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INTRODUCTION

The Seminar on the Reduction of Post-Harvest Food Losses in the Caribbean and Central America was held in Santo Domingo, Dominican Republic during August 8-11, 1977. It was attended by 90 persons representing 12 countries and 9 international organizations.

The proceedings were published as presented (Spanish or English) in Volumes I thru IV. The list of the participants program and conclusions and recommendations were published in Volume V.

Although the Seminar was conducted with simultaneous translation, many important presentations were published in Spanish only. To meet the demands of the English speaking Caribbean countries IICA is publishing this sixth volume which contains all of the presentations which were made in the English language and the English translations of selected documents which were presented in Spanish.

It is hoped that these documents will prove useful in the identification and implementation of projects to reduce post-harvest food losses in countries of the Caribbean.

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TABLE OF CONTENTS

DOCUMENT VI-H

TITLE: Comments on Insect-Caused Post-Harvest Crop Loss Assessment

AUTHOR: Fernando Agudelo

DOCUMENT VI-I

TITLE: Post-Harvest Losses of Potatoes Quantified During the Marketing Process: From Rural Assembly to Wholesale and Retail Assembly in Santo Domingo, during 1976

AUTHOR: Jorge Mansfield

DOCUMENT VI-J

TITLE: Study of Post-Harvest Losses of Salad Tomatoes in the Dominican Republic

AUTHOR: Gilberto Mendoza

DOCUMENT VI-K

TITLE: Summary of Study of Post-Harvest Losses of Cassava in the Dominican Republic

AUTHOR: Romero Tejada

DOCUMENT VI-L

TITLE: Potato Storage as Part of a Total Potato Production Programme With Special Reference to South Korea

AUTHOR: Robert H. Booth

DOCUMENT VI-M

TITLE: Transfer of Post-Harvest Technologies to Small Farmers

AUTHOR: Michael J. Moran

DOCUMENT VI-N

TITLE: Elements of Regional Program to Reduce Post-Harvest Food Losses

AUTHOR: Jerry La Gra

DOCUMENT VI- A

THE ROLE OF POST HARVEST FOOD LOSS REDUCTION IN IMPROVING THE ECONOMIC AND NUTRITIONAL STATUS OF TROPICAL POPULATION*

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*Prepared for the Seminar on the Reduction of Post-Harvest Food Losses in the Caribbean and Central America. Santo Domingo, D. R., August 8-11, 1977.

INTRODUCTION

Most tropical countries have long recognized that one of the major problems that needs attention in their program for development is that of increasing the supply of food, because a population that is not well fed is prone to deficiency diseases, more susceptible to infectious diseases and does not have the energy to work hard. As a result of this recognition of the food problem a great amount of effort has been devoted to increasing the production of food. This increase has been accomplished through three avenues of activity i) increasing the area of land under production; ii) increasing the yield per unit of area; and iii) multiple cropping systems in which more than one crop is produced from a given plot of land in a year.

Each of these avenues to increase the production of food have had successes. However, increasing the production of food is not the real goal of these activities. The real goal is to put more food into the mouths of the people and this necessitates moving the food through the delivery system all the way to the point of consumption. Many activities are required to take the raw agricultural product that is harvested in the field and to transport and convert it into food on the plate ready to eat. In this "pipeline" that takes the food from the farm to the table, there are many opportunities for the food to be lost with the result that much of the food that is being produced never reaches the consumer for whom it was intended. The problem is shown in cartoon fashion in Figure 1.

A number of people over the years have pointed out that the post harvest preservation and storage of food are matters of importance, but in general these comments have not received a great deal of attention. There

was an abrupt change in the interest level of post harvest handling and storage of foods on September 19, 1975 when the United Nations General Assembly, meeting in New York, passed the following resolution: "The further reduction of post harvest food losses in developing countries should be undertaken as a matter of priority, with a view to reaching at least a 50% reduction by 1985. All countries and competent international organizations should cooperate financially and technically in the effort to achieve this objective". This resolution has drawn the attention of the highest levels of governments and donor organizations around the world to the problem of post harvest food losses and has resulted in a number of actions being initiated.

Within a given region the daily demand for food is constant over the course of a year (if we ignore population changes) but the supply of food for the region is very uneven from day to day over the course of the year. Food preservation, storage, and transportation are the mechanisms which mankind has developed in an attempt to match the very uneven day-to-day supply of food with the even day-to-day demand for food. This problem of matching the uneven food supply to the even demand for food has been one of the classic historical problems that has always faced mankind. Today, thanks to increased knowledge, and better equipment we are better able to solve this problem than in any other period in the history of the world.

There are a number of benefits to be obtained from reducing the wastage of foods in the post harvest chain. The first of these is nutrition. Since less food will be lost there will be more nutrients available for the people. Although food losses are usually assessed on a weight basis we need to remember that many losses give a higher percentage nutrient loss than the weight loss figures alone would show.

Post harvest loss of food represents an economic loss, and the economic loss increases as the food moves down the pipeline that connects the farmer to the consumer because to the cost of the food that is lost at each step must be added the cost of storing and handling of the food in all the previous steps of the chain. This is demonstrated in Table 1 which shows the average prices for foods in the U.S. in 1976.

The first column of figures in table 1 show the average price the U.S. farmer received for typical foods while the second column lists the average retail price paid in the U.S. The third column gives the ratio: retail price/farm value. The increases in price as the food moves along the marketing chain are substantial. One pound of rice lost at the farm represents a loss of 10.5 cents, but the same pound of rice lost in the supermarket represents a loss of 44.7 cents. It is necessary to reduce losses at every step along the marketing chain that connects the producer to the consumer.

Another important economic aspect of post harvest food losses is that the importation of food in substantial quantities places a very heavy burden upon the overseas currency reserves of tropical countries. If these countries could reduce their post harvest losses it would reduce or eliminate that country's dependence upon imported foods thus reducing the problems that importing of foods places upon their overseas currency reserves.

Yet another important aspect of post harvest food losses is the "feed back incentive". In many instances farmers could well increase their production but at present they are unable to store food for any lengthy period of time and the food is spoiled and lost. There is no incentive for

these farmers to increase production when they know full well that the extra production will spoil before it can be utilized or sold. If the post harvest losses that they suffer at present could be reduced or eliminated there would be more incentive for them to increase production.

It should be realized that the U.N. goal of reducing post harvest food losses by 50% by 1985 is a major undertaking that has never before been attempted in the history of the world. It is a most worthy and noble goal, but it is also a tremendous challenge. It will require the total mobilization of the world resources in the field of post harvest food technology and storage engineering to achieve this goal.

What is a Post Harvest Food Loss?

An important preliminary action in working in this area is to define the exact meaning of the term "post harvest food loss" and establish the boundaries of concern. A preliminary working definition of this term is given below. For the sake of convenience it is divided into three parts:

"POST HARVEST" means after separation from the medium and site of immediate growth or production of the food.

Post harvest begins when the process of collecting or separating food of edible quality from its site of immediate production has been completed and ends when the food enters the mouth. The food need not be removed any great distance from the harvest site but it must be separated from the medium that produced it by a deliberate human act with the intention of starting it on its way to the table. Three periods of time may be identified during which food may be lost

a) preharvest losses occur before the process of harvesting begins.

For example, losses in growing crops due to weeds, diseases, insects and rodents.
b) harvest losses occur between the onset and completion of the process of harvesting. For example, losses due to shattering when harvesting grain.
c) post harvest losses occur between the completion of harvest and the moment of human consumption.

Harvest losses and post harvest losses are sometimes grouped together under the heading "post production" losses.

"FOOD" means weight of wholesome edible material that would normally be consumed by humans, measured on a moisture-free basis. Inedible portions such as hulls, stalks, leaves, skins, bones and shells are not food. Potential foods (for example, single cell protein, leaf protein and waste) are not foods; they do not become food until they are accepted and consumed by large populations. Feed (intended for consumption by animals) is not food.

"LOSS" means any change in the availability, edibility, wholesomeness or quality of the food that prevents it from being consumed by people.

Appendix A lists a number of specific examples to show how this definition of post harvest food loss works out in practical situations.

Causes of Losses

There are many ways in which food may be lost and become unavailable for human consumption. The problem with food is, that although man harvests or hunts food for his own personal consumption there are many other living organisms that want to use this food for their own use. The organisms range from large animals such as deer and monkeys through small animals such as birds and rodents, down to small forms of life such as insects, and on down to microscopic forms of life such as molds and bacteria.

In addition, there is a natural tendency for food, which is built up principally from inorganic carbon and nitrogen sources into complex energy-rich compounds, to degrade again to the simple ~~inorganic compounds~~ from which it was produced in the first place. These biochemical and chemical reactions occur spontaneously and lower the quality of the food. It is for these reasons that the preservation of foods has been one of the prime concerns of mankind throughout recorded history.

The major causes of losses are listed below under the headings primary causes, and secondary causes (Bourne 1977).

A. <u>Primary Causes of Loss</u>

a) Biological and microbiological. Consumption or damage by insects, mites, rodents, birds, and large animals and by microbes such as molds and bacteria.

b) Chemical and biochemical. Undesirable reactions between chemical compounds that are present in the food such as the Maillard reaction, fat oxidation, and a number of enzyme activated reactions; accidental or deliberate contamination with harmful substances such as pesticides, or obnoxious substances such as lubricating oil.

c) Mechanical. Spillages, abrasions, bruising, excessive polishing, peeling or trimming, puncturing of containers, defective seals on cans and other containers.

d) Physical. Excessive or insufficient heat or cold, improper atmosphere.

e) Physiological. Sprouting of grains and tubers, senescence in fruits and vegetables, and changes caused by respiration and transpiration.

f) Psychological. Human aversion, such as "I don't fancy eating that today", or refusal to eat a food for religious reasons.

Some of these causes of losses interact. For example, respiration generates heat which if not dissipated will accelerate biochemical and chemical changes. If the temperature continues to rise, the point is reached in stored grains where insects infecting the food move away from the hot spot or are killed. In extreme cases the temperature can rise to the point where the food begins to blacken and eventually burn (spontaneous combustion).

In some cases more than one of these causes may be responsible for food loss. Multiple causes may work simultaneously or sequentially. Simultaneous action is the growth of mold and insects at the same time. An example of sequential action would be first the growth of mold which is stopped by drying, followed by biochemical reaction caused by the enzymes elaborated by the mold that results in unacceptably soft texture, rancid flavor or inferior color.

B. Secondary Causes of Loss

Secondary causes are those that lead to conditions in which primary cause of loss can occur. These usually are the result of inadequate or non-existent input. Examples are:

a) inadequate drying equipment or poor drying season;

b) inadequate storage facilities to protect the food from insects, rodents, birds, rain and high humidity;

c) inadequate transportation to get the food to market before it spoils;

d) inadequate refrigerated or cold storage (for perishables);

e) inadequate marketing system;

f) Legislation. The presence or absence of legal standards can affect the eventual retention or rejection of a food for human use.

There are times where it is possible to use a primary cause to offset a secondary cause and vice versa. For example, the problem of an inadequate transportation system can be partially overcome by drying of grain so that it does not become moldy so quickly, or by growing a variety of tuber that has longer keeping properties. Conversely, insufficiently dried grain can be rushed to market and sold before it molds if good transportation and marketing services are available.

All stored foods undergo deteriorative changes during storage which may cause loss of flavor, color, texture or nutritional value. There is no known method of stopping these deteriorative changes. This is a fundamental fact that lies behind all food preservation activities. Food preservation technology can slow down the rate of deterioration of quality but it cannot stop the deterioration. Every food, no matter how well preserved, will eventually become unfit for human consumption if stored for sufficient length of time. From a practical viewpoint, however, we know that cereals and many other dried foods, together with some of the processed foods, can be stored and maintained in good condition for periods of several years provided they have been correctly preserved and subjected to good storage conditions and good management practice.

Losses may occur anywhere from the point of harvest up to the point of consumption. These may be classified into the following headings:

1. Preparation is the preliminary separation or extraction of edible from non-edible animal and agricultural production. For example, the dehulling of grain, slaughtering and dressing of animals, extraction of sugar from sugar cane, and peeling of fruits and vegetables.

2. Preservation is the prevention of loss and spoilage of foods. For example, the drying of grain or fruit, the refrigeration or canning of vegetables

or fish, and the use of antioxidants to delay the onset of rancidity in fats and oils.

3. Processing is the conversion of edible foods into another form more acceptable or more convenient to the consumer. For example, making bread from wheat, brewing beer from barley and making sausages from meat.

4. Storage is the holding of foods until consumption. Some foods are more highly perishable than others and do not have as long a shelf life before spoilage begins. The perishability of foods may be arbitrarily divided into three classes:

Class I. Highly perishable foods that spoil within a few days unless some method is applied to control the spoilage. Examples in this group are milk, fish, meat, and many fruits and vegetables.

Class II. Perishable. These foods take from several days up to several months before spoilage occurs. Examples are potatoes, apples, citrus fruits, and fats and oils.

Class III. Stable foods. These can be kept for months or years before spoilage. Typical examples are cereal grains, nuts, oilseeds, sugar, and honey.

5. Transportation. Many different forms of transportation are used to move the food step by step along the pipeline that connects the point of production to the point of consumption.

6. Home preparation. There are some losses of food in the home. For example, studies in the U.S. have shown that the average American household discards approximately 10% of the solid food that has been purchased (Harrison et al. 1975). It is not known how high in-home losses of foods are in tropical countries but since the cost of the food in relation

to income is very high in most tropical countries it is probable that the in-home losses of food are less in tropical countries than in the U.S.

Of the six locations of loss named above, probably the more important ones for food loss reduction programs are preparation, preservation and storage.

What do we cut in half?

A very important segment of the problem of responding to the U.N. resolution to reduce losses by 50% is to know how large is the quantity that has to be cut in half. We need to know how much food is presently lost in the post harvest food chain and where it is lost if we are to have any means of measuring how close we are coming to accomplishing the goal of the 50% reduction. This is where we run into a major problem. Most experts acknowledge that post harvest losses of foods are large, especially in tropical countries or that they are needlessly higher than they need be and that they can be substantially reduced at an economic cost but there is very little reliable data based on experimental measurement to tell us exactly how much food is lost overall. We do know that millions of tons of food worth billions of dollars are lost after harvest each year.

Losses are highly variable depending upon the commodity that is being considered, the country, the climate and other conditions under which the food is handled, and the length of time the food is stored. We would expect to find higher losses in perishable foods than in stable foods, we would expect the extent of loss would increase as the time of storage is lengthened, and we would expect that the losses be higher in hot climates than in cold climates but having stated these generalities we are still faced with the problem of exactly how much food is lost.

The honest answer to the question, "How much food is lost"? is that we do not know exactly. We are presently faced with the problem of obtaining reliable factual data on the extent of losses for a given food under a given set of conditions stored for a given time. One of the principal objectives of this seminar is to get information along these lines. This information should show us where the greatest losses occur and point out those loss reduction activities that have the highest priority. They will also provide a benchmark against which progress in reducing losses can be measured.

Many of the figures for the extent of losses that are quoted by the communications media and sometimes in the scientific literature are unreliable because the amount of loss has been estimated and not obtained by actual measurement. There is often the temptation to cite "worse case" figures to dramatize the problem in order to obtain some action. Yet another problem that complicates the reliability of data is that even some of the figures that have been obtained by careful measurements are manipulated for various reasons. In some cases there is the temptation to exaggerate the figures of loss, particularly if there is a prospect that high figures of loss will prompt aids or grants from some donor. In other cases there is a temptation to minimize the loss figures in order to prevent the embarrassment of acknowledging the magnitude of losses, or for financial or trading reasons. DePadua (1975) has estimated the losses of rice in the Philippines to be as follows:

Table 2. Post Harvest Losses of Rice in the Philippines

Operation	Range of Losses (%)
Harvesting	1-3
Handling	2-7
Threshing	2-6
Drying	1-5
Storing	2-6
Milling	2-10
Total	10 to 37

Cutting these losses by 50% would increase the supply of rice in the Philippines by a figure that lies between 5% and 18.5%.

Special Problems of Tropical Countries

Tropical countries have a number of problems in their battle to reduce post harvest food losses that are not found in temperate climates. Even if the tropical countries had the same per capita income as the developed countries the special problems that they face pose a much more difficult set of conditions in preserving their food supply than is experienced in the temperate zones. Some of these problems are listed below:

1) High temperature - The continual high temperature of the tropical countries provide ideal conditions for rodents to multiply all year long; and for favoring the growth and multiplication of insects and molds. The cold winters of temperate climates slows down or stops the reproduction of rodents and insects. The feeding of insects ceases below about 15°C, and in very cold climates the insects can be killed.

Deteriorative changes that result from chemical and biochemical changes in stored foods proceed at a faster rate at higher temperatures

causing the quality of foods to deteriorate more rapidly in tropical climates. For example Figure 2 shows how the quality of canned goods, (which are looked upon as being very stable items), deteriorate more quickly under warm conditions of storage. Figure 3 shows the loss of vitamins in canned foods stored at different temperatures. The rate of physiological changes in horticultural products is also dependent upon temperature. Unless subjected to some kind of cooling they will deteriorate more quickly in a tropical climate than in a temperature climate. This is shown in Figure 4 where the loss of quality of lettuce and asparagus is plotted against storage time.

2. High Humidity - Cereals and other dry foods are resistant to the growth of molds when their moisture content is too low to support mold growth. The normal molds require for growth a moisture content in the food that is in equilibrium with an atmosphere of 80% or higher relative humidity. The RH in the humid tropics is above 80% much of the time with the result that it is difficult to reduce the moisture content of dry foods to less than 80% equilibrium relative humidity. After the moisture content has been reduced to the required level the food will absorb moisture from the high humidity air and become moldy unless protected from the moist atmosphere. This problem is not encountered in climates where the prevailing relative humidity is below 80%.

3. Knowledge - The causes of losses in foods are known and the means of minimizing these losses are also known. In many countries this knowledge is not widespread among the population.

