THE DEVELOPMENT OF AN EXPORT PACKAGE FOR MANGOES FROM PAKISTAN

Thesis for the Degree of M. S.
MICHIGAN STATE UNIVERSITY
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1975

ABSTRACT

Pakistan, although being the second largest grower of mangoes in the world has not developed extensive markets in foreign countries to the degree of countries like the Phillipines, which has become the largest mango exporter even though it ranks only fourth in the world for production of the fruit.

The main objective of the project is to explore packaging methods or techniques which would protect the perishable fruit from environmental hazards.

Environmental hazards consist of such things as atmospheric conditions like heat and cold which can cause microbial growth in the fruit. Other hazards to be concerned with which the fruit might be subjected to are physical hazards like shock during transportation and also storage and sales hazards.

Another important factor to consider for perishable fruit is the shelf life and how it can be extended for better marketability.

The Indians have done a great deal of work concerning the extension of the shelf life. For example, they have discovered that mangoes can be preserved longer when wrapped with tissue paper treated with biphenyl and placed individually in a partitioned, ventilated corrugated box and stored at a temperature of 45-50° F and relative humidity of 85-90%.

Mangoes can also be coated with an aqueous wax which has been mixed with disinfectants. This treatment controls the microbial growth to such an extent that the shelf life is increased up to 60 days.

Further modifications can be made on this method as well be explained in Chapter IV.

Present methods being used are adequate in that they provide protection, however, in the future there is a need to investigate new methods like the stick pack in order to promote and expand the mango trade.

The stick pack is a method in which 4 or 5 fruits are placed end to end and wrapped with a shrink film which creates an artifical wax coating that controls not only microbial growth but also reduces bruising since it prevents the fruit from knocking against each other. The shelf life can be further increased if the package is stored at a temperature of 45-50° F and relative himidity of 85-90%.

THE DEVELOPMENT OF AN EXPORT PACKAGE FOR MANGOES FROM PAKISTAN

by

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A THESIS

submitted to

Michigan State University

in partial fulfillment of

the requirements of the degree of

Masters

School of Packaging

1975

To my parents

Mr. and Mrs. Mohsin Shah

ACKNOWLEDGMENT

I would like to express my gratitude to Dr. Wayne Clifford my major professor for his assistance in the preparation of my thesis.

My special thanks for Dr. Syed Abdullah Hassan and Syed Tahir Hassan both Alumni of Michigan State University, without whose encouragement and aid I would have been unable to complete my Masters.

I am extremely grateful to Laurie Smith who gave me necessary moral support for the culmination of my studies.

Last and most important I would like to give my thanks to my parents Mr. and Mrs. Mohsin Shah and Buwaji for their ever present guidance and blessings.

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INTRODUCTION

This work was undertaken with great enthusiasm to promote the export of fresh produce including vegetables and fruit in general and mangoes in particular through providing a better package for safe transportation.

The emphasis has been placed on the fact that exporting countries, being under-developed should try to utilize their manpower and resources, such as exportable crops, more effectively.

In this way those countries would be able to reduce not only the employment problem of unskilled labor, but save money also by not importing huge machinery from developed and mechanized countries.

Pakistan, being a potential and prospective exporter of mangoes would benefit the most, where packaging industry is still in the initial stage, which may be one of the limiting factors in the export of many products including fruits and vegetables.

As time passes and export to other countries flourishes, mechanized and automatic methods can be introduced to export more and more produce in less time. This would create incentive to the farmers to produce greater yields to help in building up the economy of the country.

Thus the impact of this type of export will be multifold in a way to strengthen the national economy of Pakistan.

CHAPTER I

PRODUCT LOGISTICS

Pakistan is the second largest producer of mangoes after India, in the world. According to the statistics published in 1973 by the Central Food Technological Research Institute, Mysore, India, Pakistan produces one million tons of mangoes annually.(1) According to the information gathered by Food and Agriculture Division circulation for Ministry of Food and Agriculture, Government of Pakistan, the production is up by 2.5% since 1973.

In spite of being the second largest producer of mangoes in the world; Pakistan has not exported this fruit to any country.(2) The entire crop is consumed locally, part of which perishes due to poor packaging while in transition or storage.

There has not yet been any work done to study appropriate packaging which would facilitate safe handling, shipment, and storage not only to foreign countries, but within Pakistan as well. As a result, part of the crop rots and prices go up.

Part of the reason for unsatisfactory packaging is that local shipment is handled by non-professionals who are inadequately qualified to understand the necessity of suitable

packages and who are hampered by their lack of technological know-how. Furthermore, it is easy to avoid meeting the grading standards for packages set by the Food and Agriculture department, government of Pakistan, due to a lack of qualified supervisory personnel.

Packaging centers are rather autocratically controlled by individuals, each of whom has his own method of packing the mangoes in a very deficient way. Some use wooden crates, others use bamboo baskets, according to their convienence, with cushioning composed of paddy straws in common use.

Wooden crates are mostly in the size of 18" x 11" x 18" and hold a weight of about 30 to 32 lbs/crate, which can be easily broken in shipment due to the cheap quality of the wood used. A bamboo basket is a low cost package that varies in size, however a sound mango merchant would avoid making use of bamboo baskets due to certain shortcomings in shipment, like lower stacking strength.

As far as the closure is concerned, wooden crates are nailed shut around the top by spacing boards two inches apart across the top. Bamboo baskets are covered with nets made of jute. This creates the need to develop suitable methods of packaging to protect fruit from perishing, being damaged and consequently wasting money.

Recently on December 2, 1974 a Pak-German seminar on the promotion of non-traditional export was held in Lahore Pakistan to discuss the possibility of fruit and vegetable export.

The President of Pakistan's Chamber of Commerce and Industry stated that nearly 50% of the fruits and vegetables harvested in Pakistan went to waste because of the lack of proper packaging, storage and transportation.(3) I would also like to refer to another aspect of this seminar where it was mentioned that there should be a great scope for the export of Pakistani fruits (mangoes being one of them) without sacrificing the country's need.

Poor transportation is another drawback to limit the export of such perishable crops. Pakistan is immediately starting a vending service in which Pakistani vessels would be equipped with cold storage to transport fresh fruit from port to port in the Middle East and the Gulf area. There are plans to extend this latter to European coasts, Singapore and Japan. This is a direct outcome of the recent seminar held in Lahore Pakistan by the Export Promotion Bureau.(4)

The mango is said to be the king among tropical fruits and some of the varieties grown in the sub-continent are greatly relished for their succulence, exotic flavor and delicious taste in most countries of the world. The world's estimated annual production of mangoes is 9 million tons, of which Pakistan and India are the major growers.(5)

Following is the chart of countrys which grow mangoes and their exporting markets for fresh mangoes.

