	Dhania, Dhase Pata	*Coriendum sativum*	November- April

Table-7: Countries Importing Vegetables from Bangladesh

Countries	2002-2003			2001-2002		
	Taka	Dollar	% of Total	Taka	Dollar	% of Total
UK	217578	3758	28.38	214284	3733	24.37
KSA	175417	3030	22.88	184018	3505	20.93
UAE	106876	1846	13.94	155365	2706	17.67
Kuwait	97316	1681	12.69	94260	1642	10.72
Qatar	49232	850	6.42	59479	1036	6.77
Bahrain	44154	736	5.76	47739	832	5.43
Oman	39094	675	5.10	53021	924	6.03
Singapore	12102	209	1.58	13931	243	1.58
Italy	6538	113	0.85	7774	135	0.88
Germany	5691	98	0.74	13329	232	1.52
France	3082	53	0.40	4684	82	0.53
Malaysia	2484	43	0.32	1570	27	0.18
Uganda	1180	20	0.15	---	---	---
Greece	975	17	0.13	957	17	0.11
USA	962	17	0.13	2536	44	0.29
Kenya	750	13	0.10	---	---	---
Ukraine	559	10	0.07	---	---	---
Netherlands	439	8	0.06	2393	42	0.27
Bulgaria	263	5	0.03	---	---	---
Pakistan	234	4	0.03	66	1	0.01
Spain	198	3	0.03	---	---	---
Japan	197	3	0.03	83	1	0.01
Thailand	153	3	0.02	---	---	---
Australia	132	2	0.02	---	---	---
Andorra	129	2	0.02	176	2	0.02
Canada	---	---	---	3772	66	0.43
China	---	---	---	2013	35	0.23
Hong Kong	---	---	---	3703	65	0.42
Korea Rep.	---	---	---	228	4	0.03
Local Sale*	---	---	---	8445	147	0.96
PNG	---	---	---	548	10	0.06
Panama	---	---	---	848	15	0.10
Total	766581	13240	100.00	879124	15313	100.00

Note: *Deemed to Export (sold through international tender)

However, a main problem with the Bangladesh export of fresh fruits and vegetables is that the exporters rely primarily on the "ethnic" market in other countries and are not proactive in entering the world supermarket chains.

CHAPTER 2

PACKAGING MATERIALS & METHODS

2.1 The Function of Packaging

Packaging usually represents about 2% of any country's gross national product and the figure for worldwide expenditure for packaging production and services is between US $ 400 and 500 billion annually (Thompson A.K, undated).

In the food sector it was estimated that on average 16% of the price of the produce is represented by packaging (Townshed, undated). Liv O'Hanton (Weekend Gurdian 9 may, 1992) found that about 14% of the cost of a basket of goods from a supermarket was for packaging. Packaging material in developing countries frequently costs 50-100% more than the equivalent materials in industrialized countries, which means that the share of packaging costs for fruit and vegetables may be as high as 50% of free on board export price. (Townshend, undated).

The function of a package is primarily to contain and protect the produce. The size of the package is therefore important and should be designed in terms of the amount the market pr customer requires in a single unit. In other circumstances the package size may be dictated by what a person can reasonably lift or carry. Protection of the produce is influenced by the length of journey, the environmental conditions, the type of handling and any hazards it may be exposed to, the cost and cost-effectiveness of the package and whether it is easy to assemble, fill and close are primary considerations. The use of standard pellets is increasing and the package may have to be designed to fit these or to fit standard refrigerated container. Fruit and vegetables, being living organisms, give out heat and gases which can be detrimental if allowed to accumulate in the package, so it may need to be ventilated. Certain types of packaging can be used to extend the storage life of crops, such as plastic film to modify the atmosphere or to protect the crop from infection or infestation. Root crops can be packed into material such as coir dust, peat or even screw dust to protect them and provide a humid environment to preserve them (Thompson et al 1973 a). The package may also help in presentation of the crop to enhance its value or help its sale.

A package is created when fresh produce is brought together and contained. The package could conceivably contain different types, sizes, grades, or stages of maturity of produce. The important thing to remember is that the reason for bringing the produce together in the first place is to create a more manageable unit for conveying more than one item of produce in one handling step instead of several.

Packaging must withstand:

- Rough handling during loading and unloading;
- Compression from the overhead weight of other containers;
- Impact and vibration during transportation; and
- High humidity during precooling, transit, and storage.

Packaging materials are chosen on the basis of the product and environmental considerations. Factors to be considered are method of packing, temperature, humidity, and desired atmosphere around the product, packaging strength, cost, availability, buyer specifications, graphics, labeling, freight rates, and government regulations. Packaging manufacturers, foreign buyers, wholesale markets, retail stores, packaging magazines, and consultants are an important source of information on current packaging trends and desires.

All packaging should be recyclable or reusable and the necessary amount of material should be used to protect the product. Packaging also should be standardized to facilitate unit loading on standard-size, reusable pallets.

2.2 Survey of past practice in packaging

The earliest packages were mostly constructed of plant materials such as woven leaves, reeds and grass stems and were designed to be carried by hand. Even today, most packages are handled manually at some stage, and are sized accordingly. In the past no serious considerations were given in designing a package as a result fresh produce was carried to the consumers from the producer's field or home in packages which were made of local materials without giving much thought to the suitability of these packages to carry particular produce resulting in damage, loss of qualities and acceptability of the produce to the customer. Non-standardized packages were the major cause of the damage of fresh agricultural produce. In the past

many vegetables and fruits were sold with no packaging thus water melons and jackfruits were sold in bulk in carloads and carrots were handled in bunches in armfuls by truck. Unpackaged vegetables and fruits exposed to dirt and dust were subject to severe wilting. Non-standardized packages were much overloaded, badly packed with little protection for the goods. Traditional practices of packaging are gradually giving way to modern practices in which packages are designed scientifically, keeping in mind the physicochemical properties of the produce.

Wood

Pallets literally form the base on which most fresh produce is delivered to the consumer. Pallets were first used during World War II as an efficient way to move goods. Over the years, the 40-inch wide, by 48-inch long pallet has evolved as the unofficial standard size. Standardization encourages re-use, wooden pallets which have many benefits. Besides reducing cost because they may be used many times, most pallet racks and automated pallet handling equipment are designed for standard-size pallets. Standard size pallets make efficient use of truck and van space and can accommodate heavier loads and more stress than lighter single-use pallets.

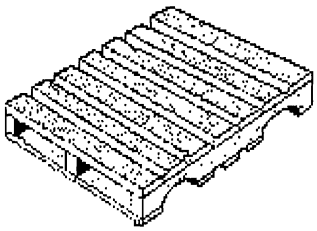


Fig-2.1

Slip-sheets

In the early 1950s, an alternative to the pallet was introduced. It is a pallet-size sheet (Slip-sheets) of corrugated fiberboard or plastic (or a combination of these materials) with a narrow lip along one or more sides. Packages of produce are stacked directly on this sheet as if it were a pallet. Once the packages are in place, they are moved by a specially equipped fork lift equipped with a thin metal sheet instead of forks.

Slip-sheets are considerably less expensive than pallets to buy, store, and maintain; they may be re-used many times; and they reduce the tare weight of the load.

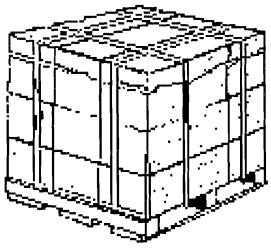


Fig 2.2

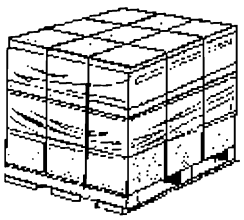


Fig 2.3

Depending on the size of produce package, a single pallet may carry from 20 to over 100 individual packages. Because these packages are often loosely stacked to allow for air circulation, or are bulging and difficult to stack evenly, they must be secured (unitized) to prevent shifting during handling and transit. Although widely used, plastic straps and tapes may not have completely satisfactory results. Plastic or paper corner tabs should always be used to prevent the straps from crushing the corners of packages.

Pallet Bins:

Substantial wooden pallet bins of milled lumber or plywood are primarily used to move produce from the field or orchard to the packing house. Depending on the application, capacities may range from 12 to more than 50 bushels. Although the height may vary, the length and width is generally the same as a standard pallet (48 inches by 40 inches). More efficient double-wide pallet bins (48 inches by 80 inches) are becoming more common in some produce operations.

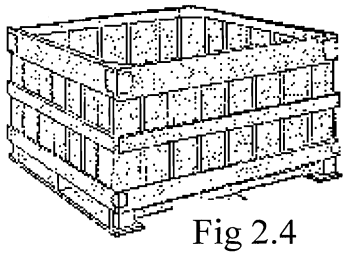


Fig 2.4

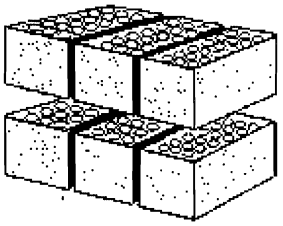


Fig 2.5

Wire-Bound Crates:

Although alternatives are available, wooden wire-bound crates are used extensively for snap beans, sweet corn and several other commodities that require hydro cooling. Wire-bound crates are sturdy, rigid and have very high stacking strength that is essentially unaffected by water. Wire-bound crates come in many different sizes from half- bushel to pallet-bin size and have a great deal of open space to facilitate cooling and ventilation. Although few are re-used, wire-bound crates may be dissembled after use and shipped back to the packer (flat).

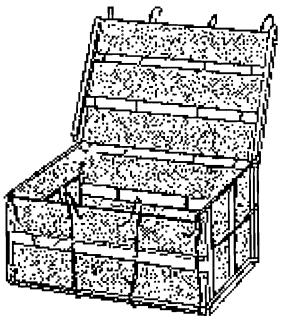


Fig 2.6

Wooden Crates and Lugs:

Wooden crates, once extensively used for apples, stone fruit, and potatoes have been almost totally replaced by other types of containers. The relative expense of the container, a greater concern for tare weight, and advances in material handling has reduced their use to a few specialty items, such as expensive tropical fruit. The 15-, 20-, and 25-pound wooden lugs still used for bunch grapes and some specialty crops are being gradually replaced with less costly alternatives.

Fig 2.7

Wooden Baskets and Hampers:

Wire-reinforced wood veneer baskets and hampers of different sizes were once used for a wide variety of crops from strawberries to sweet potatoes. They are durable and may be nested for efficient transport when empty. However, cost, disposal problems, and difficulty in efficient palletization have severely limited their use to mostly local grower markets where they may be re-used many times.

Corrugated Fiberboard

Corrugated fiberboard (often mistakenly called cardboard or pasteboard) is manufactured in many different styles and weights. Because of its relativity low cost and versatility, it is the dominant produce container material and will probably remain so in the near future. The strength and serviceability of corrugated fiberboard have been improving in recent years.

Most corrugated fiberboard is made from three or more layers of paperboard manufactured by the Kraft process.

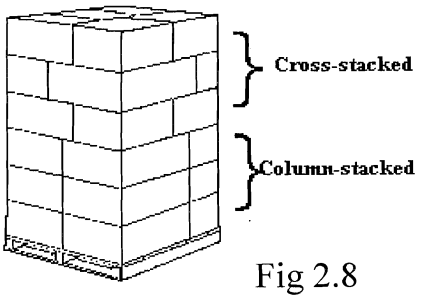
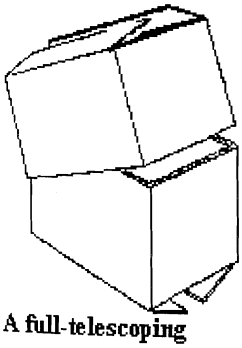


Fig 2.8



A full-telescoping container

Fig 2.9

Interlocking the packages (cross stacking) is universally practiced to stabilize pallets. Cross stacking places the corner of one produce package at the middle of the one below it, thus reducing its stacking strength. To reduce the possibility of collapse, the first several layers of each pallet should be column stacked (one packages may be cross-stacked as usual with very little loss of pallet stability). There are numerous styles of corrugated fiberboard containers. The

two most used in the produce industry are the one piece, regular slotted container (RSC) and the two -piece, full telescoping container (FTC). The RSC is the most popular because it is simple and economical. However, the RSC has relatively low stacking strength and therefore must be used with produce, such as potatoes, that can carry some of the stacking load. The FTC, actually one container inside another, is used when greater stacking strength and resistance to bulging is required.

Pulp Containers

Containers made from recycled paper pulp and starch binders are mainly used for small consumer packages of fresh produce. Pulp containers are available in a large variety of shapes and sizes and are relatively inexpensive in standard sizes. Pulp containers can absorb surface moisture from the product, which is a benefit for small fruit and berries that are easily harmed by water. Pulp containers are also biodegradable, made from recycled materials, and recyclable.

Paper and Mesh Bags

Consumer packs of potatoes and onions are about the only produce items now packed in paper bags. The more sturdy mesh bag has much wider use. In addition to potatoes and onions, cabbage, turnips, citrus, and some specialty items are packed in mesh bags. In addition to its low cost, mesh has the advantage of uninhibited air flow. Good ventilation is particularly beneficial to onions.

Plastic Bags

Plastic bags (polyethylene film) are the predominant material for fruit and vegetable consumer packaging. Besides the very low material costs, automated bagging machines further reduce packing costs. Film bags are clear, allowing for easy inspection of the contents, and readily accept high quality graphics. Plastic films are available in a wide range of thickness and grades and may be engineered to control the environmental gases inside the bag.

Wrap Shrink

One of the newest trends in produce packaging is the shrink-wrapping of individual produce items. Shrink-wrapping has been used successfully to

package potatoes, sweet potatoes, apples, onions, sweet corn, cucumbers and a variety of tropical fruit. Shrink-wrapping with an engineered plastic wrap can reduce shrinkage, protect the produce from disease, reduce mechanical damage and provide a good surface for stick-on labels.

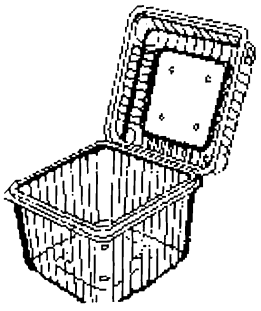


Fig 2.11

Rigid Plastic Packages

Packages with a top and bottom that are heat formed from one or two pieces of plastic are known as clamshells. Clamshells are gaining in popularity because they are inexpensive, versatile, provide excellent protection to the produce, and present a very pleasing consumer package. Clamshells are most often used with consumer packs of high value produce items like small fruit, berries, mushrooms, etc., or items that are easily damaged by crushing. Clamshells are used extensively with precut produce and prepared salads. Molded polystyrene and corrugated polystyrene containers have been test marketed as a substitute for waxed corrugated fiberboard. The move to biodegradable or recyclable plastic packaging materials may be driven by cost in the long term, but by legislation in the near term. Some authorities have proposed a total ban on plastics. In this case, the supermarket of the early 21st century may resemble the grocery markets of the early 20th century. **(M. D. Boyette et. Al., 1996)**

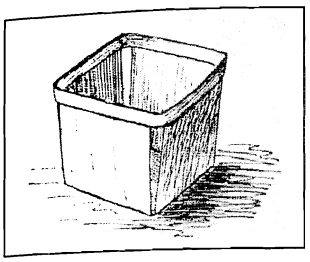


Fig 2.12

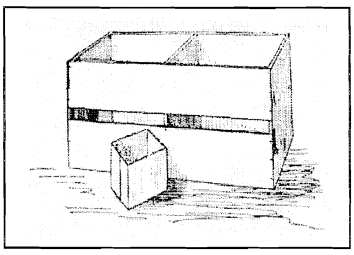


Fig 2.13

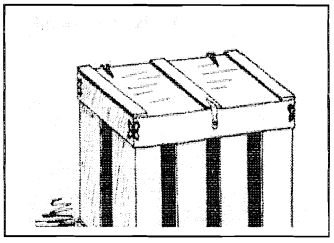


Fig 2.14

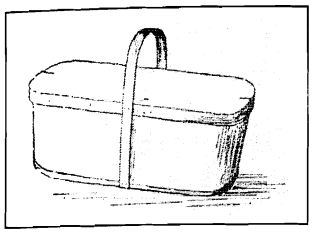


Fig 2.15

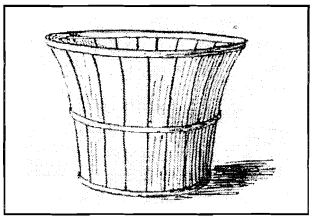


Fig 2.16

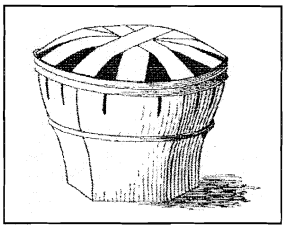


Fig 2.17

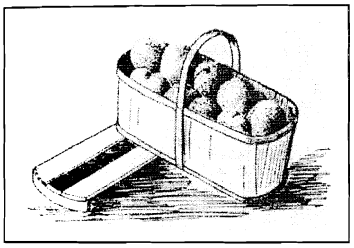


Fig 2.18

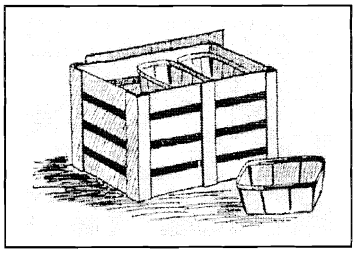


Fig 2.19

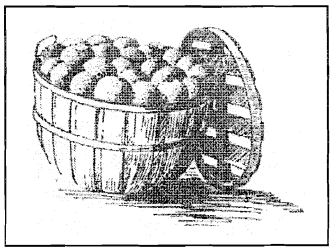


Fig 2.20

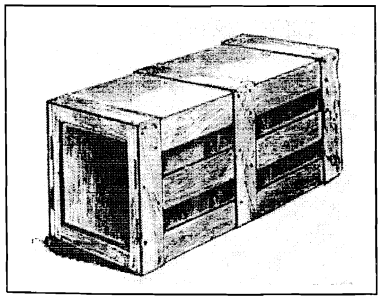


Fig 2.21

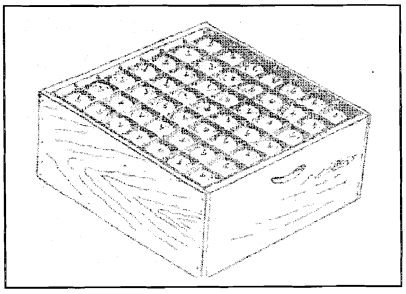


Fig 2.22

2.3 Current practice in packaging containers for fresh produce

Current practice in packaging focuses on above points while designing and developing packaging containers. Special attention is given to the physicochemical aspects of the items (fruits and vegetables) while developing packaging containers. The retail customers also develop specially designed containers for packaging individual items to shelf life, taste, freshness, and acceptability. Current practice in developing packaging materials are becoming more and more scientific in protecting produce, accelerating sales, advertising, educating consumers and developing good salesmanship.

There are many types of packing containers. The three containers illustrated below are constructed from corrugated cardboard. The regular slotted container is fully collapsible and the most economical.

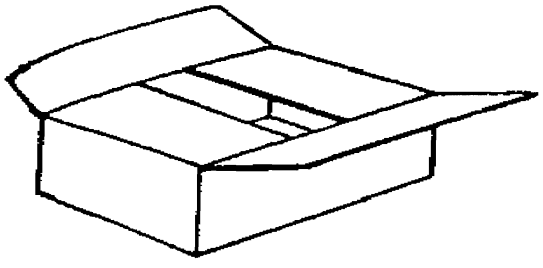


Fig 2.23 Regular slotted container

Telescopic containers (half or full) have the highest stacking strength and protect against bulging but are more costly.

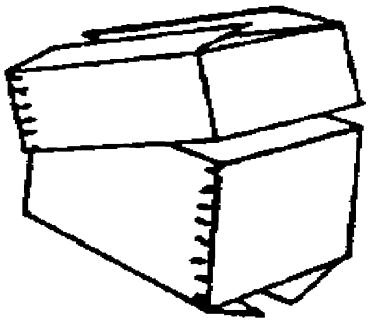


Fig 2.24 Telescopic container

The container known as a Bliss box has very strong corners, but is not collapsible.

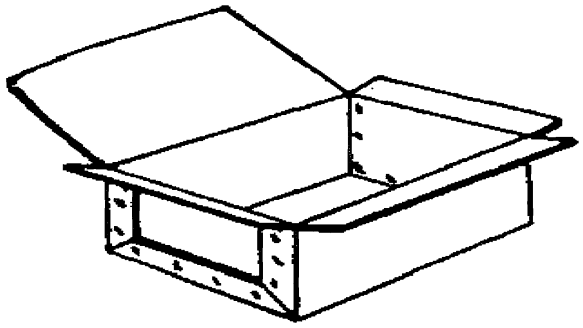


Fig 2.25 Bliss box

Source: Peleg, K. 1985. Produce Handling Packaging and Distribution. Westport, Connecticut: AVI Publishing Co., Inc.

Sacks are often used to package produce, since they tend to be inexpensive and readily available. The following table provides some information regarding the characteristics of different kinds of materials used to make sacks.

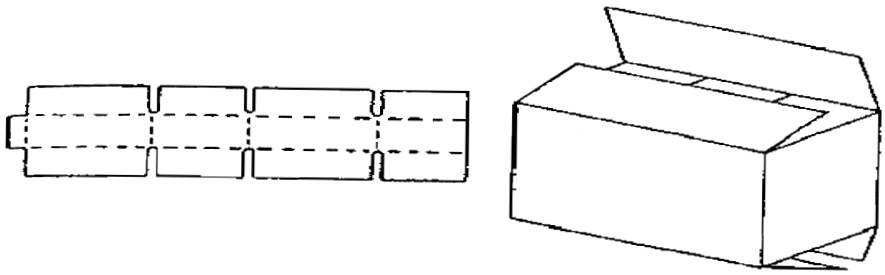
Table 2.1 Characteristics of sacks as packaging units

Sack types	Tearing and snagging	Impact	Protection against		Contamination	Notes
			Moisture absorption	Insect invasion		
Jute	Good	Good	None	None	Poor, also cause contamination by sack fibers	Bio-deterioration Insect harborage Odour retention
Cotton	Fair	Fair	None	None	Fair	High re-use value.
Woven plastics	Fair-Good	Good	None	Some protection (if closely woven)	Fair	Badly affected by ultra-violet light. Difficult to stitch.
Paper	Poor	Fair-Poor	Good - WFP multiwall sacks have plastic liners.	Some protection, better if treated.	Good	Consistent quality. Good print.

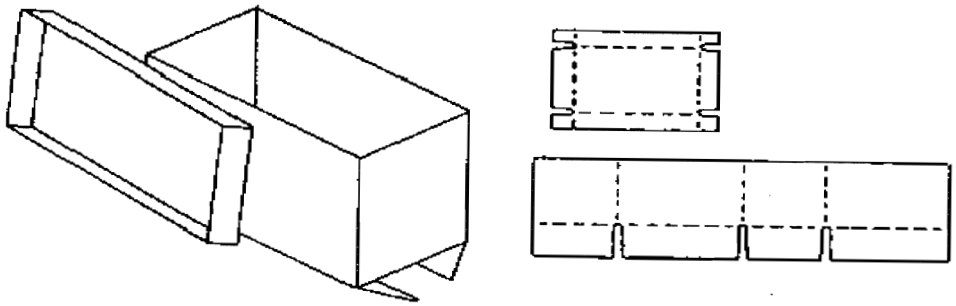
Source: Walker, D.J. (Ed) 1992. World Food Programme Food Storage Manual. Chatham, UK: Natural Resources Institute

The diagrams below are for a variety of commonly used fibreboard containers. Final dimensions can be altered to suit the needs of the handler.

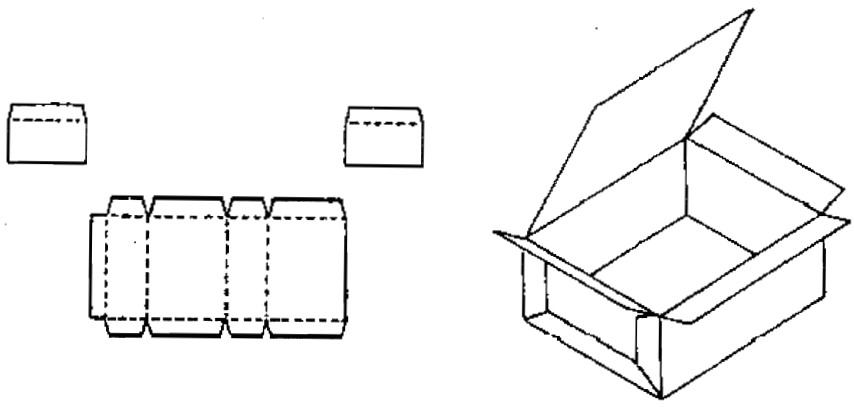
One piece box:



Two-piece box with cover:



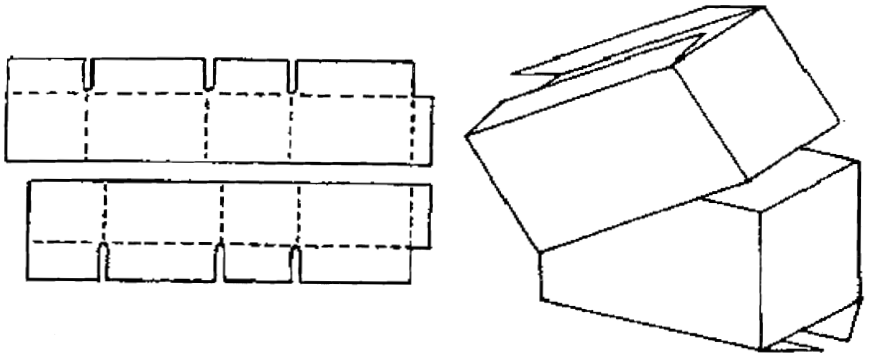
Bliss-style box:



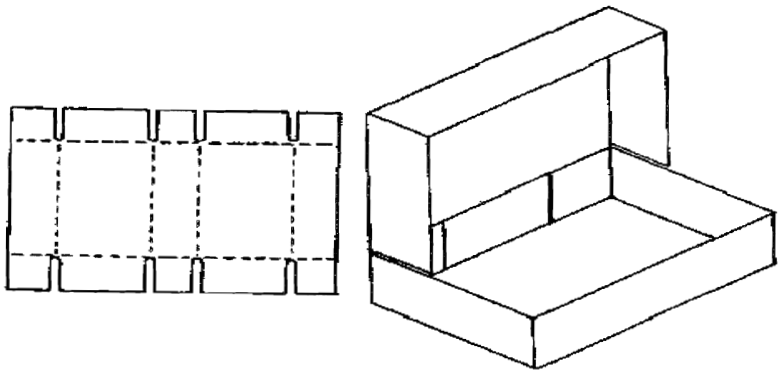
Source: McGregor, B. 1987. Tropical Products Transport Handbook. USDA, Office of Transportation, Agricultural Handbook Number 668.

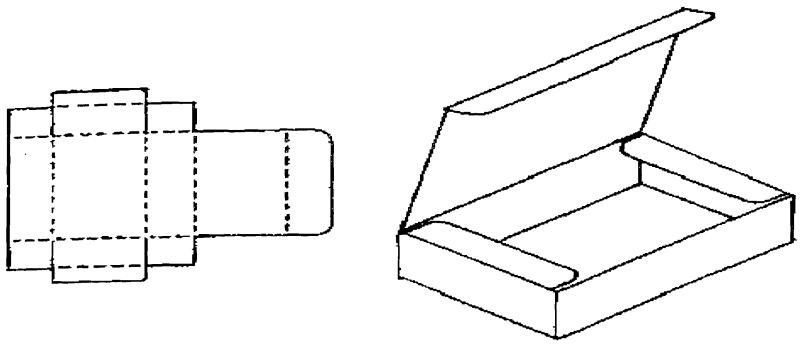
The diagrams below are for a variety of commonly used fiberboard containers. Final dimensions can be altered to suit the needs of the handler.

Full telescoping box:



One-piece telescoping box:

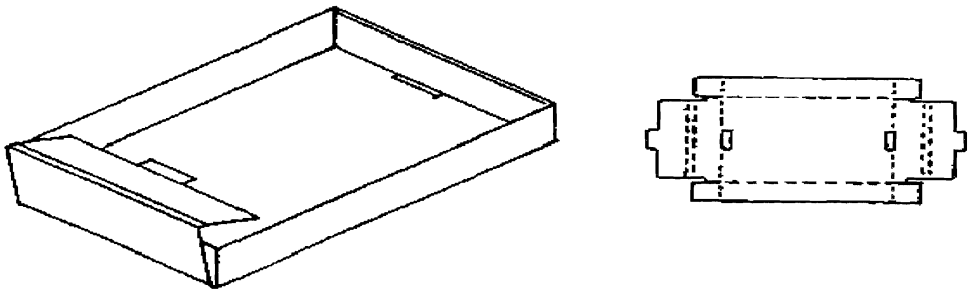




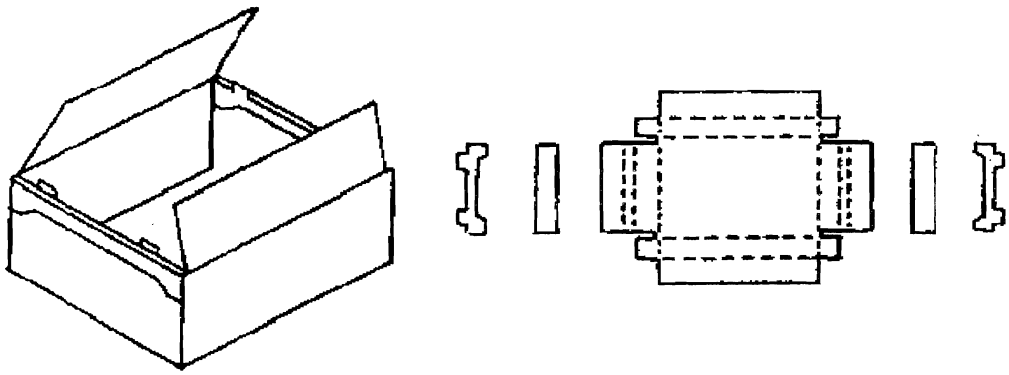
One-piece tuck-in cover box

The diagrams below are for a variety of commonly used fibreboard containers. Final dimensions can be altered to suit the needs of the handler.

Self-locking tray:

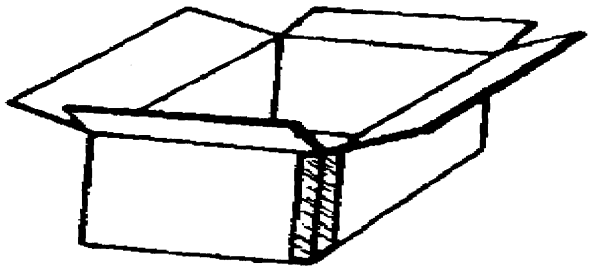


Interlocking box:

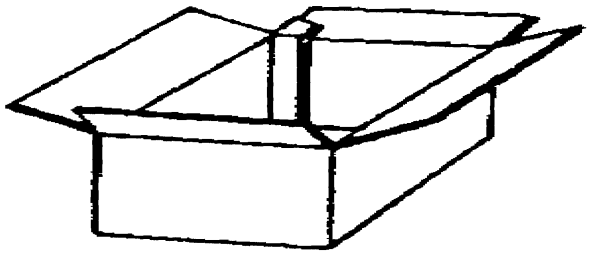


Source: McGregor, B. 1987: Tropical Products Transport Handbook. USDA, Office of Transporation, Agricultural Handbook Number 668. Shipping containers can be designed and made by the user from fibreboard in any size and shape desired. Three types of joints are commonly used to construct sturdy boxes.