Needed Actions

a). Commodities. Attention should be given to a wide variety of foods

that suffer post harvest losses. This should include cereal grains, dry legumes, roots and tubers, and a limited number of perishable foods. One problem with perishable foods is that there are so many of them that it is impossible to adequately pay attention to all of them. Hence it would be valuable to select for attention a limited number of perishable foods (such as a few fruits, vegetables and fish) for attention in reducing post harvest food losses. If the number of perishable foods was restricted to pehaps 10 or 12 of the most important it would enable the problem to be reduced to a manageable level and much progress would be made. If an attempt is made to reduce post harvest losses in all perishable foods the effort will be spread so thin that there is a good liklihood of small accomplishment.

b) Equipment - There is a need for construction of many storage and food handling facilities in developing countries. This includes storage for grain, storages for tubers, and refrigerated storage capacity for perishables.

Many any smaller food extraction plants that are used for extracting sugar from sugar cane and oil from oilseeds could be improved. In contrast to large operations which usually provide a highly efficient extraction, these small scale extraction plants are generally inefficient, extracting only 50 to 75% of the desired ingredient, which results in considerable loss of edible material.

The dehulling and milling of cereals are frequently sources of losses in food, especially rice. There is a need to improve the efficiency of these operations.

c) Education - It is significant that methods for controlling post

harvest food losses are well known and widely used in the developed countries but to a much lesser extent in developing countries. Therefore, a major educational effort across the whole spectrum of society in developing countries is needed in order to make the populations aware of the fact that large post harvest losses in foods are not inevitable and that there are known causes for losses and known cures for each of these losses.

d) Adaptative research - Although the basic knowledge of food preservation and storage is well known and the technology is well developed in developed countries there is a need to develop packages of low cost appropriate technology that will fit right into the existing practices and customs of each country. Most of this work should be country specific, taking into account local customs, local building materials, and the existing incentives for farmers and food handlers to adapt the new package of practices. It will be necessary to work out every aspect of the total package in detail and check it out in practice before it is taught on a wide scale.

In some cases common sense is what is needed. For example soft fruits should be stored and transported in shallow containers in order to minimize losses due to bruising and squashing. All foods should be shaded to keep them out of the direct rays of the sun. Foods that are in direct sunlight can be 20 to 30° higher in temperature than foods that are shaded. This higher temperature in direct sunlight greatly accelerates the rate of deterioration.

There needs to be adaptive research in the drying and storage of grains and some of the perishables. There is a need to develop low costs methods for reducing the temperatures of stored foods. Even

partial cooling will extend the shelf life of many foods, and although not as effective as complete refrigeration for perishables, it is better than no cooling at all. Many of the tropical roots, tubers and fruits have a optimal storage life at temperatures in the range 50-55°F and subject to chilling injury at normal refrigeration temperatures which are in the range of 32-40°F. Simple methods of reducing temperature should be of particular use for extending the storage life of these products because it is easier to achieve a temperature of 50°F than a temperature of 32°F.

Figure 5 is a sequel to the cartoon shown in Figure 1 and shows how the above mentioned activities can increase the quantity of food available to the consumer.

Conclusions

The large numbers of undernourished people in the world who are sick, lethargic, apathetic and stunted in physical and mental development bear eloquent testimony to the need for greater food intake. But most of these people do not have the money to buy more food. Even when jobs are available their poor state of health often prevents them from working and earning the money to buy the food they need. The prices paid to the farmers cannot be reduced to any extent because the farmers are close to the subsistence level themselves. How can we make more food available at lower cost and break this vicious cycle?

Figure 6 shows schematically the increase in price that occurs as food is moved from the producer to the consumer and how reduction of post harvest losses might reduce the price of food to consumers without lowering the price paid to the farmer. The cost of post harvest losses need no longer be absorbed by the farmer and the middleman. If these savings are passed

on, the consumer can purchase food at a lower price with no reduction of income to the farmer or the middleman. It is a situation in which every person wins, and the only losers are the "stealthy thieves" - the rodents, insects and molds that steal and spoil our food.

It is my hope that the participants in this meeting will take a hard look at the entire post production system that moves food from the producer to the consumer and using their knowledge and experience of conditions in this region of the world, plan and implement those activities that will most effectively reduce post harvest food losses in this region. You have the opportunity to change the course of history of the food supply of your country. This represents a great challenge and a lot of hard work, but the payoff will come when you see your people better fed, and your country becoming more prosperous as a result of your actions.

Table 1. Average Prices of Foods in the U.S. - 1976

Food	Farm Value Cents	Retail Price Cents	Retail Price/ Farm Value
rice 1 lb.	10.5	44.7	4.26
dry beans 1 lb	24.6	54.4	2.21
sugar 5 lb	51.5	126.6	2.40
white flour 5 lb	34.9	95.1	2.72
white bread 1 lb	3.8	35.3	9.29
cookies 1 lb	10.6	94.6	8.92
potatoes 10 lb	49.3	149.9	3.04
onions 1 lb	10.2	24.5	2.40
tomatoes 1 lb	23.8	57.7	2.42
oranges 1 doz	22.0	108.7	4.94
beef, choice 1 lb	77.7	142.1	1.83
eggs, large, 1 doz	58.2	86.0	1.48

(Data from Agricultural Outlook, May 1977)

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APPENDIX A

This appendix lists a number of specific examples to show how the definition of post harvest food loss (given on page 4-6) works out in practical situations.

1. Grain becomes post harvest after it is separated from the stalks and brought in from the field. It need not be removed from the farm; thus on-farm storage of grain is post harvest, but untouched grain on the stalks in the field is preharvest, and bundles of grain in shocks in the field are in the process of harvest. Ears of corn that are turned down and allowed to remain on the stalks in the field are in the process of harvest. The corn does not enter the post harvest stream until it is separated from the stalks and removed from the field.

2. Animals and birds become food after slaughter and dressing. Losses before slaughter are not post harvest losses. Carcasses that are discarded after slaughter because they are diseased or otherwise unfit for human consumption are not post harvest losses; they were unfit for human consumption before slaughter but the defects were not evident until after slaughter. Carcasses that pass inspection after slaughter, and subsequently develop defects that make them unfit for human consumption are post harvest losses.

3. Fish becomes post harvest after it has been pulled into the boat. A fish escaping through a hole in the net before being landed is not a post harvest loss. If after being landed, an edible fish is thrown back into the water because it is of the wrong kind, size or quality, it is a post harvest loss. If it is thrown back because it is inherently inedible (e.g., a poisonous species) it is not a food loss.

4. Fruit becomes post harvest after it has been picked from the tree and placed in containers. Fruit that falls from the tree and is allowed to rot on the ground is not a post harvest loss because it was never harvested; however, if fallen fruit is picked up and placed in containers for the

purposes of utilization, then it becomes subject to post harvest losses. Similarly vegetables become post harvest after separation from the plant by human intervention; roots and tubers must be removed from the soil to enter the post harvest system.

5. Milk becomes post harvest as soon as it is drawn from the udder unless it is rejected as being unfit for human consumption at the time the animal is milked. Any subsequent losses in milk or products manufactured from milk are post harvest losses.

6. Eggs enter the post harvest food chain as soon as they are separated from the hen by human intervention. Eggs broken by the hens are not post harvest losses. Eggs that are rejected for human consumption because of defects present in the egg when they were laid are not post harvest losses even though the rejection might occur some time after laying (e.g., if candling discloses excessive blood spots).

7. A quantity of rye is found to be contaminated with ergot and is condemned. This is not a post harvest loss because the rye was unwholesome at harvest but this fact was not discovered until later.

8. A quantity of peanuts is condemned because it is contaminated with aflatoxin. If the aflatoxin was present in the peanuts at the time the plants were pulled from the ground it is a preharvest loss. If the aflatoxin developed during the time the peanuts were curing in the field, it is a harvest loss and if the aflatoxin was formed because of faulty storage conditions after the peanuts were brought in from the field it is a post harvest loss. This is one of the difficult cases because it is not always possible to determine at which point the Aspergillus mold grew and formed the aflatoxin. Since the contamination usually occurs during curing in the field, aflatoxin should be considered a harvest loss unless there is strong evidence to show that the mold grew while the peanuts were in post harvest storage.

9. 100 tons of paddy rice are milled yielding 80 tons of unpolished rice. There has been no food loss because the hulls are inedible.

10. 100 tons of paddy rice are milled yielding 60 tons of whole polished grains, 20 tons of broken grains and 20 tons of hulls and bran. The 20 tons of broken grains are a food loss if they are not used for human consumption because this is edible material. The small quantities of endosperm that are rubbed off by abrasion and are removed with the bran are a food loss. The weight of hulls removed is not a food loss. The weight of bran is another difficult case because it contains valuable nutrients and sometimes it is eaten. Since the bran is usually not eaten it should probably be excluded as a food loss, but this is a debatable decision.

11. 120 tons of rice with 20% moisture are dried, yielding 110 tons of rice at 10% moisture. There has been no food loss because the only change was in the moisture content.

12. Food that is condemned because it fails to meet legal standards is a loss if it was in compliance with those standards when it first entered the post harvest system.

13. Theft is not a food loss. The fact that the food moves from legal channels into illegal channels does not alter the fact that the food is, presumably, still used for human consumption.

14. Food that is spilled is a loss unless it is picked up and reclaimed.

15. Food that is consumed by rodents, birds, and other non-domestic animals after harvest is completed, is 100% loss.

16. Grain that is contaminated by insects can range from a small loss to 100% loss because insects cause both weight losses and quality losses. Insects usually consume only a small portion of the food they contaminate. The confused flour beetle larva (a heavy feeder for an insect) is estimated to consume 26 milligrams of food during its development to adulthood. It requires an enormous number of larvae to directly consume a significant quantity of food and occasionally the insect population becomes so high

:hat significant direct weight loss occurs. However, insects damage much iore than they consume. Their frass and webbing can spoil many times the imount of food they actually consume. When the extent of insect infestation .s small the food can generally be reclaimed making the loss small. A ›oint is reached in heavier infestations where health, legal, cultural, iesthetic or fiscal factors, or the difficulty of reclamation cause 100% .oss, even though only a small percentage of the food has actually been :onsumed by the insects.

.7. 1,000 lbs of field run potatoes are passed through a cleaning & grading ›lant and yield 800 lbs saleable potatoes, 100 lbs of undersized potatoes and .00 lbs of rocks and dirt left in the washing tank. The reduction in weight 'esulting from the removal of rocks and dirt is not a food loss. The 100 bs of undersized potatoes are a food loss even though they have no present conomic value and are discarded, because they represent edible food.

8. When the quality of a food deteriorates to the extent that it is onsidered unfit for human food and it is diverted into animal feed, it hould be considered 100% loss. We are concerned with <u>food</u> for humans, not <u>eed</u> for animals. It might be argued that the food returned by the domestic nimal should partly offset the food → feed loss. SInce the conversion fficiency of animals is generally less than 10% it seems that writing this ff as 100% loss would be the simplest method of handling this situation, nd that it would not cause any significant decrease in the accuracy of he bookkeeping. Foods that are produced expressly for animal feed are not ood losses since it was the intention to use them as feed from the outset. his example refers to crops that were intended to be used as food ut were diverted into feed because of loss of quality.

9. Food that is discarded for minor or major quality defects after ntering the food chain is considered 100% loss. Examples of minor quality efects are day-old bread, and fruit with a blemished skin or unusual iape. Examples of major quality defects are food that is burned in cooking, oldy bread, stale eggs, overripe fruit and rotten vegetables and fish.

20. A quantity of apples in cold storage suffers internal breakdown of the flesh after two months when the expected storage life of this variety is six months. Investigation shows that the cause of the problem is calcium deficiency in the orchard. This is a post harvest food loss even though the correction of the problem (better calcium nutrition for the trees) is preharvest because the apples were in a wholesome, edible condition at the time of harvest and there was time for them to be marketed and consumed before the problem of internal breakdown appeared.

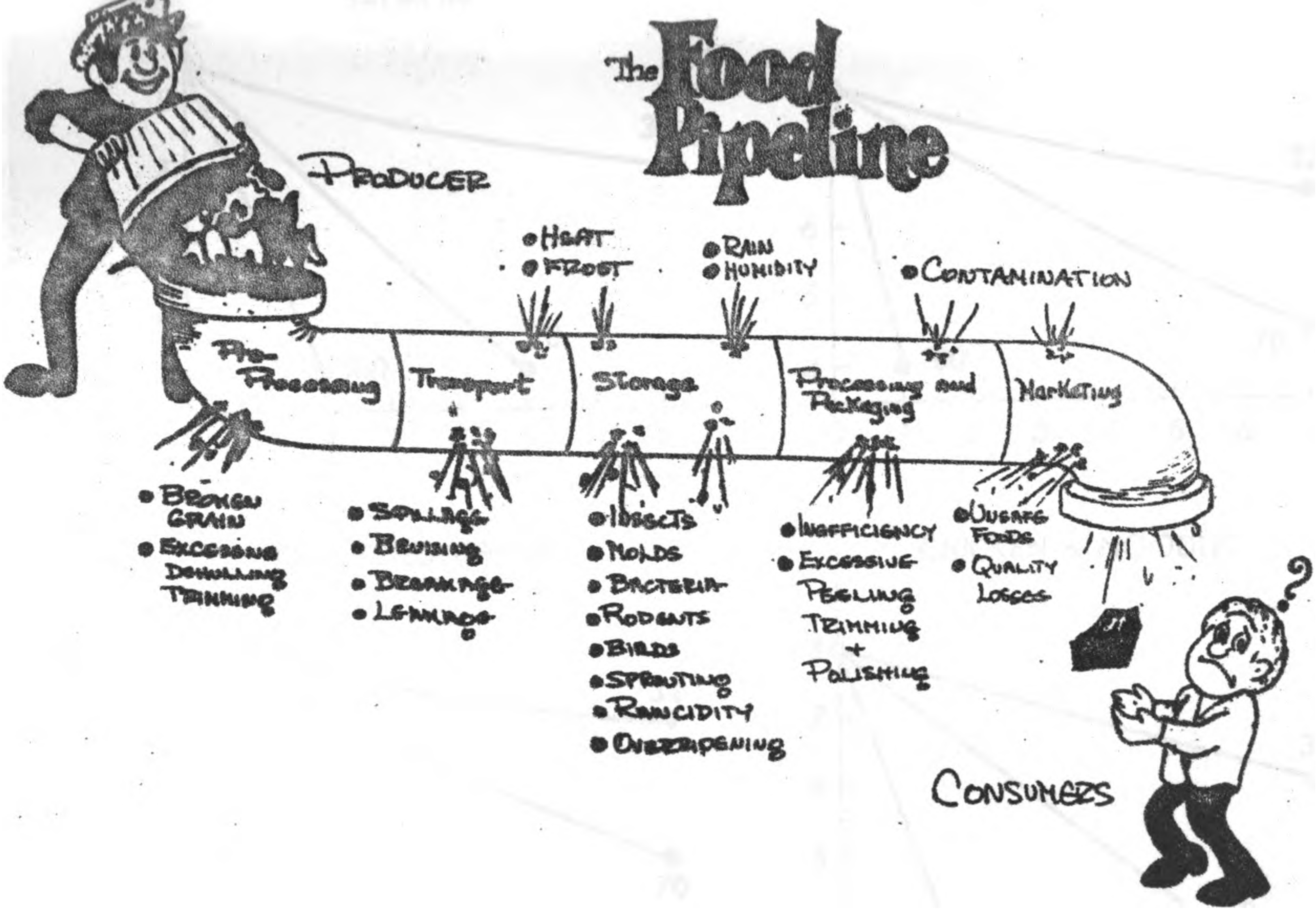


Figure 1. **Schematic representation of the problem of post harvest food losses where much of the agricultural and fisheries production never reaches the consumer.**

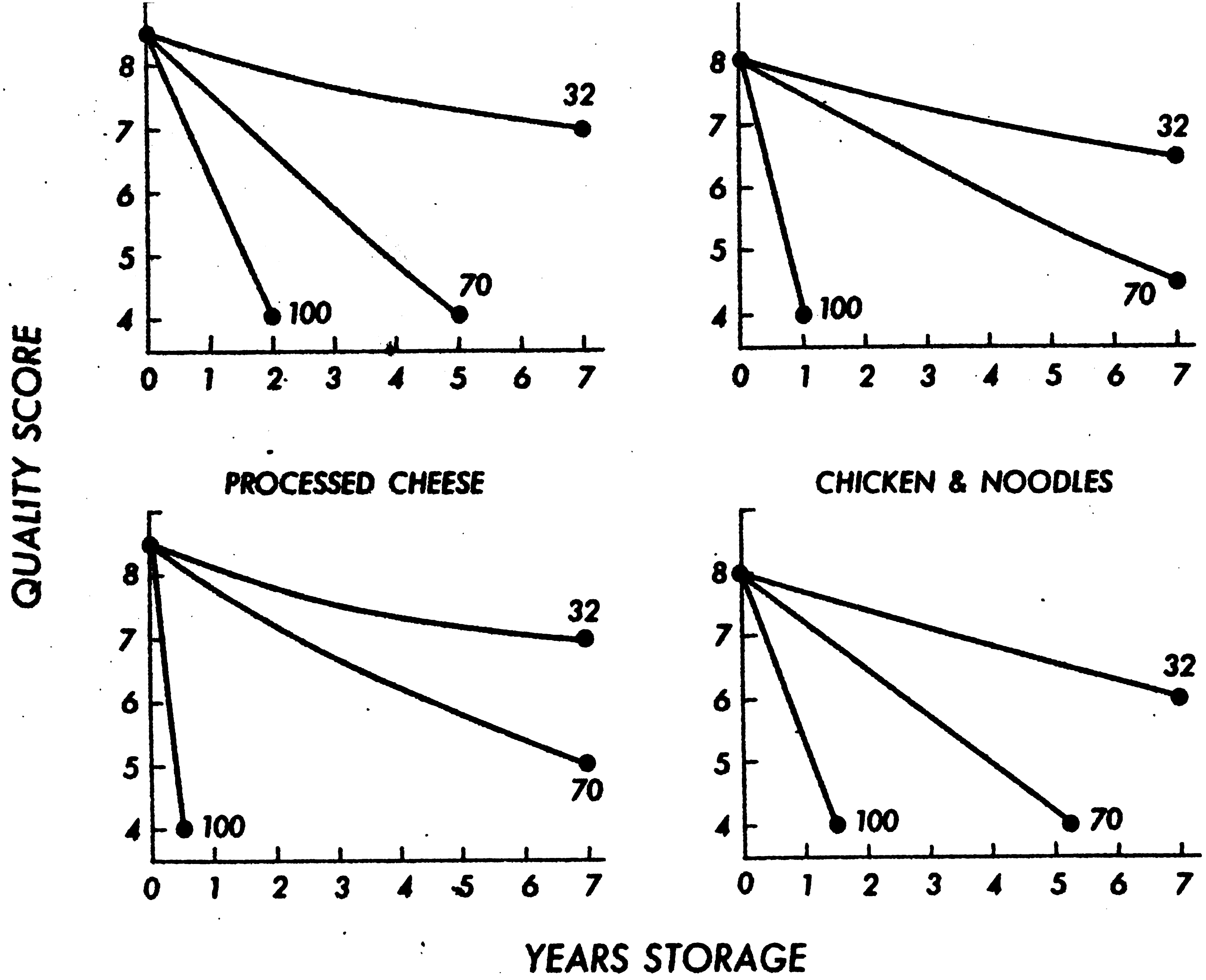


Figure 2. Quality changes that occur in canned foods during storage at 32°F, 70°F and 100°F. Quality is measured on a sensory scale of 1 (extremely poor quality) to 9 (extremely good quality).