Trade of fresh mangoes is about 300 tons in European Economic Community whereas for EFTA (European Free Trade Association), the total is estimated at about 400-500 tons.

For other countries of Western Europe, except Spain which is producing mangoes itself, the annual imported tonnage is not more than 50 tons.(6) As shown in Table 1, the Phillipines and Thailand are the largest exporters of fresh mangoes while India takes the next place.

TABLE 1

ANNUAL PRODUCTION OF MANGO GROWING COUNTRIES OF THE WORLD AND EXPORT MARKETS

Country	Annual Production in Tons	Export	Import Destinations
India	7,000,000	1,488	Middle East, Europe
Pakistan	1,000,000	none	none
Africa	154,000	none	none ?
Philipines	131,500	3,243	Hong Kong
U.A.R.	88,000	none	none
Thailand		2,243	Singapour, Malaya
South Africa			
Brazil			
Mexico	625,500		
Cuba			
U.S.A.			
Carribean area			
Ceylon			

The export of fresh mangoes constitutes a very small fraction of production, thus Pakistan being the second largest grower stands bright chances to establish her market in foreign countries provided she attains high standards of quality and outlook needed for a competitive and sophisticated export market. A suitable package would be one of the important considerations besides transportation to keep the quality, shape and freshness of the fruit.

The Mango is a native of the subcontinent and is one of the most popular fruits. The major growing areas are located in the central region of Pakistan where the climate is perfect for mango cultivation.

Multan, Muzaffargarh, Dera Ghazi Khan, Hyperabad, Rahimyar Khan, Bahawalpur and their vicinities constitute the mango growing belt of the country. Approximately 125,000 acres are under cultivation of mangoes with about 1,000,000 tons produced annually.(7) A better quality has been achieved by grafting different varieties producing better flavor and more succulant properties than the ungrafted mango. In my plan, grafted mangoes will be the prime export fruit due to their high acceptability by the consumers. Pakistan grows more than thirty varieties of mangoes. Some of the more popular ones are Dusahri, Langra, Summera Behisht, Choaisa, and Malta. As a matter of fact India exports some of these varieties of fresh mangoes to the Middle East and Gulf area.(8)

These grafted varieties are all sweet by nature and nonfibrous; they vary in size and color as indicated in Table 2.(9)

It takes about 8-10 years for a mango plant to mature and bear fruit. The flowering season extends from December to March which are the cooler months in Pakistan. The fruit takes 12-16 weeks for full development after setting and its weight continues to increase until harvest. The growth is slower between the 9th and 14th week which corresponds to

the period of development of the stone. Starch continues to accumulate during growth and development.

TABLE 2

PHYSICAL CHARACTERISTICS OF SOME VARIETIES OF MANGO

Mango Variety	Dusahri	Chowsa	Langra
Surface color	yellow	greenish yellow	greenish yellow
Size	5 1/2 in.	4 in.	6 in. and over
Sp. gravity	1.02	1.02	1.03
Weight in gm.	250	275	300
Pulp	67%	65%	65%
Peel	15%	15%	17%
Stone	18%	20%	18%

Respiration shows a peak during growth climactric.[10] The fruit is harvested from April to July. The harvest time is determined by the color, size, shape, and hardness of the fruit. In southern areas the crop is harvested in mid April. Several parameters have been suggested for testing the maturity of the fruit but none of these appear to be useful for commercial purposes. However, the total soluble solids, acid: sugar ratio, starch content, flesh color, together with non-destructive characteristics such as shape, weight and skin color appear to be useful indicators for harvest.[11]

Harvesting is done by manual labor plucking individual fruit with the help of bamboo poles with a net attached at the end and are lowered to the ground in a basket with the help of rope to avoid damage. Mechanical harvest is not possible in view of the large spreading habit of the tree.

After harvesting, mangoes are brought to the nearest

packing centers in trucks to grade them before packing.

Grading and standardization are common features in advanced countries. Although the Department of Food and Agriculture encourages the growers and traders for the systematic grading, the merchants do the grading on their own in an unorganized and unskilled manner.

Grading is based on the shape, size, weight and surface color which indicates nothing but the maturity of the mango. Later, the mangoes are packed either in wooden boxes or bamboo baskets depending upon the fruit merchant. The size, shape and closure method has already been mentioned.

However in countries like India which is the 3rd largest exporter of fresh mangoes, grading includes weight, skin color and specific gravity.(12) Specific gravity has a great deal of influence regarding the shelf life of mangoes. Fruits having specific gravity of more than 1.02 ripen faster and have a reduced storage life but are suitable for consumption in fresh state. On the other hand, fruits with specific gravity of 1.0 to 1.02 require a longer period for ripening, have a longer storage life and thus are safe to transport for longer distances. If the specific gravity is lower than 1.0 it will take even longer to ripen but it will also cause infection of the fruit, thus resulting in poor quality of mango.(13)

The grading standard is one of the most important principles of modern trade, both on a national level an international level, since it leads to considerable improvment

in quality, enhancement of productivity, reduction of costs and in optimum utilization of available resources. Thus grading standards are absolutely essential for any agriculture program.

An article published by J. S. Pruthi emphasized the advantages relating to standardization in respect to production, handling, and grading of fruit only.(14)

Grading in a way eliminates the necessity of inspecting the contents of every package, therefore effecting considerable economy in labor, time and money at all stages of marketing.

What is more important is that the fruit escapes the possible damage which otherwise can be caused by unnecessary handling during inspection of individual packages. Thus grading minimizes wastage and helps to select the fruits that keep longer and better.

Standardization also provides a means for intellegent comparison of prices according to quality of grade, thus simplifying long distance national and international trading.

Standardization also speeds up handling and distribution of which is particularly advantagous for perishable products like mango fruit.

These above advantages for grading fruit promote greater confidence in the mind of consumers, which in turn goes a long way in further boosting the trade on both national and international levels.

Standards for mango packages are set by the Marketing

division of the Ministry of Food and Agriculture, Government of Pakistan. These rules are flexible as stated in draft. They specify that the mangoes should be packed in a clean crate or carton as may be agreed between buyer and seller, and the package should be strong enough to stand strain during storage and transit. All crates or cartons in a consignment should be of the same type and approximately of same weight within usual commercial limits.