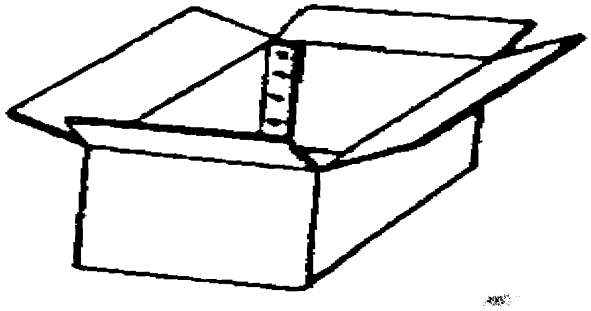
Taped joints:



Glued Joints:

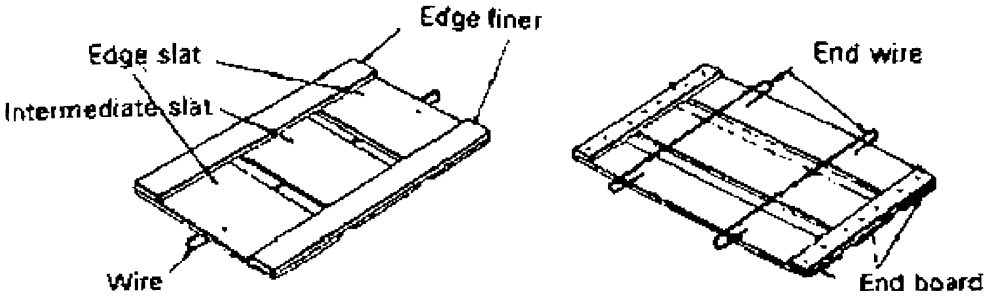


Stapled joints:



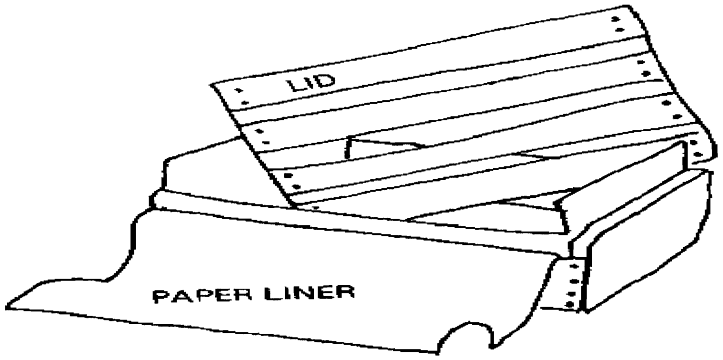
Source: Peleg, K. 1985. Produce Handling Packaging and Distribution. Westport, Connecticut: AVI Publishing Co., Inc.

Containers can be constructed from wood and wire, using the general diagrams provided below. A special closing tool makes bending the wire loops on the crate's lid easier for packers to do.



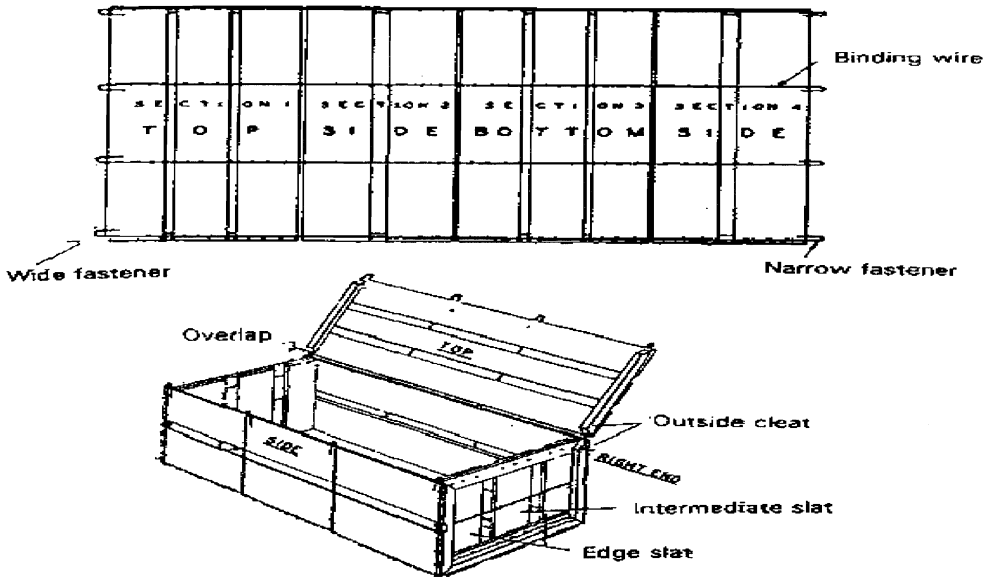
Ends

Blank for body:



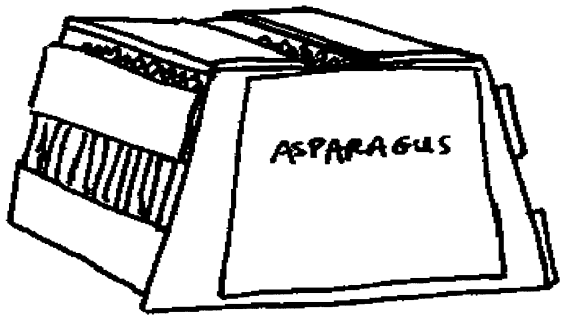
Source: Peleg, K. 1985. Produce Handling Packaging and Distribution. Westport, Conn.: AVI publishing Co., Inc.

A wooden lug is the typical packing container for table grapes. This container is very sturdy and maintains its stacking strength over long periods of time at high relative humidity. Rigid plastic containers are also widely used.

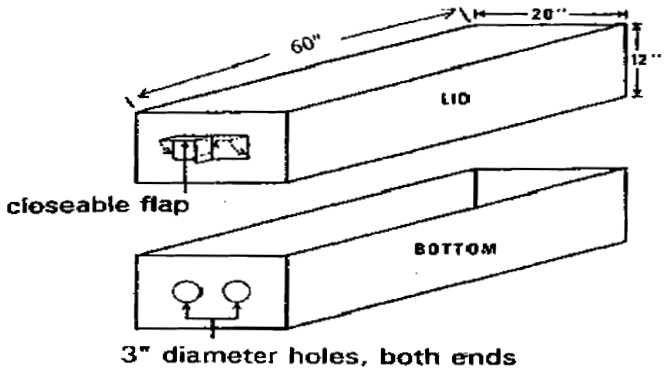


Often, a paper liner is folded over the grapes before the top is nailed closed. The liner protects the produce from dust and water condensation. If a pad containing sulfur dioxide can be enclosed with the grapes within a plastic liner as a treatment to control decay. Most commodities other than table grapes can be damaged (bleached) by sulfur dioxide treatments.

Rigid plastic or wooden containers are also used extensively for asparagus. The trimmed spears are packed upright in containers that provide for a large amount of ventilation.

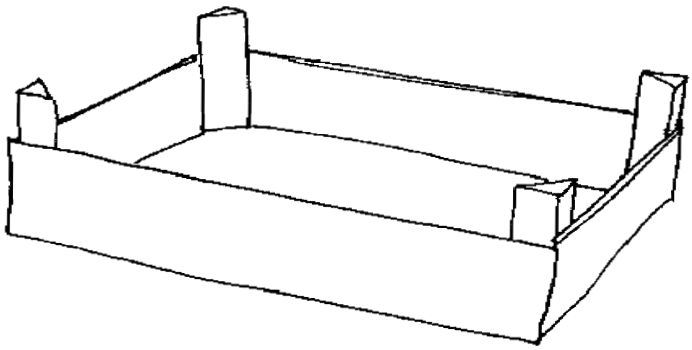


Containers for cut flowers are often long and narrow, of full telescopic design with vents at both ends to facilitate forced-air cooling. The total vent area should be 5% of the total box surface area. A closable flap can help maintain cool temperatures if boxes are temporarily delayed in transport or storage in an uncontrolled temperature environment. (Ri)R etal.1979)



Source: Rij, R. Et al. 1979. Handling, precooling and temperature management of cut flower crops for truck transportation.

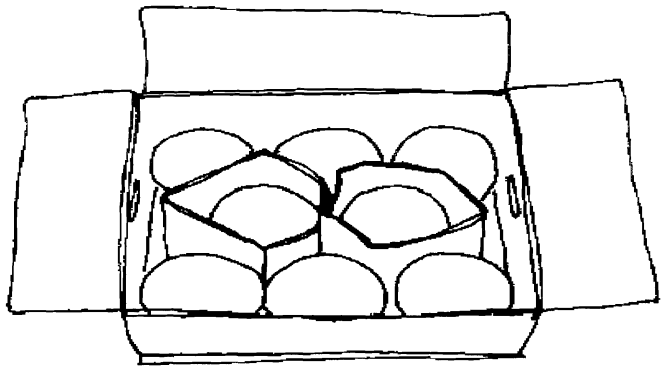
A simple wooden tray with raised corners is stackable and allows plenty of ventilation for fragile crops such as ripe tomatoes. (FAO.1985)



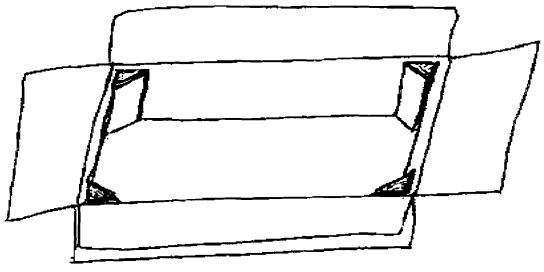
Source: FAO. 1985. Prevention of Post-Harvest Food Losses: A Training Manual. Rome: UNFAO. 120pp

Adding a fiberboard divider to a carton will increase stacking strength. The use of dividers is common with heavy crops such as melons. The dividers also prevent melons from vibrating against one another during handling and transport. Wooden inserts, or fiberboard folded into triangles and placed in all four corners can be especially useful when a carton needs strengthening. (MC Gregor,B.1987)

Fiberboard divider:

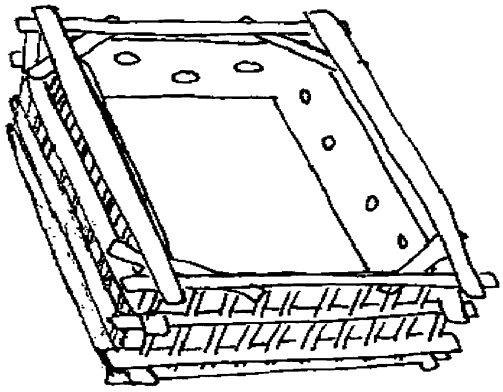


Triangular corner supports:



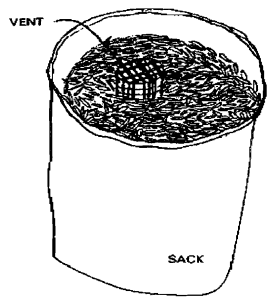
When locally made containers have sharp edges or rough inner surfaces, a simple, inexpensive inner made from fiberboard can be used to protect produce from damage during handling.

Cardboard liner for a palm rib crate:



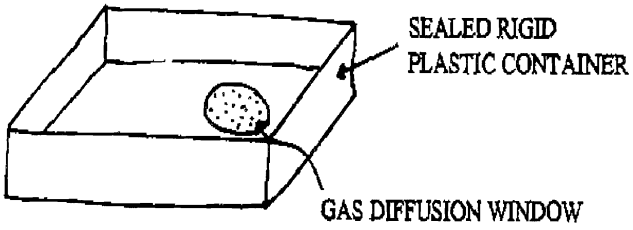
Source: Blond, R.D. 1984. The Agricultural Development Systems Project in Egypt (1979-83), USAID/Ministry of Agriculture, Egypt/University of California, Davis.

If large bags or baskets must be used for bulk packaging of fruits or vegetables, the use of a simple vent can help reduce the buildup of heat as the product respires. In the illustration below, a tube of woven bamboo (about one meter long) is used to vent a large bag of chili peppers.



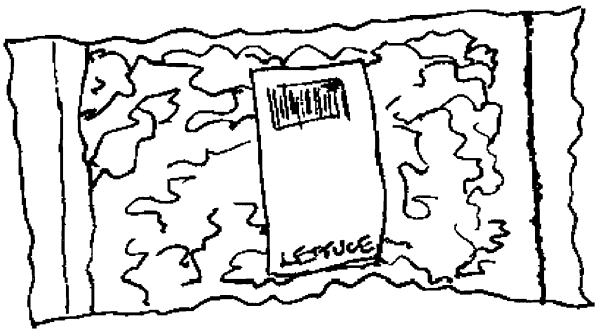
Modified atmosphere packaging (MAP)

Within a consumer package: If commodity and film permeability characteristics are properly matched, an appropriate atmosphere can evolve passively through consumption of O_2 and production of CO_2 during respiration (Kader, 1992). Some rigid plastic consumer packages are designed with a gas diffusion window.



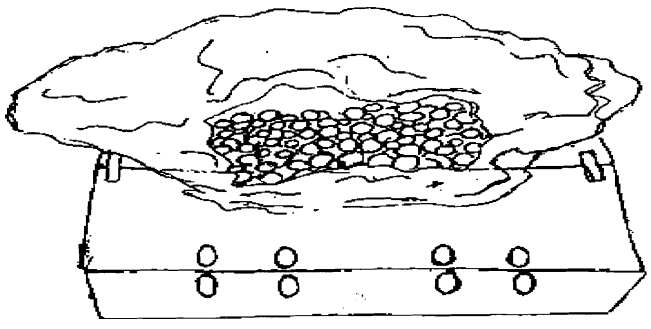
Lightly processed lettuce (shredded or chopped) can be packaged in 5-mil plastic bags. After a partial vacuum is created, a gas mixture of 30 to 50% O_2 and 4 to 6% CO_2 is introduced into the bag, which is then sealed.

SEALED PLASTIC BAG



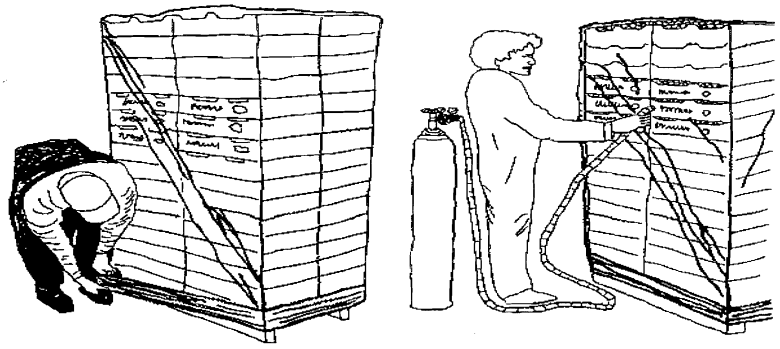
Within a shipping container: Polyethylene liners are added to shipping containers in cherry boxes, and polyethylene bags are used for bananas destined for distant markets.

PLASTIC LINER



Within a pallet: A single pallet load of produce such as strawberries can be sealed within a shroud of 5 mil polyethylene bag and a plastic sheet on the

pallet base using wide tape. A slight vacuum can be introduced and 15% CO_2 added to the air introduced via a small hose.



Many plastic films are available for packaging, but very few have gas permeability's that make them suitable for MAP. Low-density polyethylene and polyvinyl chloride are the main films used in packaging fresh fruits and vegetables. Saran and polyester have such low gas permeability's that they are suitable only for commodities with very low respiration rates. The following table shows permeability's of the films currently available for packaging fresh produce (Kader, 1992).

Table 2.2

Film type	**Permeabilities (cc/m2/mil/day at 1 atm)**		**CO_2:O_2 Ratio**
	CO_2	**O_2**	
Polyethylene: low density	7,700-77,000	3,900-13,000	2.0-5.9
Polyvinyl chloride	4,263-8,138	620-2,248	3.6-6.9
Polypropylene	7,700-21,000	1,300-6,400	3.3-5.9
Polystrene	10,000-26,000	2,600-7,700	3.4-3.8
Saran	52-150	8-26	5.8-6.5
Polyester	180-390	52-130	3.0-3.5

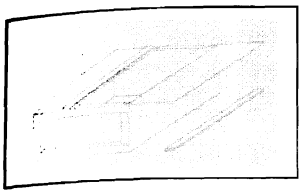


Fig 2.26

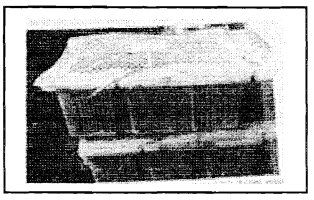


Fig 2.27

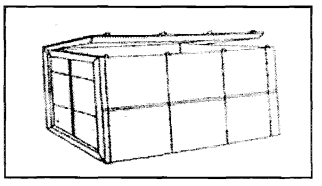


Fig 2.28

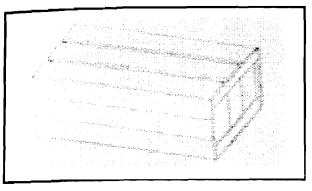


Fig 2.29

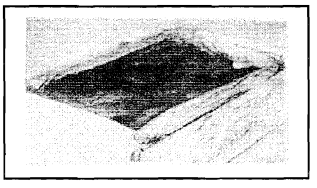


Fig 2.30

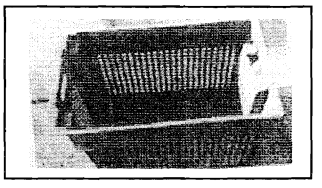


Fig 2.31

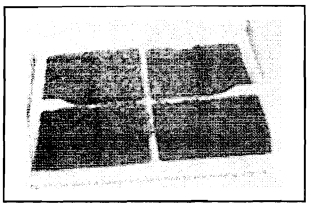


Fig 2.32

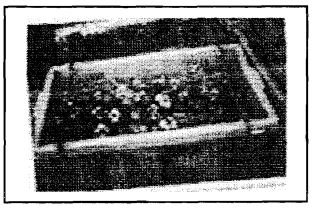


Fig 2.33

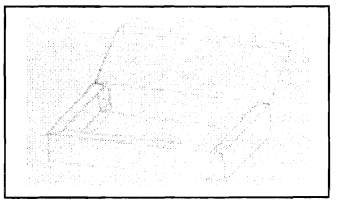


Fig 2.34

2.4 Modern Packaging Design

Quality packaging is important at all stages of product distribution system as it ensures the product travels safely from the production line through handling, storage and transportation, until it reaches the ultimate consumer in sound condition. Good package design contributes a great deal to the quality image of the product, attracts the consumers and is essential for both successful export and domestic marketing. Packaging is the technology or process that ensures adequate protection and safe delivery of produce from producer to the consumer. Considering the physicochemical properties of individual fresh fruits and vegetables ideal packaging container should be developed which may retain / prolong the freshener of these produces. Improved packaging plays a decisive role, since the success of failure of sales, both within the country or export depends to large extent on the

packaging the type selected, its particular features how it is suited to its contents.

With the rapid advance of technology, there is interest in producing increasingly sophisticated packaging. The term 'active packaging' has been coined to describe packaging that offers levels of control over package condition and how they vary with product (e.g. ethylene production) and environment (e.g. temperature) factors. An example might be a polymer film whereby the permeability to oxygen and carbon dioxide can increase or decrease as temperatures rise and fall, respectively. In the context of modern materials science, it is only a matter of time before such films are commercially available.

Water loss in packages can be reduced by the use of entire or micro perforated (pin-hole size) or macro-perforated films. However, condensation within moisture barriers can become a problem. In film-wrapped produce (e.g. citrus wrapped in heat shrink film), condensation is generally not a problem because the film is in intimate contact with the fruit and assumes the same temperature as the fruit. In the case of loosely wrapped produce (e.g. cut flowers within a plastic carton liner or fruit in a consumer pack), condensation can be reduced with simple or elaborate moisture sinks, such as newspaper and salts in spun-bonded polyethylene, respectively. Chemical anti-fogging treatments can be applied to films, and films with relatively high water permeability can be used (e.g. cellphone, polyvinyl chloride). Importantly, these precautions to avoid condensation also maintain product visibility (e.g. blueberries in over wrapped punnets). Water absorbents can be incorporated in packaging to capture and hold the free water resulting initially from condensation, which is followed by droplet formation and finally pooling.

Ethylene can be scrubbed from the package using blocks or sachets of high surface area materials (e.g. florists' foam, aluminum oxide particles) coated with potassium permanganate or using films impregnated with another oxidant, such as tetra zine. Tetrazine is a particularly promising compound since, unlike potassium permanganate, it is relatively specific or small double-bonded volatiles like ethylene. However, whatever the active ingredient, ethylene scrubbers are generally unlikely to work effectively unless they are positioned solely to intercept incoming ethylene. Ethylene is deleterious at part per billion (ppb) levels and is produced by the harvested plant tissue itself. Concentration differences at ppb levels do not constitute

gradients of sufficient magnitude to drive ethylene to a point (e.g. sachet) or planner (e.g. film). Thus the provision of ethylene scrubbers within packages can sometimes be a waste of money and effort. It is tempting to envisage small ethylene scrubbers with tiny motorized fans that draw in the in package air in order to lower in package ethylene concentrations.

Modern packages and packing for fresh produce is expected to meet a range of basic requirements. They must:

- Have sufficient mechanical strength to protect the contents during handling and transport, and while stacked,
- Be largely unaffected, in terms of mechanical strength, by moisture content when wet or at high Related humidity(RH)
- Stabilize and secure the product against movement within the package during handling,
- Not contain chemicals that could become transferred to the produce and taint it or be toxic to the produce or to humans,
- Meet handling and marketing requirements in terms of weight, size and shape,
- Allow rapid cooling of the contents and / or offer a degree of insulation from external heat or cold,
- Use gas barriers (e.g. plastic films) with sufficient permeability to respiratory gases in order to avoid any risk of anaerobiosis,
- Offer security for the contents and/ or ease of opening and closing in some marketing situations.
- Identify the contents, proffer handling instructions and aid retail presentation through comprehensive and accurate labeling,
- Either exclude light (e.g. from potatoes) or be transparent (e.g. for orchids)
- Facilitate easy disposal, reuse or recycling, and
- Be cost-effective in relation to the value and the required extent of protection of the contents.

It is becoming increasingly important to reduce the many types (sizes and shapes) of packages through standardization. Unitization (e.g. pallets) and mechanical handling (e.g. forklifts) make standardization essential for economical operation.

Two important practical requirements must be met when packaging perishable produce:

- Individual items should not be allowed to move with respect to each other or to the walls of the package in order to avoid vibration injury, and
- The package must be full without packing too tightly, which increases compression and impact bruising.

Objectives of improved packaging

- Protect products and cause no injury
- Economic use of space and easy to handle
- Easy to open and close
- Does not contaminate the food
- Facilitate pre-cooling and cooling
- Maintain quality standards and promote marketing
- Provide information of the produce.

Function of packaging

Good packaging for fresh horticultural produce has the following characteristics

Contain a convenient size or amount of a produce – The package should act as a container for the product in order to create an efficient handling unit, easily handled by a person and easily maintained during transport, storage and marketing. Many packages in Bangladesh do not fit this description, as they are too big and therefore they harm the produce and handling very difficult.

1. **Protect the produce** in transit physical damage, which affects external and internal appearance. **The source of damages;**

(a) **Impact damage** –The damage absorbed by the product due to collision between produce or between produce and a hard surface. This is mostly caused by dropping or throwing the packaging (due to big size and excessive weight), and shocks during transport caused by excessive braking and by fast driving, and movements of the produce and also inadequate conditions of road. This problem is common in Bangladesh due

to excessive weight of package, inadequate condition of vehicles, and driving and poor conditions of roads. This damage can be avoided by using small packages that can be easily handled by one person and by training drivers to handle these crops carefully, and to follow better roads.

(b) **Compression bruising** – The injury resulted due to overfilling of the package, improper stacking and deterioration of the package or heavy weight on the top of commodity. It can be avoided by packaging in containers strong enough to withstand multiple stacking and not to overfill the packages. Packages in Bangladesh are commonly overfilled, which results in excessive injury and losses. Packages should always be full but never overfilled.

(c) **Vibration rubbing** – This damage is resulted from vibration of the loose product in the packages or between each other during transport, which can causes abrasions. This can be avoided by packaging the product tightly (but not overfilled). Several other means can also be implemented to reduce this problem including the use of different types of liners and wrapping with paper or other materials.

(d) **Cut and punctures** – These are common when hard packages such as wooden crates and some baskets are used.

2. **To facilitate handling:** Packaging eliminates individual handling of the produce and facilitates marketing.

3. **To promote sales:** Once a package has fulfilled the requirements of containing, protecting and facilitating handling, it must then be a good "Sales person" for the product. The attractive package itself is used as a display case, the country of origin and the quality class of the produce variety.

- **Different levels of packaging:**

  o **Harvesting packages:** These are packages that are used to collect / harvest the product from the field.

o **Field package:** These packages are used to accumulate the harvested product in the field before transporting it to the packinghouse or the pre-cooling site. These packages are commonly made of wood or plastic.

o **Shipping packages:** These are different packages used during shipping, but also can be used during storage and marketing. They can be made of wood, plastic, fiberboard etc.

o **Consumer packaging :** These packages are increasingly used for direct marketing to consumers and they are made of different types of plastic, paper and fiberboard carton. They have several advantages including reduced damage and handling to the produce, increased marketing and profits, and more convenience to the consumer.

Choosing the right package

The right package should be chosen on the basis of;

Type and perishability of the product – the package should protect **the** product and not cause injury to it.

Type of market – different market requires specific package.
Safety measures – The package should not contaminate the product, and therefore it is recommended not to use used packages that were not meant for perishable foods.

Size and weight – The package should be handled easily by one person and never beyond the capacity.

Facilitate cooling – the used package should facilitate the cooling of product, and never causes it to heat.

Packing Fresh Fruits and Vegetables

The packing of fresh fruits and vegetables is of concern due to their highly perishable nature. Growers, processors, packers, shippers, and re-packers should:

- Ensure adequate sanitation during harvesting and packing to avoid contamination of produce with pathogenic organisms that can cause food-borne illness;
- Use a chlorinated wash to remove dirt, debris, and organisms present in harvest operations;
- Sort out bruised, cut, decayed, insect-infested, odd-sized, immature, or overripe items;
- Use the minimum amount necessary of fungicides/bactericides to limit decay on certain products, strictly in accordance with label instructions and foreign country restrictions;
- Use the minimum amount necessary of officially approved wax or resin coatings to reduce moisture loss on certain products, strictly in accordance with label instructions and foreign country restrictions;
- Use the minimum amount necessary of officially approved pesticides for certain products to eliminate insect pests, strictly in accordance with label instructions and foreign country restrictions;
- Remove field heat (pre-cool) as soon as possible after harvest, and maintain the cold chain;
- Use grade standards or buyer's specifications in packing;
- Place only uniform sizes or amounts in each box;
- Place only products with a uniform level of maturity in each box; and
- Clearly mark the grade, size, weight, or count on the box, along with any other required label information, such as country of origin, exporter, importer, gross and net weights in kilograms, total number of packages, size of package in centimeters, handling marks (international pictorial symbols), cautionary marks, port of entry, pesticides, and fungicides used, or wax or resin coatings used, in a language accepted by the destination country.

Damaged fresh products can ruin an entire shipment and reduce importers' confidence in the grower and shipper. Products in this condition:

- Spread decay to other products in the load;
- Produce more ethylene gas and heat, which cause further ripening and decay; and
- Lose more water resulting in shriveling and wilting.

Packing methods for fresh produce include:

Field Packing--Products are placed in fiberboard boxes or wood crates during harvesting. Some products are wrapped. The filled containers are then taken to a precooling facility to reduce field heat.

Shed Packing--Products are processed or packed indoors or under cover at a central location. The product is brought from the field to the packing shed in bulk in field crates, bins, or trucks. The products are precooled either before or after they are placed in shipping containers.

Repacking--Products are taken out of one container, regraded, and placed in another. This is often done to make smaller boxes for the retailer or consumer packages.

Fresh-cut Processing--Products are washed, trimmed, shredded, peeled, cut, and otherwise processed into salad mixes or ready-to-eat items under sanitary and temperature-controlled conditions using Hazard Analysis Critical Control Point (HACCP) or similar systems of quality control. These items are then placed in modified-atmosphere consumer and foodservice packages, which are then grouped in fiberboard boxes for distribution under constant refrigeration.

Standardization

Different groups interpret produce package standardization differently. The wide variety of package sizes and material combinations is a result of the market responding to demands from many different segments of the produce industry. For example, many of the large-volume buyers of fresh produce are those most concerned with the environment. They demand less packaging and the use of more recyclable and biodegradable materials, yet would also like to have many different sizes of packages for convenience. packers want to limit the variety of packages they must carry in stock, yet they have driven the trend toward preprinted, individualized containers. Shippers and trucking companies want to standardize sizes so the packages may be better palletized and handled.

Produce buyers are not a homogeneous group. Buyers for grocery chains have different needs than buyers for food service. Selecting the right container for fresh produce is seldom a matter of personal choice for the packer. For each commodity, the market has unofficial, but nevertheless

rigid standards for packaging; therefore it is very risky to use a nonstandard package. Packaging technology, market acceptability, and disposal regulations are constantly changing. When choosing a package for fresh fruits and vegetables, packers must consult the market, and in some markets, law may require standard packages.

Due to the large number of different box sizes in use, box and pallet standards have been developed by the fresh produce, frozen food, floral, and grocery industries in Europe and the United States to reduce handling damage and packaging waste. Standardized boxes can:

- Reduce box inventory for manufacturers and growers;
- Provide unit loads and more stable mixed pallet loads;
- Reduce transportation and marketing costs; and
- Use 90 to 100 percent of the pallet surface with no overhang and little underhang.

2.5 Low Cost Packaging Materials available in Bagladesh

There are many different types of package in use throughout the country, many of which have been carefully evaluated with respect to produce and market systems, while other types have often been adopted for general use without evaluation.

- Fiberboard--Pallets, slip sheets, bins, boxes (glued, stapled, interlocking), lugs, trays, flats, dividers, and partitions.
- Wood--Pallets, bins, crates (wire bound, nailed), baskets, trays, and lugs.
- Paper--Bags, sleeves, wraps liners, pads, excelsior, and labels.
- Plastic--Pallets, bins, boxes, trays, bags (mesh, solid), containers, sleeves, film wraps, liners, coatings, dividers, and slip sheets.
- Polystyrene--Foam boxes, trays, lugs, sleeves, liners, dividers, and pads.