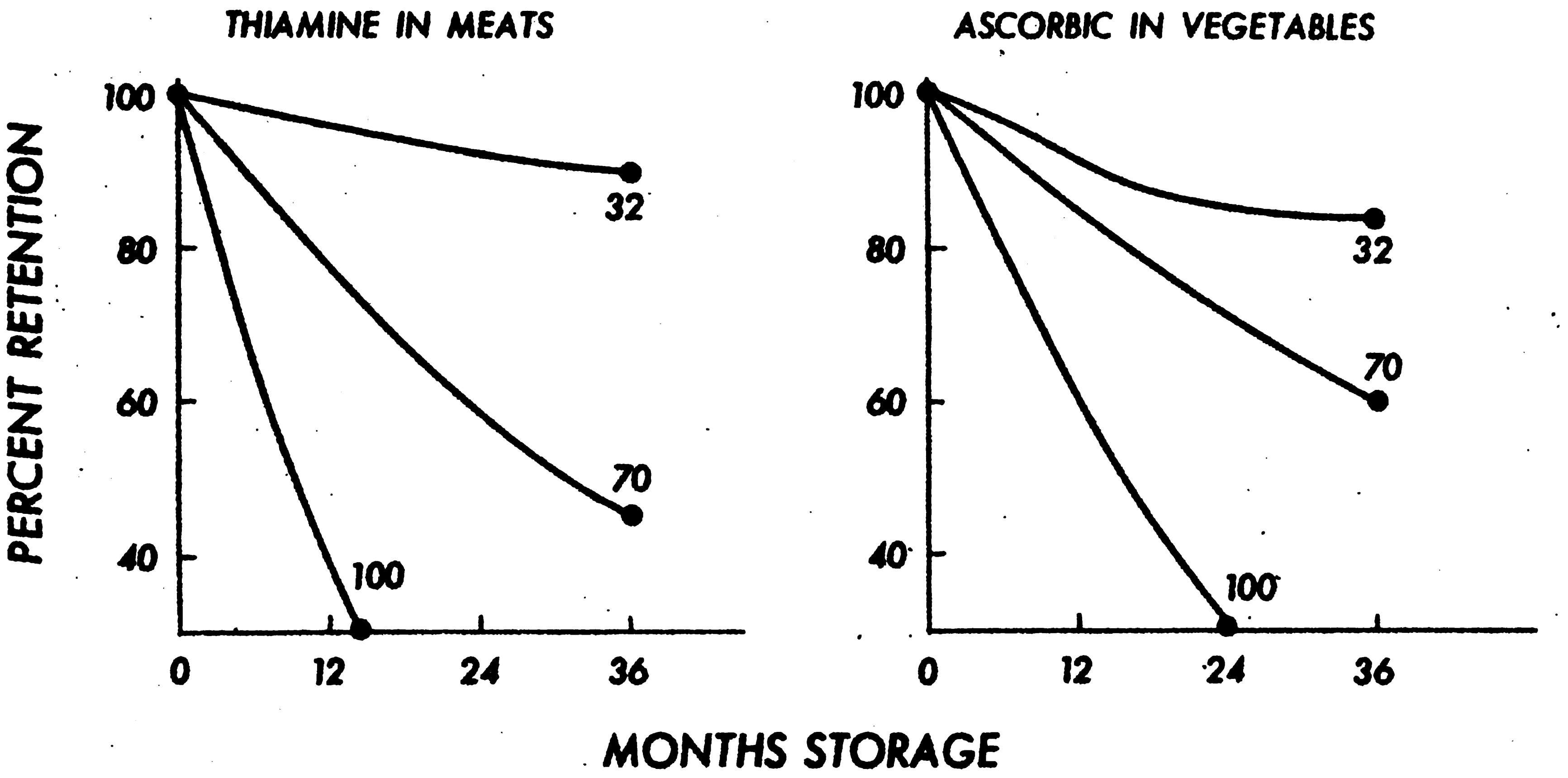


Figure 3. Loss of vitamins in canned foods during storage at 32°F, 70°F, and 100°F. Figures plotted from data of Cecil and Woodroofe (1963).

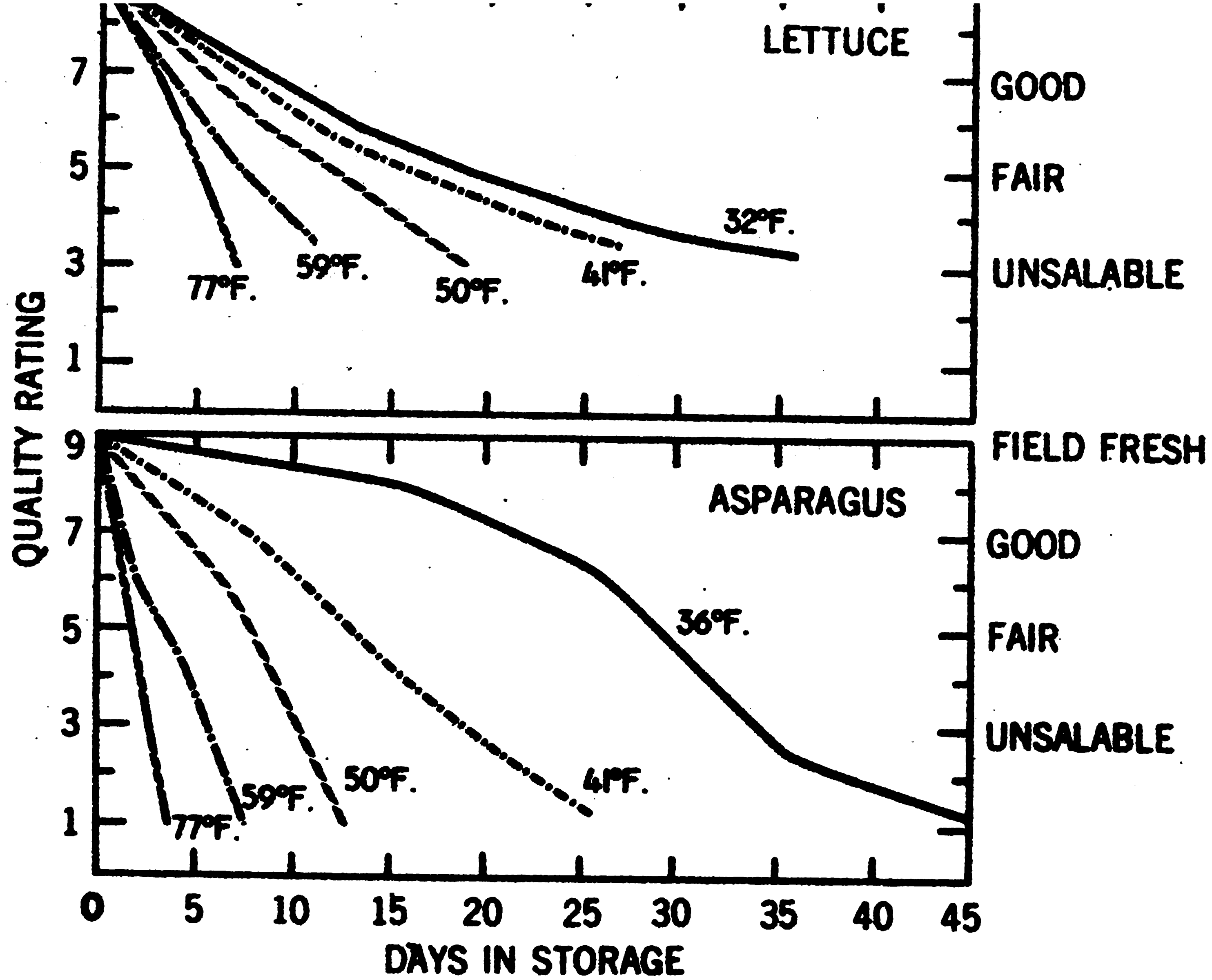


Figure 4. Loss of quality of lettuce and asparagus at various temperatures. (From U.S.D.A. Handbook #66).

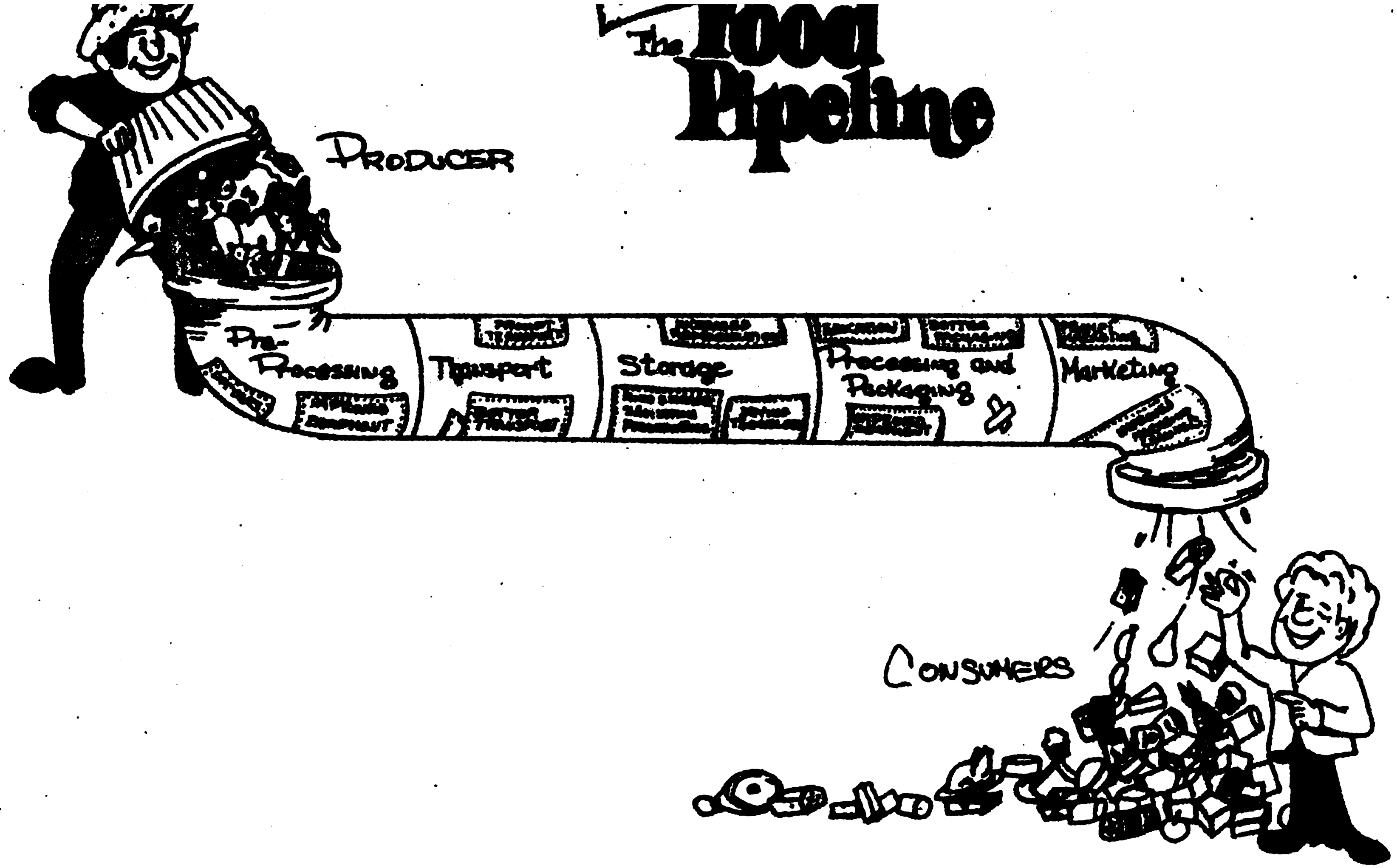
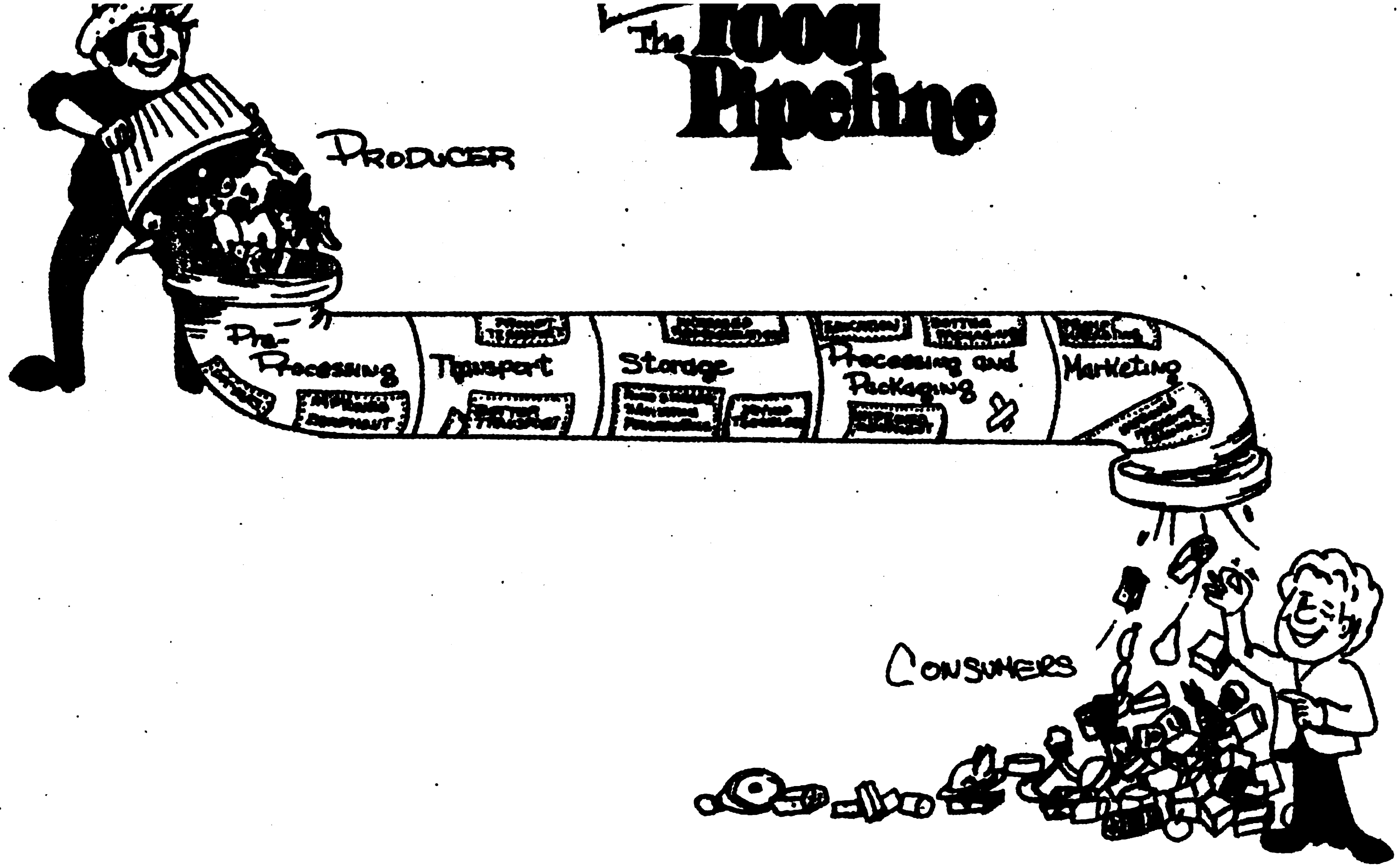


Figure 5. Schematic representation of how post harvest food losses may be reduced thus providing more food to the consumer with no increase in agricultural production.