The mangoes in a package should be of the same variety and grade, in other words, should have uniform maturity levels.

Finally each package should be marked with a stamp of approval which indicates weight of package, variety of the fruit, grading level and consignment number indicating the name of the packing center.

As it was said earlier, rules and regulations have been set by the Government of Pakistan but they are not in practice.

The importance of packaging becomes quite evident when part of fresh produce is lost or wasted due to its perishable nature, mishandling, improper packaging and also when grading is overlooked or neglected. The major purpose of modern packaging is that produce should reach the consumer in as much of a fresh state as possible by maximizing its shelf life and storage time and to make it more safe against damages which are usually incurred during transportation, handling by either equipment or manual labor.

A significant amount of work has been done by Indian

experts to maximize the shelf life of fresh fruit by using different suitable standards of packaging. In this text I would like to review the work that has been done relating to fresh mango packaging for export purposes.

A reasonable number of aspects have been explored for such purposes as wrapping of individual fruit in tissue paper treated with biphenyl which is useful in minimizing decay and damage during transit and storage of mangoes.(15)

Tissue paper or kraft paper lining between layers is another suggestion, it has been further modified by wrapping the fruit in polyethylene and packing into a ventilated corrugated container or ventilated wooden crate.(16)

The above methods have been used by Indians to export mangoes abroad. A review of literature also indicates that the storage life of fruit can be increased up to 60 days. Wax coating is the method used for such a purpose.

An appropriate means of transportation for the shipment of these packages is another important aspect. Pakistan has recently made an agreement with Germany to buy vessels which are equipped with cold storage; air cargo facilities are already available.

Thus, after reviewing the literature and performing the tests if necessary, I would draw a guide line to divise an improved packaging method for mangoes for successful export, which would include the selection of material, package requirements, provision of handling facilities and means of transportation.

CHAPTER II

EXPORT HAZARDS

The study of export hazards helps a great deal for selection of proper material and design of package. The purpose of suitable design and selection of proper material is always to reduce the damages done to the products to a maximum extent. However it is humanly impossible to eliminate all the hazards completely. Therefore a provision is always made for possible damages incurred during distribution and handling.

The goal of packaging is to insure the arrival of goods in an undamaged condition. In order to fulfill the protection of goods it will be necessary to study those hazards which are found to happen under any kind of transportation system and thus resulting in considerable loss.

These hazards are varying in nature but can be generally classified as follows;

A) Environmental hazards

B) Sales hazards

C) Physical hazards

D) Miscellaneous hazards

A) Environmental hazards are said to be some of the most serious hazards of the distribution process.[17] These hazards are largely influenced by atmospheric conditions and thus are

quite difficult to control. The specific hazards which can be refered to mango package in this aspect are heat and cold. Under the influence of heat, mangoes may spoil due to blistering, and under cold temperature the fruit does not ripen satisfactorily. The recent investigation on an intensive scale indicates that fruit stored at a temperature below 25°C does not ripen satisfactorily even though the critical temperature for development of chilling injury is below 10°C.[18]

The individual with the responsibility of packaging for export must possess an awareness of the possible situations which a shipment will encounter while being transported to a particular destination, as well as climatic conditions prevailing in that particular area.

Climatic conditions are important considerations since they do have impact in causing damages to fresh fruits. An example of a package for a synthetic product like Kool-Aid would clearly explain the job played by different climates for its preservation. Kool-Aid had to change its waxed laminated glue sealed package to a foil lamination when shipped to Latin American countries.[19] This can be further explained for a tropical fruit like mango coming from Pakistan to U.K. will have to go through two zones of temperature which has a definite impact on the preservation of the fruit.

The solution to these hazards for perishable fruit which is subject to spoilage as the result of exposure to heat or cold is that the fruit package must be kept in insulated or refrigerated storage areas and carriers in which the temperature and humidity can be controlled. The package itself must

be designed so that air flow or heat transfer is facilitated and to provide temporary safeguards when optimum conditions do not prevail.(20) A ventilated wooden or corrugated board box would serve this purpose. These are already in common use in developed countries such as the United States.

B) A thorough study needs to be made to extend new markets in foreign countries because of their concepts, beliefs and standards which may be quite contradictory to one prevailing in Pakistan.

The basic ingredient necessary to sales expansion in foreign markets was well defined by John Castle, "If we want to sell in this market we must do it their way."(21)

In order to perform important functions of packaging and merchandizing it will be necessary to have a thorough study of the many aspects that compose a sociological structure within a particular geographical area. Such aspects are language, religion, weight measures, custom restrictions and package requirements within a particular country.

Most countries if not all have set up rules and regulations regarding importing goods, especially food products. These rules essentially require an indication of content, weight, size of package, destination and packaging date.

Language plays an important part in this since the shipment is mostly handled during distribution by common laborers especially countries in the Middle East where a laborer, if able to read at all would be able to read his own native language only. Religion is an exceptionally

delicate area which needs to be handled very carefully. It may not be as critical in European countries but Islamic countries are quite rigid. For example, the existence of crucifics on packages should be banned for packages destined for Islamic countries.

Weight measures vary from country to country, some countries use the old English system of pounds while others follow the metric system. Often the pound must be replaced by the kilo, or quart by the liter because quantities to which the exporter is accustomed are not those to which the importer is accustomed.

Weight in Pakistan is measured in seers which would need to be converted to pounds or kilos depending on the country to which the package is destined.

Export and import formalities regarding revenue and rules and regulations in different countries are perhaps the most important factors to be studied. If the package does not fulfil their requirements, the shipment would not be delivered to the foreign customer thus an exporter would loose his contract and bring a bad name to his country. Hence a thorough study of rules and regulations is an essential factor for package development whether the product is fruit, food or something else. Of course in the case of fruit export, and obsticle that would delay the delivery might cause spoilage to the fruit. Under such circumstance this can be expected to meet strong sales resistance abroad from the retailer and consumer.

C) Physical hazards in general are of two natures; one is due to the transportation systems and the other being the dynamic and static stress which are caused by these systems.