Package types include sacks and nets, wooden crates, cartons or fiberboard boxes, plastic crates, baskets, pallet boxes and other such shipping containers. The uses, advantages and disadvantages of each of these packaging types is described below.

Sacks and Nets

Sacks are the cheapest form of packaging available, and are often used several times over, being easy and cheap to return. The sack occupies very little space itself, which gives some advantage to the shipper in the regional trade. However, cheapness is the only advantage that sacks have over other forms of packaging.

Baskets

Traditional round wicker type baskets have been used in Bangladesh for many years for exports. The baskets have the advantage that they are relatively cheap and are made from locally available and readily renewable resources.

Fiberboard Cartons

Fiberboard boxes or cartons may be of solid or corrugated fiberboard construction of varying thicknesses and resilience depending on the produce to be contained and the market to be supplied. They have the advantages of being light to carry, clean and smooth surfaced, they allow for easy printed application of labels and can be manufactured to a wide range of sizes, shapes and strength specifications.

Fiberboard boxes are the most widely used packaging, due to their versatility and recyclables. There are many fiberboard box styles and sizes. A minimum 19.3 kg/cm^2 (275 lb/in^2) bursting-test-strength or 7.86 kg/in (44 lb/in) width edge crush test fiberboard is recommended for boxes intended for export. The strength is needed for the handling, transport conditions, and high humidity the boxes must endure. Many boxes are now certified with an edge crush test instead of the bursting strength test. This information is available from the packaging supplier and stamped on each box. Foreign buyers or importers should be consulted about the size, pack, and box style desired.

Wooden Crates

Wooden crates are widely used by the fresh producer in Bangladesh. There are no standard sizes and designs in current use except for the wire-bound veneer crates. The normal procedure is for the traders to make up their own

crates, typically from broken down pallets, with the result that the crate may be up to one cubic meter in dimension and weighing many kilograms empty.

Stacking

The majority of fiberboard boxes and wood crates are designed to be stacked top-to-bottom. Compression strength and product protection are sacrificed when boxes or crates are stacked on their ends or sides. Misaligned fiberboard boxes can lose up to 30 percent of their strength, while boxes that are not stacked top-to-bottom (stacked either crosswise or off-center) can lose up to 50 percent of their top-to-bottom compression strength.

Plastic Crates

Plastic crates and containers can be manufactured to a wide variety of specifications, generally from either high-density polyethylene (HDPE) or polypropylene (PP). Usually, plastic crates are more expensive than other forms of packaging, but have a very long lifespan allowing their use on a return basis for many Journeys.

Paper, Plastic Film and Plastic Bags

Paper or plastic film is widely used as lining material and dividers for other forms of packaging. Tissue paper, shredded paper or plain Kraft paper helps prevent produce rubbing together or against the package walls and is generally only used with high value delicate commodities. Plastic film liners or bags are used to retain moisture, provide for a modified atmosphere, or maintain product integrity, such as in a cluster of grapes or tomatoes.

Chapter 3

Transportation from farmyard to market places

In this chapter, past and present transportation practices in Bangladesh are reviewed. Particular attention is paid to the current condition of roads, the distances travelled and modes of transport used for conveying fresh produce. A survey of the transport practices of farmers and transporters was undertaken. Analysis of the results of this survey yielded important information about the advantages and disadvantages of existing transport practices, and the problems that need to be overcome in order for fresh produce to be able to be transported, with minimum damage and maximum retention of freshness, to its final destinations.

3.1 Early forms of transportation: river, rail and road

Bangladesh is basically a state of rivers. In the past, the main transport in Bangladesh was by waterways. The total length of waterways in Bangladesh is 24000 kilometers. The principal rivers are the Padma, Jamuna and Meghna. They and their many tributaries form the largest delta in the world. Two third of the land area of Bangladesh is floodplain and remains in a submerged condition from two to five months of the year. Because of this, maintenance and development of roads and railways is very expensive.

On the other hand, the waterways transport system is relatively less expensive and convenient. In some areas of Bangladesh, boats are the only means of transportation. The history of transportation in Bangladesh is dominated by water transport. In the past, due to the geographical condition, there were not many roads so commercial communication and transportation was mainly dependent on the waterways with commercial commodities being transported from one place to the other by boats and ships. Goods from all over the world, especially from Arab countries, Turkey, Portugal, France and Britain were carried to India in the past by waterways.

The British played an important role in improving the transportation system when they established a railway in what was to become Bangladesh for the first time in 1862. However, during colonial era and before the split with Pakistan the transport system of the region was neglected. The expectations of the people of the area were not met. During the liberation war of Bangladesh in 1971, what transport infrastructure that existed – including roads, terminals, rail stations, bridges – were destroyed by the Pakistan

Army. During last three decades after liberation of Bangladesh extensive improvement was made in all transport sectors including railways, waterways, and road transportation system. Among these tremendous growth in road transport system is worth mentioning. All most all the villages of Bangladesh are connected by road transport system. High ways are linked by feeder roads. Many bridges and culverts are built to avoid ferry system.

3.2 Transportation Infrastructure of Bangladesh Today

Today the transport system of Bangladesh consists of four modes: road, rail, inland waterways and airways. The transportation network of the country is shown in Table 1. At present the total of National Highway, Regional Highway and 'Feeder Road Type A' amounts to 21,174 km. 'National Highways' are the roads connecting the national capital with divisional headquarters, old district headquarters, port cities and international highways. 'Regional Highways' are the roads connecting different regions with each other, which are not connected by national highway system. 'Feeder Road Type A' roads connect Upazila (each district consists of a number of upazilas) Headquarters and important growth centers with the main arterial road networks. 'Feeder Road Type B' roads connect growth centers with other growth centers and Upazila Headquarters.

Table 1: Roadway Inventory of Bangladesh (Length in Km)

Survey Year	National Highway	Regional Highway	Feeder Road Type A and B	Total
2001	3086	1751	16337	21174

(Source: Economic Review of Bangladesh 2002)

Rail transport is a public sector concern. Bangladesh Railway has a total 2,768 route kilometers at the end of the financial year 2000-01 and operates through 452 rail stations nationwide. About ninety percent of the country's area is accessible by railway.

The navigable waterways of the country consist of approximately 5,968 km of rivers and channels during monsoon, which reduces to approximately 3,600 km during the dry season (BIWTA, 99). The waterway network

facilitates natural drainage of the country and serves as one of the major means of transportation for some areas, specifically the southern districts of the country. (Jobair B, et al 2003)

Transportation of fresh fruits and vegetables from farmyard to the market place deserves special care and precautions to bring this produce in perfect condition to the market place. Several modes of transportation are used and the transportation method is being improved gradually. Research is being undertaken by the author to create better transportation practices. In some cases specially designed transportation systems are being developed, keeping in mind the physico-chemical properties of the produce to be transported. Packaging and transportation systems both need to be specially designed to keep the produce fresh in transit.

In Bangladesh, after harvesting from the field, horticultural produce is normally carried to the farmer's house on head load for cleaning, trimming, sorting, cooling and storage. Relatively big farms sometimes use bullock and buffalo carts to carry the fresh produce from the farmyard to the sorting house. Rickshaws, vans, small pickups and even trucks are used in the case of large firms if there are suitable access roads to the farm. If the farm is situated near a river, lake or navigable waterway boats are used for transportation. In this case, head loads of produce are carried to the boat-landing place and transported to the farmhouse. After cleaning, sorting and packing these are transported to the market place in river ways.

Transportation has become increasingly important in the vegetable/fruits business, as the market for produce has increased over the years. During the present century, motor-truck transportation has become increasingly important in the movement of perishable vegetables.

3.3 Past transportation practices for farm produce (1850 – 1971)

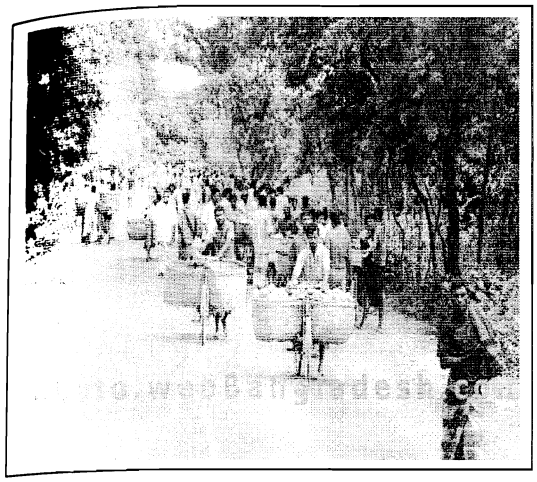
In the past, fruits and vegetables from the field were generally carried by head load by the farm workers to the farmer's homestead for cleaning, sorting, grading and packing. Sometimes special types of carrying baskets were used in which two baskets were tied with rope at two ends of a bamboo pole usually three to four feet long. The two baskets were filled with the fresh produce and carried by placing the center of the bamboo pole on the shoulder. All the members of the farmer's family took part in washing,

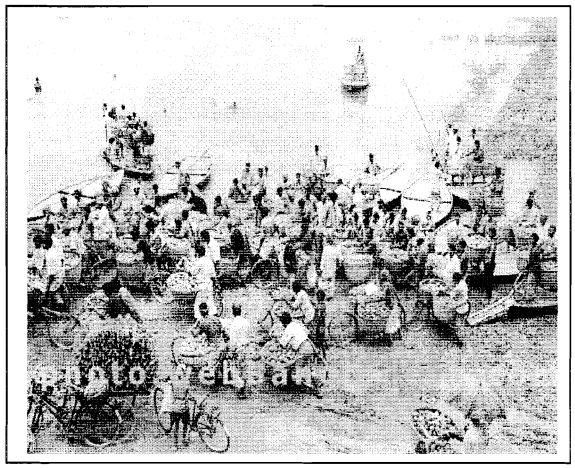
sorting, grading and packing in appropriate containers. After completing these operations, the fresh produce was loaded to bullock or buffalo cart for transportation to nearby markets. If the quantities of the marketable produce were large they were usually transported to the wholesaler's warehouse. For small quantities, the farmers usually transported their produce on head load and sold directly to the consumer through retail market.

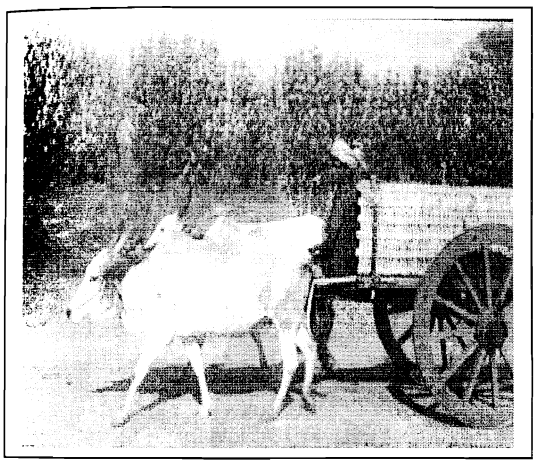
Due to poor road conditions in rural areas the most common transport was bullock and buffalo carts, head loads, shoulders loads etc. Where waterways were within the reach of the farm, the most common transport was boat manually operated by a boatman. Due to lack of knowledge about the physiology of horticultural produce a lot of damage was incurred during transportation. In the past, due care was not taken during harvesting and storage. The factors responsible for post harvest loss of produce in the past were ignorance, lack of training and lack of quality awareness of the farmers and farm workers.

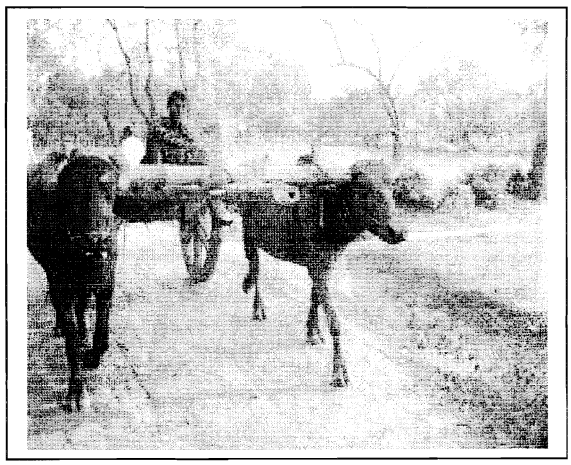
Some inappropriate harvesting, storage, packaging and transportation related losses of fresh agricultural produce are:

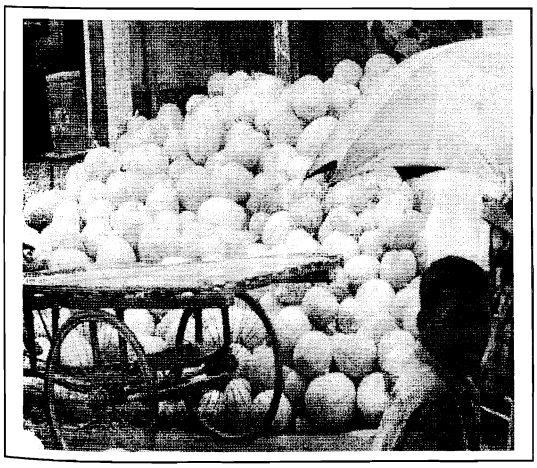
- Harvesting of immature and over mature crops.
- Exposure of produces to sun and / or rain after harvest.
- Excessive and rough handling of the produce.
- Dumping of produce on heaps for several hours at the collection centers.
- Minimum sorting or no sorting therefore damaged products at the selling or collection centers.
- Rough handling during loading and unloading, mishandling during packaging.
- Use of large sized, non-rigid and off shaped packages during transportation from collection center to port of shipment.
- Use of rickshaws vans, buses and / or trucks not equipped for the transporting horticultural produce.
- Rough road conditions
- Inappropriate packaging of the produce.
- Use of ordinary unventilated rooms for storing produce at the wholesale and retail markets.
- Exposure of the produce to the open during selling hours and display of produce on the open ground at wholesale markets.

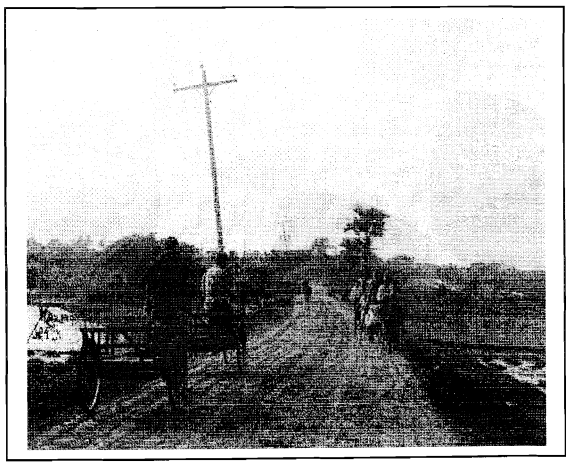


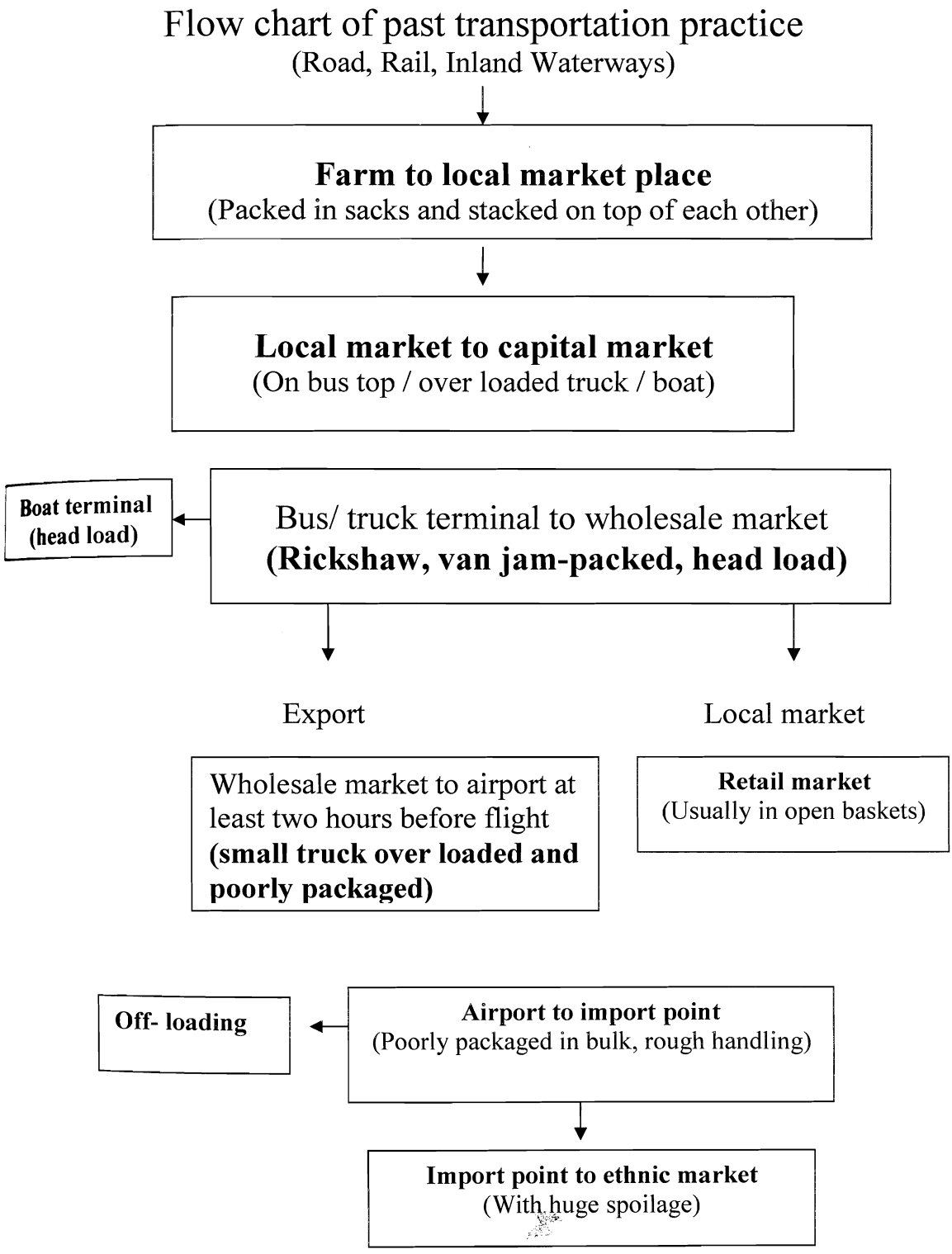











Flow chart of past transportation practice
(Road, Rail, Inland Waterways)
Farm to local market place
(Packed in sacks and stacked on top of each other)
Local market to capital market
(On bus top / over loaded truck / boat)
Boat terminal (head load)
Bus/ truck terminal to wholesale market
(Rickshaw, van jam-packed, head load)
Export
Local market
Wholesale market to airport at least two hours before flight
(small truck over loaded and poorly packaged)
Retail market
(Usually in open baskets)
Off- loading
Airport to import point
(Poorly packaged in bulk, rough handling)
Import point to ethnic market
(With huge spoilage)

3.4 Current transportation practices for farm produce – survey

Research was undertaken to establish the current situation and future transport needs of rural farmers in Bangladesh. The purpose of this study was to find out about farmers' transport practices, to observe advantages and disadvantages of existing transport practices and their reaction to them.

Three different sets of questionnaires, one each for farmers, produce merchants and transporters were designed for the purpose of information collection. Information sought included home - farm and home - market distances, mode of movement and conveyance of produce, routes plied and vehicle ownership. Eight major food-producing zones in the surveyed area were selected for the study. These were Barishal, Rajshahi, Dinajpur, Bogura, Mymenshing, Tangail, Pabna and Jessore. The points of information collection were urban food markets, village markets, villages and farmers' residence, farms, collection points and motor parks. The questionnaires were administered during field visits by giving them to the respondents to fill in. These were retrieved at the end of the visit, while additional items of information were gathered through personal communication and focus group discussions. Personal observations were also made by the author on study trips between the field research periods in March 2005 to October 2006.

A total of 271 questionnaires made up of 160 farmers, 35 Transporters and 76 Produce Merchants were distributed and collected. Respondents were purposively selected ensuring that they were full time farmers, transporters and produce merchants respectively. Farmers were selected through the assistance of extension workers of the States' Agricultural development programs while the transporters were selected through the assistance of the officials at the motor parks. Some of the produce merchants and transporters were identified at the markets.

3.5 Analysis of Transport Survey Results

Travel Distances and Means of Transportation

Tables 1 and 2 show the distances often traveled in delivering farm produce to the end-users. About 65% of the farmers have their farms located between one and six km from their home villages while the rest are at a greater distance. For home – market distances, 42% of the farmers travel less than

six km. The farmers, whose farm distances are less than six km, usually walk to their farms as no form of farm vehicle is available, while those whose farms are farther than six kilometers usually travel by bicycles, motorcycles and public transport (especially buses) and pick-up vans. Trekking is not only physically taxing but takes between one to two hours in each direction. Clearly, not only is useful energy dissipated but also much time is also lost.

Most farmers don't return everyday but rather spend a few days sleeping in the nearest hamlets to their farms. Those farmers, whose farms are above 15 km, sleep more on the farm and many have farmhouses, which provide a place of abode during such periods. Besides the issue of home to farm distances, the security of produce is another reason why some farmers sleep at their farms.

Produce can either be stored on the farm and taken directly to the market or brought home for temporary storage before being taken to the market. Human portage is normally used for conveyance of produce to markets within the neighborhood not usually more than six kilometers while for longer distances, bicycles, motorcycles, buses and Pickup vans are used. As a result of volume of produce to be conveyed, produce merchants employ more of farm vehicles than human portage, the travel distance notwithstanding.

Table 1: Travel distances by farmers

	Home-Farm Distance		Store – Market Distances	
Distance (Km)	Frequency	%	Frequency	%
1-3	35	20.0	29	17.6
4-6	61	38.2	36	21.8
7-9	30	18.0	24	14.5
10-12	9	5.5	21	12.7
13-15	9	5.5	12	7.3
Above 16	7	12.8	43	26.1
	151	100	165	100

Table2. Distances traveled by produce merchants

Distance (km)	Frequency	%
1 – 10*	24	31.6
11 – 20	28	36.8
21 – 30	4	5.3
31 – 40	4	5.3
41 – 50	2	2.6
51 – 60	2	2.6
61 – 70	4	5.3
71- 80	2	2.6
Above 80	6	7.9
Total	76	100.00

*** Distances mainly covered by Rural Produce Merchants.**

Although water transport system was a major means of transport in the past, during last three decades land transport in Bangladesh has become the most important transport system. This is due to the development of road infrastructure. Modern metallic roads connect almost all the villages and access by road is very easy. As a result in commercial transportation of fresh produce road transport is playing a vital role. Its advantage over water transport system is that it is much quicker and every corner of the country can be reached within a reasonable short time.

Vehicle Type and Ownership

Table 3 shows the types of farm vehicles available for farm transportation in the area surveyed and ownership among farmers, produce merchants and Transporters. About 32.7% of the farmers, 86.8% of produce merchants and 26.8% of transporters do not own any form of transport, the main reason being the inability to acquire one. The implication of this is that most of them have to convey their produce by human portage in the case of farmers, which is tedious, or depend on commercial transportation especially for the merchants, which is both irregular and expensive, and reduces the net profit. Only about 10.6% of produce buyers own buses and pick-up vans which are the common vehicles in the study area. This group of merchants also uses their vehicles for other commercial purposes. About 63.4% of the transporters own buses/pickup vans/lorries / trailers which are the ones

mainly patronized by produce merchants. The remaining 26.8% of the transporters do not own any vehicle. The vehicles they use belong to either civil servants or businessmen with whom they have an agreement on the mode of financial returns and legal compensation.

Table 3 Transport ownership

Transport Type	Farmers		Produce Merchants		Produce Transporters	
	Frequency	%	Frequency	%	Frequency	%
None	54	32.7	66	86.8	11	26.8
Bicycle	39	23.6	=	=		
Motorcycle	21	12.7	2	2.6	2	4.9
Car	9	5.5			2	4.9
Bus	18	10.9	4	5.3	12	29.3
Pick-up Van	18	10.9	4	5.3	9	22.0
Trailer/	6	3.6	=	=	2	4.9
Lorries	=	=			3	7.2
Total	165	100	76	100	41	100.00

Road Network, Conditions and Maintenance Culture

The routes available in the surveyed area include footpaths, non-surfaced roads and all weather roads. Farmers' accesses to these routes are presented in Table 4. The width of footpaths ranges from 700 mm to 1100 mm, which limit their use to pedestrians, bicycles and motorcycles. They are often divided into primary and secondary. The primary ones link farm plots, villages and in some cases link the plots to a tarred road. The secondary footpaths are mainly for movement within the plots. Earth, non-surfaced or seasonal roads are the major vehicular routes in the areas surveyed and the width vary from 3,600 mm to 4,000 mm. During the rainy season, the poor drainage system results in water logging and the roads become marshy. This is further aggravated by the heavy traffic usually experienced at the peak of farming activities. The water puddles and potholes, which develop on the road surfaces, result in wear and tear of vehicle parts especially the tyres. Roads transport authority reported that poor road maintenance multiplies the cost of repair by 200% - 300% after every rainy season, and increases cost to vehicle owners by more than 50% for paved roads and much more for gravel and earth roads.

Because of road conditions there is often a delay in the conveyance of produce and losses are incurred while in transit. In a few cases, harvested crops have been lost because of disappointment by transporters with whom previous arrangements have been made. In most cases, fares are indiscriminately raised which increase food prices and reduce the net profit accruable to farmers. During the dry season, vehicles are enveloped in thick cloud of dust which constitutes health hazards to route users and contaminates the produce being conveyed. The few farmers, who have their farms in communities far away from where they live, make use of all weather or tarred routes except for the last stretch to their farms. There is no organized form of maintenance on most routes. The users do not show any commitment to road maintenance even though that is their source of livelihood. It is only on a few occasions when the route becomes almost impassable such as when a culvert or bridge collapses and it becomes impossible to use the route that they show concern and carry out some maintenance to enable the continuous use of the road.

Table 4. Road conditions

	Type of Journey			
	Home – Farm		Home - Market	
Route Type	Frequency	%	Frequency	%
Untarred	102	61.8	45	27.3
Partly untarred/tarred	48	9.1	39	23.6
Tarred	15	29.1	51	49.1
Total	165	100	165	100.00

Transport Pattern and System

The farm transportation system between the farms and urban centers can be broken into two parts. The produce could be stored on-farm or in the villages from where it is taken to the village markets. As already indicated, this is done mainly by human portage and to a lesser extent by vehicles. Urban-based produce buyers adopt two methods in their operations; one method is to have a collection center in a village where produce within that village and neighboring ones are purchased and kept before arrangement is made to convey them to the urban area; another method is to study the rural markets calendars and visit them for immediate purchase and transportation. This is done for produce with short shelf life such as vegetables, fruits and plantain. This second stage of transportation is essentially by vehicles.

Figure 1: Map of Bangladesh showing Transportation Network.

Rail versus Truck

The railroads have major advantages in moving perishable produce in large quantity for long distances. It would take 80 to 100 trucks, with two men for each truck to move a trainload of vegetables. For local movement the truck is indispensable. Where the dividing line between the two transport modes is to be found is matter of service and costs. At distances of 200 to 800 miles, the competition between the two is constant and keen. The railroads have excellent refrigeration facilities, and their terminals are generally good. Trucks can pick up goods at the field or packinghouse and deliver them at the store door, but many of our markets were built before the day of motor transport, and congestion and delays are often serious. Refrigeration of trucks is improving. Railroads have shortened their delivery times. Adjustment between the two is constantly going on.

In all transportation, security in loading is important. In car or truck a comparatively light container will serve provided that there is no shifting of movement of the produce. In railroad cars, special systems of strapping and bracing are used to prevent movement of the load. The railroads insist upon good practice in this respect as well as in specification of containers so that losses to shippers and damage claims against the companies may be kept at minimum.

These days refrigerator rail cars are available practically everywhere. Both rails cars and rail service are well standardized. The rail cars are carefully constructed to resist water, as package and top icing keep them thoroughly wet. Many experiments have failed thus far to render mechanical refrigeration practical for rail cars, though it is used to some extent on trucks. The ice is renewed at stations along the road. "Reefer" trains (Refrigerated bogies of Train) make 60 miles an hour at times, but they still take days to get across the country like India. Bunker ice is supplemented by top ice finely ground and blown in over the packages. Some times bunker ice is omitted with dependence solely upon package and top icing. Since refrigerated rail cars are well insulated they are used to keep produce cool even when the actual refrigeration system is not needed.

3.6 Current transportation practices

Bangladesh remains primarily a rural society, with about 80% of the population living in rural areas. Although rural Bangladesh is poor, it has many characteristics, which result in a highly active rural cash economy in which mobility and trading are of crucial importance. As a predominantly rural country, rural infrastructure plays a vital role in supporting economic growth. Some of its most important components include transport, markets and electrification. These have advanced a long way since separation from India (1947), when as East Pakistan, it had only 600 km of hard surface roads and rural areas had virtually no access to electricity. At the time of independence of Bangladesh (1971), the primary and secondary highway networks had increased to 4,000 km. Today, Bangladesh has a stock of 4,440 km of railway track, 5,200 km of National and Regional Highway, 10,000 km of Feeder Roads Type-A. The country rural transport & trading infrastructure consists of 2,100 identified growth centers, 15,000 km of B-type feeder roads, 90,000 km of rural roads and about 8,500 km of inland waterways on which 300,000 country boats cater. As regards the small-scale Water resource related infrastructure, 1,000 km of embankment and 4,000 km of canal have been earmarked for development

In recent years transportation practices have changed radically due to the development of rural infrastructure, specially the rural road network. In Bangladesh almost all villages are connected with major towns, cities and their markets by modern metallic road enabling the farmers to transport their produce to the market place by modern transport systems, motor driven, rickshaw van, motorized boat, pickups and trucks are now to common sight in rural Bangladesh. Economically marginal farmers are still transporting their produce in old traditional ways such as head load, shoulder load etc. However, farmers owning medium to relatively large farm are taking advantage of modern transport system.

Current transportation practices in Bangladesh need lot of modification to prevent large-scale deterioration and damage of the perishable produce. Internal transportation facilities in Bangladesh are very poor and unorganized. The refrigerated transport is not adequate. Packaging is mostly not standardized and lack of training and skill development of packers and loaders results in frequent unnecessary handling and too much loading and unloading. For external transportation of Bangladeshi horticultural produce it is usual practice to use passenger flight with their inadequate storage

space. Airport handling is not satisfactory and very rough. Cargo booking and loading at the airport takes a long time; furthermore there is no cooling facility available at the airport. **(Hossain MA 2005.)**

In general, horticultural produce is marketed as rapidly as possible after harvest since most fruits and vegetables have short post harvest lives. It is, therefore advisable to keep the produce after harvesting under optional environmental conditions (temperature, humidity etc.) to slow down any post harvest changes. During transporting and storage the packaged produce faces numerous hazards: mechanical, environmental or biological.