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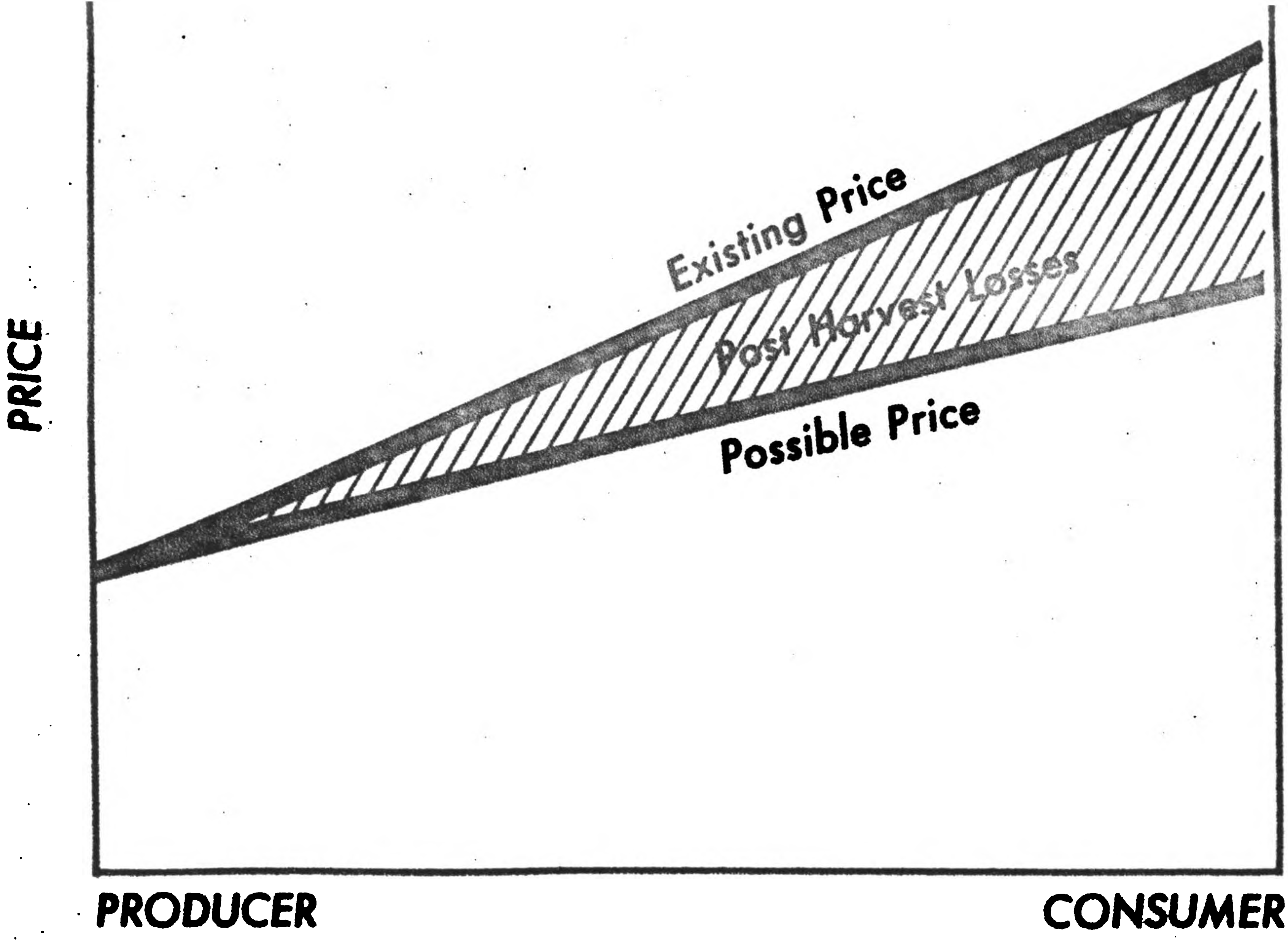

Figure 6. Schematic representation of how reducing post harvest losses has the potential to reduce the price of food paid by the consumer without reducing the price paid to the farmer.

DOCUMENT VI - B

POST HARVEST FOOD LOSSES IN GUYANA *

By:

A. V. Downer, W. C. Smith, Y. Thomas

*Prepared for the Seminar on the Reduction of Post Harvest Food Losses in the Caribbean and Central America, Santo Domingo, D. R., August 8-11, 1977

INTRODUCTION

Guyana with its land area of some 83,000 sq. miles and population of just less than one million people, forms part of the continen of South America. It is a relatively young country with less than four undred years of recorded history and is peopled by descendants of Amerindians, Europeans, Africans, East Indians, and admixtures of those ethnic groups. It is a country in which Agriculture has enjoyed pride of sectoral place from the inception with all energies directed to building on the Amerindian and European heritages to its current population.

Agriculture is still considered to have an important role to play in the process of the development of the country and the nation, but the impact of the sector on economic growth has been, and is, limited by the vicious cyclic relationships between production and conservation. In the absence of requisite levels of production, systems of conservation have not proven to be economically feasible; in the absence of adequate systems of conservation, production has not been effectively stimulated. In fact, the absence of necessary systems of conservation has constituted a strong dis-incentive to production while promoting severe wastage of the limited volume of production. Nevertheless, agriculture provided 31% of the GDP of the nation in 1975 as compared to 34% from each of the service and

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and industrial sectors.

In 1975, Agriculture provided approximately 63% of the total exports with sugar and its by-products accounting for 51%, rice 10%, shrimp 1% and other items 0.75%. This reflects the historical advantages afforded sugar and rice in the evolution of production and marketing systems in Guyana. Sugar production is a plantation exercise, while rice is grown by individual families on holdings varying in size from 0.5 ac. to 1,000 ac. The two crops occupy most of the coastal belt of the country. Hinterland agriculture includes extensive beef production and small scale food crop production on the shifting cultivation pattern. These supplement the production of food in the coastal areas.

All in all, agricultural activities involve some 70% of the population and utilise somewhat less than 20% of the country's land mass. These activities benefit from infrastructural works which include an extensive system of sea defences and a network of canals for drainage and irrigation of the low-lying coastal clays. This area also benefits from some 400 miles of all weather roads and approximately 1,500 miles of fair weather access routes. Approximately 550 miles of fair weather roads and innumerable trails allow access to the remote areas of the country.

In general terms, the impact of Agriculture can be assessed by a nation's ability to feed itself. This is dependent not only on the volume of production and its level of imports, but also on the efficiency

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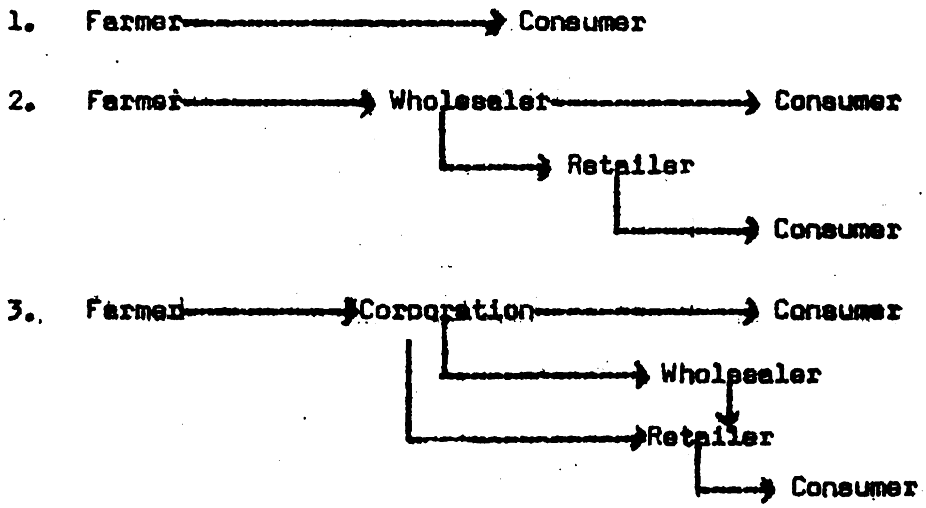
of its system of distribution. Some 12% of the value of Guyana's imports are items of food or feed and the volume of production of some food items is shown in the table below:

ESTIMATED PRODUCTION OF SOME FOOD ITEMS IN GUYANA FOR 1976.

Product	Population	Estimated Total Production	Average Farm Gate Price	Estimated Total Value at Farm Gate
	(acres)	10^6. lb.	G$/lb.	10^6.G$
CROPS				
Plantains	5,000	18.00	0.22	3.96
Eddoes	568	5.11	0.18	0.92
Sweet Potatoes	220	1.76	0.25	0.44
Cassava (sweet)	2,028	8.11	0.10	0.81
Yams	700	5.60	0.50	2.80
Bananas	1,400	11.20	0.10	1.12
Citrus	2,670	16.02	0.10	1.60
Pineapples	1,130	5.65	0.14	0.79
Tomatoes	700	4.06	0.50	2.03
Peppers	125	0.75	0.30	0.23
Cabbage	250	1.25	0.40	0.50
Blackeye Peas	840	0.55	0.55	0.30
Corn	3,500	4.20	0.18	0.76
Peanuts	350	0.32	0.80	0.26
Coconuts	33,000	62.04	0.15	9.31
LIVESTOCK	Animals			
Cattle:	265,000	—	—	—
Beef	—	2.14	2.10	4.49
Milk	—	2.70 gal.	1.35	3.65
Poultry:	8.5M	—	—	—
Meat	—	20.60 lb.	1.56	32.14
Eggs	—	56.00	0.18 ea.	10.08
Pigs:	101,000	—	—	—
Pork	—	5.00 lb.	1.80	9.00

The machinery for the distribution of food in Guyana comprises three distinct systems. These can be summarized as follows:



The wholesaler assists in the function of collection since he is usually mobile and buys from farmers over a selected area. He is known locally as a huckster and may be supported by a retailer who is part of his family operating from the home or from a municipal market. He may also retail to buyers along his route. The retailer here, refers to the vendors in the municipal or other markets including supermarkets. The corporation - Guyana Marketing Corporation - is the national agency authorised to perform the marketing functions for all agricultural produce except rice and sugar. It is the most recent system having been introduced just thirteen years ago. It replaced a system by which farmers transported and sold their produce to depots in two locations. The depots engaged in some processing and the Corporation has maintained and extended this practice. In addition it has established "Buying Centres" at strategic locations so that the food grower

has been afforded the facility of a range of selling points and no longer needs to transport his produce over the same distances he previously did. The Corporation also attempts to keep food prices relatively low, but has not developed to the stage where it can exert any real control over the prices demanded by the wholesaler and those retailers which do not fall within its chain of supermarket outlets.

If we exclude rice, sugar and green vegetables, the Corporation channels about 32% of Guyana's food products from the farm to the consumer. Estimation of the level of post-harvest losses in the marketing system is difficult in the Guyanese context, because the first two systems still embrace the traditions of selling whatever is saleable and discarding what is not. They decide what is to be discarded, but there is no system of recording this activity. The Corporation is also faced with the need to discard material and though this can be recorded, there has so far been no published information as to the respective levels for the various commodities.

POST-HARVEST LOSSES

There is no doubt that a substantial portion of our Agricultural production is lost between the field and the consumer. The volume and value of this loss has not been assessed, but there can equally be no doubt as to the negative economic consequence to the nation of lost production and the implication that the national capability for feeding itself is less

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than adequately exploited. To the physical loss of production, must be added the economic consequences of the need to import some non-food items e.g. paper, cardboard, etc. These are twin aspects of the absence of a technology for the utilisation and preservation of indigenous produce. Importation of packaging material implies that the problem of post-harvest losses is unlikely to be reduced in the near future. The institution of even preliminary measures of handling is unlikely if not impractical in the circumstances. In addition, the absence of grading systems results in a poor quality product and visible waste of useable material.

The bimodal pattern of rainfall distribution in Guyana allows utilisation of two seasons for crop production. The first season extending from May to October and the second from November to April. Failure to plan production so that the time for harvesting of grains and beans particularly, coincides with the dry periods, could, and often does, result in loss of the crop or substantial parts thereof. Infant mortality in livestock enterprises could also assume disastrous proportions if the farmers do not attempt to have the young produced at propitious times in the wet/dry cycle.

The absence of a 'winter period denies tropical area of the natural assistance that lowered temperatures offers temperate areas in storage of food, and in the control of weeds, pests and diseases. It results in a continuous growing season, but high humidity, particularly in the wet seasons introduces a risk factor in operations of harvesting and of storage. In the wet season, fungal infestations tend to be severe and

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in the dry periods insects seem to be dominant, though weevils, termites and acoushi ants (Acta spp.) seem to be at work all year round.

Sugar and rice have enjoyed a relatively ordered evolution of technology of production, processing and marketing, but the general absence of structures designed particularly for storage and/or drying of produce tends to increase the negative impact of the climate on losses at, and after, the harvesting of all other crops.

On farms storage of food crops has not been a major feature in the course of development of Guyanese agriculture. Traditionally, except for planting material, the farmer, or a member of his family, markets his produce by retail or wholesale arrangements. Loss on the farm therefore includes loss of viability and volume of materials which are to be used for propagation and deterioration of produce up to the time of sale. This loss is enlarged by the absence of drying facilities. In recent times livestock products particularly poultry, have been stored on farms in a frozen state.

Perhaps the major source of post-harvest losses of food occurs in the course of transportation to market. This arises largely from improper and inappropriate packaging and the high amounts of mechanical damage which ensues. The road surfaces and distances to market may increase the volume of damaged goods. River transport is also a source of loss. Large numbers of items are in some instances stacked in boats without very much prior packaging. Small items may be put into large baskets

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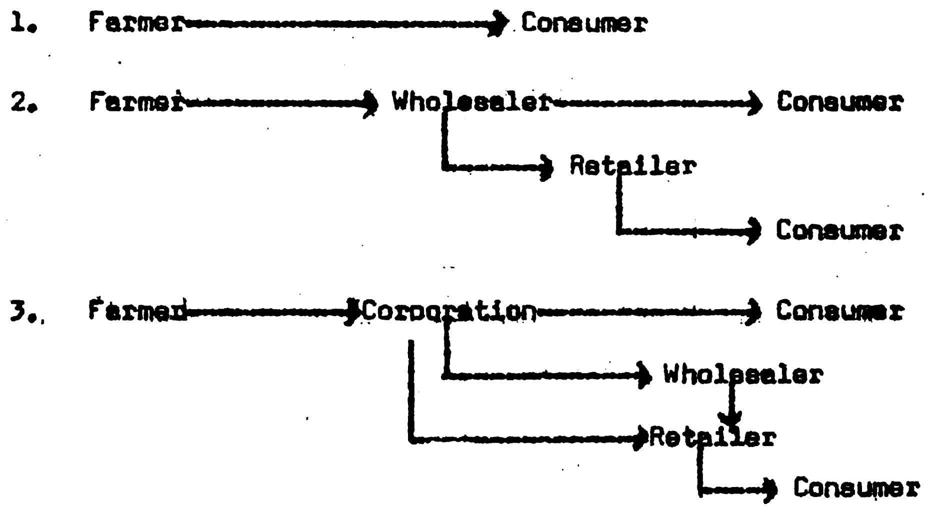

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which are then stacked. Where distances are short mechanical damage is not as serious as might be expected, but over longer distances and with larger vessels, damage can be substantial and may be augmented by high temperatures developed on the vessel.

Meat, particularly beef, is shipped by air and then frozen so that losses are minimal. Small retailers try to sell all meat items within the business day, but do on occasions hold their merchandise on ice overnight. This detracts significantly from the appearance of meat and though no estimate has been made of loss from this source, the ability of the retailer to acquire adequate stocks of ice and the nature of his freezing chest will determine how much of what is stored can subsequently be offered for sale. Thus much of the loss of food which is experienced after the harvest is due to the structure of the market system.

<u>PRODUCE CONSERVATION</u>

The conservation of agricultural produce in Guyana has not been a major area of activity probably because of the non-existence, on the one hand, of any real programme for the utilisation of all such produce and of the stultification, on the other hand, of cottage industries. Traditions comparable to those which grew into industries in the developed countries have not survived in Guyana and perhaps in the greater part of the third world. A useful illustration is seen in the role of hay in the cattle industry of temperate countries, on the one hand, while in the tropics,

on the other hand, pastures grow faster than they are grazed in the wet season and in the ensuing dry season animals lose their conditions for lack of food, however fibrous. There is no programme in Guyana for the conservation of fodder and beef production suffers accordingly.

The conservation of food crops requires the existence and/or availability of several ancillary industries and services. The nature of these industries and services depends on the perishability of the material to be handled. Highly perishable green vegetables and meats could be conserved by controlled temperature. Fruits can be conserved either by temperature control or by processing operations aimed at extraction of juices or manufacture jams, jellies or nectars. Root tubers, grain, etc. can be conserved by partial cooking operations while beans and grains must be protected against insect infestation and excessively humid conditions. The absence or inadequacy of the technological capability to sustain these industries and or services renders the exercise of conservation impractical in the Guyanese milieu.

Packaging of agricultural produce has traditionally utilised the jute bag and wooven baskets for transportation to market. Kraft paper and more recently polyethylene are utilised in retailing operations. Polyethylene is utilised particularly in the retailing of meats and green vegetables and dried fruits. Packaging prior to storage relies on jute bags. Crates have not enjoyed any significant degree of utilisation.

ECONOMIC CONSIDERATIONS

Post-harvest losses represent a direct reduction of the Gross Domestic Product. This reduction can be measured relatively easily when compared to the hidden effects which cumulatively amount to retardation of economic development. One of the hidden effects is a lowering of returns to the farmer population. This constitutes a negative stimulus to the development of the agricultural sector since it discourages production and negates increases in productivity. Another hidden effect is that fluctuations in the cost of food and therefore in the cost of living could ultimately frustrate efforts at improvement of the level of nutrition over the nation and add further to the lowering of the actual Gross Domestic Product. The continued or increased need for importation of food items constitutes another effect that might not be immediately obvious.

The elimination of losses hinges on the development of an effective system of marketing. In the Guyanese context, marketing of rice over the years through a single agency has demonstrated two very positive effects on production and productivity in that industry. In the first place, the farm family needs to spend no time in marketing of that product, that time can be spent in further production. In the second place, the existence of accepted grading standards has had a marked impact on the productivity of the rice farmer. He has become eager to adopt improved technology e.g. the use of fertilizers, of improved varieties, the control of weeds, pests and diseases, etc.

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on the other hand, pastures grow faster than they are grazed in the wet season and in the ensuing dry season animals lose their conditions for lack of food, however fibrous. There is no programme in Guyana for the conservation of fodder and beef production suffers accordingly.