One important factor in the development of packaging overlooked so far in Pakistan is the physical limitations of a package. The physical limitation of a package is the ability to survive the fatigues during the transportation, storage and distribution process. The fatigues that a package experiences during shipment are vibration (scuffing to fracturing) impact (crushing to breading) puncture (leaking to denting) compression (crushing to deflection), and miscellaneous conditions of tension, shear, torsion, and tear.[22]

As once stated, a complete environmental survey is necessary for the development of package.[23] Environmental study refers to the source or type of transportation that would be used, how the package is handled by the manual labor, what equipment is available for handling and what are the storage conditions. All that essentially refers to what is technically called the drop height for a package, frequency of transportation, handling capabilities of labor and equipment.

The drop height is the height at which a laborer could possibly drop the package, this is measured so as to protect the package against the most severe drop. It varies from size to size. In the case of a fruit package which should generally weigh not more than 50 lbs. and is handled by an

individual the drop height is 36" as shown on the table.

TABLE 3

TYPICAL DROP HEIGHTS

Weight Range Gross Wt. in Lbs.	Type of Handling	Drop Height in Inches
0-20	1 man throwing	42"
21-50	1 man carrying	36"
51-500	2 Men carrying	24"

While at sea or in the air, packages are subjected to both static and dynamic compression.

Static stress is experienced when packages are stacked one on another. The stacking resistance is a function of stacking duration as it affects material fatigue and the influence of handling and environment on the strength of materials.(25)

Shifting of cargo as a result of weather conditions causes dynamic stresses on goods in a direction other than that of compression caused by stacking.(26)

In other words, if the package is developed in such a way that it can withstand the compression for total period of stacking during shipment, a package would succeed against breakage hazards.(27)

Vibration during transportation is another factor to consider for physical hazards. Each item which exists has a frequency called natural frequency at which the item will vibrate freely. Also each carrier has a frequency or range

of frequencies known as the forcing frequency which act upon the objects (package in this case) being carried. When the forcing frequency of a carrier becomes equal to the natural frequency resonance occurs which magnifies the input greatly with a resultant degree of destruction of the package and its contents. In the case of a fruit package, fruit being the content may not be affected but it may spoil due to its being in a damaged package.

Thus a proper selection of material, relevant cushioning and suitable design (convenient to handle during distribution process) of package will overcome this problem.

D) Pilferage has been a problem ever since trade was started and is responsible for 20% of total losses.[28] It varies from country to country and further depends on the package container.

CHAPTER III

REVIEW OF LITERATURE

A review of literature reveals that every packaging method developed for mangoes is based on an important factor; respiration of fruit.[29] The stage of maturity at harvest, grading, and post harvest treatment play an important role in keeping the respiration rate of fruit at a minimum and subsequently the safe arrival of fruit packages in the market as is explained further.

The literature reviewed for this purpose is mostly by Indian experts and some by the United Fresh Fruit and Vegetable Association reports.

India has been involved in this study for several years but there is no set standard method of mango packaging.[30] There are several export centers and all of them may not use the same method. However, there are only a few packaging methods which have been implemented.

Prior to further discussion I would like to elaborate on the above mentioned factor; the role of respiration of fruit and why it is important in fruit packaging.

The rate of respiration is determined by measuring the amount of carbon dioxide released. As long as the fruit is on the tree it recoups its losses due to respiration from

the parent tree, but as soon as it is harvested the fruit has to utilize its own reserve for vital physiological processes. Thus any condition which increases the rate of respiration will cause decay to the fruit as it will therefore reduce the fruits ability to resist microbial attack and so reduce or minimize the storage life of the fruit. At the same time anerobic respiration starts in complete absence of oxygen and the fruit ferments and is spoiled. Minimum oxygen is required for aerobic respiration.

Therefore it is necessary to minimize the rate of respiration after the fruit is harvested so that its freshness and quality are retained for as long a time as is possible to facilitate transportation, storage and marketing.

Following are the factors which affect the respiration rate during handling, packaging, storage, and transportation.(31)

Variety: Early maturing varieties of mangoes have a higher rate of respiration as compared to late maturing ones. Some varieties because of their initial low rate of respiration behave better during storage and transit than do some others. Thus one of the important considerations for developing export packaging is to choose varieties of mangoes which have a low respiration rate by nature.

Temperature: Temperature has a great influence on the rate of respiration. If the fruit is subjected to high temperatures (42°C and above) even for a short period of time, such as an hour, the respiration increases thus resulting in reduction of storage life and heavy spoilage during transit.

It is therefore necessary to avoid storing mangoes in large heaps or exposing them to the sun. The critical temperature in cold storage is 10°C.[32]

Age of fruit: The age of the fruit is determined by the time that has elapsed after harvest and can be divided into pre-storage, storage, and post-storage.

The rate of respiration is at a minimum during pre-storage since the fruit is just picked and has enough reserve and then it starts to fall during storage and post-storage. Therefore the best stage for fruits to be transported especially for export is when they are just harvested and are still green and hard. The Department of Agriculture and Marketing of India does not allow the export of any mangoes which are ripe or stored earlier than its pronounced maturity.

Ventilation: Proper ventilation neutralizes the heat and humidity generated during respiration. It provides the cooling effect which further reduces the respiration rate. The use of ventilated containers has shown best results during transition by sea.

Influence of micro-organisms: The spores of micro-organisms, when numerous, contaminate the fruit. The enzymes liberated by these spores weaken the skin which results in easier penetration of spores to the inside of the fruit. Once these microbes enter the fruit they multiply rapidly and increases the spore load inside the package or storage place, causing decay of other healthy fruits.

The spore load also increases the respiration rate and

enhances metobolic changes. This can be controlled by making use of preservatives. For example, fruit coated with aqueous wax emulsion gives a sharp decrease in respiration, thus protecting fruit against microbial attack.

Influence of injury during transportation: Shock during transportation and handling causes injury to the fruit which again results in an increase of the respiration rate, thus the damaged cells are prone to microbial attack.

Injury is caused either by improper method of picking, rough handling or inadequate packaging and transportation. Thus rough handling of fruit should be avoided, also adequate packaging provision should be made to protect against shock during handling of packages and during transportation.

The above mentioned factors clearly indicate that control of respiration activity is a basic consideration for successful packaging. To overcome this need, general grading standards of fruit have been set by India's Department of Agriculture and Marketing.[23] These standards are based on physical characteristics such as size or weight, quality which represents the maturity stage at which a fruit is capable of ripening in the ordinary course of transportation and marketing. Technically the term quality means that fruit has enough reserve to keep a minimum rate of respiration during storage, handling, and transportation. Thus to fulfill the basic need "control of rate of respiration of fruit", it is important to determine the stage of maturity at which the fruit should be harvested.