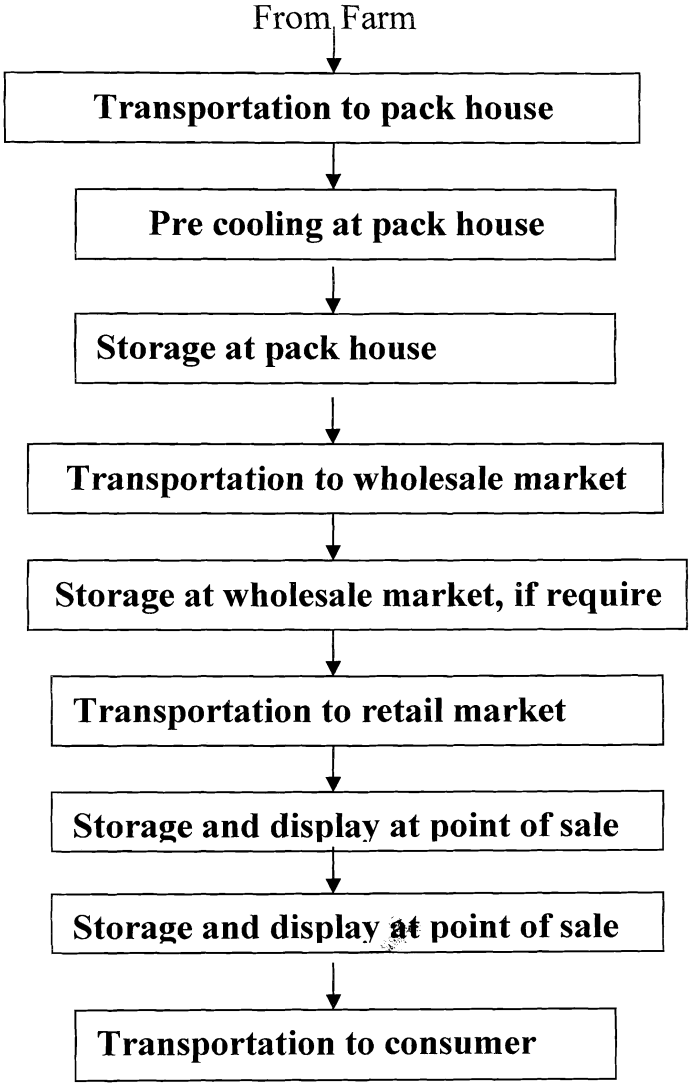
Mechanical hazards can be defined as those caused by impact, vibration, and compression and puncturing. Impact damage is likely if packages are carelessly dropped or thrown. The fruits or vegetables can move around inside the container causing contact between them and leading to bruising. To reduce this, packaging can be designed in such a way that there is no scope for the produce to move around and the loads are spread on individual pieces and provide cushioning. Adverse effects of vibration include abrasion due to the motion of the produce relative to the package and other produce. Compression damage may arise due to overfilling, improper stacking, deterioration of the package, or due to the pressing of the produce by upper layer. However, if the produce is handled roughly, thrown or dropped, there is again a risk that the produce will damage, no matter the quality of the packaging and how well it is filled **(Ahmed MS, 2004).**

Environmental or biological hazards can be defined as those caused by seasonality, water availability, extremes of heat and cold, drought and rain. The transportation of perishable horticultural produce to the customer requires selecting the fastest and most efficient mode of transport that will deliver the shipment in the best possible condition at the lowest possible time and cost. Rail and roads are the two important modes of transport in Bangladesh for movement of goods. Railways can play a very significant role in the shipment of fruits and vegetables by improving the movement of trains carrying fruits and vegetable.

For the management of fresh produce (fruits and vegetables) attention should be given to the following: a) Vehicle and load should be pre cooled. b) Air circulation should be uniform and adequate. C) Stacking pattern and package design should allow adequate air circulation. d) Loading and unloading should be done fast and carefully.

While good quality road and rail transport can assist farmers in getting their produce to urban markets, transport infrastructure can improve rural life in other ways. Farm transportation plays a key role in the agricultural and economic development of Bangladesh as it provides access for extension agents to transfer new and improved agricultural technologies to the rural and farming communities, timely delivery of inputs to the farm and evacuation of harvests to the urban areas where they are mostly demanded. These ensure improvement in agricultural production, food availability in urban areas and improvements in the economy of the rural communities. As established, accessibility and mobility made available to rural farmers will help reduce isolation and poverty.

Flow chart of transportation for fresh produce



Chapter 4

Towards Improved Packaging Practices and Skill Development

This chapter discusses cost benefits of packaging and some of the cost barriers to improving the packaging of fresh agricultural produce. It also reports on fact-finding field trips and workshops conducted with farmers, landless workers, transporters, produce merchants and manufacturers of packaging. The need for up-to-date knowledge about packaging operations, technologies and materials is elaborated by outlining: (i) modern pack-house operations (ii) issues concerning the use of plastic as a packaging material and (iii) controlled atmosphere packaging.

4.1 Cost barriers to Improved Packaging of Fresh Agricultural Produce

As has been argued in earlier chapters, improved packaging is urgently needed to reduce post-harvest losses of fresh agricultural produce and to increase the economic return to producers.

The largest cost element in a food trade including the business of fresh fruits trade is packaging, although most of the existing packaging is poor quality in appearance and innovativeness. The cost structure of large business units trading fresh fruits and vegetables in the country is such that the basic input costs are barely 15% and additional 15% is transport. The 70% chunk consists of packaging (35%) advertising and profit margin competition.

Cost effective production of packaging material is needed to boost popularity of fresh agricultural produce like fruits and vegetables. But large duties and taxes on packaging material and the high cost of printing make packaging uneconomic for many producers and produce merchants.

Quality awareness and proper control and assurance of quality of both the packaging and the produce are very important and proper emphasis should be given to ensure quality of the packaging and produce to enable it to be competitive and cost effective. The quality of packaging is contingent upon the quality of raw materials used. Since most of the packaging materials manufacturers are operating in small and cottage scale, no sophisticated quality control measures are taken. The manufacturers should be aware of the fact that the cost incurred to ensure quality will be returned many times

more if the product can satisfy the customers and users. By ensuring the quality, cost effectiveness of the product will be assured.

During the present course of the studies we felt that training needs of the packaging manufacturers should be fulfilled to appreciate the importance of quality in order to ensure cost effectiveness.
Infrastructure development and quality equipment and machineries are also contributing factors to achieve cost effectiveness of the locally produced packaging materials. Presently, it was found that there is a lack of modern infrastructure and manufacturing in the country. Inadequate transportation, poor distribution, inadequate facilities and unreliable power supply are the main short coming to develop cost effective packaging materials.

The packaging industries are handicapped at present by high production costs as well as lack of adequate supplies of uniform high quality raw materials suitable for manufacturing world class packaging material at a competitive price and consistent quality for both the domestic and overseas markets.

Market research is still essential for export as the stakes are much higher. Continuous monitoring of the changing requirements of the consumer and suitable designing and modifying the product mix is essential to become successful in domestic and particularly in the export market.

Research and development to import better quality packaging materials to cut down the cost of production and to absorb improved technology is also an essential step to improve the sales. In order to promote export of packaging containers for fresh agricultural produce such as fruits and vegetables efforts should be made to establish better representation both by the public and private sector in large foreign markets particularly to publicize specialty products.

The principal requirements for success for export from Bangladesh are competitive price and quality and reliability of supply, but other hurdles must be overcome too.

These are:

- Tariffs on selected items.
- Quotas on selected packaging items.
- Sanitary, phytoxinary regulations and control
- Trade and commercial standards and specifications.

For achieving effective outputs the agro-business should be grouped around activities, which involve substantial volumes of the same primary sector raw materials forming the basics for production-system selection and integration. This approach has been found very satisfactory in Asia and the Pacific region (Hicks 2004) and may be a successful attempt in Bangladesh.

There has been increased awareness on the development of packaging items for fresh agricultural produce in the country, but some irritants hinder process. The recent steps taken by the government of the Peoples Republic of Bangladesh to promote agro processing sector including quality packaging development, is encouraging, but the steps taken by the government are not very effective due to lack of explicit national policy on this issue.

Cost effective, competitive and quality packaging development is a crying need at this moment in Bangladesh for reducing post harvest losses and improving the handling and processing of fresh agricultural produce. This is demonstrated in the following example.

4.2 Cost-benefit analysis: an example

Assume 6000 kg of cucumbers are produced. Market price is $0.30 per kg and packaging costs $0.05 per kg. The other marketing costs are $0.05 per kg so the net revenue is $0.20 per kg. With packaging there are no losses. Without packaging the losses vary, as does the selling price. A cost-benefit analysis needs to take into account both price differences and losses and the calculation are therefore a bit complicated.

	Case			
	A	B	C	D
Net revenue — packaged sales ($0.20 per kg x 6 000 kg)	1200	1200	1200	1200
Net revenue — unpackaged sales				
Net revenue — unpackaged sales	1104			
Losses 10% Market price $0.27		1158		
Losses 5% Market price $0.26			1182	
Losses 5% Market price $0.27				1242
Use packaging	Yes	Yes	Yes	No

Note: In calculating the impact of losses, the value of the lost produce is the gross value, which includes transport costs, because these will be incurred

even though the produce is wasted. The net revenue to the farmer for unpackaged sales is calculated as follows:

6 000 × (Selling price − Transport costs) − Cost of Losses

(Price × 6 000 kg × the loss expressed as decimal [i.e. 10% loss = 0.1]).

So, where losses are 10% and the market price is $0.26 then the calculation is

(6 000 × ($0.21) = $1 260 − ($0.26 × [6 000 × 0.1] = $156) = $1 104.

4.3 Skill development of producers

Attempts are being taken to introduce professionalism in the packaging manufacturing houses of the traditional cottage and small industries. By skill development of workers in standardization, new avenues can be opened up in this sector. Trained workers are more likely to find jobs in local industries and skilled workers have also great potential to find a better job in overseas concerns. Thus systematic training with scientific knowledge on packaging materials, testing and quality control procedures makes the trained manpower an available asset to this trade.

Due to the introduction of the free market economy, there is no alternative but to develop skill, and skill can only be developed by importing training periodically and regularly to keep the workers knowledge up to date. Locally available traditional raw materials can only be considered a value added product if the skilled and knowledgeable craftsmen can design with innovative ideas and excellence in performance.

During the present course of studies several field trips were made in the rural areas to assess the needs of the farmers (producers) of fruits and vegetable. Intensive interviews were undertaken in different part of the country and questionnaires were handed out to farmers to answer. Eight major food-producing zones in the surveyed area were selected for the study. These were Barishal, Rajshahi, Dinajpur, Bogura, Mymenshing, Tangail, Pabna and Jessore. The points of information collection were urban food markets, village markets, villages and farmers' residence, farms, collection points and motor parks. A total of 271 questionnaires made up of 160 farmers, 35 Transporters and 76 Produce Merchants were distributed and collected.
The questionnaire was designed in such a way that the small and big farmers both educated and illiterate could understand the questions and answer in

their own way and in own language. The original questions were asked in Bangla. (An English translation of the Questionnaire is in Appendix 7.)

Most of the farmers, transporters and produce merchants were not educated and did not have vast knowledge about transportation and packaging system. So, at first we (The Merchants Limited) told them that we were doing the survey for research purpose to identify problems and solutions associated with transportation & packaging systems. Respondents were purposively selected ensuring that they were full time farmers, transporters and produce merchants respectively.

As a result of these field trips and the responses to the questionnaires and interviews, it was felt that the growers need expert advice and assistance to develop their skills at different stages of production, including development and design of packaging containers, this to enable them to sell their produce at a premium price both in local and overseas markets.

To develop awareness among the vegetables and fruits growers of Bangladesh, major vegetable and fruit growing areas were identified and grouped into five regions namely North East, South East and Central Bangladesh. Each region has characteristic geographic features and climate conditions and as such the variety of vegetables and fruits grown in each region require special packaging containers. Workshops to develop awareness among the farmers and to help them understand the benefit of having suitably designed packaging containers for packaging and transporting to local and distant markets were organized in different regions. A sample of the workshop proceedings is given in Appendix-5.

The workshops were attended by local farmers and other interested parties namely agriculture extension officers small, medium and whole sale fresh produce traders local small scale packaging manufactures and potential entrepreneurs who are interested in engaging themselves for manufacture of packaging containers suitable for fresh produce.

Interactive workshops were arranged with the container manufacturers (Rafiq Tin containers limited, Padma Cans & Closures Limited, Quality Can Industries Limited, Metalon Industries Limited, Cosmotron Limited, M/S Dias Metalic Industries) and ideas were exchanged to acquire more knowledge from both sides. The advantage and disadvantage of both the traditional and modern packaging containers were discussed, which helped

the makers of traditional containers to develop and improve their skill in this trade and inform them about the modern concept of packaging design.

Two other workshops were held. One was held at 'Pabna' district in July 2006 on the topic "Packaging perishable produce (Fruits and Vegetables) in underdeveloped countries". Another workshop on "Pack house operations for fruit and vegetable", attended by the farmers, produce merchants was held at 'The Merchants Ltd.' on 10th August 2006. Both workshops were arranged by myself. Special guest of this workshop was Professor Dr. Anisur Rahman.

During the initial phase of research, response from the target group of rural population was not very encouraging, but after several visits to these areas the people gained confidence and we started co-operating. We organised small workshops and seminars, encouraging people to participate by producing different types of containers as per designs supplied to them. We have developed a system to purchase the best packages produced by them and by doing so, silent competition to produce items better than the best was noticed among the participants. So initial suspicion and non willingness to co-operate disappeared and ultimately we were rewarded by the formation of enthusiastic group of rural people both men and women, who have started to develop skill in themselves thereby forming a confident group of skilled workers. We can now confidently say that our research method worked very well among the target group we have chosen. Now these people understand our purpose and they are willingly participating in our program, seeing a possibility of becoming self employed or securing a profitable employment.

We also held several sessions with exporters and traders to identify their needs. This lead to the development of new packaging items (Appendix 8). The criteria of these newly developed items were determined in various ways by testing external elegance, durability and smooth packaging of various produce so that little or no damage occurs on loading produce into these containers. Stability of these packages after loading was also determined. Space utilization during transportation was also considered.
From initial trial it may be concluded that the various packaging containers developed during present work will serve the purpose very effectively. These newly developed and modified designs for packaging containers have extra advantages of reducing environmental pollution because of their biodegradability, waste minimization and low cost.

4.4 Pack house operations for fruits & vegetables

Various systems have been developed to take produce from the field to the consumer and the selection of a particular method depends on several factors, including perishability and value of the crop. One method is to harvest the crop and take it to a pack house for grading, treating and packing for transport and marketing. The factors that should be considered in the setting up and operation of a fruit and vegetable pack house are as follows:

Site layout:
The pack house is the focus of a major handling operation. Crops from the field arrive in a variety of containers and leave in a variety of different containers. There are several important factors that must be considered with respect to the external arrangement of the building in order to achieve efficient running of the enterprise. (Brian. C undated)

The orientation of the building must permit efficient movement of traffic. Out loading vehicles are usually large trucks, which are loaded from the rear. They will enter the site from the nearest road way and need a high-quality road surface up to the out loading point, where there should be ample room for reversing. Reversal up to any of the loading bays should be a simple procedure.

Truck tailgates are approximately 1.25 m high. The access of the trucks should therefore be at the same height to aid loading by forklift truck, which can lift all the produce on to the truck without the need for a loading step.

The most popular orientation for pack house is to have the out loading bays facing the road so that trucks can drive straight in, backup, load and drive away.

If the incoming produce cannot be immediately loaded into the pack house it must wait in turn for a convenient time. In hot or wet climates some form of shade or shelter would normally be provided.

Intake equipment:
The system must be matched from one stage to the next. If pallet boxes are used to bring the produce in from the field then a box tipper must be employed to set the produce into the hopper feeding the conveyor, which

will then take it into the pack house. The conveyor will then ensure a steady flow of produce. If the boxes are loaded into an automatic feed line they can be left to feed the hopper in turn and provide full loading to all the subsequent process into the pack house. Any other system of intake is likely to be uneven, leading to inefficient operation.

Advantages of Grading

Some of the advantages that may or may not accrue from grading are:

- Avoidance of loss in selling price that might result from the presence of substandard specimens.
- Avoidance of heavy marketing costs on goods that are not of high enough quality to bring a price sufficient to pay those costs.
- The furnishing of a common language between buyer and seller. Buyer by inspection on public market is a costly and troublesome way to do business. Grocers prefer to give an order and to be assured of the quality they want. This requires a language that both parties understand. It may take the form of a definite designation of grade, size, and maturity.
- Relief of oversupply by removal of low-grade goods from competition in selling.
- Avoidance of damage to good specimens through contact with bad, especially diseased, ones.

Manual inspection and grading

Much has been published about advances in grading but the fact remains that a vast amount of fruit is still graded by hand and eye. Certain types of fruit and vegetables have unusual requirements or physical attributes, which demand a manual approach. For example, grapes and bananas are an unusual shape and invariably sold in bunches and cluster rather than individually, so that none of the usual grading techniques can be used. Bananas have to be very carefully graded in terms of ripeness, color, length and blemishes, all of which are usually carried out manually, although color and blemishes could be monitored automatically.

Post-grading treatments:

Washing and polishing

Many fruits benefit from the application of waxes and subsequent polishing. This is not simply to enhance the appearance, which is of course very important, but also to improve the storage quality of the product. When the crop is in the field, or even during harvesting, transport, washing or grading, it can undergo some scratching or abrasion, which not only removes the natural layer of wax but also scars its protective layer of skin. Washing in particular is essential to remove bird muck, insect marks, chemical residues and general field dirt, but can remove much of the natural wax layer, especially if used with detergents. The natural layer of wax reduces moisture loss from the fruit.

Spray systems often apply an excess of fluid so the surplus flows through the conveyor back into the holding vessel ready for reapplication. The crop must be dried before and after waxing to give good adhesion and retention of the wax. Drying is usually done in a drying tunnel, which may also incorporate soft brushes. A blast of warm air is often directed at the crop as it passes along the conveyor under the fan. Or else the heaters are under the crop and the fan draws the air through it by suction.

Trimming

Many vegetables need to be trimmed before packaging, such as cauliflower, carrots and cabbage. This may be carried out in the field to some extent, but there is still much done in the pack house. This is largely a manual process and the usual ergonomic guidelines apply. Jigs and automatic devices exist for length cutting of crops such as asparagus and other crops sold to a uniform length, Rutledge (1991) emphasizes the point that the rotary cutter or fine-tooth saw should be very sharp to avoid leaving ragged edges.

Labeling

The final process before packaging is labeling, often with an individual label attached to each fruit. The fruit is carried separately in cups and passed beneath a drum bearing a cassette of presumed labels attached to a backing sheet. The trays carrying the fruit are synchronized to pass under the cassette and pick up a label by light pressure. A simpler way of marking individual fruit is to use an ink stamp. This is a matter of simulating the fruit on a grommet roller conveyor and passing it under a linked roller pad. This

approach is not so impressive from a marketing point of view and in some countries, such as Japan. It is not allowed, despite the use of food-quality dye inks. On the other hand, the stamp is not as easily lost as the paper label. The label does, however, carry much more information than a stamp, which is often just one word.

Packaging methods

The method of packaging clearly depends on the type product and the size of package to be employed.

Sack packs

These are usually handled I a semi-automatic way. Packaging may be considered in several parts: handling, weighing, filling and sealing. The labeling often takes place at this stage when the crop is accurately weighted.

The crop is fed into the reception hopper from where it is elevated to a short belt conveyor. It feeds from here into a weigh hopper, which is preset, to the required weight. The belt stops feeding when it reaches about 1 kg short of the programmed weight and a further slow rate of feeding tops it up until it exceeds that shown on the label. With bulk pack the produce is bought by standard prescribed weight, such as 25 kg, rather than by individual pack size.

The handling parts of the machine are fairly standard. The ridged plastic belt can elevate the potatoes at capacities up to 10 kg^{-1} at an angle of about 80^0 from the horizontal. This belt at the top has to be able to handle at least ties amount to avoid overspill. This belt is again made of plastic, with side guard to prevent the spoilage. The accuracy of feeling is dependent on the average size of potato. If the weight is just a fraction below the set weight and a large potato comes along to fill the bag up to capacity, then the finishing weight may be ½ kg overweight. This is acceptable for low-value crops such as potatoes, carrots or onions, but as the value increases consideration has to be given to more accurate means of filling. One way of minimizing this effect is to grade the crop prior to packing and then use only the smaller, until at pack sizes of 5 kg and less the individual bag weight would usually be recorded and the appropriate price attached. The actual weathers themselves are very accurate within the limitations of measuring a bouncing crop, which has just fallen into the weigh hopper. One way of dealing with this is to

incorporate two hoppers, one just above the other so that the upper one takes the major impact load and then feeds relatively gently into the lower one for check weighing and final topping up.

Small bag packs

A wide variety of small bag packing machinery is available based on the same principles as the larger bulk packers. Most of these are fully automatic and capable of handling up to 12 packs min^{-1} for weight weights up to 7 kg. This leads to an output of about 3-5 tones $hour^{-1}$ depending on the crop. Smaller packs can go through a machine more quickly and so 3 kg packing machines are available with throughputs of up to 24 bags min^{-1}. Semi-automatic machines have a significantly smaller throughput but naturally the cost less. Throughputs of up 400 packs hour-1 may be expected, with pedal operation for pack sizes up to 7kg.

The smaller the pack size the more important is the need for accuracy in weighing .An alternative to the variable-priced package is the multiple-hopper feed system where up to 10 small hoppers may be filled with produce and individually weighed. A computer rapidly identifies the best combination of hopper weights to provide the ideal weight combination. Accuracies to within 5 kg are possible with this machine on corps such small onions.

Netting

The film difference between the operation of a netting machine and a bag packing machine is that in the former the netting is carried on a tube and possible requires more frequent replacement than the polyethylene bag, which is carried on a much longer cassette. Sealing of the plastic film is simply by heat sealer while the netter is closed by a double metal clipping device which closes the top of one net at the same time as the bottom of the next net. A knife then comes between the two clips to separate nets. The lower one goes off on a conveyor for stacking while the upper one awaits the next charge of produce.

Both nets and film packs can have a label attached showing the weight, the cost per kg, the retail price, the name of the retailer and any other reference coding.

Ergonomics of packing

The general principals of ergonomics apply equally well to packers as to any manual worker. In addition to the physical layout of the workstation there is also the morale and comfort of the worker. If any of these things are not considered low production can result.

Lighting of packing area

The light intensity in any inspection zone obviously has to be at a high level to avoid eyestrain, but also to guarantee an adequate sight of the fruit.

Worker environment

The workers should be comfortable. The temperature, humidity, air condition, ventilation and noise level must be controlled to give a tolerable environment. Ear defenders may be necessary in certain places where the noise level suppressed, but these are not very comfortable for permanent wear and should be avoided if possible by removing the source of noise from the packer. Music is often provided to prevent excess boredom, and although this can be provided in ear defenders it is still not ideal. Workers located in convivial grouping can also improve morale. Isolated workers often feel dehumanized and more like a machine than an individual with a personality.

The quality of the floor is also to be considered, especially in developing countries where the workers might have very poor-quality shoes. Elevated platforms on many machines do not provide the best flooring for long periods of standing so some form of matting or boarding is recommended.

The choice between sitting and standing is another issue, which needs to be addressed. Both approaches are used. Generally, if the packers need to stretch, as for visual inspection across a conveyor belt, then they usually stand. However, if the crop can be presented close to hand then the workers would normally prefer to sit.

Packaging movements

Assuming the worker is standing, the typical layout of the workstation is described by Peleg (1985). The crop should fall readily to hand in both the vertical and the horizontal planes as it flows from the grader or conveyor. It should not be necessary to move the arm excessively. If the crop is delivered accurately to the right place to be packed up then little more than wrist movements should be needed to take it from the delivery tray to the box.

Larger crops are often allowed a wider space from which to be collected, so that at least two items may collect side by side in readiness to be packed. The delivery should arrive at the same height as the rim of the box. There may be a small stopper to prevent the fruit actually falling in to the box, but not a significant obstacle over which the hand must lift the fruit. The fruit may arrive both in front of the box and at either side of it. In this way the hand can lift a fruit, which is nearest the empty space in the box, thus having the minimum distance to travel. A comfortable height for the top rim of the box is between 5 and 10 cm above waist or belt height for most people.

There is different preference among workers about whether they should sit or stand, although there is rarely a choice for a particular team of workers. Usually they all sit or they all stand. If they wish to sit the only requirement is that they can reach out easily for the empty boxes, separators and dividers. Chairs have again to be of adjustable height.

In all cases ample supplies of empty boxes and separators must be readily to hand. The empty boxes are often provided on a rail passing above and behind the workers and the other recruitments at one side. The empty boxes should therefore be positioned within range of a combined arm and single step movement for quick and easy grasp.

Discharge of the full boxes is often by hand or foot lever. This is far superior to the simpler and cheaper method of lifting the box, twisting sideways and placing it on a stack or roller conveyor set behind the workers. This could clearly lead to injury if carried out for a prolonged period.

The position of the box should be as near as possible to the body of the worker so that there is always a clear view into the bottom of the box and the arms. do not stretch too far. Regular rests and breaks will ensure that the workforce does not get overtired and that a high level of efficiency is maintained.

Once all the above principles have been observed a high packing efficiency can be expected which is likely to be much more cost and time effective than a fully automatic machine. A robot of this type is probably possible with existing technology but is not commercially available. This situation may well change in the future.

Safety and hygiene of the workforce

In some countries there are strict laws to control the health and safety of all workers as well as the consumers, and these, of course, must be adhered to. For example, Codex alimentarius (1985) Volume A provides a recommended international code of practice. Further information is given in EC council Directive 93/43/EEC on the hygiene of foodstuffs.

Clothing that is suitable for each task should be provided. Most workers will be engaged on inspection of packing, which requires simply an overall, a cap or hat and probably rubber gloves if preferred. The overall will often be of the coat type with a zip or button front. Trousers or skirts will be open to personal choice, although some employers may well provide trousers for work in what is often a cool, draughty and elevated position. Shoes would also commonly be provided, with a firm, non-slip sole and sturdy foot support. Boots are not normally necessary but the lighter, ladies fashion shoes and high heels etc. must clearly be avoided.

4.5 The Use of Plastic as a Packaging Material: Discussion

The use of agricultural by-products and locally available biodegradable plant materials has been highlighted in as the preferred source of raw materials for the manufacture of high class, customer attracting and produce quality-enhancing packages. Although our main focus in this work is on biodegradable, environment friendly natural products as the raw material for packaging perishable produce, other packaging materials are now discussed in this study, keeping in mind the requirements of the global market and the demand of Bangladeshi exporters of horticultural produce to the overseas market. We still believe and hope that in future agricultural by-products and plant materials will be the main materials for packages for agricultural produce. Improving present design and fulfilling the requirements of exporters and consumers could achieve this. As this transition from present day synthetic products to the natural product cannot be achieved overnight, we have to use the synthetic packaging materials suitable for special produce and special environment. Some of these packaging materials will now be discussed.

Although special packaging materials are all expensive and beyond the reach of ordinary fruits/vegetables producers and traders, still a few world class

packaging materials are required by some exporters and their number is increasing day by day. As a result of introducing the Bangladeshi fruits and vegetables in the global market, the forward-looking exporters who are quite knowledgeable on the requirements of the global market will look for special packaging acceptable by consumers and traders alike.

Presently this type of special packaging is used by only a few Bangladesh exporters for some highly perishable, high value exotic fruits and vegetables, which require special handling and packaging. But with time, demand for this special packaging will increase even in Bangladesh as the Bangladeshi fruits and vegetables are enjoying increasing acceptability in the global market. The crops which will benefit most from this kind of packaging are litchi, custard apple, mangoes, tomatoes, mushrooms and fruits like Latkan, Betol, Dheper which are non-conventional wild fruits are becoming commercial commodities and in many areas these wild fruits and vegetables are being cultivated in a scientific way.

Use of Plastic as a packaging material, especially for food items is condemned by environmentalists all over the world because it imparts negative impacts on the environment as it goes into landfill and leeches chemicals or becomes litter. However, the technology of plastic/polymer has attained such a height, that it is now very hard to abandon it. We have to wait until the packaging materials made of biodegradable natural products attain the same quality as plastic packages if not superior quality. Until then, we have to hang on to these versatile packaging materials for our horticultural business, knowing all the adverse effects of using this material. Research in this sector is also advancing to produce bulk quantity of biodegradable plastics and without any harmful effect of radiation and carcinogens.

Biodegradable plastic are a new generation of polymers emerging on the Bangladeshi market. Biodegradable plastic have an expanding range of potential applications, and driven by the growing use of plastic in packaging and the perception that biodegradable plastic are 'environmentally friendly', their use is predicted to increase. However, issues are also emerging regarding the use of biodegradable plastic and their potential impacts on the environment and effects on established recycling systems and technologies.

There are some biodegradable plastic listed below which environmentally friendly. Such as-

- Starch based products including thermoplastic starch, starch and synthetic aliphatic.
- Polyester blends, and starch and Polyvinyl alcohol (PVOH blends.
- Naturally produced polyesters including Polyvinyl blend (PVB), polyhydroxybutyrate (PHB) and Poly-hydroxybutyrate-co-polyhydroxyhexanoates (PHBHs).
- Renewable resource polyesters such as Polylactic acid (PLA).
- Synthetic aliphatic polyesters including Polycaprolactone (PCL) and Polybutylene succinate (PBS).
- Aliphatic-aromatic (AAC) co polyesters.
- Hydro-biodegradable polyester such as modified PET.
- Water-soluble polymer such as polyvinyl alcohol and ethylene vinyl alcohol.

The plastic recycling collection, sorting and reprocessing industry is established in Bangladesh. This situation has led to the development of a viable plastic reprocessing industry in Bangladesh. The plastic reprocessing industry and policy makers are concerned about the potential impact of biodegradable plastic on the current mechanical recycling industry and its continued expansion.

One of the challenges faced by the plastic recycling sector over the past decade has been to build confidence in the technical integrity of the reprocessed material and to demonstrate its ability to perform as a viable alternative to virgin plastic.

Plastic sorting and separation is required to produce quality end products and maximize economic return. Most plastic are mutually incompatible with each other. If incompatible plastic are melt blended (by extrusion) then on cooling the mixture phase separates and the resultant products usually have low mechanical properties since cracks develop through the plane of weakness between the immiscible phases. Plastic enrichment and purification to a level to enable marketability of the recycled is therefore necessary.

4.6 Controlled atmosphere packaging: benefits and costs

Improved packaging systems for fresh fruits and vegetables are very important to enhance the shelf life and prevent spoilage of the produce. Recent work on improvement of existing packaging systems is going on in many countries including third world countries longing to export fresh produce. Among the many modifications of the packaging system is atmosphere packaging used in the storage of fresh fruits and vegetables. The term refers to their storage in plastic films, which restrict the transmission of respiratory gases. This results in accumulation of carbon dioxide and depletion of oxygen around the crop, which may increase their storage life. (Kader et.al 1989 b).