The conservation of food crops requires the existence and/or availability of several ancillary industries and services. The nature of these industries and services depends on the perishability of the material to be handled. Highly perishable green vegetables and meats could be conserved by controlled temperature. Fruits can be conserved either by temperature control or by processing operations aimed at extraction of juices or manufacture jams, jellies or nectars. Root tubers, grain, etc. can be conserved by partial cooking operations while beans and grains must be protected against insect infestation and excessively humid conditions. The absence or inadequacy of the technological capability to sustain these industries and or services renders the exercise of conservation impractical in the Guyanese milieu.

Packaging of agricultural produce has traditionally utilised the jute bag and wooven baskets for transportation to market. Kraft paper and more recently polyethylene are utilised in retailing operations. Polyethylene is utilised particularly in the retailing of meats and green vegetables and dried fruits. Packaging prior to storage relies on jute bags. Crates have not enjoyed any significant degree of utilisation.

ECONOMIC CONSIDERATIONS

Post-harvest losses represent a direct reduction of the Gross Domestic Product. This reduction can be measured relatively easily when compared to the hidden effects which cumulatively amount to retardation of economic development. One of the hidden effects is a lowering of returns to the farmer population. This constitutes a negative stimulus to the development of the agricultural sector since it discourages production and negates increases in productivity. Another hidden effect is that fluctuations in the cost of food and therefore in the cost of living could ultimately frustrate efforts at improvement of the level of nutrition over the nation and add further to the lowering of the actual Gross Domestic Product. The continued or increased need for importation of food items constitutes another effect that might not be immediately obvious.

The elimination of losses hinges on the development of an effective system of marketing. In the Guyanese context, marketing of rice over the years through a single agency has demonstrated two very positive effects on production and productivity in that industry. In the first place, the farm family needs to spend no time in marketing of that product, that time can be spent in further production. In the second place, the existence of accepted grading standards has had a marked impact on the productivity of the rice farmer. He has become eager to adopt improved technology e.g. the use of fertilizers, of improved varieties, the control of weeds, pests and diseases, etc.

/...11

Within the market system there is a further source of concern to the economists. The wholesaler who wishes to maintain his profit margin at the maximum may create conditions of scarcity by dumping produce that he might be able to sell at a lower price.

REDUCTION OF POST-HARVEST FOOD LOSSES

Attempts at reduction of post-harvest food losses have taken two general directions, viz:

Institutional Arrangements

In an attempt to emulate the positive effects seen in the system of marketing of rice, the Guyana Marketing which has been alluded to earlier was created in 1964; supermarkets have since then installed facilities for refrigerated storage of food items pending purchase by the consumer. The acquisition and distribution of seed material has not been put on a similar administrative footing to that for rice, but seed processing facilities and storage in conditions of controlled temperature and humidity have had very positive effects.

Processing installations utilising known technologies have been set up for a limited number of items, for example, for the treatment and preservation of milk, the production of ham and bacon, the manufacture of juices, jams and jellies, the production of salted fish and the conversion of cassava to flour. These are all state-run enterprises, as distinct from

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a collection of smaller businesses within a growing food industry which produces a variety of preserves. The various processing installations have not yet exerted any really significant influence on post-harvest losses of food apart from milk. This may be due in part to their relatively small sizes or to incomplete mastery of the technologies required.

Proposed Programmes

One programme which seems to be of relevance at this point is on Food Crop Project which has among its objectives:

- The establishment of facilities of drying, grading and packaging of relevant farm produce at strategic locations over the country.
- The acquisition of refrigerated transport systems for the movement of food items.
- The development of standards for grading of produce for food or for industrial use.

Further reduction of post-harvest food losses is still very much needed. Such reduction might best be achieved, however, after studies have been conducted with the objective of establishing:

- A methodology for the assessment of actual losses.
- Desirable methods of harvesting and incorporating the most appropriate technologies available.
- Influence (quantitative) on level or losses by untimely harvesting.

— Means of packaging for effective pre-treatment, storage and transportation on the farm and in the retail exercise.

— Structures for storage at regional and national levels.

— Biochemical properties of various products as they influence conservation, handling, etc.

RESOURCES AVAILABLE FOR WORK IN POST-HARVEST OPERATIONS

Like most developing countries, Guyana suffers from a dearth of professional personnel. There are two food technologists, thirty agronomists and pasture agronomists, three agricultural economists, five entomologists, one plant pathologist, nine Veterinarians and four animal scientists. There are several individuals being trained in relevant disciplines in different parts of the world. Among these are ten pursuing studies in food technology.

Training programmes do not usually provide yields of 100%. This is sometimes due to the absence of a structure which allows pursuit of an area of investigation of interest to the individual. Thus the grave need for trained personnel is accentuated by the additional need for work arrangements which provide professional development and satisfaction. The limitations to the existence of such work arrangements are in Guyana derived from financial and historical considerations.

Attention to conservation of food products has not been much as to have allowed the existences now of a unit which can expand to accommodate younger individuals in satisfyihg circumstances. Finances for developing projects which could contribute to growth of market for processed food products and relevant ancillary industries has not been always available. The need for expenditure in the area of food conservation has been recognised, but no real estimate of the volume of such expenditure has been seen and no real indication can be given at this time as to what financial resources might be available for this exercise.

MARKETING OF BLACK-EYE PEAS (Vigna sinensis)

It has not been practical for a case study as such to be done by this team, but we recognise that the ideal marketing system encompasses the functions of:

collection and grading

storage and processing

domestic distribution and export.

We decided therefore to attempt to follow a harvested crop of black eye peas through such a system even though the national marketing agency in Guyana has not yet attained the status of an ideal marketing system.

Prior to collection at the Guyana Marketing Corporation's Buying Centre, there will have been some actual and/or potential post-harvest losses. The harvesting operation may have not been as timely as it should

have been. Because of the unavailability of labour harvesting may be delayed. There is likely to be actual losses because of shattering of the excessively dry pods and damage to beans during threshing. No estimate of losses due to shattering can be offered, but mechanical damage during threshing has been observed in the form of beans which have been visibly broken - splits. Such damage has also been seen in the reduction of viability of whole beans, selected for seed. Both forms of loss approximated a level of 20% in the particular case. Material suitable for use as "seed" would normally go directly to the seed storage facility.

When the harvesting operation is premature, that is to say, the beans have not been allowed to dry adequately in the field, loss may again take two forms. Firstly, some pods will be pulverised in the process of threshing; secondly, some pods will heat and encourage fungal infestation. This loss is potential in that its actual level will be determined by opportunities for drying. With no drying opportunities available, the entire harvest could be lost through fungal infestation. Timely drying might permit all harvested material to be offered for sale.

The location of the Buying Centre is generally some distance from the farm gate and the farmer has the responsibility of packaging and transporting his produce to the nearest Buying Centre from which material thus collected is transported to Georgetown. Material thus collected will have been harvested a few days earlier. It may remain at the Buying Centre for a few days before it is moved, but grading is not done at this stage,

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so that very dry material might be stored alongside inadequately dried or insect infested material. For the purpose of this exercise, the Buying Centre utilised is located 80 miles up the Berbice River and material collected is therefore shipped by river over that distance.

Along the way further quantities of ungraded material are taken from other buying stations during the 24 hour journey. At the end of the river journey there might be some losses arising from bad packaging and handling, but this is normally minimal. The material is usually transported over the remaining 68 miles to the central warehouse of the Corporation in Georgetown by road. The time of arrival in Georgetown is determined by the availability of lorries and could sometimes be considerably delayed. Storage during the period of delay could easily allow for infestation by insects or the migration of insects to other stored items. Damage and therefore loss by rodents could also easily occur.

On arrival in the central warehouse, the produce collected poses several risks. The material could act as a reservoir of insect infestation. It may contain beans with high mycotoxin contents. However, because there is no blending or processing of beans at this point, individual packages can be separated and discarded as necessary, prior to distribution to the retail units. The major problem in the retail units is the likelihood of increasing insect populations, but the re-packaging exercise allows for detection and discard of unsaleable material. If the period for which repackaged beans remain on the shelves is usually short - less than one week - then the consumer can have an item of an acceptable quality.

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No estimates are now available as to the actual losses which result from conditions on the farm and during storage which are conducive to losses at a later stage in the marketing channel. It is nevertheless, obvious that there is need for:

— improved systems of harvesting, threshing and storage on the farm;
— installations at strategic locations which can ensure that drying to a requisite level is practical;
— practice of grading and effective packaging at the point of initial collection so that materials of similar grades can be transported together;
— ensuring that storage facilities - intransit and final - do not promote any increases in the potential for post-harvest losses.

Some progress has been made in regard to drying and threshing but it is the elimination of these needs which will determine whether the nation can aspire to the capture of export markets for its black-eye peas.

CONCLUSIONS

Post-harvest food losses in Guyana are considered to be very substantial even though no real estimates of such losses have been made. It is recognised that these losses take place at various points between the field and the consumer - during the harvesting operation, in storage

- Means of packaging for effective pre-treatment, storage and transportation on the farm and in the retail exercise.
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No estimates are now available as to the actual losses which result from conditions on the farm and during storage which are conducive to losses at a later stage in the marketing channel. It is nevertheless, obvious that there is need for:

— improved systems of harvesting, threshing and storage on the farm;

— installations at strategic locations which can ensure that drying to a requisite level is practical;

— practice of grading and effective packaging at the point of initial collection so that materials of similar grades can be transported together;

— ensuring that storage facilities - intransit and final - do not promote any increases in the potential for post-harvest losses.

Some progress has been made in regard to drying and threshing but it is the elimination of these needs which will determine whether the nation can aspire to the capture of export markets for its black-eye peas.

CONCLUSIONS

Post-harvest food losses in Guyana are considered to be very substantial even though no real estimates of such losses have been made. It is recognised that these losses take place at various points between the field and the consumer - during the harvesting operation, in storage

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on the farm, during transportation or the period of storage in the warehouse, etc. and even during the final stages of distribution. The impact of these losses is perhaps most clearly seen as a negative influence on economic development since such losses provide a strong dis-incentive to production. Any attempts at reversing the negative influence should therefore begin at the planning stage. This, in light of other conditions, suggests that the strategy for development in Guyana should have as its central theme the growth of an integrated indigenous agriculture. That is to say, the objectives of the plan for development should be stated as far as is possible in terms of secondary and tertiary products, particularly food products. Production targets should be stated as quantities of items in specified states of conservation or preservation. Implicitly, the plan must recognise and cater for the means of such preservation and conservation. It must also cater for the further ordering of the market system and the promotion of agro-based industries, more particularly, a strong food industry. Planning in this way would permit the elaboration of conditions of work which favour the growth of the much needed technological capability. It would allow recognition of the need for training to be relevant and to be of such as to maximise the beneficial returns to the nation.

The growth of a food industry in Guyana would need to be based on improved organisation of farms, such that storage becomes an accepted farm function aimed at a minimum of loss in quantity and quality of produce. It would need to be based also on a market system which, by its

awareness of the domestic food demand and the trends thereof, could influence the expansion of production along directions which promote conservation and exploit potential for the growth of export markets. The market system must be such as to allow for the minimization of loss during transport and storage. It must promote processing of produce and embrace a system of effective distribution.

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DOCUMENT VI- C

THE MARKETING OF AGRICULTURAL PRODUCE, AND POST-HARVEST LOSSES IN JAMAICA*

By:

C. V. Smikle

*Prepared for the Seminar on the Reduction of Post-Harvest Food Losses in the Caribbean and Central America. Santo Domingo, D. R., August 8-11, 1977

Jamaica has a total land area of 4,411 square miles. At the end of 1976 the population stood at 2,085,200 with an average annual rate of increase of 1.6 percent between 1970 and 1976. Until 1972 the extent of illiteracy stood at approximately 20 percent. However, a literacy programme designed to wipe out illiteracy was introduced in 1972 and has to date reportedly made significant progress. Over the past two years the Jamaican economy has undergone rapid changes in institutional structure. Rate of real growth in the economy has declined and in 1976 negative growth of-6.9 percent was experienced. The level of unemployment in 1976 also stood at 24 percent compared with 20 percent in 1975.

Gross Domestic Product (G.D.P.) at constant prices was $2076 million at the end of 1976. The percentage contribution of the different sectors to the total G.D.P. at current and constant prices are shown in table I.

Table I Percentage contribution of different sectors to G.D.P. $ million

SECTOR	G.D.P.		Percent of total G.D.P	
	Current prices	Constant prices	Current prices	Constant prices
Manufacture	539.1	376.2	19.5	18.1
Distributive Trade	384.5	325.9	13.9	15.2
Producer of Government Service	381.3	276.6	13.8	13.3
Contruction and Installation	257.8	197.7	9.3	9.3
Real Estate	252.1	157.2	9.1	.6
Mining	240.0	201.3	8.7	9.7
Agriculture, Fishing Forestry	229.0	169.5	8.2	8.1
Transport Storage & Communication	170.9	138.4	6.2	6.7
Miscellaneous Services	161.2	125.9	5.8	6.1
Financial Institutions	130.6	122.4	4.7	5.9
Electricity and Water	57.0	23.7	2.1	1.1
Household and private non-profit institutions	56.0	45.2	2.0	2.2
Less imputed charges	91.5	78.9	3.3	3.8
Total G.D.P. in purchasers value	2768.0	2076.2	100	100

Per capita income in 1976 stood at $1,180.50. This economic indicator, however, does not reflect the true income distribution of the population as extremes of wealth and poverty continue to be a noticeable feature of the Jamaican society. Indeed, the labour force survey of 1976 shows that in October of that year approximately 68 per cent of employed wage earners earn under $50.00 per week with the remaining 32 per cent earning over $50.00 weekly.

Over the past few years Jamaica's foreign exchange reserves have deteriorated to critical levels. This is due largely to steady decline in its major export crops as well as to a rising import bill. In spite of several import restrictions as well as efforts to boost local production, foreign exchange reserves in 1976 fell into negative position as balance of payments stood at -$240.5 million. Total imports for that year was just over $850 million while total export amounted to only $560.6 million.

The Agricultural Sector

In 1976 the contribution of Agriculture to G.D.P. was 8.2 per cent at current prices. The relative position of this sector to other sectors in terms of contribution to G.D.P. is shown in Table 1. The data show that agriculture took seventh position among the twelve sectors contributing to G.D.P. This relatively poor performance of the Agricultural sector in 1976 is also evidenced by the level of food import in that year. The food import bill for 1976 amounted to $166.4 million or 20 per cent of total imports.

The total labour force in Jamaica stood at 895,000 in October of 1976. A total of 255,400 or 28.5 per cent of the total labour force is currently engaged in Agriculture. G.D.P. per capita in the Agricultural sector therefore stood at approximately $897.00 The percentage distribution of the labour force among the different sectors is shown in Table II.

Table II ....

Table II: Percentage Distribution of the Total Labour Force among Different Sectors

Sector	Number	Percentage of total Labour Force
Agriculture, Forestry, Fishing	255,400	28.5
Manufacture	96,500	9.0
Consttuction and Installation	53,700	6.0
Transport, Communication etc.	35,900	4.0
Commerce	999,000	11.1
Public Administration	126,400	14.0
Other Services	152,100	16.9
Industry (not specified)	52,000	0.5

The data in Table II show that the Agricultural sector retains the highest percentage of the total labour force. The major export crops are:-

Sugar Cane
Banana
Citrus
Cocoa
Coffee
Pimento
Ginger

Total export of these crops are shown in Table III.

Table III: Export of Main Export Crop 1976

Crops	Units	Quantity	Value J$	Country of Destination
Banana	Tons	76,611	11,921,108	United Kingdom
Sugar Cane	"	229,786	55,858,963	U.K., U.S.A, Canada
Citrus	lb.	-	-	
Coffee	"	2,119,304	1,414,594	Japan
Cocoa	"	3,080,998	3,784,989	U.K., Canada, W.I,
Pimento	"	4,394,518	4,593,126	Europe, Canada,
Ginger		-	-	U.S.A. etc.

The island's ....

The island's total land area is estimated at 2.7 million acres. Approximately 1.4 million or 62 per cent of this acreage is considered suitable for agriculture. The Agricultural Census of 1969 shows a total of 193,000 farms. Data from this Census also reveal that 78 per cent of the total number of farms occupies just about 15 per cent of the total agricultural acreage. This means that approximately 85 per cent of the total acreage is occupied by only 22 per cent of all farms. The data also show that the 78 per cent of the total number of farms constitutes farm sizes in the category of "less than 1 to less than 5 acres". In summary, the agrarian structure is characterized by a large number of small farms (under 5 acres in size) occupying just 15 per cent of total acreage and a few large farms occupying 22 per cent of total acreage.

Tenure arrangements include both free-hold and lease-hold. Leasehold tenure tends to dominate the small farming community while the larger farmers or property owners are almost entirely holders of free-hold tenure. Since 1973, however, fundamental changes occured in the agrarian structure. In that year Government introduced a new land reform programme with Project Land Lease as its most prominent feature. Under this programme Government seeks to acquire large idle properties and then sub-divide and distribute these to small farmers on lease-hold tenure agreement. This programme is designed to redress the imbalance in ownership of land in the traditional agrarian structure.

Jamaica's agriculture continues to be export oriented with the production and marketing of such crops as sugar cane, bananas, coffee, citrus and cocoa being fairly well organised. Indeed, the greater part of the island's agricultural resources, land, capital and management have been allocated to these industries. At the same time Domestic agriculture has been largely neglected, being left in the hands of small scale producers who have little or no capital and training and who operate largely on small plots of marginal lands. The nation's food requirements therefore have been largely imported from metropolitan countries and by 1975 the food import bill exceeded $118 million.

The local production of selected commodities are shown in Table IV.

Table IV ...