It requires considerable experience to judge the stage of maturity, however to assess the correct maturity of mango fruit the following four stages have been defined.[34]

1. "A" stage- the shoulders are in line with the stem end and the color of the fruit is olive green.

2. "B" stage- the shoulders outgrow the stem end and the color is olive green.

3. "C" stage- the shoulders outgrow the stem end and the color becomes light green.

4. "D" stage- flesh becomes soft and blush developes.

During studies on storage of mangoes it has been found that fruit harvested at any stage of maturity A, B, C, or D ripened normally but "B" and "C" stages gave the best taste and odor. These methods of determination of maturity may not hold true in all countries in the world, that is why it is advisable to rely on physical or chemical tests in judging the maturity rather than on visual observation. The starch content and specific gravity of hard fruit have been found to be associated with the stage of maturity; direct measurement of the percentage of starch in the flesh is found to be a comparitively accurate method for determining maturity in hard green fruit.

Fruits with specific gravity of 1.01 to 1.02 are considered to give satisfactory results in respect to uniform ripening and quality. These tests have not yet been standardized but based on these factors, physical and visual observations can be standardized.[35]

The advantage in this system of determination is that even an inexperienced person can judge the correct maturity.

After harvesting, the fruit is sorted out by several grading procedures because mangoes picked from one tree may not be alike in terms of maturity. Therefore it is necessary to reject the ones which are over-mature or under-mature to assure better quality in foreign markets.

Post harvest treatment is another essential factor to assure proper ripening during transition. Post harvest treatment consists of fruit being laid in single layers on mats with paddy straw in a cool place so that fruit should not be exposed to critical temperatures. Soon after, the fruit should be brought to export centers for packaging. Packaging methods vary as to whether preservatives are needed or not, depending upon the destination of the fruit.

Packaging Methods

After harvesting and grading, mangoes are ready to be packed. Different methods have been used for packaging, I would discuss three of them which have been used from time to time in India and other exporting countries.

Method I: Mangoes are individually wrapped in squares of tissue paper with an area of 25 sq. cm. treated with biphenyl at 30-40 mg. per wrapper. The tissue paper is treated by various methods.(36) In one method, biphenyl crystals are rolled with the help of hot rollers on tissue paper of known area to ensure the correct amount of chemical goes on each wrapper.

In another method, which is comparitively easy, an alcohol solution of biphenyl of known strength is sprayed on a known area of tissue paper so that an area of 25 sq. cm. receives about 30-40 mg. of chemical. These wrappers are then packed in a heat sealed cellophane bag and later kept in a cool dry place.

After being wrapped individually in these tissue papers, the mangoes are packed in baskets or wooden crates. Two types of containers are used; baskets which contain 25 kg. of mangoes and wooden boxes which contain 20 kg. The mangoes are packed in four to five layers and the cushioning may be either waste paper cuttings or any other material which should be clean and appealing to the eye and also give enough protection to the fruit against shock. Ventilation is provided in both wooden and bamboo containers.

The packages are then shipped by air at a temperature of 40-50°F. Mangoes would usually stay fresh for about 6 days after they reach foreign markets. This method is not only used in India but other countries like the West Indies and Israel. The United States, although it does not export mangoes, uses this method for local shipment.[37]

India, Israel and the West Indies have used this method to export mangoes to England and France. It has been found to be successful in maintaining quality and storage life of fruit especially when wooden crates were used.

For every packaging method it is essential to protect fruit against microbial attack or influence, shock and handling

damage and also to make sure containers are capable of greater stacking strength during storage and transportation.

Wrapping of individual fruit not only increases eye appeal but also checks transmission of disease from one fruit to another. This wrapper, when impregnated with biphenyl checks spoilage during storage and transit and it is effective for a long time. Essentially the wrapper controls the respiration rate of fruit which protects the fruit against microbial attack.

The containers used are ventilated which keeps mangoes at the proper temperature by air circulation, thus mangoes do not overheat because of their respiration, since heat increases the respiration rate of mangoes and causes damage due to decay. Wooden boxes of dimensions 18x18x11 and 1/2" thickness of wood proved to be strong against shock and compression during storage. However when baskets are used instead, this method does not seem to lend a great deal of security to the fruit due to the following reasons. Bamboo baskets can not withstand compression for long distances. Results showed that shipments were damaged when bamboo baskets were used.

Results also showed that loss due to damage and pilferage was 3.9% for wooden baxes and 16.1% for bamboo baskets.[38] This means that loss for basket packaging is four times greater than for wooden boxes. Also on an average, wooden boxes earned Rs. 2.0 to Rs. 6.0 more than those packed in baskets. One Indian Rupee is equivalent to $.14.

Wooden boxes can be stacked 4 to 5 high whereas baskets

can be stacked only 2 high and even then stacking stability is not assured. Also baskets are more susceptible to damage due to a lower compression strength.

Another drawback of using baskets is that they do not have adequate space to indicate destination, weight and other necessary information due to their irregular shape.

India and other exporting countries realize the drawbacks of using baskets for mango packaging and thus do not make use of them for export as is described in the next packaging method.

Method II: As the mango trade flourished in countries like England and France, new trends in packaging methods were also explored.

A new method which used corrugated containers with or without vent holes was explored. This method can be put to use in two different ways, one using pre-packaging and the other wrapping.(39)

In using pre-packaging, a polyethylene bag of thickness 0.002 inches is filled with a dozen mangoes soon after harvest. The bag is then heat sealed. The polyethylene bag (a consumer unit pack) is provided with ventilation through holes which constitute 0.4% of the total area of the bag.

These bags are then placed in a container in one or two layers. Paper cuttings or paddy straw may be used as cushioning and Kraft paper for lining between layers.

The type of corrugated container was not mentioned, however it is believed to be lug boxes. The dimensions are

17½ x 11½ x 5½ inches. Two such boxes can be combined on top of each other and later tied with string.(40)

This method is only used for countries where mangoes are not sold by weight but by the piece, for example the U.S.A. or European countries. One advantage is that the dealer in foreign countries doesn't have to rearrange the packaging for local markets but merely has to take the bags out and place them on the shelf, also the consumer can see the fruit before purchasing it. Essentially pre-packaging is done for effective presentation at retail shops. The use of polyethylene does not change the fundamental perishable character of the fruit but gives some protection and makes handling and marketing easier.

If this method is carefully examined, the packaging of fruit has a great deal of influence with respect to marketing but less towards the protection of fruit during transit and storage.