The actual concentration of the gases in the crop will also be affected to a limited degree by the amount of space between it and the plastic film, but mainly by the permeability of the film; this is affected by the chemical properties of the film, its thickness, temperature and humidity. Several different plastics are used for this purpose. Some of these are listed below:

Cellulose acetate (CA)
Ethylene vinyl alcohol copolymers (Evotton EVAL)
High- density polyethylene (HDPE)
Linear low-density polyethylene (LLDPE)
Low-density polyethylene (LDPE)
Polyethylene terephthalate (PET)
Polystyrene (PS)
Polyvinyl Chloride (PVC)
Polyvinyl dine Chloride (PVDC)

A range of high-shrink, multiple high-speed machinable shrink films made from polyolefin are available. Polyethylene is also used for shrink film packaging. Their permeability to gases (including water vapor) varies with the type of material from which they are made, temperature, in some cases humidity, the accumulation and concentration of the gas and the thickness of the material.

The changes in the atmosphere inside the sealed plastic film bag depends on the characteristics of the material used to make the package, the environment inside and outside the package as well as the respiration of the produce it contains. Changes in gas content may take some time to reach equilibrium,

but gas flushing can accelerate the speed at which the atmosphere is changed. Figure shows the effects of flushing chilli peppers stored in plastic film with mixture containing 10% carbon dioxide and 1% oxygen compared to no gas flushing (Zagory 1990).

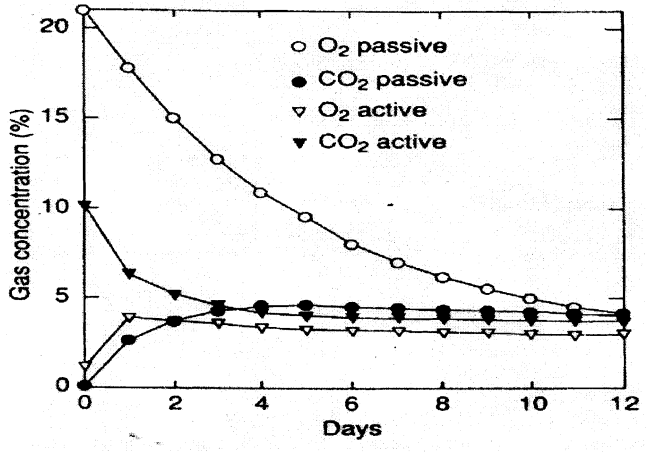


Fig 1: Simulation of a passive versus active modified-atmosphere pack aging of 'Anaheim' chilli peppers at 10°C in Cryvac ssd-310 (source: Zagory 1990)

The number of fruit packed in each plastic bag can influence the effect. An example of this is that plantains packed with six fruits in a bag ripened in 14.6 days at 26-30°C compared to 18.5 days when fruits were packed individually (Thompson et al 1972)

Table 1: Effects of wrapping packing material on ripening and weight loss of plantains stored at tropical ambient conditions of 26-34° C and 52-87% rh (source: Thompson et al 1972)

Packing material	Days to ripeness	Weight loss at ripeness (%)
Not wrapped	15.8	17.0
Paper	18.9	17.9
Moist coir fibre	27.2	(3.5)*
Perforated polyethylene	26.5	7.2
Polyethylene	36.1	2.6
LSD (P=0.05)	7.28	2.81

*The fruit actually gained in weight.

Mathematical models have been developed (Cameron et al 1989, Lopez-Briones et al 1993) which can help to predict the atmosphere around fresh produce sealed in plastic film bags.

Zagory (1990) also demonstrated the relationship between weight of produce in a package (20*30 cm) and its oxygen and carbon dioxide content for one type of plastic film. The relationship between oxygen and carbon dioxide levels was linear, but varied considerably with a fourfold variation in produce weight, which illustrates the important of varying just one factor. The gas permeability of some plastics used for film packaging is sensitive to environmental humidity.

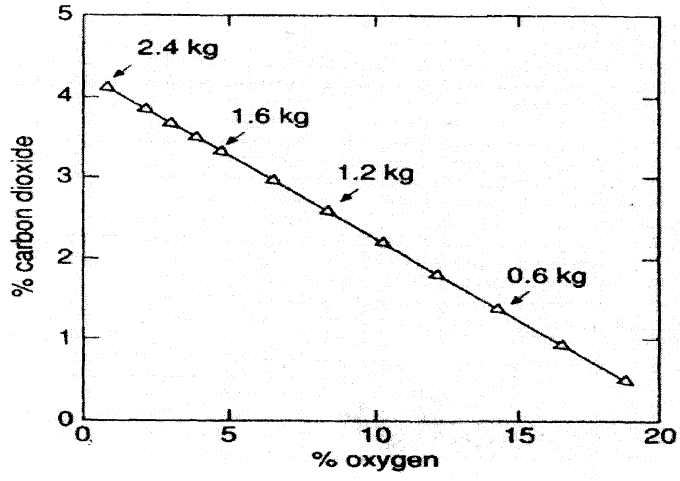


Fig 2: Equilibrium gas concentrations in a modified-atmosphere package as a function of product weight for 'Anaheim' chilli peppers in Cryovac SSD-310 (source: Zagory 1990)

Robarts (1990) showed that gas transmission of polyamides nylons can increase by about three times when the relative humidity is increased from 0 to 100%, and with ethyl vinyl alcohol copolymers the increase can be as high as 100 times over the same range.

'Active packaging' of fresh produce has been carried out for many years. This usually involves the inclusion of a desiccant or oxygen absorber within or as part of the packaging material. These are mainly used to control insect damage, mould growth, rancidity and discoloration in a range of perishable food products, such as meat, herbs, grains, beans, spices, and dairy products.

Table 2: Effects of number and size of perforations in 3 1b (1.36kg) 1502 gange polyethylene film bags of yellow globe onions on the relative humidity in the bags, rooting of the bulbs and weights loss after 14days at 24°C (Source : Hardenburg 1995)

No.of perforations	Perforations size (mm)	% rh in bag	% onions rooted	% weight loss
0			71	0.5
36	1.6	88	59	0.7
40	3.2	84	40	1.4
8	6.4		24	1.4
16	6.4	54	17	2.5
32	6.4	51	4	2.5
0		54	0	3.4

*Kraft paper with film window

A major source of deterioration of limes during marketing is their rapid weight loss, which can give the skins a hard texture and an unattractive appearance. Packing limes in sealed polyethylene film bags inside cartons resulted in a weight loss of only 1.3% in 5 days, but all the fruits degreened more rapidly than those, which were packed just in cartons, where the weight loss was 13.8% (Thompson e al 1974d). However, this degreening effect could be countered by including an ethylene absorbent in the bags.

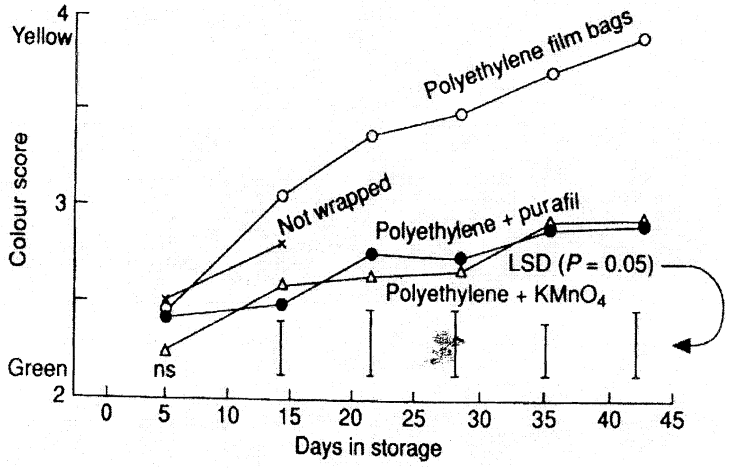


Fig 3. Effects of packaging on the colour of limes during storage at Sudanese ambient condition of 31-34°C and 29-57°C rh (source: Thompson et al 1974)

Plastic film wraps have been developed which can give protection as well as modified atmospheres to produce. One such packaging system is being marketed as 'Air box', but because of the cost, the space taken up by the package and the difficulty in packaging it has only limited application in the fresh produces industry.
Partially ripe tomatoes, packed in suitably permeable plastic film giving 4-6% carbon dioxide and 4-6% oxygen with about 90% rh, can be expected to have 7 days longer shelf life at ambient temperature than those stored without wrapping (Geeson 1989). Under these conditions the eating quality should not be impaired.

Table 3: Commercially available films in Japan (source: Abe 1990)

Trade name	Manufacturer	Compound	Application
FH film	Thermo	Ohya stone/PE	Broccoli
BF film	BF distribution film	Coral sand/ PE	Home
Shupack V	Ashai-kasei	Synthetic-zealite	-
Uniace	Idemitsu pet chem.	silicagel mineral	Sweetcorn
Nack Freshs	Nippon Unicar	Cristobalite	Broccli And sweetcorn
Zeomic	Shinanen	Ag-zeolite/PE	

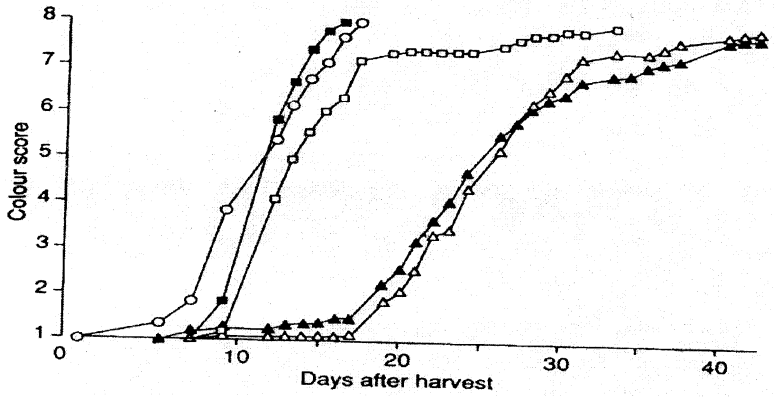
But film packaging those results in higher carbon dioxide and lower oxygen levels may prevent ripening and result in tainted fruit when the fruit are ripened after removal from the packs. Geeson (1989) also showed that film packages with lower water vapor transmission storage properties can encourage rotting. Modified-atmosphere storage in polyethylene bags has been shown to extend the storage life of bananas (Scott et al 1997). Their storage life was extended for 6 days compared to non-wrapped fruit at 20°C. In a subsequent trial, bananas were packed in 13.6 kg commercial packs inside polyethylene film bags. During 48 hours transport to Australia the fruit could be kept in good conditions at ambient temperatures and then be held in a commercial ripening room for several days, and still had a low weight loss, good flavor and nice appearance when subsequently ripened (Scott et al 1971). Satyan et al (1992) stored Williams bananas in 0.1 mm

thick polyethylene tubes at 13, 20 and 28 °C, and found that their storage life was increased two to three times compared to unwrapped fruit. Fruits sealed in polyethylene tubs with ethylene absorbents could be stored for 6 weeks at 20 °C or 28 °C and 16 weeks at13 °C (Satyan et al 1992).

Latundan bananas (Musa AAB) can be stored in 0.08 mm thick polyethylene bags at ambient temperature of 26-30 °C for up to 13 days, before color break down upon exposure to air (Abdullah and Tirtosoelotjo 1989, Abdullah and pantastico 1990). Tiangco et al (1987) also observed that the green life (preclimacteric period) of saba bananas (Musa BBB) held in modified – atmosphere conditions at ambient temperature was considerably longer than those stored in air.

Combining both modified atmosphere and refrigeration can further extend the preclimacteric period of bananas. Tongede (1988) found that the green life of Kluai Khai fruits (Musa AA) could be maintained for more than 45 days in polyethylene bags at 13 C. This is more than 20 days longer than fruits stored at 25 °C under the same treatment. Nair and Tang (1988) reported that pisang mas had an extension of 4-6 weeks at 17 °C when it was stored in evacuated collapsed polyethylene bags by applying vaccum not exceeding 300 mmHg. A more practical method was to wrap the fruits in polyethylene film, which reduced fruit weight loss by evapotranspiration and slowed down banana respiration, modifying the atmosphere in the packs allowed fruits to be stored for several weeks (Marchal and Nolin, 1990)

Plantains stored in modified atmospheres had a considerably longer post harvest life than those stored unwrapped. Plantains stored on polyethylene, which had holes in it, ripened at the same speed as unwrapped fruit, and although the speed of ripening was more variable in fruits packed in perforated polyethylene (Thompson et al 1972a).



o = Unwrapped, Δ = Polyethylene, □ = Perforated Polyethylene (individual fruits),
▲= Polyethylene (evacuated) ■ = Perforated Polyethylene 6 (fruits)

Fig 4: Effects of wrapping material on the change on the change in skin color of plantains during storage in ambient conditions in Jamaica (Source: Thompson et al 1974c

Generally, the acceptable time, which fruit can remain in a modified atmosphere, varies with cultivars and storage conditions respectively, but it is usually 2-4 weeks, which meets the requirement of export shipment and marketable life.

Investigations into the effects of modified-atmosphere conditions were made by Ali Azizan (1988, quoted by Abdullah and Pantastico 1990). He observed that the total soluble solids, total titratable acidity and Ph in pisang mas did not change during storage in modified atmosphere at ambient temperature. However, wills (1990) mentioned that an unsuitable selection of packaging material can still accelerate the ripening of fruits or enhance carbon dioxide injury when the ethylene accumulates over a certain period.

Modified-atmosphere packaging is expensive packaging. Most of the farmers of Bangladesh are poor and they would not able to afford it. There are very few rich farmers' able to afford it. They are using this type of packaging for some valuable major fruits such as- Mango, Lychee, Papayas, Potatoes, Pumpkins, Tomatoes, Radishes, Beans, Cucumbers, and Ladies

Fingers etc. However, in domestic markets, price-spread between the glut and the lean seasons are found to be very wide. In addition, the availability of fresh fruits and vegetables at reasonable price, particularly during lean period remains extremely limited. One of three major reasons for these drawbacks is, probably, the slow pace of developments in post-harvest sector in comparison with that of contemporary developments in production sector.

For better utilization of increased production, developments as well as proper implementation of appropriate post-harvest technologies together with the development of infrastructural facilities assume great importance. These measures would go a long way in providing quality produce at reasonable price in domestic market, and would also help in promoting export significantly. In horticulture sector, Government of Bangladesh has given major trust on technology development for various post-harvest operations including packaging and storage.

Processed fruits and vegetables products are becoming increasingly common throughout the world since these are convenient, ready-to-eat, toothsome, appealing and durable. However, in general, processed products are no substitute for fresh wholesome fruits and vegetables. Fresh fruits vegetables are the rich sources of mineral, vitamins and dietary fibers and hence are considered an integral part of any dietary system. Thus, fresh fruits and vegetables always enjoy good market demand. However, most fruits & vegetables are seasonal and have short-life. Moreover, they begin to lose their orchard freshness shortly after they are harvested. One of the major objectives of Modified Atmosphere Packaging (MAP) is retain the orchard-freshness of the packaged produce for longer periods.

By employing Controlled Atmosphere (CA) storage technology, the storage life of various fruits and vegetables can be increased between 2 and 4 times the normal life. However, CA stored produce deteriorate rapidly when exposed to normal atmospheres during marketing etc. It shortens the post-storage life of the produce, which eventually affects marketing. In this context, it is relevant to mention here that in Bangladesh, fruits and vegetables are commonly transported, retail stored and marketed under ambient conditions or at best, under refrigerated conditions. The involvement of bulky and sophisticated equipment limits the use of CA technology during transport as well as retail storing of fruits and vegetables. The construction of airtight storages and continuous monitoring as well as

controlling of storage air composition makes the technology cost-intensive. Thus, in view of the existing transport, retail storage and marketing facilities in Bangladesh, the scope of CA storage technology is restricted to the bulk storage of fruits and vegetables having high commercial value.

The production of plastics is not without pollution and other environmental risks, but many uses of plastic helps to conserve energy and reduces pollution such as recycled and reuse of plastic packaging can reduce environmental pollution. Plastic packaging is able to protect the fruits and vegetables from the external influences such as oxygen or microorganisms and sometimes light. They are also capable of reducing the loss in various components of the food such as water and flavors. From this protection, plastic packaging enables the consumers to purchase foods in completely hygienic conditions and to store them without loss of quality over an extended period of time. Issues like the lifecycle cost of a product in energy, materials consumed and pollution generated increasingly are taken into account when businesses, policy makers and consumers in Bangladesh consider the environmental impact of plastics and other raw materials. Recently, the government of Bangladesh banned polythene bag because it has long-term bad impact for environment. Consumers are also aware about this bad impact and they use jute or paper made bags.

The plastics recycling collection, sorting and reprocessing industry is well established in Bangladesh, from pre-consumer industrial scrap right through to post-consumer domestic packaging materials. This situation has led to the development of a viable plastics reprocessing industry in Bangladesh. The plastics reprocessing industry and policy makers are concerned about the potential impact of biodegradable plastics on the current mechanical recycling industry and its continued expansion. One of the challenges faced by the plastics recycling sector over the past decade has been to build confidence in the technical integrity of the reprocessed material and to demonstrate its ability to perform as a viable alternative to virgin plastics.

Chapter 5

Towards Improved Transportation Practices

As stated in earlier chapters, Bangladesh is gradually emerging into the international market with fresh agricultural produce. In order to compete in the market, standardization of the produce and packages is essential. As in other developing countries, because of a lack of proper knowledge in packaging and preservation, much perishable agricultural produce is wasted in huge quantities. Seasonal fruits and vegetables could be transported to distant places and exported to other countries if proper packaging and presentation techniques using low cost and appropriate technology were to be developed.

Damage in transit is one of the oldest problems in packaging. Complete eradication of damage is not a realistic goal, because all hazards that packages meet cannot be anticipated and are mostly accidents. Protection is required against the average hazard encountered and not against the most severe that might occur in any particular journey.

In the previous chapter, improved packaging practices were discussed. In this chapter, the focus changes to methods of transport, specifically, what needs to be understood and how transport practices could be improved. To link the two issues, we will first consider the relation between packaging and modes of transport.

5.1 Modes of transport: effect on packaging selection

The first step in selection of a package for a specific product and for a particular target market is to form a clear picture of the distribution pattern, which the product must follow. To do this, a distribution model should be drawn up.

The method of transportation is one of the most important factors to be considered in the choice of packaging to be utilized. Transport costs are considerable in the fruit and vegetable trade. And consequently packing should be chosen to minimize these costs. Each distribution model viz. Road, air transport and water transport, has its particular characteristics with respect to the available technology, constraints on package dimensions and stresses imparted on the packaged goods. Due to the difference in demands, a package designed for a particular distribution pattern will not be suitable for other distribution patterns without some modifications.

Road transport mode

The principal problems in road transport are vibration (repetitive shock) and bouncing of the packaging due to resonance of loading and the suspension system characteristics of the vehicle concerned and also the road conditions. Vertical vibrations cause more damage to produce than lateral and longitudinal vibrations. In order to prevent damage due to vibration, high headspace in the package should be avoided. Open trays should be equipped with net, film or paper covers secured to the tray. Also some fruits are very sensitive to orientation while considering injuries like bruising. Hence it is particularly important that the correct orientation is maintained during road transport.

Even though stacking height in practice (approx.2m) is moderate in transport because poorly maintained vehicles and road, vibration results in the reduction in the stacking strength of the boxes.

Insulated vehicles are not adequate due to respiration by fresh produce. Temperature controlled vehicles (refrigerated trucks) are desirable. In places where temperature controlled vehicles are not available, the temperature can also be brought down by using liquid nitrogen of ice bunker system. It is desirable to transport the produce during night time if no other means are there to control the temperature to prevent transpiration losses. Normally there is no facility in the vehicles to produce high humidity and maintain it. But since the produce gives off moisture, humidity within the vehicle will be normally very high.

Air Transportation Mode

Compared to all other modes of transport, air transport is less hazardous. Air transport involves high costs and can be used only for highly respiring and transpiring commodities like leafy vegetables and cut flowers whose shelf life is very short. Any damage due to the produce in air transport is due to the associated ground operations and rough handling. The major hazard during transportation arises out of a relatively high frequency vibration from the aircraft engines and relatively low temperatures and pressures associated with flying at high altitudes in unheated and non-pressurized cabins. The low pressure results in the loss of weight of the produce and it loses its freshness at the arrival destination. In aircrafts no cooling facility is available. The precooled product will keep sufficiently cool for long until it can be recooled at the destination point. This is true as long as there is no

delay in starting and landing of aircrafts. The problem will be serious if there is delayed transportation, because of lack of proper facilities in airports for cooling and holding. The quality of the produce gets affected due to heat produced during respiration.

The packages in aircrafts can be loosely handled, on pallets or in containers. The size of consignments varies from a full load to a few packages. Mixed consignments are frequent, but this raises difficulties in handling and sorting operations.

Sea Transport Mode

The hazards of this mode of transport are strongly dependent on storage conditions. The produce is normally stacked 6-10m high and subjected to low frequency vibrations from the engine and propellers. In addition, pitching and rolling of the vessel can result in appreciable stresses, particularly in the lower levels of the cargo. Regarding environmental conditions in ship transport, temperature and air refreshment control is very much required due to the length of the time involved. The produce should be pre-cooled to a desired temperature before loading into the ship. The refrigerated containers will maintain only the precooled temperature. Ventilation has to be sufficient in the container in order to prevent accumulation of carbon dioxide and ethylene. The venting in the refrigerated container can be adjusted between 30 to 150 cubic feet per minute depending upon the type of produce. For some produce it is essential to maintain very high humidity in the container, to prevent weight loss shriveling of the produce due to moisture loss. Mechanical humidity control is normally not possible in ship transport. Hence it is essential to prevent the moisture lose by some packaging means. The moisture loss in the produce due to venting is less because the relative humidity outside the container is very high (85-95%)

In the case of corrugated fiberboard boxes, the risk of collapse of the box during stacking is very high due to high humidity surrounding the packages and also the length of time involved in transportation. The former can be overcome by using some water resistant coating on the corrugated fiber boxes between the two surfaces of the outer liner. High air humidity increases the risk of rusting of staples, nails, strapping seals and other steel components. For packaging of fresh produce, galvanized components could solve this problem. Alternatively use of these can be avoided and replaced by hot melt gluing of joints and heat sealing of straps.

5.2 Actions to address transportation problems

Inadequate transport conditions, unsuitable containers and improper handling and stacking are some factors which contribute to serious product damage during transport. The losses are estimated to millions of rupees worth. A vital step to eliminate this problem is to reduce wastage by taking into consideration the following factors:

1. Long distance transport:
Use rigid containers to protect commodities better. They do not break easily and protect the produce from injuries.

2. Heat builds up and gas concentration:
Arrange the containers to allow air circulation freely on pallets or in containers. This prevents heat build-up of commodities and allows free exchange of gases in between the commodity and the environment.

3. Use of traditional containers such as bamboo baskets etc.
Use newsprint, dried leaves of paddy straw to line the sides and bottom to protect the commodity from injuries due to sharp edges.

4. Under packed and over packed commodities:
Ensure that commodities are not under-packed or over-packed. Under-packaging results in more vibration damage while over-packaging increases damage due to compression.

5. Control of respiration and transpiration:
Transport the commodities preferably at dawn or night when temperature is low. This inhibits fast respiration and water loss of product.

6. Jerk injuries to commodities:
Make sure that transport vehicle does not make jackrabbit starts.

7. Up down movement of containers inside the vehicles:
Use transport vehicles with good shock absorbers.

8. Space for ventilation in the vehicle:
Allow space between the cover/top of truck and the produce for ventilation.

9. To reflect the heat of sun during day time transport:
Paint the canvas/roof of the truck with white color.

10. Use of deep containers:
Avoid using deep containers since the produce at the bottom will be more prone to compression and injuries.

11. Placement of fragile materials inside the vehicle:
Load more fragile materials near the centre of vehicle since the vibration input are less compared to front and near ends.

5.3 The Cool Chain

Harvested fruits and vegetables are still organic matter, they continue to respire and lose water, and as a result they suffer from detrimental changes. To inhibit or minimize these post harvest changes transportation system should be redesigned and /or modified. It is not possible to improve the quality of the produce after harvest, but it is possible to slow down the rate of undesirable change by the modification of transportation system. The main aim of modification is to ensure the slowing of crop deterioration, so that fruits and vegetables reach the market in the exact condition as required by the purchaser / consumer.

All the modes of transport identified (road, rail, water and air) require a cooling facility to be provided in order to keep the farm produce in good quality and to slow down the deterioration process.

Transportation is a long chain, from farm to ultimate consumer, to deliver farm produce to the ultimate consumer in good quality, keeping its aroma and taste. Refrigerated transportation associated with necessary cooling facility constitutes the "cool-chain" and plays an important part in post-harvest operation.

The following points should be checked for effective cool-chain transportation:

1. There should be adequate refrigeration capacity.
2. Vehicle and load should be pre-cooled.

3. Air circulation should be uniform and adequate.
4. Stacking pattern and package design should allow adequate air circulation.
5. Loading and unloading should be done quickly and carefully.

The present transportation system for carrying fruits and vegetables can be modified by making provision for cooling and ventilation, providing better handling facilities at platforms and providing special storage space till the goods are delivered. Similarly, road services can be considerably improved with smooth surfaces for speeding up transportation with refrigerated facilities. Proper transport management is essential in modern horticulture. Good transport requires effective packing, palletization, stacking, proper temperature, air circulation and ventilation.

Transport vehicles should be well insulated to maintain cool environments for pre-cooled commodities and well ventilated to allow air movement through the produce. During transport, produce must be stacked in ways that minimize damage, and then be braced and secured. An open-air vehicle can be loaded in such a way that air can pass through the load, and provide some cooling of the produce as the vehicle moves. Traveling during the night and early morning can reduce the heat load on a vehicle that is transporting produce.

Mixed loads can be a serious concern when temperature optima are not compatible (for example, when transporting chill sensitive fruits with commodities that require very low temperatures). High ethylene producers (such as ripe bananas, apples) can induce physiological disorders and/or undesirable changes in color, flavor and texture in ethylene sensitive commodities (such as lettuce, cucumbers, carrots, potatoes, sweet potatoes). (Lisa Kitinoja et al, 1995)

As said, transportation is a long chain, from farm to ultimate consumer. In most part of this chain, cooling facility is essential to keep the quality of the produce at a level desired by the consumer. Refrigerated transportation associated with necessary cooling facility constitutes the cool chain and plays an important part in post harvest operation. In addition to refrigerated transportation system, design modification of the existing transport system should be carried out to reduce damage of the produce during transportation at different levels due to pressure improper handling and shock.

Looking at the traditional practices of handling and transporting fresh farm produce, especially fruits and vegetables, it can be concluded that fresh farm produce was sold in the market place with no packaging. For example, banana branches are carried from the field balanced on people's shoulders, but bruising and neck damage to the banana fingers is normally the consequence. Wooden trays padded with plastic foam on which the branch is placed will reduce this damage (Stamford et al 1971).

5.4 Other considerations in transporting fresh produce

Another common practice of transportation of fresh farm produce is the use of second hand containers. Harvesting and transporting produce in cartons, wooden boxes or metal containers which have been used for other commodities, is common practice for small-scale farmers in many developing countries. Second hand containers must be clean, especially where they are used for products, which are to be consumed unwashed and uncooked, because of the contamination risk (John Love 1994).

In general, horticultural produce is marketed as rapidly as possible after harvest since most fruits and vegetables have short post harvest lives. It is, therefore advisable to keep the produce after harvesting under optional environmental conditions (temperature, humidity etc.) to slow down any post harvest changes. During transporting and storage the packaged produce faces numerous hazards: mechanical, environmental or biological.

The transportation of perishable horticultural produce to the customer requires selecting the fastest and most efficient mode of transport that will deliver the shipment in the best possible condition at the lowest possible time and cost. Rail and roads are the two important modes of transport in Bangladesh for movement of goods. Railways can play a very significant role in the shipment of fruits and vegetables by improving the movement of trains carrying fruits and vegetable.

For the management of fresh produce (fruits and vegetables) attention should be given to the following:

1. Loading and unloading should be done carefully and fast.

2. Stacking pattern and packaging design should allow adequate air circulation.
3. Air circulation should be uniform and adequate.
4. For refrigerated transportation vehicle and load should be pre-cooled.
5. Vehicle and load should be pre-cooled.

While good quality road and rail transport can assist farmers in getting their produce to urban markets, transport infrastructure can improve rural life in other ways. Farm transportation plays a key role in the agricultural and economic development of Bangladesh as it provides access for extension agents to transfer new and improved agricultural technologies to the rural and farming communities, timely delivery of inputs to the farm and evacuation of harvests to the urban areas where they are mostly demanded. These ensure improvement in agricultural production, food availability in urban areas and improvements in the economy of the rural communities. As established, accessibility and mobility made available to rural farmers will help reduce isolation and poverty.

5.5 Towards an effective farm tranportation system

The vehicles found on farm routes in the area surveyed include bicycle, cars, buses, pick-up vans and trucks. Most farmers are linked to their farms and markets through footpath and seasonally traversable earth roads as a result of which produce are conveyed by human portage. Most of the farmers produce merchants and transporters respectively don't own any form of transport and hence depend on commercial transport which is scarce and expensive. A few produce buyers own vehicles, which they also use for other commercial activities. Most of the routes are footpaths and earth roads, which are often impossible especially during the rainy season when they are most needed. Poor condition routes for the evacuation of farm produce, particularly in the important wet season transportation period, characterize the current situation. There is a shortage of appropriate low cost transport vehicles and services. Crops losses are significant, control of transport is largely outside of the control of the producers and unit transport costs are unnecessarily high. This constrains agricultural income and market potential.

An effective farm transportation system depends on the availability of good condition vehicles and good routes that minimize the wear and tear to which

vehicles are subjected. Towards the provision of an effective transport system, the following recommendations are made.

a) It is recommended that road users associations able to mobilize labor and resources be formed because communal participation has proved to be an effective means of maintaining rural infrastructures including roads so that produce can be transported conveniently from farm to home and market.

   In many instances, only a small obstruction such as the development of a channel across the road, the collapse of a bridge or culvert renders some roads impassable. Such problems require remedial measures within the technical and economic limitations of the road users but the problems are left to aggravate because the users feel it is a government property. There is lack of commitment even though the road serves them.

b) It is suggested that loans be extended to farm transportation since there are prospects of loan recovery if handled with seriousness as it has been done with other schemes.

   A number of non-governmental organizations such as the Farmers' Development union have provided soft loans for farmers and farmers' associations for the acquisition of processing machinery which have been effectively managed and have improved the economy of such groups.

c) Both produce and persons compete for the bad conditioned vehicles on farm routes.

   If the country-wide transport services operated by the states were to be extended to some of these remote but memorable areas, the pressure on the existing commercial vehicles will reduce and become more available for the conveyance of farm produce. This will reduce the cost of transportation and food prices in the urban areas.

d) The local government must give priority to rural roads development through the recruitment of appropriate personnel and equipment to maintain existing routes and open up new ones.