Table IV Production and Value of Selected Agricultural Commodities 1976

Commodities	Units	Production	Value			
				J$m.		
Sugar Cane	000 tons	3571	55.8	for	export	only
Banana	000 stems	10346	11.9	"	"	"
Citrus	000 boxes	2044		"	"	"
Coconut	000 nuts	86205	-			
Cocoa	000 lb.	913	1.4	"	"	"
Coffee	000 lb.	3116	3.8	"	"	"
Pimento	000 lb.	5221	4.5	"	"	"
Ginger	000 lb.	1860				
Vegetables	000 tons	85.2				
Legumes	000 tons	5.8	0.095 ~~01085~~			
Tubers	000 tons	195.2	120.300			

Extremes of weather over the past 4 years have been largely responsible for decline in a gricultural production between 1971 and 1976. Table V shows the volume of agricultural production 1971 - 1975.

Table V Volume of Agricultural Production: 1971 - 1975

Item	1971	1972	1973	1974	1975
Sugar (000 tons)	379	373	326	367	355
Bananas+ (000 tons)	126	127	108	72	68
Citrus+++ (000 boxes)	1,366	1,102	1,062	1,007	1,028
Pimento+ (000 lb)	4,372	4,551	5,681	5,795	3,873
Cocoa (tons)	1,827	2,333	2,071	1,593	1,771
Coffee++ (000 boxes)	299	214	308	240	380
Ginger+ (00 lb)	618	766	1,056	739	630
Rum (000 proof gal.)	3,296	4,792	5,100	5,735	6,455
Molasses (tons)	150	144	129	121	120
Copra (short tons)	21,205	17,936	15,137	9,411	6,856
Meat (million lb)	77	79	97	89	103
Fish (million lb)	38	40	38	36	36
Eggs (million)	159	123	136	139	147
Milk (million quarts)	42	41	41	43	43
Root Crops+++ (million lb)	429	452	403	443	460
Vegetables+++ (million lb)	2209	218	205	215	203

Government is now taking steps to stimulate increases in agricultural production in an effort to increase foeign exchange earnings and to reduce the country's reliance on imports. These steps include:-

(a) an administrative re-organization of the Ministry of Agriculture and the island's Extension Services;

(b) credit to small farmers is also being re-organized to remove traditional barriers to the use of credit by this group of farmers;

(c) new marketing policies and price incentives have also been announced.

Until early 1977 a number of food items were being imported but which have tremendous potential for import substitution. Some of these items include vegetables (fresh and processed), peas, beans, peanut and onions. Under proper organization and with adequate financial and technical support as well as with suitable marketing arrangements, Jamaica could reach self-sufficiency in these items within a few seasons. Maize is also imported in large quantities. Imports of this item in 1976 amounted to over 352 million lb. at a value of approximately $20 million. Total import substitution of this item, however, is not likely to take place within the short run mainly because of unavailability of suitable lands for large scale and economic production of the crop.

In addition to fruits and vegetables, priority attention is being given to such crops as rice, corn, red kidney beans and onions, all of which are imported in large quantities. It is difficult to make accurate demand projections of these items because of the unavailability of important data. However, the estimated demands are based on annual imports plus local production. The importation of these items and local production for 1976 are shown in Table VI.

Table VI: Local Production and Imports of Selected Commodities 1976

Crops	Local Production	Imports	Projected Increases for 1977
	million lb.	million lb.	million lb.
Rice	5.1	101.0	18.0
Maize	24.6	352.8	20.0
Red Kidney Beans	4.6	2.9	1.1
Onions	6.5	5.6	11.2
Other peas and beans	6.6	1.0	8.0

The Internal Marketing System

Over the last decade pressure on local food supply brought about by increasing population, rising prices of imports and adverse balance of payments have caused attention to be focussed sharply on the local production of food. Government took the initiative and provided this sub-sector with capital through various credit and subsidy schemes. Between 1965 and 1975 over $12 million were provided under the Subsidy Assistance Scheme. Recent agrarian reforms have also been designed to increase local food supply.

Attendant upon these efforts, domestic agricultural production increased significantly between 1965 and 1975. Production estimates show an increase of over 157 per cent as production moved from 140,000 tons in 1965 to 360,000 tons in 1975. These increases have placed great pressure on the internal marketing system.

This system traditionally consists of a large number of small private individual traders (higglers) who make purchases at the farm gate and retail in public markets in both urban and rural areas. Since 1963, however, the system has taken on new dimensions. A public marketing institution, the Agricultural Marketing Corporation (AMC) was established and new private institutions, supermarkets and green groceries introduced. The main outlets in the distribution system therefore are -

1. Parochial markets
2. The Agricultural Marketing Corporation (retail shops and wholesale centres)
3. Supermarkets
4. Green groceries
5. Curb-side markets.

Parochial Markets

A survey conducted in 1976 revealed that there are 100 parochial markets distributed throughout the island. Physically these markets vary from well constructed buildings with partitions and built-in stall to empty sheds with concrete base only. It is estimated that 70-80 per cent of total domestic food crops production is distributed through these markets.

Parochial markets, however, are becoming increasingly inadequate as outlets for agricultural produce. Most of these markets are perhaps 70-80 years old and therefore lack not only physical space for display of goods but also modern facilities and amenities. In fact, the 1976 survey shows that over 50 per cent of the total

number of higglers operating in these markets reported a lack of space in parochial markets as a major marketing problem. Similarly, 49.6 per cent of curb-side higglers reported a lack of space in parochial markets as their main reason for selling at curb-side locations.

The problem of inadequate marketing facilities is currently being redressed by the Government. In this regard a market rebuilding programme estimated to cost $10.6 million has been initiated.

The Agricultural Marketing Corporation (AMC)

The AMC through its various wholesale and retail outlets provides the second largest outlet through which farm produce reaches the ultimate consumer. This organization was established by legislation in 1963. The summary functions as provided by Law are as follows:-

- To provide and maintain adequate marketing outlets for agricultural produce grown primarily for domestic consumption.
- To buy and sell agricultural produce
- To provide for the collection, transportation, storage, grading, packaging and processing of agricultural produce.

The operations of the Corporation are organized under eight (8) branches distributed throughout the island. Each branch is surrounded by a number of buying points and presently number about 144. Retail operation is carried out through a network of 18 green groceries located in the Corporate and rural areas.

Supermarkets

The distribution of farm produce by supermarkets came as an expansion in supermarket chains. Compared with other goods, however, the expansion in the distribution of farm produce has not been significant. Consequently the quantities of domestic crops distributed by supermarkets are still relatively small. The fact that supermarkets do not carry the full range of farm produce as well as the little space provided for display of these crops make these markets of lesser importance than the other outlets in the distribution system.

Green Groceries

Green groceries outside those operated by the AMC are privately owned. They are relatively few in number, small in operation and are in fact not developed as important outlets of farm produce. Quantities distributed through these outlets are therefore relatively

small. These outlets tend to be oriented to the sale of meats, and other farm produce appear to be merely incidental

Curb-side Markets

Markets existing on side walks, shop piazza, open lots and by road sides are all referred to as curb-side markets. They represent the third largest area of retail distribution. Rapid expansion in these markets, particularly in the Corporate Area has taken place only in recent years. Indeed, in well populated areas, the rate at which these markets appear has been phenomenal. In Kingston and St. Andrew alone recent investigations had identified 210 locations in which a total of 1,400 higglers operate.

The Higgler System

Basically the higgler system encompasses just over 13,000 higglers, 50% of whom purchase directly from farmers at the farm gate and sell either wholesale to other higglers or retail directly to consumers in parochial markets. It has been suggested that the higgler system has its beginnings as far back as the pre-emancipation era. Today the system is a strongly rooted socio-economic institution that provides a means of livelihood for thousands of Jamaican families. In spite of its long history as a system of marketing the distirbution of domestic food crops remains an outstanding problem in Jamaica. The fact is that unlike most other economic systems the higgler system had never been subjected to the processes of planning and organizing as one entity. Rather, it is a system that has, over many decades, evolved out of a growing need for an internal distribution system of domestic food crops.

The major weaknesses of the higgler system are -

(a) it fails to provide incentive for any meaningful increase in the production of domestic food crops because of the small weekly individual purchases at the farm gate;

(b) it lacks the ability to perform the functions of marketing efficiently thereby resulting in wide market margins and high consumer prices;

(c) it fails to rationalize the distribution of the crops it handles throughout the island as scarcities and surpluses often exist simultaneously in different markets.

The Agricultural Marketing Corporation has so far not been able to influence prices in the marketing system. This is due largely to the fact that its present market share stands at about 20% of total domestic production. Steps are now being taken however, to increase the volume of produce to the Corporation and to enable it to play a more dynamic role in the marketing system.

The net effects of the overall system of distribution therefore are:-

(i) it allows for considerable loss of produce at the market place or intransit to the market;

(ii) it creates an indifference to, or discourages increased production of domestic crops and even at times frustrates the will of farmers to produce;

(iii) it is partially responsible for the low levels of income that exist among farmers as well as among higglers themselves;

(iv) it results in wide market margins with consequent high prices to consumers.

Improvements to the present system calls for strong

centralised and co-ordinated approach.Centralised control,however, is not possible so long as higglers continue to play the leading role at all levels of distribution. A system must be devised therefore, which will centralise and co-ordinate the processes of marketing but at the same time accommodating the 14,000 higglers.

Post Harvest Losses in Jamaica

Jamaica experiences post harvest losses mainly in fruits, vegetables and certain root crops. Causes of losses as well as the extent of these loss vary significantly within these three groups.

Fruits

With few exceptions fruits are produced without proper planning and management of orchards. Basic practices which include -

Soil testing
Seed selection
Pest and disease control
Suitable climate conditions
Suitable methods of harvesting and transporting
Drying and storing

are often neglected. Much of the post harvest losses in fruits therefore are due to pre-harvest factors.

Vegetables and Root Crops

Because there is organised production of vegetable and root crops the basic cultural practices are in most instances observed. Post harvest losses therefore usually bear little or no relation to pre-harvest conditions and occur mainly in the marketing system.

Work in the area of post harvest losses in Jamaica has been limited to a few crops only and investigations have been oriented ɔ causes and treatment rather than to quantifying the extent of losses.

Institutions involved in the work of post-harvest losses include the Storage and Infestation Division of the Ministry of Marketing and Commerce and the Food Technology Division of the Ministry of Industry and Foreign Trade. Other institutions with interests in post harvest losses include the Agricultural Marketing Corporation and Commodity Boards (citrus, coffee, banana etc,) The work of the Storage and Infestation Division are summarised below.

The Storage and Infestation Division of the Ministry of Industry and Commerce was established in 1958 to make provision for the storage of food for the prevention of loss of food by infestation and for purposes connected therewith. The Division was initially concerned with dry produce storage, that is, cereals, spices, etc. and later with the storage of wet produce, that is, fresh fruits and vegetables.

The Division has worked closely with the AMC to attempt to identify the major post-harvest problems, reduce wastage during marketing and extend the shelf life of the crops. Detailed information is not available on the wastage of wet produce but it has been estimated to be in the region of above 25%. The following results summarizes the main areas and crops involved and are presented alphabetically by crops.

Banana

The Storage and Infestation Division with the Banana Board has co-operated in projects on handling methods from field to boxing plants.

Breadfruit (Ortocarpus)

Investigations have been carried out on all aspects of harvesting, handling and storage and the storage life has been extended from a few days to about two to three weeks.

Cabbage (Brassica)

Optimum storage conditions have been defined for locally grown produce and storage losses of new cultivars assessed to allow pre-selection of the ones with the most desirable characteristics and optimum storage periods.

Cassava

Storing cassava in moist dust has been found to extend storage life from a few days to over four months.

Dasheen

Storage losses have been considerably reduced by ~~using~~ ~~and~~ storage at cool temperatures.

Escallion (Allium)

Work has has been done to delay the senessence of the green tops of this crop during marketing.

Limes

Harvesting handling and storage have been investigated and a way has been found to keep limes in the green state for over two months after harvest.

Mango

Investigations have been confined largely to the St. Julian cultivar. Methods have been found to delay development of anthracnose during ripening to develop a more attractive colouration in ripe

fruits and to significantly extend storage life.

Onions

Various drying methods and storage bin designs have been developed for varieties grown under local conditions.

Papaya

Various methods of extending storage life and reducing storage losses of cultivars has been investigated.

Plantains

Investigations have been carried out on the handling, storage and ripening of plantains.

Sweet Potatoes

The effects of curing, waxing, wrapping and finger guides have been investigated.

Tomato

Effects of temperature, humidity and wrapping on storage have been investigated.

Yams

Storage losses have been considerably reduced and storage life significantly extended (for one specie from a few days to over 3 months) by curing and storage at cool temperature. Details of preliminary work on cassava and mangoes are attached as Appendix I and II.

The overall problems in post-harvest losses in Jamaica appear to be -

(i) lack of appreciation among farmers of post harvest losses;

(ii) inadequate communication between producers, marketing agencies and research departments;

(iii) generally poor transportation and handling practices;

(iv) inadequate storage facilities in marketing boards;

(v) storage technique presently limited to the experimental stage and may not be applicable to small farmers.

There is need for -

(a) up-grading of the skills of all concerned in the production and marketing of agricultural produce;

(b) research not only in the areas of Horticulture and Agronomy but also in the area of storage. It is indeed desirable that simple and economical methods of storage applicable at the farm level be developed.

APPENDIX I

Preliminary Note on the Storage of Fresh Cassava

Summary

Traditionally cassava has been marketed or processed within a few days of reaping because of its rapid post harvest deterioration and heavy losses have resulted whenever delays occurred. Recent research at CIAT in Colombia has developed simple methods by which fresh cassava can be preserved at ambient temperature for at least two months by packing so as to promote curing of root injuries. In trials at Storage and Infestation Division, locally grown varieties have been successfully stored for four weeks by packing in the field into boxes lined with perforated polyethylene. It is likely that any other procedure which minimised water loss and mechanical damage from the point of harvest would allow storage of cassava for several weeks. Action is necessary to devise and test practicable and economic procedures for handling and storage of the increasing crop of cassava projected from Operation Grow and other sources.

A major increase in cassava production and utilization in Jamaica is projected from 1975 onwards. The Crop Research Division of the Ministry of Agriculture is currently conducting trials with three selected local varieties and two varieties obtained from CIAT (Internation Centre for Tropical Agriculture) in Colombia which has a major programme on cassava. These five varities and locally available ones are being multiplied and distributed to supply a factory capable of handling 15,000 tons of cassava per year. The AMC is also interested in exportation of sweet cassava. These notes are produced to assist in planning the handling of the increased quantities so as to minimise losses between harvest and utilisation.

A cassava storage project at CIAT in collaboration with Tropical Product Institute, U.K. has demonstrated that cassava can be stored in the field for eight weeks in simple structures similar to the European potato 'clamp'. At present the CIAT/TPI project is developing a method for box storage of cassava by packing into rice husks, sawdust or similar material and are investigating the effect of curing at high temperature as a pre-treatment before storage or marketing. Their results suggest that under suitable conditions, which can be developed in a 'clamp', wound healing will occur at the sites of injury from which breakdown of roots will otherwise develop and that once this occurs cassava can be stored for substantial periods.

Trials at Storage and Infestation Division, to adapt these findings for local use, have been carried out by storing cassava packed in the standard 30 lb. box used by AMC (this packs to 40 lb. with cassava). Two methods have been used, in the first, cassava was packed in moist coir dust and in the second, boxes were lined with the perforated diothene sheet which is used for packing export bananas. These methods reduced weight loss in the first week of storage from 5-10% in unlined boxes to 0.5-1% in moist coir and 1-2% in lined boxes. Both methods reduced the percentage of spoiled roots after one week from 20-60% in unlined boxes to 5-10% and after four weeks from 50-100% in unlined boxes to 10-20%. This work has used small quantities of the five varieties under test by the Soils and Crops Division and larger quantities of a local variety,"Yellow heart" grown around Bull Savannah. All have deteriorated rapidly when stored in unlined boxes and all have given a large improvement when stored in coir dust or lined boxes.

Investigations at Storage and Infestation Division has shown that post-harvest breakdown of cassava is caused by rapid loss of water from freshly reaped roots. Water loss is most rapid in injured roots particularly those in which bark is partially removed during reaping, (scuffing). Any method which reduces water loss will decrease the rate of breakdown and it is particularly important to do this quickly for roots which are badly scuffed or are broken. In samples inspected recently, reaped both for processing and exportation, breakdown was well advanced within 2 days of reaping.

At present, best results have been obtainod by packing cassava in the field, immediately it is reaped, into standard AMC boxes, lined with perforated diothene. The cost of the liner is about 5¢ per 40 lb. box. Although this method is suitable for distribution and marketing fo fresh sweet cassava it will probably be necessary to av^{o}id the use of boxes, which are expensive and bulky to distribute, for supplying cassava for processing. It is possible that a high density perforated polyethylene reusable liner, to fit into crocus bags, could be developed and used. In any event it is proposed that an integrated scheme for handling cassava from reaping to processing should be developed and tested in the immediate future to avoid large scale spoilage of cassava when full scale processing commences. The use of boxes and liners might be considered for moderate scale producers such as co-operatives and Food Farms who may wish to supply fresh sweet cassava for local markets for export.

APPENDIX II

Preliminary Observations on Handling Storage and Ripening of St. Julian Mangoes.

It is important to handle fruits carefully during all marketing stages.

Harvesting

If it is desired to store fruits or to send them to overseas markets by sea, they should picked at the mature green stage when the cheeks are level or above the point of insertion of the stalk and the flesh near the seed is changing from white to yellow. Fruits which are to be sent by air may be harvested at a later stage of maturity. Harvesting fruits when they are immeture extends their storage life. When, however, they are too immature they fail to ripen properly.

Fruits should be harvested with clippers and carefully placed into field boxes. It has been shown that if about ½" of the stalk is left on the fruit "bleeding" is considerably reduced. It is important to remove from the fruit surface all latex that oozes from the stem at picking since it seems to damage the skin.

Packing

Only unbruised and disease free fruits should be packed. Information regarding size of cartons and number of fruits each should contain should be obtained from Produce Inspection Division of the Ministry of Agriculture. Generally, cartons should contain fruits of one cultivar only.