However, a polyethylene bag with the provision of ventilation holes does have an advantage as it delays the ripening of fruit and minimizes the moisture loss during storage and marketing. But this method may not be as successful as individual wrapping of fruit in which transmission of disease can be checked. In other words, if one fruit spoils during transit and storage the other fruit in the sack is equally susceptible to damage since there is no checking medium in between. It has been clearly described earlier that microbes upon entering the fruit multiply rapidly and increase the

spore load inside the package causing decay of other healthy fruits. Therefore it is necessary to wrap individual fruit either with tissue paper or polyethylene to avoid spoilage to other healthy fruit.

When wrapping is used the fruit is harvested at "B" maturity stage. Then the mangoes are individually wrapped in tissue paper treated with biphenyl as mentioned in Method I. Later these wrapped mangoes are placed in a corrugated container.

The container used has cut strips of cardboard arranged in a criss cross patern, in other words, technically the box has partitions in such a way that each fruit can be placed in a single cell. Usually a box containing one layer of fruit will weigh up to 25 kg. Waste paper cuttings or paddy straw are used for cushioning. In some cases two layers of mangoes have been used with sufficient cushioning.

This method is also used by U.S.A. in Florida. [41] As indicated earlier boxes with one layer of mangoes can be joined together one on top of the other and tying it with string making it one package. These boxes have the dimensions of 17½ x 11½ x 4½ inches. These packages are presently being used to be shipped by air in a controlled cold storage at a temperature of 45° F to European countries from India. Mangoes stay fresh for almost a week after their arrival in the market.

Between the two methods described so far the second seems to offer the most protection against microbial attack,

injury to the fruit, and handling.

Tissue paper treated with biphenyl retards the ripening process. Research work has been done in Florida to discover the best material for wrapping.[42] It has been reported that all wrappers retard the ripening process, however plastic wrappers seem to perform better because they minimize the moisture loss rate in transit and also delay ripening. Thus polyethylene when used for wrapping individual fruit gives better results than tissue paper but it costs more.

This method also has the advantage of checking transmission of disease from one fruit to another. Furthermore the partitions in the box not only control the spread of disease but also keep the fruit firm and prevent the fruit from knocking against other fruit to cause injury. Injury causes an increase in the respiration rate of the fruit thus resulting in damage to the fruit due to microbial growth which puts a black spot on the fruit.

From a marketing point of view, fruit can be unwrapped and placed on the shelf where they can stay fresh until sold.

Corrugated containers are easy to handle and can be stacked without putting too much of a load on the fruit; the only drawback is the cost of corrugated containers may be too high in Pakistan.

Method III: Nature has provided a waxy coating to the fruit when mature (means green and unripe). This wax coating is protection against inclement weather. As soon as the fruit ripens this coating disappears and makes the fruit vulnerable to spoilage. Thus if an artificial coating is applied soon

after harvest the fruit can stay fresh up to 50 days.

The Central Food Technological Institute in Mysore performed an experiment on several kinds of fruit, the mango being one of them, and suggested a new method to export fruit by ship.[43]

Mangoes are wax coated by dipping them in a liquid wax emulsion and later they are dried. The wax emulsion alone does not control microbial spoilage and therefore disinfectants are added.

The wax emulsion can be made of any one of several waxes such as micro-crystalline paraffin, camauba, sisal, sugarcane and emulsifiable polyethylene.[44] The melting point of these waxes is 70-85° C but the best results have been achieved with waxes having a melting point of 75-80° C. In order to reduce incidence of infection or to minimize spoilage in bruised fruit, fungicides which are allowed by food laws are at times added to the wax emulsion before coating. For this purpose a 1% sodium orthophenyle phenate (SOPP) or a 0.2% Flit 406 (50% n. trichloro methyl thio tetraphthalmide) can be added. It checks microbial spoilage not only in mangoes but in many other commodities. However, if the fruit carries incipient infection, fungicide added to the wax emulsion may only delay the development of such infection but fail to control decay caused by seed infection during ripening. The addition of growth regulators like malic hydrazide at the rate of 1000-1500 p.p.m. further reduces the ripening rate, resulting in an increase of storage

life.

The following is a table of disinfectants with suggested concentrations of fungicides.[45]

TABLE 4

DISINFECTANTS WITH SUGGESTED CONCENTRATION OF FUNGICIDE

No.	Name of Disinfectant	Suggested Concentration
1	Sodium O. phenylate, SOP	0.25-2%
2	Flit 406 (Captan 83)	0.20-1%
3	Sodium hypochlorite, liquid bleach	0.10-1%
4	Benlate 50	0.10-0.2%
5	Thibendazole Tecto 60	0.20-0.5%
6	Brassicol-75	0.50-1.0%

A conveyer is used after dipping which rotates the mangoes and they are dried by a stationary heat blower which is approximately 45-35 cm. away from the fruit to avoid excessive heat. The rotation of the mangoes prevents the deposit of all the wax on one end. The mangoes should be completely dried before packing for transit or storage. Careful handling is required for such packages during the distribution process. Wooden crates or containers with dimensions 17½ x 11½ x 11½ inches have been recommended for packaging such mangoes.

The mangoes are placed in three or four layers with adequate cushioning and paper lining between the layers. Extra cushioning may be required for this type of mango so that the wax coating does not break and cause spoilage.

Prior to filling, the wooden crates must be fumigated and disinfected with hot water, steam or fungicide.(46)

These fruit containers can be stored at 70-90° F or at their optimum low temperature of 45-70° F. Continuous temperatures above 90° F cause spoilage of fruit. Thus for best results the suggested storage temperature is 45-70° F. At this temperature, the storage life of mangoes can be increased up to 100% depending on the variety.

The following table represents certain varieties which have a storage life of 21 days, however there are some varieties which can stay fresh much longer than 21 days.(47)

TABLE 5

CONDITION OF VARIETY AND CONCENTRATION OF WAX EMULSION

Variety	Condition of Variety	Concentration of Wax emulsion
Alphense	Green, unripe, 24-72 hrs old free from incipient infection	6%
Badami	Green, unripe, 24-48 hrs old free from incipient infection	6%
Bombai-calcutta	Green, unripe, mature	6%
Himsagar	Green, unripe, mature	6%

The varieties Chowsa, Dushri, and Dippasand can stay fresh up to 50 days at a temperature of 40-50° F and a relative humidity of 85-90%.(48)

Certain precautions must be taken in order for the wax

to adhere to the fruit. Concentrated raw emulsion containing 12% solids can be diluted with cold soft water to make an emulsion containing 4-6% solids which is suitable for mangoes. The use of soft water is necessary because the salt present in hard water will break up the emulsion, making the mangoes susceptible to microbial growth. It is therefore necessary to check the hardness of the water. This can be easily done by taking a small quantity of concentrated emulsion and adding it to a small sample of water. If the emulsion breaks up and precipitation occurs within five minutes, the sample of water is not suitable of dilution. The hardness of the water can be remedied either by boiling or by ion exchange for permanent purity of water.