Local governments were created for grassroots development including the provision of rural roads. There is apparent neglect of these roads by this level of government throughout the country.

e) Irrespective of economic indices, the wish of the national union of road transport workers and the road transport employers association of Bangladesh is a major factor in determining the fares paid on any route in Bangladesh. These bodies should regulate fares charged on farm routes taking into account the peculiar economic situation of the farming communities.
While the bad conditions of the farm routes are recognized, the fares on farm routes are too exorbitant.

6. Summary and Conclusion

The topic of my research, 'the problems of transporting and packaging of fruits and vegetables in Bangladesh' has been undertaken in the context of Bangladesh's recent emergence into the international horticultural market. In the past, fresh agricultural produce was sold mainly in local markets; occasionally wholesale traders used to procure from local markets in growing regions and transport fresh produce to city markets in traditional packing, such as jute bags, bamboo baskets, or simply bundled and transported in trucks within any packaging. This rudimentary practice of transporting resulted in loss of appearance, weight and quality thereby causing damage to the produce with huge quantities wasted, as such produce was not acceptable to the buyers. The present project was undertaken to address this problem and develop awareness among the horticulturists, vegetable growers and traders. The research has sought to clarify the problems and put forward solutions for packaging and transporting fresh agricultural produce and to contribute to skill development and entrepreneurship in this area of business.

During the present course of studies we have examined past and present practices of packaging and transporting, arranged various workshops to educate the growers and focused on the benefit of using better packaging and transporting system for fresh agricultural produce. Cost benefit analysis of packaging fresh produce was also carried out. We have also examined modern practices such as pack house operations and controlled amosphere packaging.

Problems identified in transportation and packaging in Bangladesh include: the grower's lack of knowledge; economic hardship; lack of training in proper packing and transport practice; poor transport infrastructure.

Past practice in packaging

In the past non-standardized packages were the major causes of the damage of fresh agricultural produce. These packages were also much overloaded, badly packed with little protection of the goods. In the past no serious considerations were given in designing packages and not much thought was given on the suitability of these packages. As a result loss of quality occurred frequently affecting acceptability of the produce to the consumer.

Present practice in packaging

Traditional packaging practice of the past is gradually giving way to modern practices in which packages are designed scientifically, keeping in mind the physico chemical properties of the produce. In current practice of designing and developing packaging items much attention is given to individual produce to increase shelf life, retain taste, freshness and acceptability.

Past practice in transporting

In the past lots of damage were incurred during transportation due to lack of knowledge about the physiology of horticultural produce. In the past post harvest loss of the fresh produce during transportation was very high and this was because the farmers were not adequately educated and trained to develop quality awareness.

In the past major cause of the produce during transportation was due to lack of proper sorting, grading, and rough handling during loading and unloading mishandling during packaging etc. Other factors identified in our study are use of large, non-rigid and off shaped packages during transportation. Use of ordinary rickshaw van, buses and/ or trucks overloaded with the produce and rough road condition.

Present practice in transporting

Although awareness is gradually developing among farmers and traders of fresh produce and some small improvements in transport practice can be made quite easily (such as careful and quick loading and unloading, stacking to allow for good air circulation, pre-cooling of produce, etc) this is still not adequate. Current transportation practice in Bangladesh needs lot of modification to prevent large-scale deterioration and damage of the perishable produce. The internal transportation scenario in Bangladesh is very poor and unorganized. The refrigerated transport is not adequate. More work needs to be done in this sector to develop fruitful and profitable fresh produce businesses..

Skills development and new product opportunities

This study had also emphasized was skill development of local farmers (producers) and sought to facilitate this by organizing various workshops, on topics such as pack house operations for fruit and vegetables. One of the major objectives of the present study was job creation among local youth

especially female population and value addition to locally available packaging materials, which we believe have accomplished to a considerable extent.

Lots of enthusiasm was observed among the participants who are willing to produce quality-packaging items using locally available raw materials. Follow up sessions were made to select really interested group who are willing to engage in this business. From each region one group of young unemployed people with primary level education were selected and trained for producing packaging items.

Extensive literature search and field trip during the progress of present study resulted in design and development of new packaging containers for fresh agricultural produce. These packaging containers are designed and developed keeping in mind: durability; resistance to shock impact during transportation; and keeping quality of the produce in storage and transportation.

During the literature search, it was felt that information related to design and development of packaging in Bangladesh is inadequate. After identifying the inadequacy of packaging design, emphasis was given in the present study to design appropriate packages for transporting fresh farm produce to different destination including overseas market. While designing new packages, attention was given to the use of locally available agricultural by-products to help waste minimization and produce positive impact on the environment.

We have kept in mind the socio economic condition of Bangladesh farmers, giving consideration to the pricing of our product so that it can be affordable to most of the farmers without affecting the quality and purpose for which they are designed and developed.

We hope that this work will open up a new avenue for the rural population, whereby they can find profitable employment, either as a self employed or working for other entrepreneurs who will set up small enterprises for production of containers according to our newly developed design.

1)

Appendix

Appendix -1(a):

FRUITS GROWN IN BANGLADESH

Sl.No.	English name	Local name	Scientific name	Family			
1.	Dessert Banana	Kola	< TD>	Dessert Banana	Kola	*Musa spp.*	Musacea e
2.	Plantain	Anazi kola	*Musa sp.*	Musaceae			
3.	Seeded Banana	Bichi Kala	*Musa spp.*	Musaceae			
4.	Mango	Aam	*Mangifera indica*	Anacardia ceae			
5.	Cashewnut	Kajubada m	*Anacardium occidentale*	Anacardia ceae			
6.	Hogplum	Deshi Amra	*Spondias mangifera*	Anacardia ceae			
7.	Golden Apple	Bilati Amra	*Spondias dulcis*	Anacardia ceae			
8.	Guava	Peyara	*Psidium guajava*	Myrtaceae			
9.	Jamun	Jam	*Syzygium cuminii*20>Ja m	*Syzygium cuminii*	Myrta ceae		
10.	Rose Apple	Golapzam	*Syzygium jambos*	Myrtaceae			
11.	Wax Apple	Zamrul	*Eugenia javanica*	Myrtaceae			
12.	Lemon	Elachi lebu	*Citrus limon*	Rutaceae			
13.	Lime	Kagzi lebu	*C. aurantifolia*	Rutaceae			
14.	Pummelo	Batabi lebu	*Citrus grandis*	Rutaceae			
15.	Wood apple	Bel	*Aegle marmelos*	Rutaceae			
16.	Mandarin	Kamla	*Citrus reticulata*	Rutaceae			
17.	Satkara	Satkara	*Citrus macroptera*	Rutaceaeo ptera			
Rutaceae							

18.	Taikar	Taikar	*Citrus sp.*	Rutaceae			
19.	Sweet Orange	Malta	*Citrus sinensis*	Rutaceae			
20.	Elephant's Foot Apple	Kodbel	*Feronia limonia*	Rutaceae			
21.	Coconut	Narikel	*Cocos nucifera*	Palmae			
22.	Palmyara Palm	Taal	*Borassus flabellifer*	Palmae			
23.	Date Palm	Khejur	*Phoenix sylvestris*	Palmae			
24.	Jackfruit	Kathal	*Artocarpus heterophyllus*	Moraceae			
25.	Monkey Jack	Deoa	*Artocarpus lakoocha*	Moraceae			
Moraceae							
26.	Aonla	Amloki	*Emblica officinalis*	Euphorbiaceae			
27.	Star Gooseberry	Arborai	*Phyllanthus distichus*	Euphorbiaceae			
28.	Lotka	Lotka	*Baccaurea sapida*	Euphorbiaceae			
29.	Litchi	Lichu	*Litchi chinensis*	Sapindaceae			
30.	Longan	Ashphal	*Dimocarpus longan*	Sapindaceae			
31.	Sapota	Shafada	*Achras zapota*	Sapotaceae			
32.	Star Apple	Taroka phal	*Chrvsophyllum cainito*	Sapotaceae			
33.	Pear	Nashpati	*Pyrus communis*	Rosaceae			
34.	Loquat	Loquat	*Eriobotrya japonica*	Rosaceae			
35.	River Ebony	Gab	*Diospyros peregrina*	Ebenaceae			
36.	Velvety Apple	Bilati Gab	*Diospyros discolor*	Ebenaceae			
37.	Persimmon	Parsimon	*Diospyra kaki*	Ebenaceae			
38.	Baichi	Baichi	*Flacourtia indica*	Flacourtiaceae			
39.	Flacourtia	Lukluki	*Flacourtia jangomas*	Flacourtiaceae			
40.	Carambola	Kamranga	*Averrhoa carambola*	Oxalidaceae			
41.	Bilimbi	Bilimbi	*Averrhoa*	Oxalidace			

			bilimbi	ae			
42lidacea e							
42.	Bullock's Heart	Ata	*Annona reticulata*	Annonaceae			
43.	Custard Apple	Sharifa	*Annona squamosa*	Annonaceae			
44.	Soursop	Tak Ata	*Annona mavricata*	Annonaceae			
45.	Kauphal	Kauphal	*Garcinia cowa*	Guttiferae			
46.	Daophal	Daophal	*Cearcinia xanthochymus*	Guttiferae			
47.	Pineapple	Anarash	*Ananas comosus*	Bromiliaceae			
48.	Jujube	Kul	*Zizyphus mauritiana*	Rhamnaceae			
49.	Papaya	Papay	*Carica papaya*	Caricaceae			
50.		50.	Avocado	Avocado	*Persa ameri cana*	Lauraceae	
51.	Elephant Apple	Chalta	*Dillenia indica*	Dilleniaceae			
52.	Fig	Dumur	*Ficus carica*	Urticaceae			
53.	Grape	Angur	*Vitis vinifera / V. labrusca*	Vitaceae			
54.	Indian Olive	Jalpai	*Olea europaea*	Oleaceae			
55.	Karonda	Karamcha	*Carissa congesta*	Apocynaceae			
56.	Passion Fruit	Passion Phal	*Passiflora edulis*	Passifloraceae			
57.	Phalsa	Phalsa	*Grewia asiatica*	Tiliaceae			
58.	Pomeg	Pomegranate	Dalim	*Punica granatum*	Punicaceae		
59.	Tamarind	Tentul	*Tamarindus indica*	Legumino sae			
60.	Water Chestnut	Paniphal	*Trapa bicornis*	Onagracea e			
61.	Macadamia nut	Macadami a nut	*Macadamia integrifolia*	Proteacee			

Appendix -1(b):

VEGETABLES GROWN IN BANGLADESH

Sl.No.	English name	Local name	Scientific name	Family		
1.	Cabbage	Bandhakapi	*Brassica oleracea var. capitata*	Cruciferae		
2.	Cauliflower	Phuer	Cauliflower	Phul kopi	*Brassa oleraa var. botryts*	Cruciferae
3.	Broccoli	Sabuj phulkopi	*Brassica oleracea var. italica*	Cruciferae		
4.	Kholrabi	Olkapi	*Brassica oleracea var. gongyloides*	Cruciferae		
5.	Chinese cabbage	China kapi	*Brassica chinensis*	Cruciferae		
6.	Petsai	Batisak	*Brassica chinensis*	Cruciferae		
7.	Saishin	Chinasak	*Brassica parachinensis*	Cruciferae		
8.	Mustard green	Sarisha sak	*Brassica campestris*	Cruciferae		
9.	Turnip	Shalgom	*Brassica rapa*	Cruciferae		
10.	Radish	Mula	Raphanus sativus	Cruciferae		
11.	Brussels sprouts	-	*Brassica oleracea var. gemmifera*	Cruciferae		
12.	Water cress	Shachi	*Nasturtium officinale*	Cruciferae		
13.	Pea	Motor	*Pisum sativum*	Leguminaceae		
14.	Hyacinth bean	Seem	*Lablab niger*	Leguminaceae		
15.	String bean	Barbati	*Vigna sesquipedalis*	Leguminaceae		
16.	French bean	Jhar seem	*Phaseolus vulgaris*	Leguminaceae		
17.	Winged bean	Kamranga seem	*Psophocarpus tetragonolobus*	Leguminaceae		
18minaceae						
18.	Sword bean	Makhan seem	*Conavalia ensiformis*	Leguminaceae		
19.	Lima bean	Rukuri	*Phaseolus limensis*	Leguminaceae		
20.	Vegetable	Soyabean	*Ghycime max*	Leguminaceae		

	soybean					
21.	Tripatri leaves	Tripatrishk	*Desmodium trifolium* DC	Leguminaceae		
22.	Yam bean	Sakalu	*Pachyrrhizus tuberosa*	Leguminaceae		
23.	Sweet gourd	Misti kumra	*Cucurbita moschata*	Cucurbitaceae		
24.	Bottle gourd	Lau	*Lagenaria siceraria*	Cucurbitaceae		
25.	Wax gourd	Chal kumra	*Benincasa cerifera*	Cucurincasa cerifera	Cucubitaceae	
26.	Cucumber	Shasha	*Cucumis sativus*	Cucurbitaceae		
27.	Cucumber (short)	Khira	*Cucumis anguina*	Cucurbitaceae		
28.	Ribbed gourd	Jhinga	*Luffa acutagula*	Cucurbitaceae		
29.	Sponse gourd	Dhundul	*Luffa cylindrica*	Cucurbitaceae		
30.	Bitter gourd (small)	Ucchee	*Momordica charantia*	Cucurbitaceae		
31.	Bitter gourd	Karala	*Momordica charantia*	Cucurbitaceae		
32.	Teasle gourd	Kakrol	*Momordica dioica*	Cucurbitaceae		
33.	Palwal	Patal	*Trichosanthes dioica*	*Trichosanthes dioica*	Cucurbitaceae	
34.	Snake gourd	Chichinga	*Trichosanthes anguina*	Cucurbitaceae		
35.	Squash	Squash	*Cucurbita pepo*	Cucurbitaceae		
36.	Muskmelon	Bangi	*Cucumis melo*	Cucurbitaceae		
37.	Snap melon	Futi	*Cucumis melo*	Cucurbitaceae		
38.	Oriental melon	Chinar	*Cucumis melo*	Cucurbitaceae		
39.	Watermelon	Tarmuj	*Citrullus lanatus*	Cucurbitaceae		
40.	Potato	Alu	*Solanum tuberosum*	Solanaceae		
41.	Brinjal	Begoon	*Solanum melongena*	*Solanum melongena*	Solanaceae	
42.	Tomato	Tomato	*Lycopersicon esculentum*	Solanaceae		
43.	Sweet pepper	Misti marich	*Capsicum annuum*	Solanaceae		
44.	Chilli	Jhal marich	*Capsicum* spp.	Solanaceae		
45.	Okra	Dherosh	*Abelmoschus esculentus* (L.) *Moench*	Malvaceae		
46.	Rozelle	Chukur	*Hibiscus sabdariffa*	Malvaceae		
47.	Stem amaranth	Danta	*Amaranthus lividus*	Amaranthaceae		

48.	Red amaranth	Lalsak	*Amaranthus gangeticus*	Amaranthacea e		
49.	Spiny amaranth	Katanotey	*Amarotey*	*Amaranthus spinosus*	Amara nthace ae	
50.	Leaf amaranth	Shaknotey	*Amaranthus viridis* L.	Amaranthacea e		
51.	Chanchi	Chanchi	*Alternanthera sessilis* DC	Amaranthacea e		
52.	Indian spinach (green)	Puishak (sabuj)	*Basella alba*	Basellacease		
53.	Indian spinach (red)	Puishak (lal)	*Basella rubra*	Basellacease		
54.	Spinach	Palongshak	*Spinacia oleracea* L.	Chenopodiace ae		
55.	Beet	Beet	*Beta vulgaris*	Chenopodiace ae		
56.	Bathua	Bathua	*Chenopodium album*	Chenopodiace ae		
57.	Helencha	Helencha	Helencha	*Enhydra fluctuans*	Comp ositeae	
58.	Lettuce	Lettuce	*Lactuca sativa var. capitata*	Compositeae		
59.	Water spinach	Kalmi	*Ipomoea aquatica* Forsk	Convolvualce ae		
60.	Kangkong	Gimakalmi	*Ipomoea reptans* L.	Convolvualce ae		
61.	Sweet potato	Misti alu	*Ipomoea batatas* (L.) Poir	Convolvualce ae		
62.	Carrot	Gajor	*Daucus carota*	Umbelliferae		
63.	Thankuni	Thankuni	*Centella japonica* L.	Umbelliferae		
64.	Parseley	Parseley	*Petorselinum crispum*	Umbelliferae		
65.						
65.	Celery	Celery	*Apium graveolens* L.	Umbelliferae		
66.	White yam	Matey alu	*Dioscorea alata*	Dioscoreaceae		
67.	Pesta alu	Pesta alu	*Dioscorea bulbifera*	Dioscoreaceae		
68.	Cassava	Shimul alu	*Manihot schott*	Euphorbiacea e		
69.	Eddoe	Mukhikach u	*Colocasia schott*	Araceae		
70.	Taro	Panikachu	*Colocasia schott*	Araceae		
71.	Tannia	Dudkachu	*Xanthosoma*	Araceae		

			violaceum			
72.	Tannia	Moulavikachu	*Xanthosoma atrovirens*	Araceae		
73.	Giant taro	Mankachu	*Alocasia macrorrhiza*	Araceae		
74.	Elephant foot aroid	Olkachu	*Amorphophallus campanulatus*	Araceae		
75.	Drumstick	Sajina	*Moringa oleifera*	Moringaceae		
76.	Plantain	Kanchkala	*Musa paradisiaca*	Musaceae		
77.	Green papaya	Papay	*Carica papaya*	Caricaceae		
78.	Bunching onion	Bunching onion	*Allium fistulosum*	Liliaceae		
79.	Asparagus	Asparagus	*Asparagus officinalis* L.	Liliaceae		
80.	Sorrel	Tak palang	*Rumex vasicarious*	Polygonaceae		
81.	Jute leaf	Patpata	*Corchorus capsularies* L.	Tiliaceae		
82.	Water lily	Shapla	*Nymphaea stellata*	Nymphaceae		
83.	Giant carandilla	Sheeta lau	*Passiflora quadrangularis*	Passifloraceae		
84.	Immature jack fruit	Echar	*Artocarpus integrifolia*	Moraceae		
85.	Baby corn	Choto bhutta	*Zea mays var. saccharata*	Graminae		
86.	Malencha	Malencha	*Jussiaea repens* L.	Onagraceae		
87.	Amrul shak	Amrulshak	*Oxalis europaea Jord*	Oxalidaceae		
88.	Nunia	Nunia	*Portulaca oleracea* L.	Portlaca oleracea L.	Portulaceae	
89.	Fern	Dhekishak	*Dryopteris filix-mas* (L.) schott	Polypodiaceae		
90.	Water plantain	Shamkala	*Ottelia alismoides*	Hydrocharitaceae		
91.	Lotus	Padma	*Nelumbo nucifera* Gaertn	Nymphaeaceae		

Appendix -2

GROWTH RATE OF DIFFERENT HORTICULTURAL CROPS

(1984-85 TO 1993-94)

A. FRUITS

Area				Production	
Sl. No.	Name	Growth rate(%)		Name	Growth rate(%)
1.	Banana	-0.519		Banana	-1.627
2.	Mango	0.924		Mango	1.940
3.	Pineapple	6.994		Pineapple	5.763
4.	Jackfruit	1.211		Jackfruit	1.490
5.	Papaya	3.470		Papaya	1.904
6.	Litchi	2.309		Litchi	2.038

B. VEGETABLES

Sl. No.	Kharif			Rabi				
	Name	Growth rate (%)		Name	Growth rate (%)			
		Area	Production		Area	Production		
1.	Pumpkin	1.	Pumpkin	3.238	-3.238	Brinjal	1.210	1.210
2.	Brinjal	1.265	-1.265	Cauliflower	2.647	2.647		
3.	Pointed gourd	2.108	2.108	Cabbage	2.545	2.545		
4.	Okra	5.721	5.721	Bottle gourd	3.649	3.649		
5.	Ribbed gourd	4.564	4.564	Pumpkin	3.608	3.608		
6.	Bitter gourd	4.562	4.562	4.562	Tomato	2.479	2.479	
7.	Cucumbe	3.565	3.565	Radish	3.041	3.041		

	r							
8.	Snake gourd	6.093	6.093	Bean	3.727	3.727		
9.	Amarant h	4.453	4.453	Spinach	4.991	4.991		
10.	Ash gourd	4.124	4.124					
11.	Yard long bean	4.344	4.344					
12.	Indian spinach	6.ian spinach	6.720	6.720				

Appendix – 3

SELECTING PRODUCE FOR CASE STUDY

SUMMER CROP									
Produce Item **EXAMPLE**	Hard or soft at harvest	Hard or soft in transport (approx no of days)	Rapid ripening/ Limited Freshness	Slow ripening/ Stays fresh for more than 4 days	Item size (large, medium, small)	Weight in bulk (heavy, medium weight, light)	At risk from sun	Need heat protection (shade or cooling)	Vulnerable from pests (high, medium, low risk)
Parble	Soft	S-5	No	Yes	Small	Medium	Yes	Shade	Low
Pumpkin	H	H-120	N	Y	L	H	N	Y	L
Ladies Finger	S	S-4	Y	N	M	M	Y	Y	M
Brinjal	S	S-5	Y	N	M	M	Y	Y	H
Arum	H	H-15	N	Y	L	H	N	N	L
Snake gourd	S	S-5	Y	N	M	M	Y	Y	M
Sweet potato	H	H-120	N	Y	M	M	N	N	L
Bitter gourd	S	S-5	Y	N	M	M	Y	Y	M
Cucumber	S	S-3	Y	N	M	M	Y	Y	M
Jack fruit	S	S-3	Y	N	L	H	N	N	L
Mango	S	S-5	Y	N	M	M	N	N	M
Black berry	S	S-3	Y	N	S	L	N	Y	M
Pine apple	H	H-7	N	Y	M	M	N	N	L
Guava	H	H-7	N	Y	S	M	N	N	L
Water melon	H	H-3	N	Y	L	H	N	N	L
Lichi	S	S-3	Y	N	S	L	Y	Y	H
WINTER CROP									
Bean	H	H-5	Y	N	M	M	Y	Y	H
Potato	H	H-120	N	Y	M	H	N	N	L
Carrot	H	H-30	N	Y	M	H	N	N	L
Radish	H	H-5	Y	N	M	H	Y	Y	L
Cabbage	H	H-5	Y	N	M	M	Y	Y	M
Cali flower	S	S-3	Y	N	M	M	Y	Y	H
Gourd	H	H-7	N	Y	L	H	Y	N	L
Turnip	H	H-10	N	Y	M	H	N	N	M

Green pea	S	S-5	Y	N	S	M	Y	Y	M
Tomato	S	S-3	Y	N	S	M	Y	Y	M
Orange	S	S-3	N	Y	M	M	Y	Y	L
Tamarind	H	H-30	N	Y	M	H	N	N	L
Olive	H	H-10	N	Y	S	H	N	N	L
Wood apple	H	H-15	N	Y	M	H	N	N	L
Acid fruit	H	H-15	N	Y	M	H	N	N	L
Papaw	S	S-4	Y	N	M	H	N	Y	L
Sapota	S	S-5	N	Y	S	H	N	N	L
Beetroot	H	H-15	N	Y	M	H	N	N	L
Star fruit	S	S-5	Y	N	S	M	Y	Y	M
Mangos teen	S	S-5	Y	N	M	H	N	N	L

Appendix-4

❖ Type of Packages and materials

Type of packages	Made of	Advantages	Disadvantages
1. Sacks/Bags and nets (Flexible): useful for less perishable crops e.g. potato, onions, chillies, yams etc. (root vegetables)	Natural fibers (Jute) or Synthetics (polyethylene, polypropylene)	Low price, easily available, easy, light and have some reuse.	a). Suitable for only hard commodities but not rigid enough to protect tender/soft crops. b). Mesh sizes are often too small for effective ventilation. c). If too large, inconvenient to handle. d). Source of decay organism as the sacks are not commonly washed or cleaned.
2. Baskets: Baskets are commonly used in developing countries especially in Asia. Efforts should be directed toward decreasing the use of baskets.	Bamboo willow or straw	Cheaper & materials are commonly available locally	a). Difficult to clean & sterilize. b). Re-use is limited to a few times. c). Lack of rigidity, which limit proper stacking. d). Sharp edges that damage produce. e). Often very large, difficult to handle.
3. Wooden crates: Wooden crates are widely used for the packaging of horticultural crops. Wooden boxes are not commonly used in Bangladesh.	Wood	Re-usable, rigid, excellent compression damages & resistance to water	a). Difficult to clean and sterilize and becomes easily contaminated with decay. b). Are not easily labeled c). Creates environmental problems (deforestation).
4. Fiberboard (Corrugated Card board) cartons.	Wood	Light, clean, smooth-surfaced, easily labeled, attractive and are bio-degradable.	a). Not re-used and therefore expensive. b). Easily water-soaked or damaged by rough handling c). Water proofing possible but adds further cost.
5. Plastic crates: Plastic crates are		-Very rigid hence provide excellent	

commonly used as field containers, having capacity of 15-20 Kg.	Plastic	protection, Provide good ventilation & smooth surface and can be cleaned much easily. Durable & easy to stack.	a). Very Expensive b). No suitable for export.
6. Plastic films and bags: The use of plastic films and bags for the packaging of fresh horticultural crops is in-creasing all over the world.	Polyethylene (low and high density), poly propylene, poly styrene etc.	-Can serve to reduce water loss and can provide a modified atmosphere around the packaged crop & can be used as liner inside the packages.	a). Need standardization. b). Labor costs are considerably higher.

❖ Packaging Requirements of Some Fresh Horticultural Produces.

The packaging must have the following characteristics;

- Should have optimal mechanical strength
- Material should be non-toxic
- Must meet handling and marketing requirements in terms of weight, size and shape standardization should be a goal.

Appendix -5: List of unfamiliar word

Lexicons of some terms are specified below:

Faria
Farias are petty traders who buy vegetables from producers in the village or in the local market and sell them to Beparis, or sometimes directly to local consumers. .

Bepari
Beparis are professional traders who buy goods from producers or Farias at the local markets, ship their consignments to urban wholesale markets and sell to retailers through commission agents.

Arathdar
Arathdars are commission agents who operate from a permanent base (shop or other establishment).

Paiker
Paikers buy vegetables from Beparis through Arathdars and sell them to retailers or consumers.

Retailer
Retailers, the last link in the marketing channel, buy vegetables from Beparis through Arathdars and sell them to consumers.

Modified atmosphere
Modified atmosphere packaging (MAP) relies on the differential permeability of selected polymers to establish a food-stabilizing environment. It works best with actively respiring foods, such as fresh-cut vegetables and raw meats.

Poverty Reduction Strategy
Poverty reduction strategy means reduction of income poverty, which covers several channels. An important channel is economic growth.

The approach sets three broad imperatives in the fight against poverty:

First, opportunities for employment and productivity growth must be created so that incomes rise and the poor are able to move out of poverty;

Second, measures must be put in place to ensure that access to basic services is equitable so that the poor can benefit; and

Third, special measures must be taken to reduce the vulnerability of the poor to unforeseen events and shocks.

Appendix –6 : Questionnaire

Questionnaire distributed to fruits/Vegetable growers, Produce merchants and transporters.

Questionnaire – Farmer

1. Name of farmer
   .....
2. Village/Thana .....

3. Distance from village to: Thana headquarters ..... district capital.....
4. Total cultivated land (decimals) .....
5. What is Packaging?.....
6. What is Vegetable Packaging?.....
7. How Vegetables should be packaged?.....
8. How fruits should be packaged?.....
9. What types of Packaging are you using?.....
10. Which type of containers do you use after pulled up vegetables?.....
11. Do you use same container for harvesting produce and sale?.....
12. Do you think there should be separate containers for harvesting and carrying to the market for sale?.....
13. Which type of package you use for your produce?.....
14. What are the advantages of present packaging?.....
15. What are the disadvantages of present packaging?.....
16. Do you take your produce after harvesting home or storage shade for cleaning/sorting and packaging?.....
17. How do you preserve your crops at home?.....
18. How many days you preserve your crops?.....
19. Which vegetable do you think Profitable?.....
20. Which vegetable is less profitable?.....
21. Do you market product by yourself? .....
22. How much profit if you sale vegetable directly?.....
23. What are the advantages if you sale vegetable to faria paiker?.....
24. What are the disadvantages if you sale vegetable to faria paiker?.....
25. How do you transport produce?.....
26. Which transport is the best transport?.....
27. What are the advantages of present transport system?.....
28. What is the disadvantage of present transport system?.....
29. Do you think farming is a profitable profession?.....
30. Is it possible to maintain family by only farming profession? .....
31. What is the disadvantage of present agricultural system?.....
32. What is the modern developed Technology?.....
33. Do you apply modern technology?.....
34. What are the advantages of modern technologies?.....
35. What are the disadvantages of modern technologies?.....

Questionnaire – Produce merchants

1. Name of Trader
   .....
2. Category of trader
faria.....
bepari.....
aratdar.....
3. Village/Thana .....
4. What is Packaging?.....
5. What is Vegetable Packaging?.....
6. How Vegetables should be packaged?.....
7. How fruits should be packaged?.....
8. What types of Packaging are you using?.....
9. Which type of containers do you use after pulled up vegetables?...
10. Do you use same container for harvesting produce and sale?.....
11. Do you think there should be separate containers for harvesting and carrying to the market for sale?.....
12. Which type of package you use for your produce?.....
13. What are the advantages of present packaging?.....
14. What are the disadvantages of present packaging?.....
15. Which vegetable do you think Profitable?.....
16. Do you market product by yourself? .....
17. How much profit if you sale vegetable directly?.....
18. What are the advantages if you sale vegetable to faria paiker?.....
19. What are the disadvantages if you sale vegetable to faria paiker?...
20. How do you transport produce?.....
21. Which transport is the best transport?.....
22. What are the advantages of present transport system?.....
23. What is the disadvantage f present transport system?.....
24. Do you think farming is a profitable profession?.....
25. Is it possible to maintain family by only farming profession? .....
26. What is the disadvantage of present agricultural system?.....
27. What is the modern developed Technology?.....
28. Do you apply modern technology?.....
29. What are the advantages of modern technologies?.....
30. What are the disadvantages of modern technologies?.....

Questionnaire – Transporters

1. Name of Transporters
   .....
2. Village/Thana .....
3. What is Packaging?.....
4. What is Vegetable Packaging?.....
5. How Vegetables should be packaged?.....
6. How fruits should be packaged?.....
7. What types of Packaging are you using?.....
8. Which transport is the best transport?.....
9. What are the advantages of present transport system?.....
10. What is the disadvantage of present transport system?.....
11. What is the cost of transport per maund ?.....
12. Do you think farming is a profitable profession?.....
13. What is the average transport cost (per maund) from the farm-gate to the market?.....
14. Is it possible to maintain family by only farming profession? .....