Storage

The best storage temperature for mangoes has been found to be about 55°F (13°C). This is the temperature of the holds of the banana boats. When fruits are stored at temperatures lower than this there is a danger of chilling. At this temperature fruits have been shipped successfully to the U.K. market from the West Indies.

Ripening

Fruits ripened best at temperatures between 65° and 73°F (18° and 23°C), and RH above 85% At the lower temperatures within this range fruit colouration was very good,much better than at ambient. Mature green fruits ripened in about 10 to 13 days at this temperature and did not start to soften until two or three days later.

Disease

Anthracnose (Collectotrichum gloesporioides Penz.) was the main problem. Latent infections frequently occur and become evident only when the fruit ripens. Dipping fruits in hot water 131°F (55°C) for 5 minutes has been found to retard the development of anthracnose.

In South Africa anthracnose in the field has been controlled to some extent by fortnightly applications of Dithane M45 sprays starting at blossoming and continuing until fruits are about the size of golf balls. Following this, a neutral copper spray of 1.5 to 2% metallic copper may be applied monthly until harvest. During dormancy a clean-up spray of copper plus 0.5% emulsifiable summer oil is recommended.

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DOCUMENT VI - D

POST-HARVEST FOOD LOSSES IN THE CARIBBEAN: THE CASE OF TRINIDAD*

*Prepared for the Seminar on the Reduction of Post-Harvest Food Losses in the Caribbean and Central America. Santo Domingo, D. R. August 8-11, 1977

TABLE OF CONTENT

POST HARVEST FOOD LOSSES IN THE CARIBBEAN

I. INTRODUCTION

A review of the literature would show that very little detailed work has been done on the estimation of post harvest losses under tropical conditions. Notable exceptions to this are the traditional export crops, cocoa and bananas.

With the change in emphasis from these traditional export crops towards production of the basic needs of the emerging countries, the problem of staggering high costs due to pre and post harvest losses must be overcome.

It is difficult to discuss post harvest losses without taking into consideration that a certain percentage of this may have been caused directly or indirectly by improper cultural techniques and that these areas of post harvest losses need to be identified and corrective measures taken at that level.

The Agricultural policies and systems being adopted by these emerging countries may, in some way, be contributing towards high post harvest losses and any examination of the subject would have to include an assessment of the extent to which these programmes and practices need to be changed if post harvest losses are to be reduced to a minimum. A brief discussion, therefore, of the marketing forces and the policies under which these forces operate would assist in identifying and explaining the inherent problems.

Figure I attempts to show the position of both the public and private sectors in the movement of produce in the marketing system. While the chart shows the percentage of direct intervention, it does not take into consideration the "behind the scenes" influence which each of these institutions may be able to exert on market forces or marketing strategies.

An explanation is also necessary on the facilities available at these various institutions which could be the limiting factor in their ability towards playing a bigger role, or the role expected of them in an efficient system.

Table I shows facilities available at major retail outlets. Lack of facilities at market places is definitely one of the factors in increasing post harvest losses both in perishables as well as dried grain.

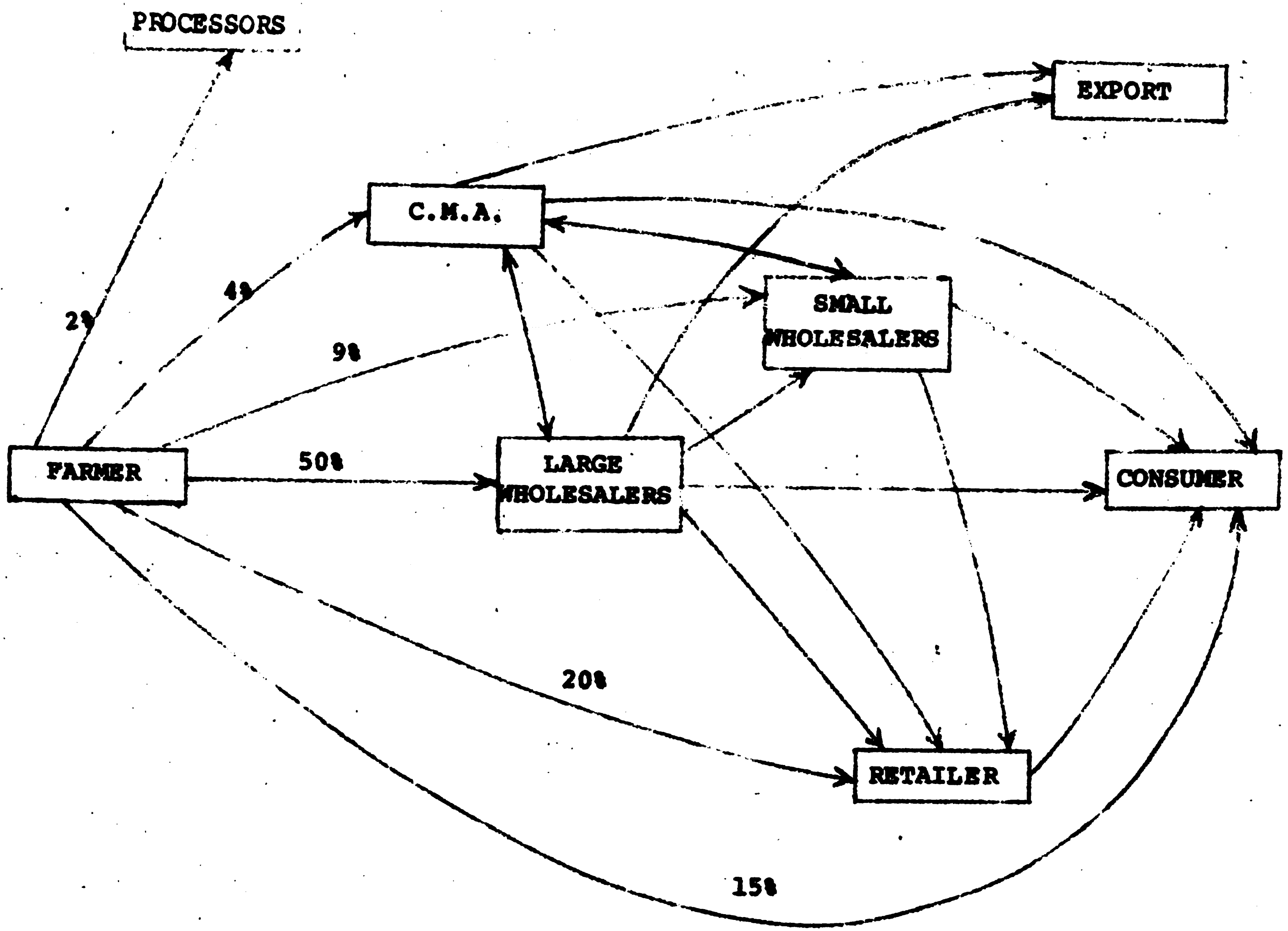

FIG. 1 FLOW CHART FOR DOMESTIC FOOD & VEGETABLE CROPS

RETAILERS INCLUDE

(1) Vendors
(2) Supermarkets
(3) Shops
(4) Greengrocers

CONSUMERS INCLUDE

(1) Households
(2) Institutions
(3) Hotels, restaurants, wayside food -le
(4) Ships' stores

TABLE 1

Market	Cold Storage	Wholesalers	Remarks
ort of Spain	Chill boxes fish - 10 tons Meat - 80 sides	Full time - 75 part time - 50	Area needs to accommodate a minimum of 200 wholesalers. Most meat from private cold stores
t. James	Nil	Nil	No facilities
arataria	Nil	Part time - 3	Roadside selling
an Juan	Nil	Nil	No wholesale facilities. Roadside selling
unapuna	Nil	Part time - 12	No wholesale facilities available
rima	Ice Boxes - fish	Nil	No wholesale facilities
angre Grande	Nil	Part time - 50	Farmers sell wholesale in available area, than stay there and sell retail on Saturdays
ayaro	Nil	Nil	No facilities
haguanas	Nil	Nil	No facilities
an Fernando	Nil	Full time - 20 Part time - 10	No room to expand because of location
rinces Town	Nil	Nil	75% trading done outside market
iparia	Nil	Nil	No wholesale facilities
rzabad	Nil	Nil	No wholesale facilities
nal	Nil	Nil	No wholesale facilities
oint Fortin	Nil	Nil	No wholesale facilities
lo Seco	Nil	Nil	No wholesale facilities
o Claro			No market, but area is marked off for one

ource: Market Survey, Land Capability Study Phase II.

The percentage of produce, particularly perishable produce, which is handled by supermarket chains is very small. Supermarkets in the Caribbean tend to concentrate on canned and bottled commodities, while farm produce in the fresh state is still handled by a network of markets, mini-markets and road-side stalls. Produce under these systems is handled by several intermediaries in its movement from the farmer to the Consumer, and losses can occur at each of these stages simply from handling, packing or exposure.

Governments in the region have set up a number of mechanisms by which they attempt to encourage local and regional production while controlling imports from outside the region and thus the movement of scarce foreign exchange. The high cost of compulsory food items has forced most Governments to institute some form of price control. In the Caricom countries, a system which combines a number of measures is operated. These systems are, a Minimum Guaranteed price for local farmers. The Agricultural Marketing Protocol and the Guaranteed Market Scheme under which produce in the region is traded at pre-fixed prices; and a common external tariff whereby all goods traded must have an import and export licence.

It is necessary to explain in some detail how these schemes operate since, in themselves, they may be contributing in some way towards higher post harvest losses.

-6-

1. <u>Minimum Guaranteed Price Scheme</u>

This scheme has been in operation in Caribbean Islands for varying periods and in Trinidad and Tobago for over 20 years. However, it has not worked well generally since farmers complained that prices offered were too low and were not changed often enough to take into account the increasing cost of inputs.

Within the last two years in Trinidad and Tobago, the scheme has been adjusted to accommodate these arguments. At present, the scheme is reviewed yearly and the price paid is computed on a cost of production plus a minimum percentage as farmer profits. In fact, the scheme cannot be considered as a strict minimum guaranteed price system since it includes a number of items where an incentive price is being paid. For example, the minimum guaranteed price of corn is 32¢ while the wholesale trading price never rises above 22¢. A number of items on the list, chosen because of high imports of the commodity and/or because recent agronomic studies show the possibility of production of these crops, enjoys these incentive prices, e.g. onion, carrot.

The problem with this system lies in the fact that it gives the farmer a market for his produce but it does not allow the marketing organization of Government enough time to properly plan for the disposal of the produce. Farmers can, without notice, offer for sale large quantities of produce leaving the Organization (Central Marketing

-7-

Agency) in a quandry as to how to effectively dispose of ungraded produce in large amounts on a glutted market and without enough time to find export markets.

What is required here may be the development of a system to gather statistics of acreages planted, times of harvest and a general system of market intelligence. It might even be necessary to explore ways of controlling the acreages under any one crop at any time towards satisfying local demand and to consciously over-produce only where there is an assured external market.

Discussions have been continuing over the years as to how to successfully establish a contract system to replace the minimum guaranteed price system. So far a method has not been found that would encourage the farmer to grow on contract by incentives rather than by legal statutes. The farmers who break the terms of a contract would not be legally prosecuted. The C.M.A. on the other hand cannot commit itself to supply on external markets as failure to supply would mean that the Agency would be legally prosecuted.

The minimum Guaranteed price system allows for extremely high levels of wastage since the amount of planning is minimal, market intelligence is lacking and even at greatly reduced prices the local market cannot absorb, in many instances, the amounts produced.

2. <u>Agricultural Marketing Protocol and Guaranteed Market Schemes</u>

These two allied schemes allow for the sale of produce of the smaller countries of Caricom in the markets of the larger islands. The schemes suffer particularly from the lack of adequate shipping facilities. Produce is carried on the decks or in unventilated holds of small sloops. It is exposed to sea sprays, heat and mechanical damage of all sorts. The quality on arrival at port of destination is usually poor and the level of post harvest losses in this system of trading is extremely high.

Cultural techniques utilised in production of the crops in the smaller islands are also deficient in many ways, and thus contribute to the high percentage losses. There is no system of washing, grading or treatment for harvest or in-storage diseases during shipping and all these contribute to the poor quality of goods received. Commodities harvested at an immature or over-mature stage are also prone to more rapid deterioration and consequently post-harvest loss.

The system utilised by the small territories is that bags are distributed to the farmer who may do his own grading. These bagged goods are then transported over poor roads and deposited wharf side. This exercise, from harvesting to delivery for shipping can take a few days, and under tropical conditions, can in some measure contribute to the degree of spoilage.

3. **Import and Export Licences**

Under the system of common external tariff, all produce traded must have import and export licences which in most instances are issued by the Ministry of Trade,

Under the Agricultural Marketing Protocol and Guaranteed Market schemes the Ministry of Agriculture or other associated organizations (C.M.A.) are given the authority to recommend licences and thus to control the flow of farm produce in or out of the island as a protection to both the local farmer and the consumer.

Where goods are in scarce supply export licences are not issued as this would further push the cost of the commodity upward. In some instances, imports are not allowed in order to protect the local farmer.

The Ministry of Agriculture can therefore exert much influence on the market forces operating in the country thereby regulating quantities of goods traded and prices.

Difficulties arise where a certain percentage of a staple commodity is imported from Caricom countries while the large percentage of that commodity must be imported from extra-regional sources. Usually the commodity from the two different sources varies in quality and in price.

As previously noted, the Caricom produce may be of a poorer quality and a higher price. This not only creates difficulty in disposing of the Caricom produce while a better quality is at the same time available on the market, but can also, as has happened frequently in the past, lead to heavy losses due to spoilage.

The shelf life (the ability to store) of the produce grown under tropical conditions may be shorter also than the shelf life of produce coming from nothern climates.

Reference is again made to the distribution system, particularly to explain the type and extent of losses that could occur either in relation to the cumbersome nature of the distribution system or the lack of adequate facilities. Produce from the farm at most times by-pass village markets and even from the furthest corners of the island is brought to the Central Market.

At this distributing centre in the heart of the capital, both the imported and locally grown commodities are brought by traders, farmers and wholesalers on specific days when an established wholesale market operates. On Tuesdays, Thursdays, Fridays and Saturdays farmers from all over the country congregate between the hours of 1.00 a.m. and 9.00 a.m. when most of the trading takes place, and where a demand and supply system operate which determine wholesale and retail prices for the entire country.

Retail traders of all types; supermarkets, mini-markets, hoteliers, come to this central area for the purpose of trade or barter. Because of this system which has been established over the years, commodities are brought long distances in open trucks containing large baskets fully loaded or in bags stacked for maximum haulage. These must be traded and a percentage also then taken by other wholesalers to secondary markets to be resold to the retailers.

The point which is demonstrated here is that perishable produce, and in the main items that are easily damaged or bruised, must be taken through a system where it is handled four to six times before it reaches the consumer. At each of these stages losses occur due to exposure to the elements, crushing, poor packaging, length of time it takes to move through the system or simple over estimation at each stage of the amount capable of being handled or sold.

Discussions are taking place at all levels of the society on the question of the need or benefit which could be derived from the use of cold or cool storage facilities in this system. Groups within the society continue to agitate for greater public storage facilities which, in their opinion, would assist the farmer and consumer alike by reducing the high rates or spoilage.

A more detailed examination of the situation raises a number of questions on the effectiveness and economics of cool or cold storage within the present system.

In more developed countries cool and cold storage are used to extend the life of the produce but this is only done where the produce has been handled in fairly defined systems. Produce is harvested at optimum maturity; the field heat is reduced immediately, it is then transferred into refrigerated vehicles which carry the produce straight into storage. It is stored under optimum conditions of temperature, humidity and even atmosphere in order to maximise its period of storage.

These conditions as described do not exist and in most instances cannot be controlled in relation to produce under the systems described within the Caribbean region. Optimum times of planting and harvesting are not observed by the farmers and, as explained above, the produce can be offered for sale at any time without any knowledge as to time of harvest, treatment between actual harvest and time of purchase or how a number of variable factors e.g. maturity, variety, cultural techniques, would affect its storability.

Preference is exhibited by the consumer for fresh produce and chilled or stored produce would in the main fetch a lower price on the market than fresh produce, detracting against the practice of storing and the cost of storage. Another factor militating against increased storage capacity is the system for marketing produce. Only a small percentage is handled by supermarkets and outlets with controlled holding facilities. Most of it is handled by open markets, wayside stalls and open air facilities in general. This means that chilled produce deteriorate faster than fresh produce under these

conditions and not only the level of spoilage is increased but the appearance so changes to detract the consumer from purchasing at all.

The general lack of statistics of any type on amounts traded within these systems or actual losses are detracting from any worthwhile improvements. The general figure given for actual losses within the marketing system of 25 to 40% usually refer to grain while the amount occurring may vary with the ease of damage and perishability of the commodity.

The point was made earlier that improper cultural techniques including regular insect and disease control, are a contributing factor although this cannot be measured in actual percentages or weights. Treatment at harvest e.g. excessive handling, lack of washing and fungal dipping to control diseases, poor packaging, do contribute towards increasing the percentage of loss.

The bibliography compiled by Sharon Laurent of CARIRI (May 1977) shows clearly the absence of substantial research in recent years on this improtant problem. C.W. Wardlaw, between 1934-40 completed preliminary studies on a number of tropical fruits but this work is in urgent need of modernizing and expanding to meet todays demands.

A brief review of the areas in which urgent research or even statistical tabulation is needed are:

(a) Ability of present day varieties grown under Caribbean conditions to store and the optimum conditions of storage.

(b) Influence of agronomic practices and handling techniques on the storage of major vegetables and fruits,

(c) Systems which will encourage farmers to plant towards a secured market eliminating gluts and bartering after harvest for highest prices without regard to quality.

(d) Research into the method of bulk handling and packing of produce under tropical conditions to minimise wastage.

(e) Research into marketing systems in the Caribbean with a view to minimising handling, distances travelled and consequently cost.