This last method helps to reduce shipment costs since the mangoes are usually transported by sea instead of by air, and besides the lower transportation cost, a greater number of packages can be sent at the same time, resulting in an even greater cost savings.

CHAPTER IV

CONCEPTUAL PACKAGING METHODS

Packaging methods which are commonly practiced in exporting countries for mango export in particular have proved successful for the safe transport of the produce.

A package for such purposes can be developed by making a few modifications on the existing one in India for those countries which are potential exporters of mangoes like Pakistan. Modifications should be made keeping in view the assurance of more safety of the fruit during storage, transportation and handling of the package.

Mangoes after being wrapped with biphenyl tissue paper can be placed in a double wall corrugated container with specific dimensions 18x18x6 inches with partitions 3 inches apart and compression strength of 200 pounds.

This container would hold one layer of mangoes, one mango per partition with a total of 36 mangoes per layer.

Where there is not an adequate supply of corrugated paper-board due to unavoidable circumstances, wooden crates with the same dimensions and the same number of partitions can be easily substituted. Fortunately Pakistan is self sufficient in paper-board manufacturing.

An individual from the Sind Province of Pakistan has

recently taken the initiative to export mangoes to Japan using corrugated containers.[49] This means that the future prospects for mango export look bright if proper exporting facilities are provided, including good packaging.

The concept of the package given in this report can be justified by the following explanations;

Dimensions; The size of mangoes vary according to the variety, from 3 to 6 inches in length and 2 to 3 inches in diameter. But most of the exporting mangoes are 4½ to 5½ inches long except Anwar-Detol, grown in Punjab, Pakistan.

Assuming the length of the fruit to be 5½ inches with a diameter of 2 3/4 inches, a box filled with 36 mangoes would weigh about 32 lbs. Each mango which is wrapped with tissue paper treated with biphenyl is placed in a partition upright so that a greater number of them can be filled in the package and also because the bottom of the fruit is stronger and better able to withstand shock.

The partition plays an important role in the package. If the fruit was filled disorderly and the mangoes were loose in the package, the fruit would be susceptible to injury due to knocking against each other causing bruising. As mentioned earlier, injury increases the respiration rate and thus causes quick spoilage. The partitions are ¼ inch larger than the diameter of the fruit which keeps the fruit firm and does not allow the fruit to knock against one another. Furthermore, the size of the partition can be decreased or increased according to the diameter of the individual size of the mango

being packed.

Cushioning; Paddy straws, paper cuttings or wooden shavings can be used to provide protection against shock. Cushioning material should be placed on the bottom and a little around the sides of the package. Before closing the package, a square board 18x18 inches should be placed on the top. This would provide extra protection during the stacking of the packages.

Wrapping: Tissue wrapper treated with biphenyl has been recommended for the following reasons. Tissue paper helps keep the respiration rate lower so that it controls the ripening process of the fruit. Biphenyl controls the spoilage of fruit by controling microbial growth; together they check the transmission of disease from one fruit to another.

Results have indicated in a test study by the Fruit and Vegetable Association in Florida that polyethylene bags used for individual mangoes prove more efficient in keeping down the respiration rate of the fruit.(50) However it is necessary to keep the package as economical as possible, and this method would be more expensive in a country like Pakistan.

Other methods like the dipping of mangoes in hot water momentarily have been used before but recent studies in Florida proved that in fact this causes heat injury to the fruit resulting in spoilage.(51)

Container; The container is tuck end style, made from double wall corrugated board, B and C flute which has high

stacking strength. The container is provided with four holes on each side to facilitate air circulation and keep the mangoes cool.

These packages can be shipped by air with or without cold storage facilities depending upon the destination. However, if the packages are kept in cold storage at temperatures of 42-50° F, the shelf life of mangoes will be increased as indicated by the data below.(52)

TABLE 6

OPTIMUM COLD STORAGE CONDITION AND APPROXIMATE STORAGE LIFE OF DIFFERENT VARIETIES OF MANGO

Variety	Temp. F	Storage life without cold storage (days)	Storage life with cold storage (weeks)
Alphanse	47-50	7	4-6
Chowsa	42-50	8	5
Dusahri	42-50	5	4
Safada	42-45	7	7
Neelum	42-45	5	5
Dilpasand	42-45	5	4
Langra	42-45	5	8

However, the temperature recommended for cold storage by a study conducted in Florida by the Fruit and Vegetable Association is above 45° F to prevent chilling injury.(53)

A wax emulsion coating can be used to increase the shelf life of fruit up to 60 days. This method is only useful when a large amount of fruit is exported to those countries which

can be reached within 20-40 days by ship, such as the Middle East countries and Japan. The same container could be used for this method as for the previous method, however individual wrapping would not be necessary.

Although the implementation of the above methods would fulfill the present needs to export mangoes, there is a need to explore new packaging methods that would give not only better protection but also create a greater market for the fruit by being more attractive.

The School of Packaging is actively engaged in developing a conceptual packaging method for fresh fruits like apples. A team of investigators led by Dr. Kalman Peleg investigated a method of packaging called a "stick pack" for apples which is a major fruit crop in Michigan.

The stick pack method consists of a row of fruit like apples 4 or 5 in number packaged end to end by a shrink film over wrap. Two rows of fruits can be placed side by side forming a "double stick" which is essentially a tray pack without a tray.

It is important to point out that this method can only be used for larger fruit with the exception of fruits like the watermelon.

This method can be applied to mangoes as well. However it is not feasible to implement such a method in Pakistan at the present time due to the high initial investment to set up such a packaging plant. There is also a very large labor pool in Pakistan which must be utilized in order to build the

economy. However an investigation of such a method would be helpful in the near future when the mango trade expands to countries like Japan, U.K. and the United States. With this in mind, it would be essential to introduce an improved package like the stick pack to replace the major existing packaging methods.