Appendix 7: Participants at the workshop

Name	Organisation	Location
Mohammed Golam Al Farooque	Deputy Managing Director, The Merchants Ltd.	Dhaka
Dr. Anisur Rahman	Professor	Dhaka
Md. Mozammel Hoque	Director, Touch Bangladesh	Dhaka
Md. Saidur Rahman	Officer, Touch Bangladesh	Dhaka
Mr. Babul Kumar Das	Padma Cap & Can	Dhaka
Mr. Shoeib Mohammed	Standard Manufacturing	Dhaka
Mr. Mahtab Uddin	Bikalpa Engineering	Dhaka
Mr. Suresh Gosh	Dias Metalic	Dhaka
Mr. Khaleq	Rafique Enterprise	Dhaka
Md. Shadhon Kumar	Officer, Touch Bangladesh	Dhaka
Md. Rana Ur Rahman	Officer, Touch Bangladesh	Dhaka
Md. Mahbub Hoque	Officer, The Merchants Ltd.	Dhaka
Md. Saidul Islam	Grower	Pabna
Md. Rahat Hassan	Produce Merchants	Barishal
Md. Shafiqul kabir	Grower	Barishal
Golam Mostofa	Asian University of Bangladesh	Dhaka.
Rashed hassan	Grower	Mymenshing
Dulal Hossain	Grower	Dinajpur

Md. Rezaul Islam	Grower	Barishal
Md. Nazrul Islam	Grower	Pabna
Md. Majibur Rahman	Grower	Pabna
Md. Salim Hossain	Grower	Pabna
MD. Abdul Kaium	Grower	Pabna
Syed Enamul Hoque	Asian University of Bangladesh	Dhaka
Mahfuzur Rahman	Asian University of Bangladesh	Dhaka
Muntasir Matin	Stamford University	Dhaka
Mahbubul Hassan	Asian University of Bangladesh	Dhaka
Md. Forhad Hossain	Produce Merchants	Mymenshing
Md. Afzal Hossain	Produce Merchants	Jessore
Md. Hasibur Rahman	Produce Merchants	Jessore
Md. Shariful Islam	Produce Merchants	Rajshahi
Md. Shamim Hossain	Produce Merchants	Rajshahi
Md. Munsur Ali	Produce Merchants	Dinjpur
Md. Abdur Noor	Produce Merchants	Bogura
Mostafa Ahmed	Produce Merchants	Bogura
Md. Siddkur Rahman	Grower	Dinajpur
Md. Shahjahan Ali	Grower	Dhaka
Md. Matin Ali	Grower	Pabna
Md. Abul Hossain	Transporter	Dhaka
Md. Arif Hossain	Transporter	Dhaka
Md. Jobbar Ali	Grower	Dinajpur
Md. Karim Ali	Grower	Dinajpur
Md. Rahim Ali	Grower	Dinajpur
Md. Barek Ali	Grower	Dinajpur
Fahad al Mamun	Grower	Bogura
Tanvir Ahmed	Transporter	Bogura
Md. Sadek Ali	Transporter	Tangail
Md. Rafiqul Islam	Transporter	Tangail
Md. Meraj Hossain	Transporter	Tangail
Maruf Hossain	Transporter	Dinajpur
Parvez ahmed	Transporter	Dinajpur
Shahed Hassan	Grower	Dinajpur
Azizur Rahman	Grower	Bogura

Appendix -8: Workshop Program

'Packaging perishable produce (Fruits and Vegetables) in underdeveloped countries'

Saturday, 01 July 2006

1.00pm - 1.10pm	Opening and Introduction
1.10pm -1.30pm	Introduction to the topic, objectives and the goals of the meeting (Mohammed Golam Al Farooque)
1.30pm - 1.45pm	Opening address (Md. Mozammel Hoque Bhuiyan)
1.45pm - 2.00pm	Introduction of the participants (self-introduction)
2.00pm-2.10pm-	Coffee & tea

Plenary 1

The objective of this session is to provide a background review of the existing evidence on the role of transporting and packaging of fruits and vegetables in Bangladesh

2.10pm-2.30pm-	Overview of Past and Present Study on transporting and packaging of fruits and vegetables in Bangladesh
2.30pm-3.00pm	Farmers, transporters & produce merchants View
3.00pm - 3.40pm	Discussion

Plenary 2

The objective of this session is to provide an overview and analysis of market information, Industry position and summary of the day's discussions

3.40pm - 4.00pm	Overview and analysis of market information (Interactive discussion)
4.00pm - 4.40pm	Industry position
4.40pm - 5.40pm	Summary of the day's discussions
5.40pm - 6.00pm	Closure
6.00pm - 7.30pm	Pre-dinner drinks Hosted by "The Merchants Ltd."
7.30pm - 8.00pm	Workshop dinner Hosted by "The Merchants Ltd."

Workshop Program-2

'Pack house operations for fruit and vegetable'

Thursday, 10th August 2006.

1.00pm - 1.10pm	Opening and Introduction
1.10pm -1.30pm	Introduction to the topic, objectives and the goals of the meeting (Mohammed Golam Al Farooque)
1.30pm - 1.45pm	Introduction of the participants (self-introduction)
1.45pm - 2.00pm	Present status of fruit and vegetable production in Bangladesh
2.00pm-2.10pm-	Coffee & tea

Plenary 1

The objective of this session is to provide an overview of the Cost barriers to packaging fresh agricultural produce, Skill development of producers, and Pack house operations for fruits & vegetables.

2.10pm-2.30pm-	Overview of Cost barriers to packaging fresh agricultural produce.
2.30pm-3.00pm	Cost benefit analysis
3.00pm - 3.40pm	Discussion

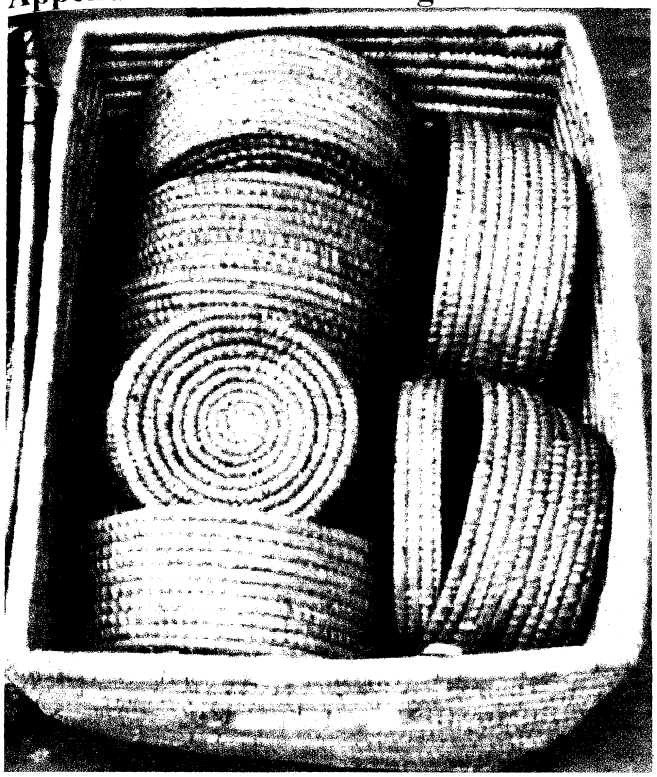
Plenary 2

The objective of this session is to provide an overview and analysis of the factors that should be considered in the setting up and operation of a fruit and vegetable pack house, effective farm tranportation system and summary of the day's discussions

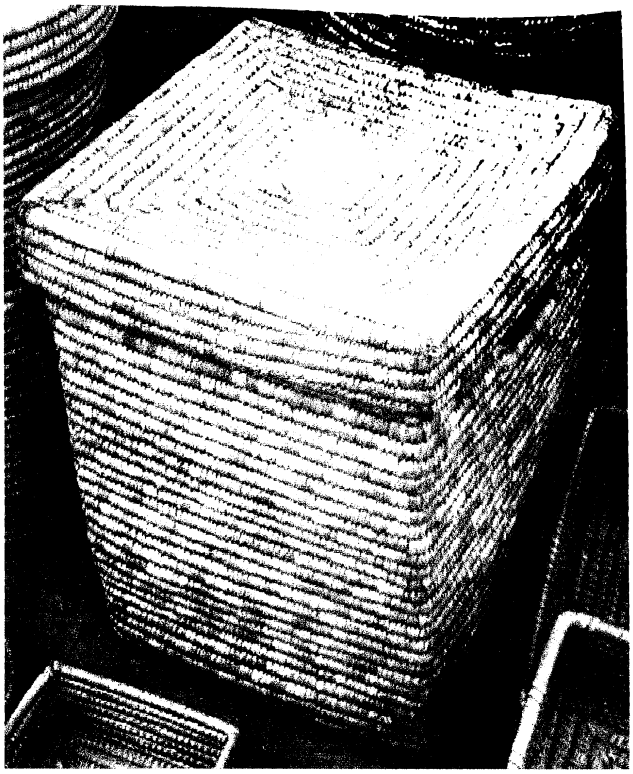
3.40pm - 4.00pm	an overview and analysis of the factors that should be considered in the setting up and operation of a fruit and vegetable pack house

4.00pm - 4.40pm	effective farm tranportation system	
4.40pm - 5.40pm	Summary of the day's discussions	
5.40pm - 6.00pm	Closure	
6.00pm - 7.30pm	Pre-dinner drinks	Hosted by "The Merchants Ltd."
7.30pm - 8.00pm	Workshop dinner	Hosted by "The Merchants Ltd."

Appendix-10 : New Packages



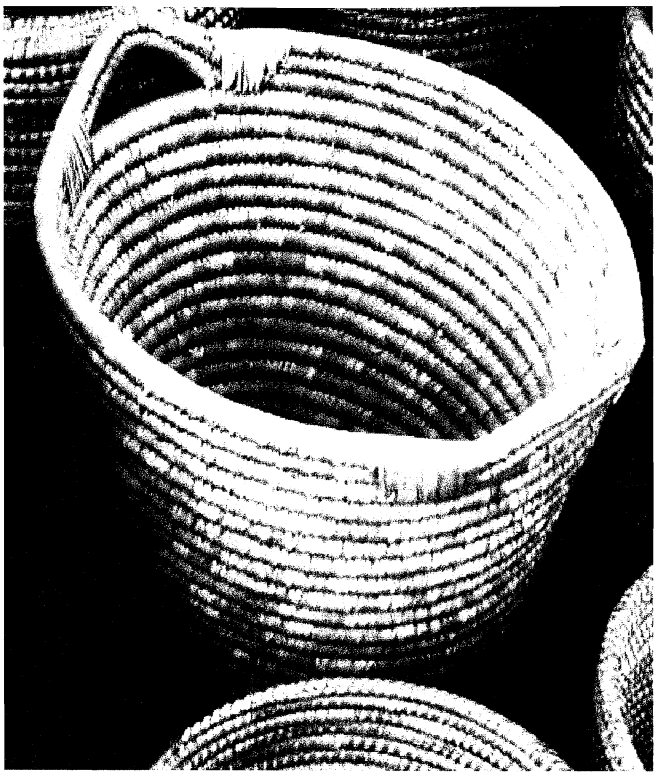
Package-1



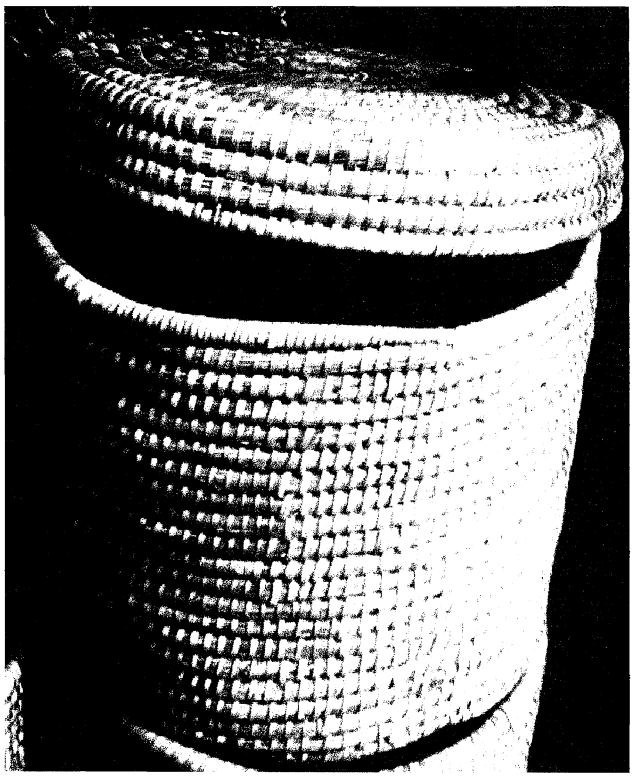
Package-2

Package-3

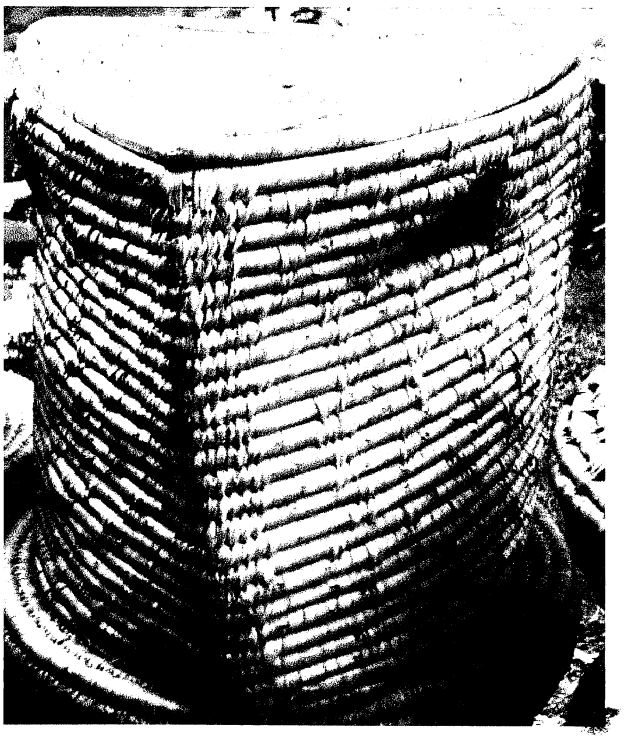
Package-4



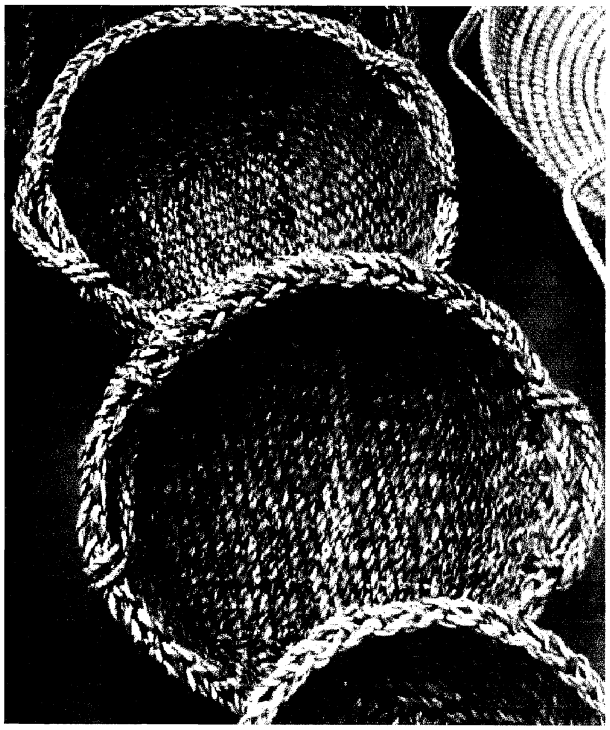
Package-5



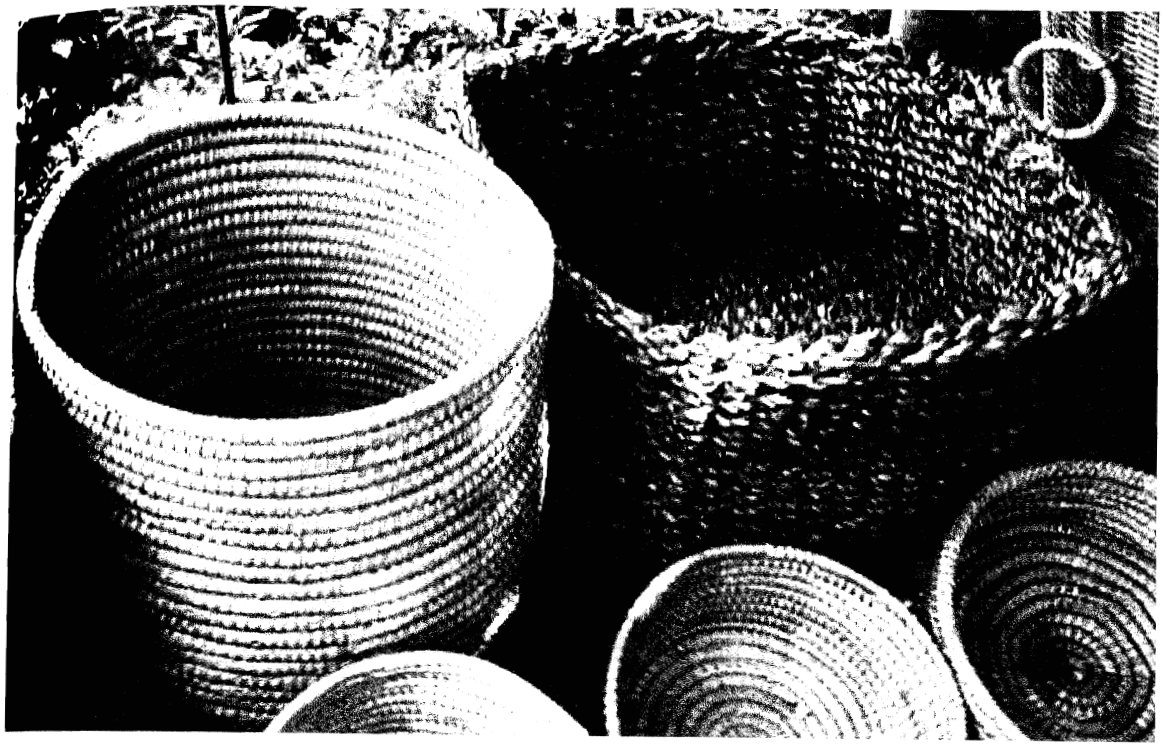
Package-6



Package-7

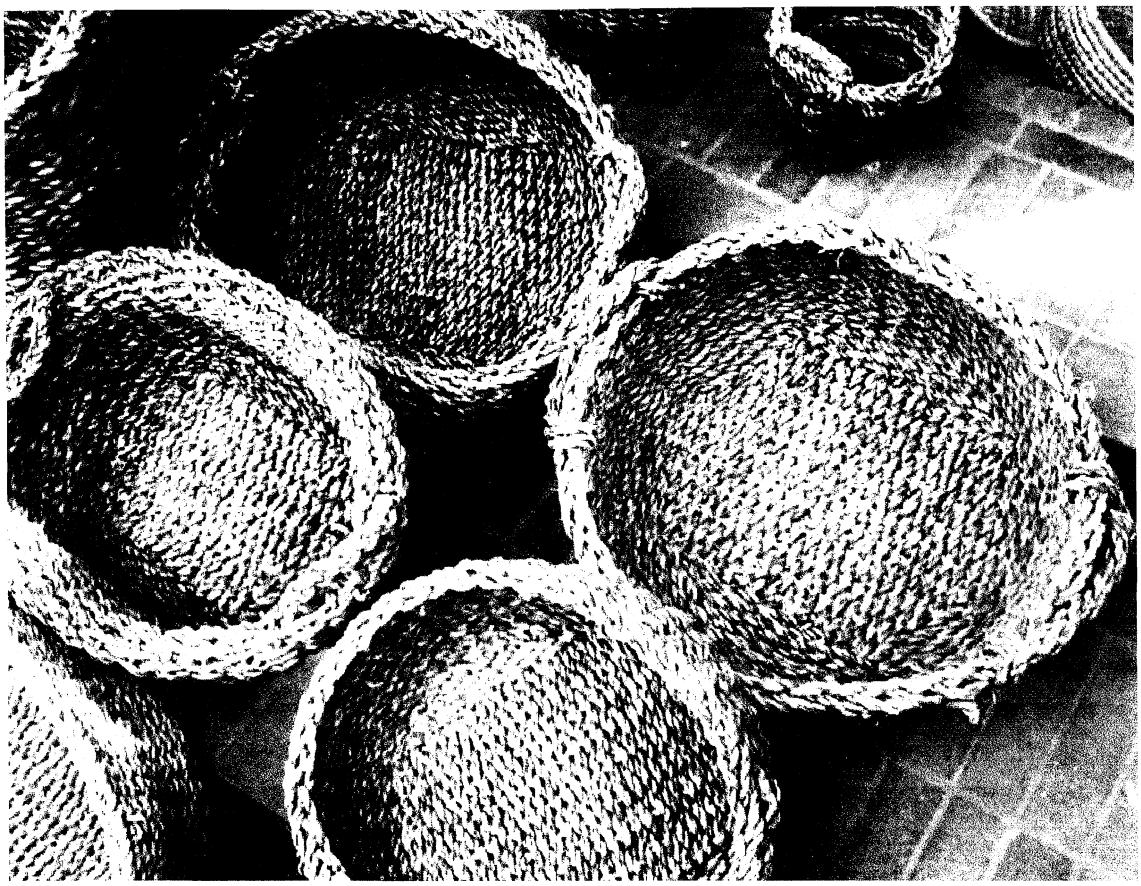


Package-8

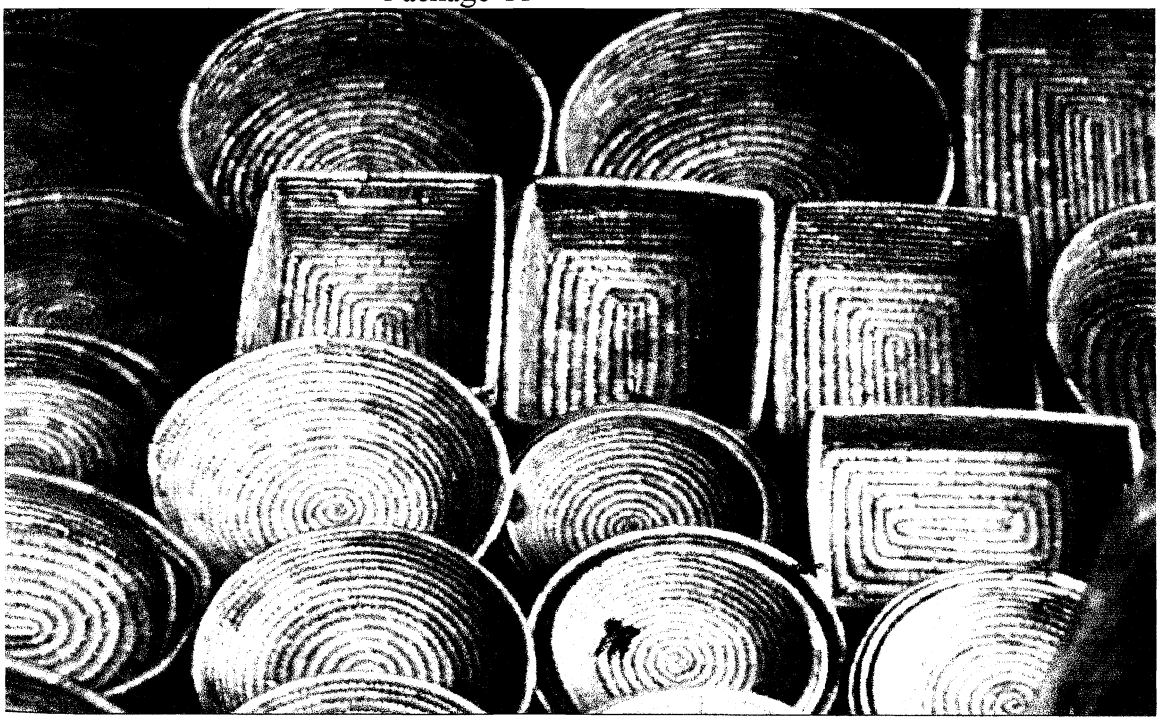


Package-9

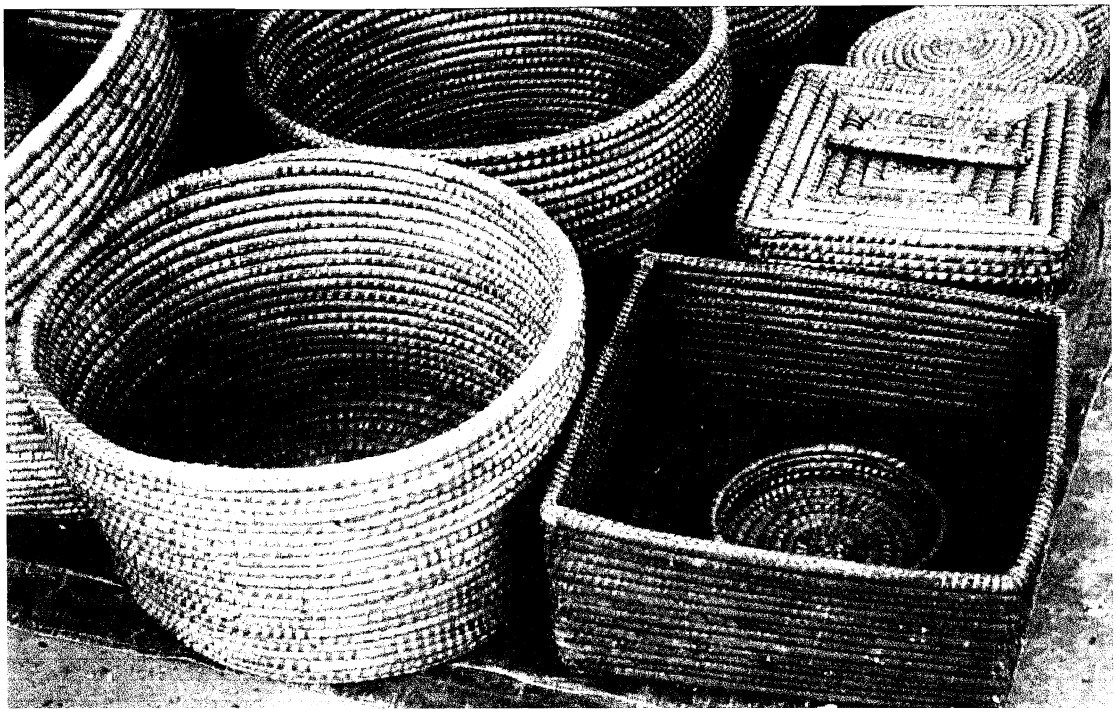
Package-10



Package-11

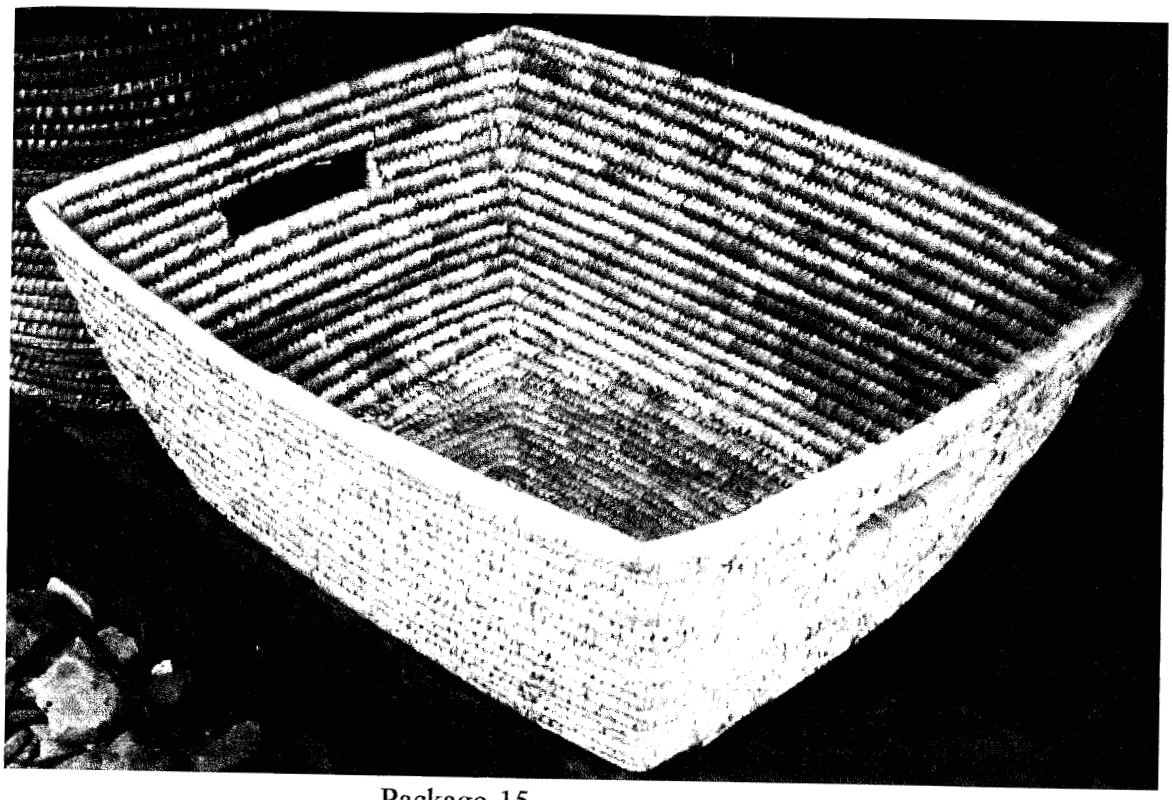


Package-12

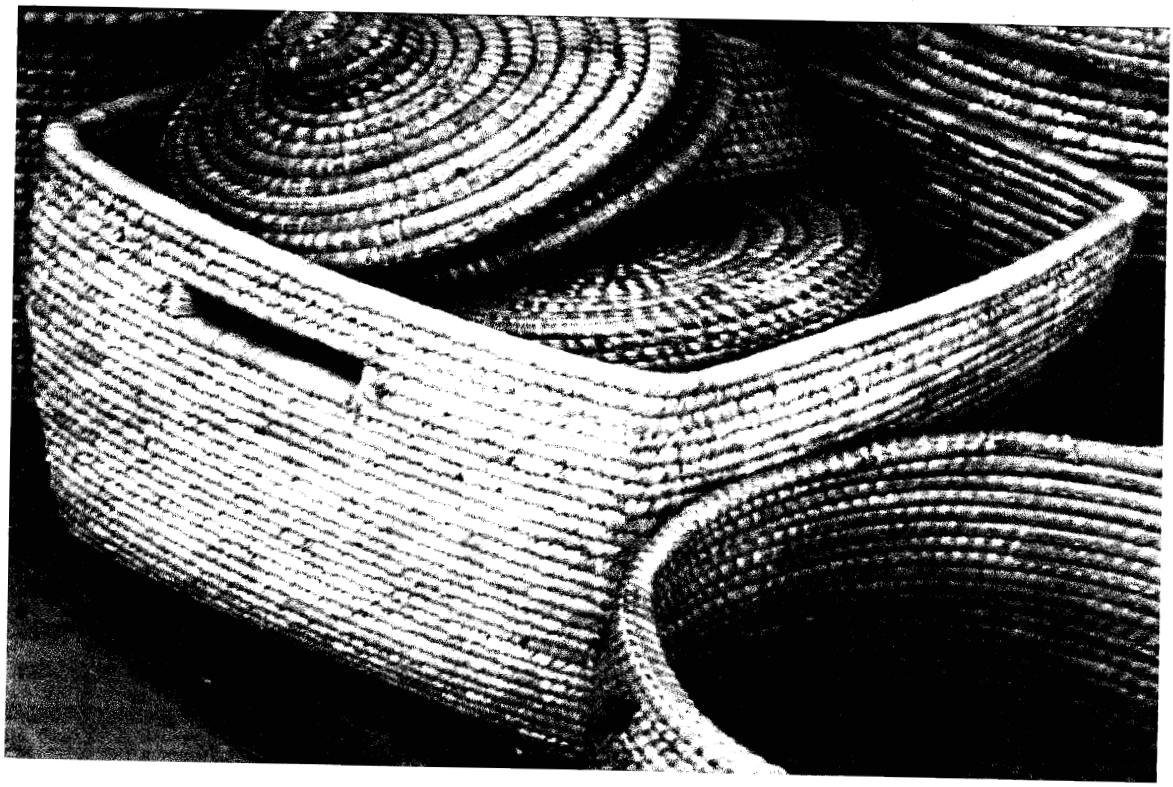


Package-13

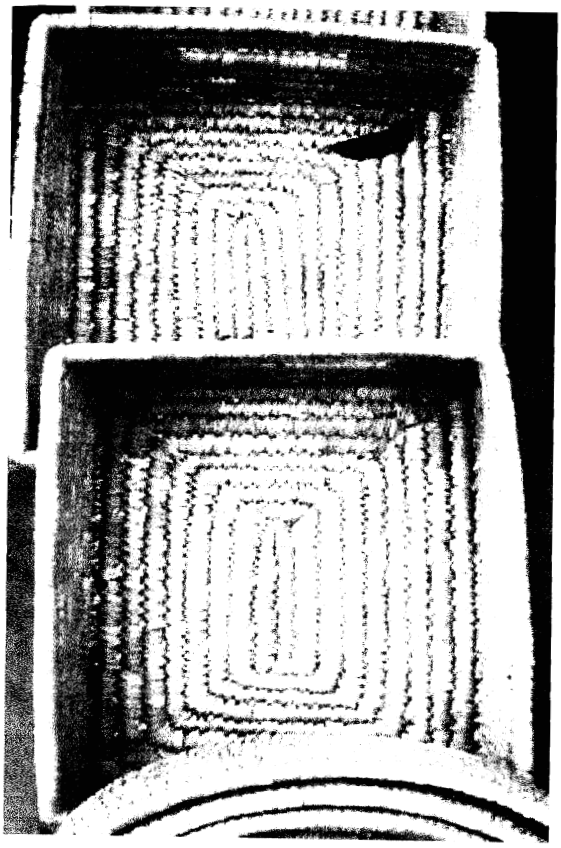
Package-14



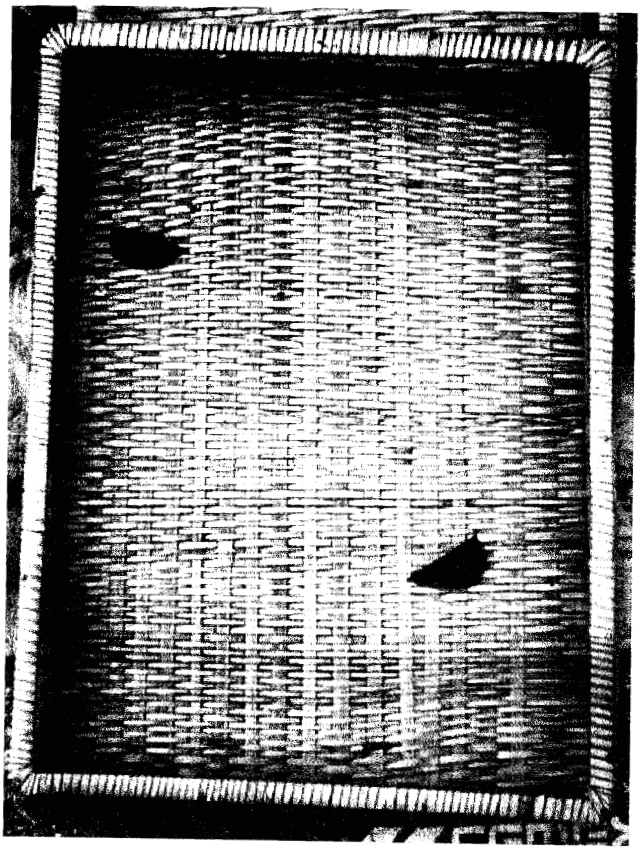
Package-15



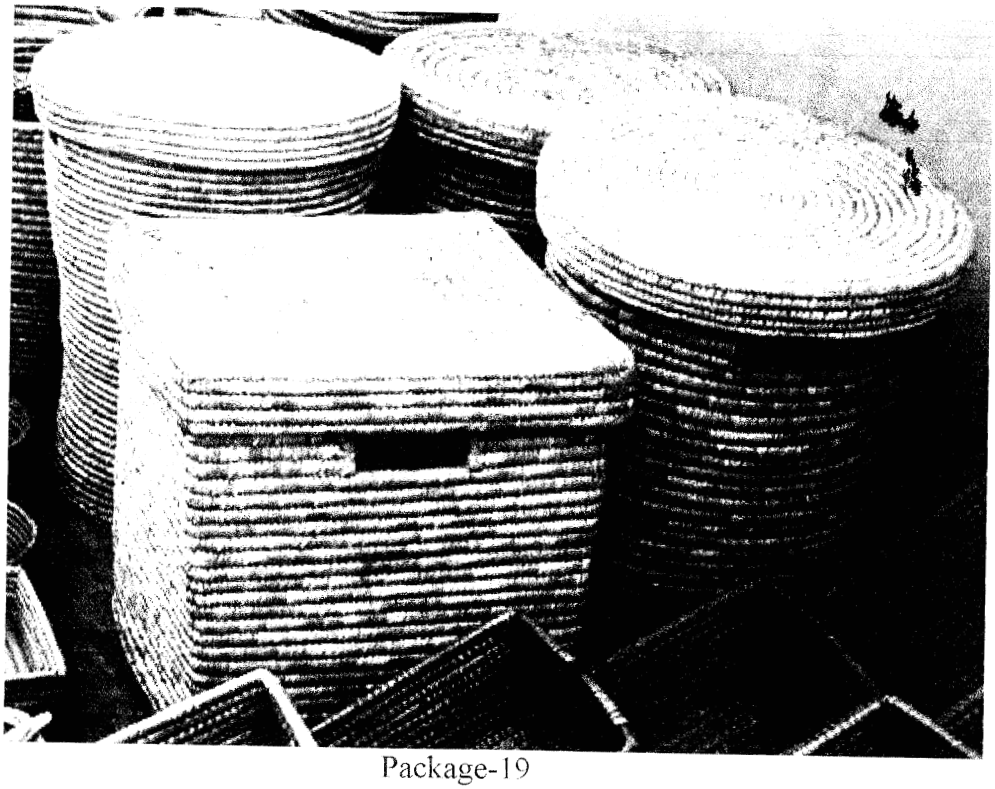
Package-16



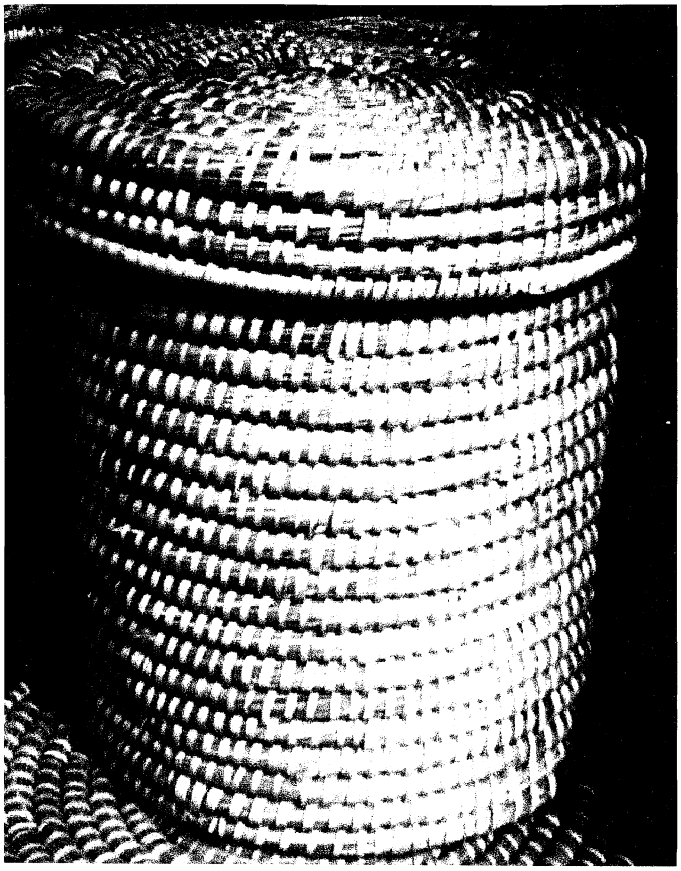
Package-17



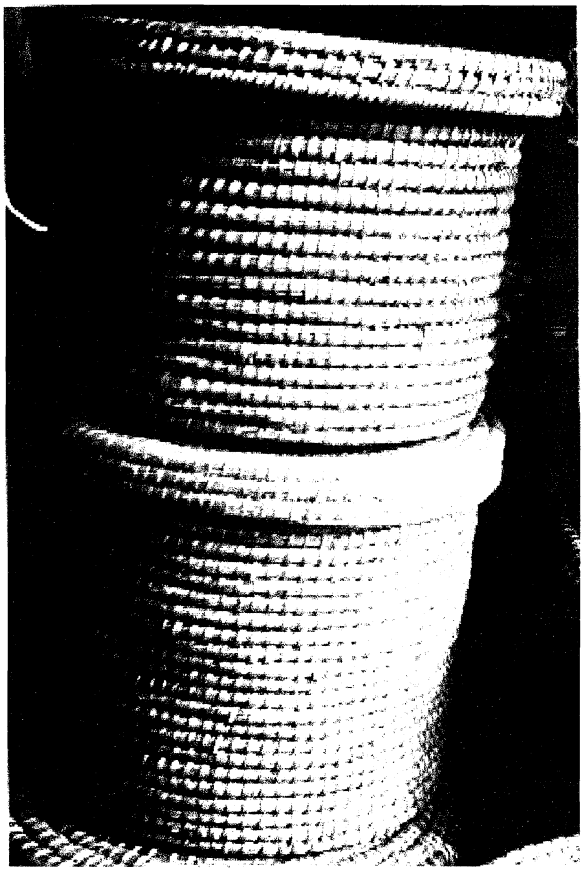
Package-18



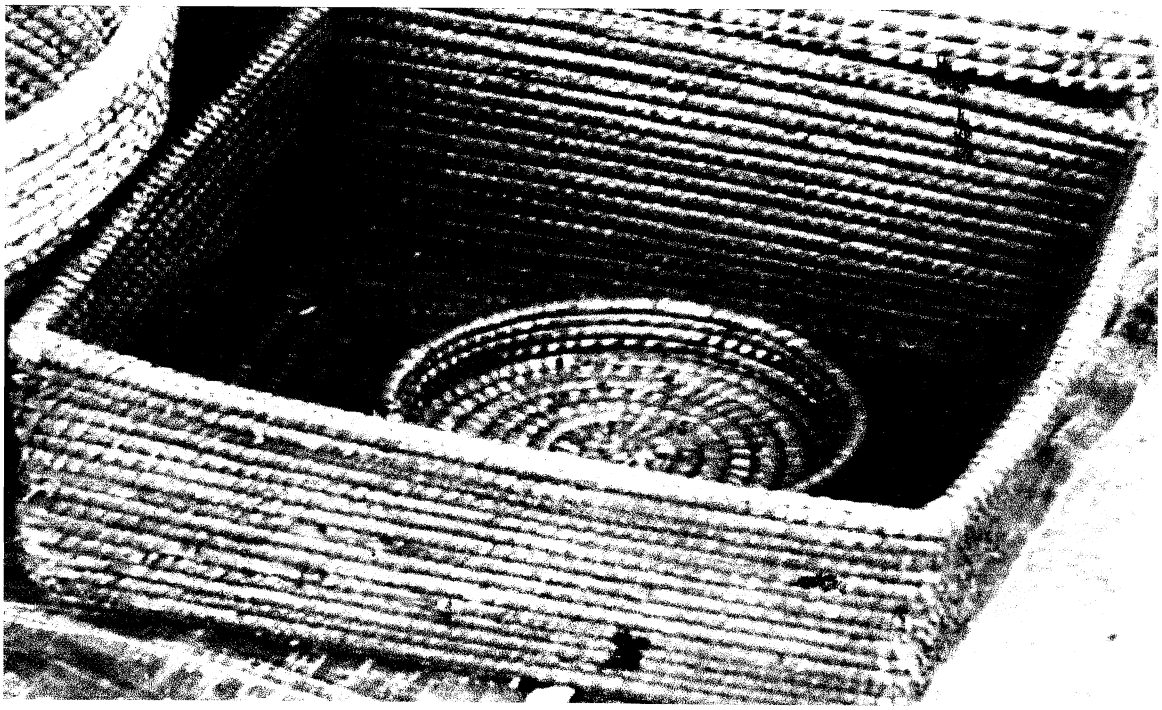
Package-19



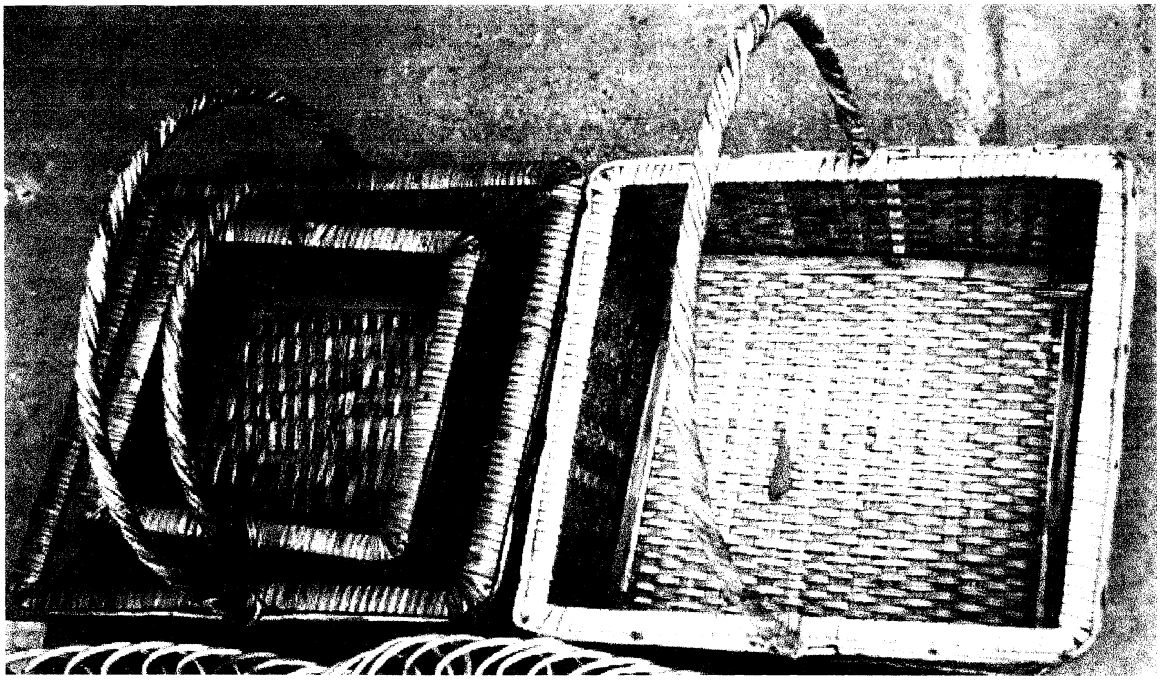
Package-20



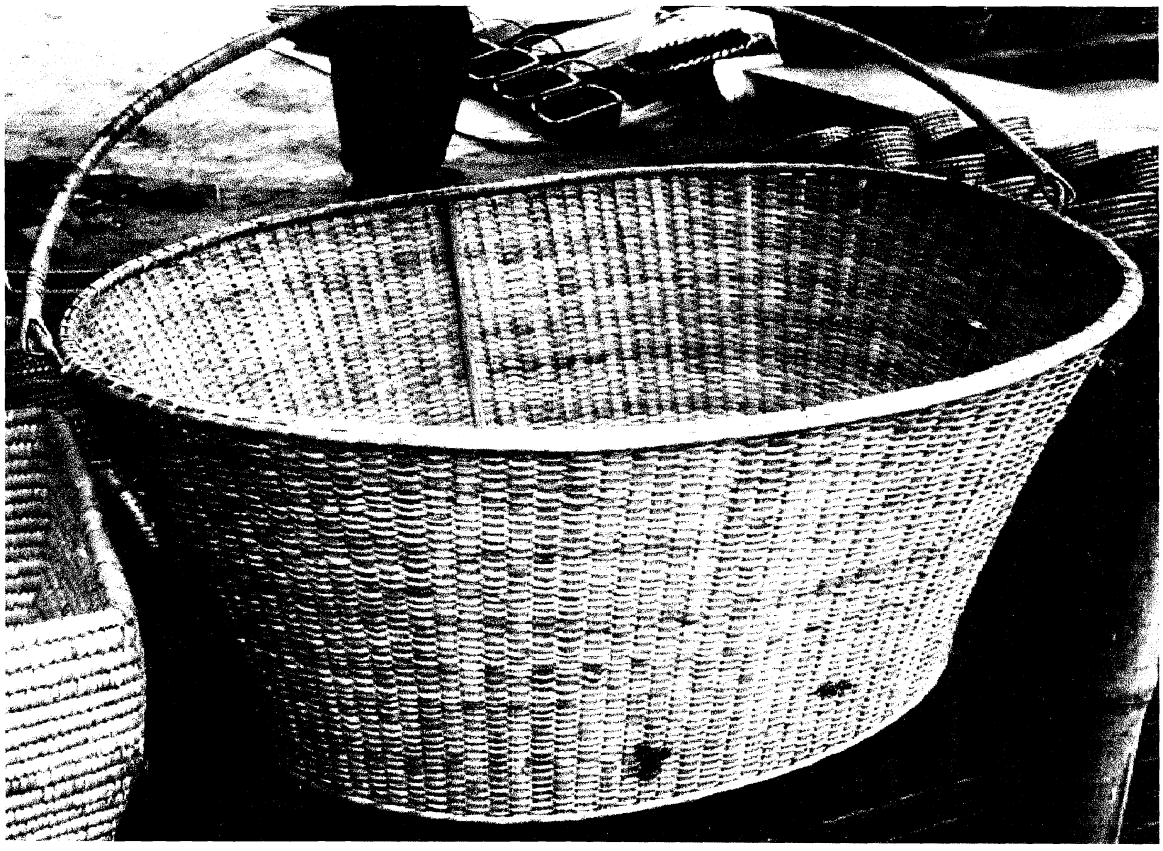
Package-21



Package-22



Package-23



Package-24

Bibliography

1. Ahmed, M S (2005) Export Potential of fruits and Vegetables for Income Generation, Organized by Bangladesh Agricultural Research Institute, Joidebpur, Bangladesh held during 28-30th March 2005 at BRAC Center Inn, Dhaka.

2. Ahmed, MS. And A Quasem (2002) ; Fresh produce export and SPS issues in Bangladesh, Presented in the International Workshop on Agricultural Diversification in South Asia initiative by International Food & Policy Research Institute (IFPRI), USA in collaboration with Royal Government of Bhutan. MOA-NCAP, India held during 21-23 November,2002, at Paro, Bhutan.

3. Anonymus 2002.Bangladesh Bureu of statistics (BBS), Statistics Division, Ministry of Planning, Government of Peoples Republic of Bangladesh.

4. ABE, K. and A.E. Watada. 1990. Ethylene absorbent to maintain quality of lightly processed fruits and vegetables. J. Food Sci. 56:1589-1592.

5. Ashby, B.H. et al. 1987. Protecting Perishable Foods during Transport by Truck. Washington, D.C.: USDA, Office of Transportation, Agricultural Handbook No. 669.

6. Bhuiyan, M A J and S. Heilemarian (2002). Report on "Pilot Project on Extra Fine French Bean Production and Freezing for export." Hortex Foundation, Dhaka-1207

7. BRAC Bulletin (2005). Bulletin of Bangladesh Rural Advancement Committee, BRAC

8. Company Brochure, The Merchants Ltd.

9. Champ, B.R,E. Highly and G.I. Johnson (1994) Post harvest handling of tropical fruits A CIAR. Proceeding Australian Centre for International Agricultural Research Act No.50.

10. Deodhar, S. Y and H. Dave (2001) Managing quality for Agri-comodities and Food products under WTO regime. In :Implication of WTO Agreement for Indian Agriculture. CMA Monograph No. 191. Oxford and IDB Publishing company (Pvt.) Ltd. New Delhi and Calcutta, India.

11. FINNEY, E.E. JR. 1972. Vibration techniques for testing fruit firmness. J. Text. Stud. 3:263-283.

12. Farruque M.M (1999). Consequences of Uruguay Round Agreements for Bangladesh. Summary Report on the Agreement on the sanitary and Phytosanitary Measures FAO.

13. FAO. 1985. Prevention of Post-Harvest Food Losses: A Training Manual. Rome: UNFAO. 120pp

14. Fellows P and A Hampton (1992). Small-scale Food Processing; A Guide to Appropriate Equipment. Intermediate Technology Publications, London 158P.

15. G. Kibria (2005) Drying and Dehydration of Fruits and vegetables. Paper presented to International workshop on Agro-processing Techniques of Fruits and Vegetables, Dhaka, March 2005.

16. G. Kibria , M M Rahman, Q R Rahman & S. A Khanom (1997-98) Institute of Food Science & Technology (IFST), Bangladesh. Council of Scientific and Industrial Research (BCSIR), Dhaka. Studies on Nutritional Quality and Shelf life of Dehydrated Carrot. Bangladesh Journal of Nutrition Vol. 10 &11 No(1&2) Page 1-7

17. GUNASEKARAN, S. 1990. Delayed light emission as a means of quality evaluation of fruits and vegetables. Crit. Rev.Food Sci. Nutr. 29:19-34.

18. Grierson, W. 1987. Post harvest Handling Manual: Commercialization of Alternative Crops Project Belize Agribusiness Co./Chemonics International Consulting Division/USAID.

19. Hortex Bulletin June 2002. A bulletin of Agricultural Services, Innovation & Reform Project (ASIRP). Horticultural Export Development Components; IDA Funded

20. Hortex Foundation (2004) Information Brochure
21. Holt J.E and School (1984). Package Protection and Energy Dissipation in apple packs. Sci. Hort.24, 165-36.

22. Hossain M.A Bhuyan MAJ. (2005). Processing of frozen vegetables and its export potentials particularly in Bangladesh perspective

23. Hardenburg, R.E., A.E. Watada and C.Y Wang (1986) *The commercial* storage of fruits, vegetables and florist and nursery *stocks* (rev. ed.), Agriculture Handbook, no. 66, US Department of Agrilture,Washington, DC.

24. http://www.sdnbd.org/bangladesh.htm.

25. Jegar, P(2002) Study for the market for Frozen French Bean in Europe. Hortex Foundation, Sech Bhaban,22, Manik Mia Av. Shere Banglanagar, Dhaka-1207

26. Jobair B. Alam Saiyid H. Sikder And Konstadinos G. Goulias : On the Role of Transportation in Regional Economic Efficiency in Bangladesh: A Data Envelopment Analysis

27. K M Haque(2005).Present status of Agro-processing in Bangladesh and its future potentialities. International workshop organized jointly by Bangladesh Agricultural Research Institute and Islamic Development Bank (IDB), Dhaka, March28-30; 2005 PPI-12

28. KADER, A.A. and F.G. Mitchell. 1989b. Maturity and quality. In: UC Publ. 3331*, pp. 191-196.

29. Kader, A.A., D. Zagory and E.L. Kerbel, (1989) Modified atmosphere packaging *of* fruits and vegetables. *Crit. Rev. Food Sci.* Nutrition 28(1): 1-30.

30. Kabir M E (2005). Packaging requirements for processed fruits and vegetables for local and foreign markets. Paper presented at

International Workshop on Agro-processing techniques of fruits and vegetables for income generation 28-30 March 2005, Dhaka, Bangladesh.

31. Klatzel, F., (2000). 'Green Roads: Building environmentally friendly, low maintenance rural roads through local participation' http://www.mtnforum.org/resources/library/klatf00a.htm

32. Lisa Kitinoja and Adel A. Kader -Small-scale post harvest handling practices - A manual for horticultural crops.

33. Lloyd J.W and Newell, H.M. (1932) "causes of damage to fruits and Vegetables during shipment."III.Sta, Bull.379,1932.

34. McGregor, B. 1987. Tropical Products Transport Handbook. USDA, Office of Transportation, Agricultural Handbook Number 668.

35. M. D. Boyette, D. C. Sanders, G. A. Rutledge- 1996. Maintaining the quality of North Carolina fresh produce. North Carolina State University, North Carolina A&T State University, U.S. Department of Agriculture, and local governments cooperating.

36. Mitchell, F.G. and A.A. Kader. 1989b. Field handling and packing. In: UC Publ. 3331*, pp. 197-208

37. Md. Saleh Ahmed (2004) Post harvest handling and export packaging of horticultural crops. Paper presented in the seminar on "Post harvest handling and export packaging of horticultural crops'" held on 10th August 2004, organized by Hortex Foundation in its conference room.

38. Nowak, J and R.M Rudricki (1990). Post harvest handling and storage of cut flowers, florist greens and potted pants. Timber press, Press, Portland, CR.

39. National Institute of Agricultural Engineering. 1979. Preparing vegetables for supermarkets. Field Vegetable Department, Silsoe, Bedford: NIAE

40. O Brian, M; B.F Corgill and R.B Friedley (1983) Principles and Practices for harvesting and handling fruits and nuts.AVI. Westport,C.T.

41. Peleg K (1985) Produce handling, Packaging and distribution, AVI, Wostport, CT.

42. Parish, Richard, A (2002). "Consulting Report on the Development of Frozen Fruits and Vegetables in Bangladesh" Hortex Foundation Sech Bhaban, 22, Manik Mia Avenue, Shere Banglanagar, Dhaka-1207.

43. Parsins RA; Mithel F G; Meyer G (1972) PARSONS, R.A., F.G. Mitchell, and G. Mayer. 1970. Forced-air cooling of palletized fresh fruit. Trans. ASAE 15:729-731.

44. Paul work, Vegetable production & markets biotech books chapter-4, Page 64-67

45. Quasem (2002) Export potential of horticultural produces. Paper presented in the seminar organized by JICA Alumni Association of Bangladesh in collaboration with HORTEX Foundation held on January 11,2002 at Hotel, Sheraton, Dhaka, Bangladesh.

46. Rahman ,M A; K.K Nath and M. Rahman (1992). Postharvest handling and processing of vegetables. Proceedings of the "National Review and Planning Workshop." Asian Vegetables Research and Development Centre, Shanhua, Taiwan, Publication No. 92-379.

47. Rashid A. 2002. Present status of underutilized fruits of Bangladesh. A paper presented in the workshop on "Processing and Marketing of underutilized fruits of Bangladesh ". Bangladesh Agricultural Research Institute, Joydebpur. 8 September 2002.

48. Rij, R. Et al. 1979. Handling, precooling and temperature management of cut flower crops for truck transportation. USDA Science and Education Administration, AAT-W-5, Leaflet 21058.

49. Rutledge (1991) Magnetic Resonance Imaging Studies of the Freeze - Drying Kinetics of Potato. J. Food Process Engineering.

50. Roberts (1990) The Role of Farmers in the Creation and Continuing Development of Agricultural Technology and Systems." In Farmer

First, eds. Robert Chambers, Arnold Pacey, and Lori Ann Thrupp, 12 34. London: Appropriate Technology.

51. Reid, M.S. 1992. In: Kader, A.A. (Ed.) Post harvest Technology of Horticultural Crops. University of California, Division of Agriculture and Natural Resources, Publication 3311

52. Story, A and DH Simons (eds) (1997) Fresh Produce Manual Australian United Fresh Fruits and Vegetable Association Ltd., Sydney.

53. Schewfelt R.L; SE Prussia (1993)- Post harvest handling – A systems approach, Academic Press, San Diego, CA.

54. Singh R.N. Mango. Publications and Information Division. Indian Council of Agricultural Research Krishi Anushandhan Bhaban, Pusa, New Delhi.

55. Subramanyam, N.V. et.al. 1972. Studies on harvesting, transport and storage of mangoes Acta. Hort. 24, 260.

56. Srivastava, H.C. (1967) Grading storage and marketing. The Mango; A Hand book. Indian Council of Agricultural Research, New Delhi.

57. Torgdees. S.C, Scott, K.J and McGlasson, W.B (1982). Packaging and cool storage of litchi fruit. CSIRO Food Research Quality 42(2); 25-28.

58. Thompson A.K, undated. in Post harvest Technology of fruits and Vegetables Page-56, Blackwell Science).

59. THOMPSON, J.F. and R.F. Kasmire. 1981. An evaporative cooler for vegetable crops. Calif. Agric. 35(3&4):20-21.

60. THOMPSON, J.F., F.G. Mitchell, T.R. Rumsey, R.F. Kasmireand C.H. Crisosto. 1998. Commercial cooling of fruits, vegetables, and flowers. Publ. 21567, Univ. Calif. Div. Nat. Resources, Oakland, CA, 61 p.

61. THOMPSON, J., A. Kader, and K. Sylva. 1996. Compatibility chart for fruits and vegetables in short-term transport or storage. Univ. Calif. DANR Publ. 21560.

62. Thomas, T.H. 1985. Plant growth regulators in the production and storage of outdoor and glasshouse vegetables. In: R. Menhenett and M

63. Wills, R.B.H. (1987) Composition of Australian fresh fruit and vegetables, *Food Technol. Aust.* 39: 52326.

64. WTO (1999) Review of the operation and implementation of the Agreement on the application of Sanitary and Phytosanitary measures Geneva : World Trade Organization.

65. Walker, D.J. (Ed) 1992. World Food Programme Food Storage Manual. Chatham, UK: Natural Resources Institute

66. Yang (1992) YANG, S.F. 1985. Biosynthesis and action of ethylene. HortScience 20(1): 41-45.

67. ZAGORY, D. 1990. Principles and practices of modified atmosphere packaging of horticultural commodities.