The stick pack is purely a mechanical process, the machine most commonly used is Veegal Model IV, manufactured by the Italian firm AUTOMAC 41058 Vignola (Modena-Italia), via Caselline 171 Italy.(54) The above mentioned machine is widely used in Europe to shrink wrap produce.

A modified shrink machine has been manufactured in the United States to automatically shrink wrap rectangular packages with maximum dimensions of 12x12x4 inches at a rate of up to 90 packs per minute. This machine costs between $18,500 and $22,500 depending on the type of accessories and attachments. Veegal IV costs about $20,500 and makes 70 single or double stick packs per minute.

Since the stick pack is not suitable for the smaller fruit, it is necessary to choose varieties of mangoes which are not very small as are 'Anwar Detol', however most other varieties of mangoes are capable of being stick packaged. The study was conducted at Michigan State University School of Packaging. The subject of the experiment centered around apples only. The apples were graded into four sizes that were stick packaged but the fifth size was rejected, being too small. Thus four Veegal machines are required for each

packing plant. Similarly four such machines would be required for each mango packing plant.

Apples have been packed end to end in a vertical direction but in the case of mangoes it would be advisable to pack horizontally for two reasons. The first reason is that when mangoes are packaged horizontally a greater number of mangoes can be wrapped and utilize less space in the package thus resulting in a more economical package. The second reason is that when mangoes are packaged horizontally they can be placed in the container which would mean each mango would be supported on its bottom which being stronger gives the fruit extra protection against shock.

Due to the size and shape of the fruit, a double stick pack may not prove as effective. The reason for this is that a shrink wrap essentially tightens around the fruit, and when applied on a double layer, each fruit would be pressing against other fruit more than in a single stick pack which would cause injury due to constant pressure resulting in spoilage such as black spots.

A ventilated corrugated container with dimensions 15x15x6 inches can be used to carry such packs. A double wall corrugated container with high stacking strength has been used often for export shipment due to its greater compression strength, stackability and easy handling. The container is tuck end style with four holes on each side to provide ventilation facilities. Each container has also the provision to be carried individually if needed.

As mentioned earlier, each stick pack is placed in a box with the mangoes standing vertically. A rectangular corrugated board with an area of 18x5½ sq. in. should be placed between the two stick packs to keep the packs firm and to avoid the knocking of stick packs against one another. Sufficient cushioning should be provided on the bottom, this can be either paddy straws or paper cuttings, at the same time, overcushioning should be avoided.

The shelf life of mangoes can be maintained up to 30 days or more by keeping them at a temperature of 45-50° F and relative humidity 85-90%. These provisions can be made while packages are in storage or transit. The mangoes will have to be shipped by air cargo equipped with controlled temperature storage.

Results have indicated that the storage of mangoes in cold storage at temperatures of 45-50° F and relative humidity of 85-90% helps in reducing spoilage and extends the shelf life at consumer centers.(55)

Better results are obtained if the mangoes are waxed or any other method which controls the respiration and microbial growth is used. The stick pack seems to be a perfect substitute since it wraps around the fruit tight enough to protect the skin of the fruit from microbial penetration.

This kind of packaging method needs sufficient capital to start, whether it is brought into use at the present time or in the future. However, should the mango trade flourish in the next few years, this is an efficient, convenient and

systematic method. The system can be further mechanized by using a machine which could sort the fruit into different sizes. The sorted fruit would then be shrink wrapped to make a stick pack and placed in a container.

Time is the biggest factor for perishable fruit and by using the stick pack, the fruit can be delivered within a short time to foreign markets, providing more protection, and consequently attain greater consumer acceptance.

The stick pack has the following advantages provided Pakistan is able to start exporting a significant percentage of the worlds total mango production so that the initial capital outlay is of no concern.

The stick pack packaging system can be completely mechanized and can be economical provided the volume is large enough to justify the initial investment in machinary and when manual labor is scarce and very costly.

From a marketing point of view, the stick pack should gain wide consumer acceptance due to the uniformity of the package. It has already been successfully introduced in Europe for fresh produce, and a study conducted at Michigan State University shows consumer interest in this type of package in the United States.(56)

One of the advantages is that the consumer can view the fruit from all sides to be sure of her purchase. The package is such that it gives a complete picture of the fruit yet still protects from the abuses during purchasing.

Thus the stick pack is a high convenience retail package

with potentially high sales appeal in countries like the United States and Europe.

From the packaging point of view, the stick pack is beneficial. It prevents the fruit from knocking against each other which causes black spots on the fruit. In Michigan this method has been under study for apples because it reduces bruising.

Also the film used for shrink wrap decreases the respiration rate of the fruit thus increasing the shelf life. The shelf life can be further increased by storing at a temperature between 45-50° F and relative humidity of 85-90%.

As far as the fragility of the package is concerned, tests were run in the M.S.U. School of Packaging laboratory on the apple stick packs.[57] These tests showed that the stick pack apparently provided better shock protection as compared to other leading packages such as the tray pack and polyethylene bags.

Based on the above mentioned tests for apples, it can be assumed that such a pack will also provide better protection against shock for mangoes than the other packages being used at the present time. Thus overall, the introduction of such a package can bring greater demand for mango fruit in foreign markets.

CONCLUSIONS

The implementation of the packaging method used by exporting countries, particularly India, would help in establishing markets in foreign countries for Pakistani varieties. However, some modifications are recommended for the package design for exporting mangoes from Pakistan that would assure further protection of the fruit.

Mangoes wrapped in tissue paper treated with biphenyl should be placed individually in a ventilated double wall corrugated container of 200 pounds compression strength. The container is to be tuck end style with partitions with the capacity of 36 mangoes in a single layer, weighing approximately 32 lbs.

To insure greater stacking strength, a square would be placed on top of each package. Such packages would be shipped by air at a temperature of 45-50° F and relative humidity of 85-90%. Tissue paper treated with biphenyl would check not only microbial growth but also reduce the respiration rate of the fruit; further more, when stored at above mentioned temperature and relative humidity the shelf life of the fruit would be significantly extended until it is purchased by consumers. Other methods like wax coating can also be implemented which would increase the shelf life

of the fruit up to 60 days, but this method is only useful on a large scale.

The above mentioned methods require more man power than automation therefore it would meet the present needs in that it would help provide jobs for the labor pool.

However, as the export flourishes the need would arise to explore more efficient and convenient methods that would help to further extend the shelf life of the fruit, such as the stick pack package.

A stick pack plant would require a greater initial investment but at the same time there would be greater returns.

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