(f) Methods of recording statistics as to actual amounts of produce traded, extent of losses and reasons for such losses. This could also be extended to include statistics on availability of produce within the Caribbean region and communication systems for exchange of statistics and trading in perishables.

1/77

DOCUMENT VI - E

SOME EXPERIENCES OF FAO IN FOOD CONSERVATION*

By:

Axel Caro.A.

*Prepared for the Seminar on the Reduction of Post-Harvest Food Losses in the Caribbean and Central America. Santo Domingo, D. R. August 8-11, 1977.

TABLE OF CONTENTS

SOME EXPERIENCES OF FAO IN FOOD CONSERVATION

I. INTRODUCTION

National and International Organizations have been studying for several years with increasing concern the ways to prevent or at least to decrease the post-harvest food losses.

The FAO has given priority within its assistance programmes to those aimed toward the improvement of the technical conditions of the several steps of the marketing chain in order to give to the consumer more and better food.

According to a study made by FAO, and presented to the Committee on Agriculture which took place in Rome in April, 1977, the calculated post harvest food losses for 1985 will reach the incredible amount of 85 million tons of cereals and basic grains per year, supposing a 10% loss as a world average.

Therefore, the reduction of such losses to one half would represent savings of more than 40 million tons of cereals per year with a value of about 7500 million U.S. Dollars.

In other words, considering the basic daily ration of cereals of 400 grams per person per day, a reduction at 50% the present level of cereal and grain losses would give additional food to more than 260 million people, without increasing the cultivated areas or the present yields.

II. FAO'S APPROACH TO THE PROBLEM

Through its Agricultural Department, FAO has given emphasis to the studies carried out on cereals and basic grains due to the fact that these are the basic food of the majority of the world's population. However, FAO has not forgotten the importance that fruits, vegetables and other perishable products have on the diet of an important sector of the world population.

FAO has increased its actions toward the reduction of post-harvest losses, following the resolution of the General Assembly of the United Nations in its seventh period of Sesions, which established a goal of 50% reduction of losses in a period of 10 years.

It is recognized in technical circles that the levels of loss in basic foods are not known with much precision. These losses vary with the product, the country and region, cultivation systems and other causes.

For these reasons, FAO in 1976 made a survey in developing countries to identify the causes, level and circumstances of those losses. Although this study does not represent the official view of the governments on the matter, it gives an approximate idea of the volume and causes of food losses and the needs and programmes needed to reduce them.

The FAO Council, in its Session of November, 1976, asked for a study of the activities realized and those to be realized by FAO, by diverse countries and by other organizations for the reduction of post-harvest losses and the resource requirements.

The Agricultural Department of FAO then prepared a document, with the help of a group of international technical experts of member countries, which was presented to the Committee on Agriculture in

April of this year.

In that document the losses of basic grains, roots and tubers are defined in quantity and quality and the causes are analyzed. The problems and difficulties to meet the established goals are identified and model programmes to be developed at a national level are indicated. The need of coordinated actions between national and international organizations to develop a common methodology to evaluate losses is pointed out.

As a part of the action plan, a proposal for the creation of a 20 million dollar fund was presented, with the aim of financing technical assistance programmes on the reduction of post-harvest losses. The Committee on Agriculture, as well as the Council of FAO, accepted the proposals presented and approved the action plan.

FAO, then, will increment its assistance toward the reduction of post-harvest food losses, and will cooperate with other organizations in the adoption of common methodologies to evaluate such losses.

III. FAO'S PARTICIPATION IN POST-HARVEST PROGRAMMES

The field programme of FAO for 1976/77 includes 21 projects on reduction of losses with a total of 23 experts, 5 associate experts and 14 consultants. The total cost of such actions in the biennium is estimated at US$2,400,000,plus the programmes of the FAO's Food Security Assistance Scheme, which give assistance on storage and conservation of basic grains.

FAO participates in regional projects on food processing with 11 experts and 16 consultants in 10 countries for the improvement of industrial processing of food, at an estimated cost of US$1,300,000.

Field programmes on marketing of agricultural products had in 1976 a cost of more than US$860,000.

FAO cooperates with bilateral assistance organisms: for the construction of warehouses in Africa (Sahel) with the G.T.Z. of the Federal Republic of Germany; in projects of loss reduction in Bangladesh Indonesia, Malaysia and Nepal with the ODM of the United Kingdom; with the AID in projects of loss evaluation and with the governments of the Federal Republic of Germany, Netherlands, Norway, Switzerland and United States on the programmes of world food security.

Moreover, FAO works in close cooperation with other assistance organizations such as CIDA from Canadá; NORAD; SIDA from Scandinavia and DANIDA of Denmark, for the organization of projects on rural storage, regional training, Seminars on farm grain storage, etc.

IV. IDENTIFICATION OF POST HARVEST FOOD LOSSES

Due precisely to the lack of a universally adopted methodology for the evaluation of losses, it is not easy to give a definition at present which will fit all the products or all the regions.

4.1 Volume of Losses

According to a survey done by FAO, losses in durables (cereals and grains) vary from 10 to 26%. These losses include quantitative and qualitative losses, the later type being very difficult to evaluate in weight or volume.

For fruits and vegetables the reports show average losses between 18% and 33% and for roots and tubers the losses are between 12 and 26%.

It is important to note, however, that the above numbers have been calculated on different countries with different methods, systems and criteria.

4.2 Causes of Losses

The direct causes of losses in quality and quantity of foods have been already identified: In the case of cereals and grains insects appear to be the most important cause of loss, followed by molds and rodents.

It is felt that the action of the diverse countries, International Organizations and FAO, should be directed to work on the indirect causes of these losses,such as the defficient infrastructure in storage of the products, inadequate methods of transport, inadequate practices in harvesting and above all, the lack of training at all levels for the personnel in charge of the marketing of products, which allow conditions which permit the existance of pests and losses.

For instance, the very common practice in the central american countries of leaving maize on the cob in the field for one or more months permits heavy losses due to rodents, insects and birds. Moreover, due to the slow drying process, very high and dangerous levels of aflatoxines have been detected on samples handled in that traditional way.

Once the product has deteriorated no corrective measure can improve its quality: at best it can only be maintained.

V. TECHNOLOGIES TO REDUCE POST-HARVEST LOSSES

In general, it can be said that most of the techniques used to reduce the post-harvest losses in agricultural products are already known and being applied on large or small scale in more developed countries. The responsibility of the institutions involved in the marketing of the products is then, to study the most practical

solutions which can be adapted to the geographical, social and economical conditions of each country.

The transfer of technology from advanced countries should be made cautiously, due to the fact that in most cases the technical equipment has been designed for conditions very different from those found in tropical countries. It has been documented on several occasions that the output of grain conveyors, dryers or cleaners is reduced drastically, as much as 50%, when they are used with products with moisture and foreign material levels above those normally found in technified agriculture.

For the above reasons, the inadequate use of machinery and technology can lead to technical and economical disasters.

FAO, as an institution for the transfer and dissemination of information, does not participate, in general, in research projects, but it does participate in programmes which have applied research on the preservation of agricultural products. The next are examples of intermediate technologies adopted to developing countries.

5.1 Harvesting

The International Rice Reseach Institute, (IRRI) in the Philippines has developed several simple machines for the thrieshing of rice, sorghum, soybeans and other small grains, with outputs much higher than those obtained by traditional systems. through a sub-contract with IRRI, the Program of Technical Assistance to the Metal Industry, ASTIN-SENA, financed by the Federal Republic of Germany in Colombia, will undertake the promotion for the production of these portable machines with capacity of one-half to one ton per hour and adapted for the conditions found in Latin America.

5.2 Drying

Technical drying of cereals is perhaps the most important step to get good quality products, and it is also the most difficult area to be implemented at the farm level.
Commercial drying machines, designed in developed countries, are not adapted, in general, to be used in small scale production schemes and their installation represents considerable investment.
The Regional Storage Project of FAO in Africa has developed several types of on-the-cob corn storage in order to obtain better and faster drying, keeping the product free from rodent attack. These metal mesh containers allow the free flow of air but cannot prevent insect infestation.
The IRRI in the Philippines has developed a bulk stationary dryer whose simple design can be adapted and manufactured in any developing country, using mostly local materials. It was designed for rice, but similar systems have been successfully used in drying corn, sorghum and other grains.
The dryer consists basically in a rectangular box made of metal or wood, with a perforated bottom which allows the drying air to pass through the product. A small ventilator moves the air which is heated by a small burner.
Different size versions of this system are being applied in several countries with good results.
The use of reusable sources of energy for the drying of grains is a very important field of study for research organizations. Solar energy, the most common dryer since the beginning of agriculture, is being used in solar collectors to pre-heat the

air. One such collector is in the shape of two concentric plastic tunnels; the external one, transparent and the internal one of black color to absorb the solar energy. Experiments carried out in the United States hace shown increments in the temperature of 10°C above the ambient temperature.

It has to be said, however, that in the field of small scale drying, the perfect solution has not yet been found.

5.3 Storage

FAO has participated in several storage projects in Asia and Africa. The experience that come from these projects indicates that traditional systems of storage such as underground pits, small mud bins, etc. have to be evaluated in detail if they are going to be applied in other areas or countries.

The use of inert atmosphere with reduced quantities of oxigen, or its complete absence, have been investigated as a way to prevent the growth of insects and to improve the conservation of the product. Two examples are shown: i) On an experimental basis, the research done in Brasil by The Institute of Food Conservation. Corn was kept in very good quality conditions for a period of several months in an underground pit lined with poliethilene; ii) also on an experimental basis, the Italian Institute SNAMPROJETTI has used 98% nitrogen atmospheres on stored grains allowing the control of the quality of the grain as well as the germinability of the seeds. This Institute, with the cooperation of a commercial wheat industry, has installed 16 silos of 500 tons capacity each, made of one piece of fiberglass reinforced resin, to investigate the behavior of inert atmospheres on wheat storage on a commercial basis.

It is noted that for hundreds of years, the system of grain storage with controlled atmospheres has been used empirically in several regions of Asia and Africa with good results.

The use of containers of different shapes and materials for the storage of cereals at farm level have been studied and propagated by FAO and other institutions through their assistance programmes. Through its Save Grain Campaign, FAO has propagated in India the use of small locally made metal containers. Its simple design permits its manufacture by local artisans and to be used throughout the country.

It is important to note the convenience of the small metal "graneros" (bins) used mainly in Guatemala and El Salvador, of similar design as the Indian ones, whose usage and benefits are already known by the small farmer. This type of low cost storage, rodent, insect and bird proof, can be taken as a very interesting example of a simple way to reduce the post-harvest losses at the farm level.

The use of warehouses or buildings c structed especially for storage of agricultural products, is the most practical system at the level of rural assemble and distribution centers. FAO considers the use of local materials and manpower of primary importance as well as the use of improved designs, which are rodent and bird proof.

The construction of silos and drying plants for governmental use must be preceeded by a careful study of the social, economical and technical situation of the country as well as the possibilities of the transfer of technologies from the more advanced countries and of the local technical capacity for their correct

operation and maintenance.

The use of provisional or semi-permanent structures of grain storage has been studied by FAO in its programmes of emergency aid to several countries of the Sahel in Africa, using synthetical fabric silos. The results, so far, are not conclusive but show that synthetic fabric silos are a good solution with the condition that competent management is present.

5.4 Processing

The industrial processing of cereals and grains has also margins of losses due to the inadequate use of technologies and machinery. As an example, the milling of rice can be noted in which an important proportion of nutrients can be lost if adjustments are not made.

FAO presents in its development projects the parboiling of rice as a good alternative for the reduction of qualitative and quantitative losses in this product.

VI. CONCLUSSIONS

The coordination of actions taken toward the reduction of Post-Harvest Food Losses is the key to obtaining satisfactory results in a relatively short period of time.

It is important to note that although the exact percentages of losses are unknown, such losses are evident and national governments, responsible institutions and International Organizations should begin immediate actions to reduce them.

For the above reason, it is felt that studies to be undertaken to evaluate the volume of losses should be undertaken at the same time as the actions themselves and not as a necessary and preliminary

project "of study". For instance, it is felt that projects for improving on-the-farm storage can be implemented immediately without interfering with the programming of more ambitious plans.
It is felt that specific projects, with durations of from one to two years for storage and processing of food products, can give better results and can be documented over the short-run.

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ANNEX No. 1

Ten model projects to reduce post-harvest losses prepared Agricultural Department of FAO, are included as part of the first document cited in the list of references are

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The first seven projects cover 10 countries, the next two, cover four countries and the last one is designed to provide assistance to 24 countries.

Two characteristics of the proposed projects are:

a) They have a duration that, in most cases, does not excede one and a half years;
b) The projects are simple and therefore their preparation and implementation should be relatively fast.

Although the programmes are described separately, it might be convenient in some cases to combine two or more projects, such as the farm storage and the drying and central storage projects.

REFERENCES

The foregoing report has been prepared based primarily on the following documents:

1. Reducción de las Pérdidas de Alimentos posteriores a la Recolección. Documento presentado a COAG. COAG/77/6. Febrero, 1977.
2. Analysis of a FAO Survey of Post-Harvest Crop Losses in Developing Countries. Document AGPP:Misc/27. March, 1977.
3. COAG. Report FAO Document CL 71/9
4. FAO Council Report. FAO Document CL 71/Rep/4.

DOCUMENT VI - F

POST-HARVEST SYSTEM IN CENTRAL AMERICA
IGAD/LAC PROGRAM IDENTIFICATION*

*Prepared for the Seminar on the Reduction of Post Harvest Food Losses in the Caribbean and Central America. Santo Domingo, D. R. August 8-11, 1977.

POST HARVEST SYSTEMS IN CENTRAL AMERICA

IGAD/LAC PROGRAM IDENTIFICATION

INTRODUCTION

This Report on Post-Harvest Systems in Central America was prepared by the IGAD/LAC Coordinating Staff. It is submitted to the agencies participating in IGAD/LAC, in accordance with the terms of reference prepared in consultation with them, for their review and consideration regarding financing of the programs identified. The Report will also serve as the basic working paper for a technical meeting on post-harvest systems in Central America to be held in cooperation with SIECA sometime in August in one of the countries of the region, with the participation of technical representatives of the countries and experts from the agencies participating in IGAD/LAC.

In submitting this Report, the Coordinating Staff gratefully acknowledges the valuable contribution of the staffs of the participating agencies, notably Messrs. Epstein, Oechsli, Caceres and Meissner of IDB; Messrs. Quijano and Donley of the World Bank; Messrs. Mensah and Applewhite of CGFPI; and Messrs. Grader and Chaij and Ms. Lansdale of USAID. All the foregoing participated actively in defining the scope of IGAD/LAC's role in this field and helped orient the work of the country missions on which this report is based. Final responsibility for the contents of the report, however, are entirely those of the IGAD/LAC Coordinating Staff.

I. Mandates and Antecedents

At the Fifth Plenary Meeting of IGAD/LAC, held in June 1976 in Washington, the participating agencies agreed that one of the principal areas of activity of IGAD/LAC should be the reduction of post-harvest food losses. This decision reflected the consensus of the agencies that IGAD/LAC could fill an important gap in this field which was not being dealt with adequately in the region. It was also the result of the interest expressed by a number of countries in initiating such programs at IGAD/LAC's Consultative Meeting with the Ministers of Agriculture of the region, held in May 1976 in Cancún, México.

Based on consultations by the Coordinating Staff with various countries and the participating agencies, the IGAD/LAC Working Group on Programs and Budget, jointly with the Coordinating Staff, adopted the decision to develop a program in Central America and Panama covering primarily food grains. It was also decided on the basis of that experience, that this program might be extended subsequently to other regions, notably the Caribbean countries and those of the Andean Group. In consultation with the Working Group, precise terms of reference for the expert missions were prepared by the Coordinating Staff.

The selection of Central America was based on several consideration. First, there was evidence (now confirmed) that post-harvest grain losses, are substantial in that region amounting in some cases to as much as 50 percent of the crop. Second, a number of important studies by external agencies (IDB/IBRD/USAID and SIECA) of the region's agriculture were in

process of termination thus providing a basis on which to build a program. Third, some efforts were already underway in some Central American countries, notably in Nicaragua and El Salvador, to curtail post-harvest food losses and there was, throughout the region keen interest in launching a comprehensive program. Finally, there was agreement that the five Central American countries being among the poorest in Latin America, especially in terms of rural income and nutritional levels, but with a high potential for increasing food availabilities through improved post-harvest systems, ought to be the first to benefit from such programs.

In line with these mandates, IGAD/LAC's Coordinating Staff organized field missions to the five Central American countries and Panama for the purpose of program and project identification in post-harvest systems and technology. The work of these missions covered the period November-December 1976 and February-May 1977. Altogether, eleven experts plus members of the Coordinating Staff were involved. (Calendar, composition of the missions and terms of reference are contained in Appendix A.)

II. <u>Purpose and Scope of the Report</u>

One of the functions of IGAD/LAC is project or program identification. This is the essential purpose of this Report. The actual preparation of projects in a form and manner consistent with the practices, policies and procedures of each agency,obviously lies outside the scope of IGAD/LAC for reasons of budgetary limitations and because to do so would mean pre-empting or duplicating functions normally carried out by the staffs of the operating agencies, which IGAD/LAC is not.

Nevertheless, the project identification contained in this Report does attempt to present all the relevant elements needed for arriving at appropriate decisions regarding the feasibility of the suggested programs and for preparing a definitive project or projeets that would satisfy the requirements of individual agencies for submission to their respective governing bodies. Viewed in this light, the Report is intended to delineate the nature of the problem, its causes and present efforts to overcome it, as well as to suggest the specific options of policies, programs, and measures to be adopted for an effective solution. The focus is on the reduction of post-harvest grain losses at the level of the small farmer, so as to increase his income and nutritional level. It presents specific types and forms of external assistance required as a complement to the adoption of domestic measures and policies for preserving the harvest, together with relevant estimates of benefits to be derived, and cost involved.

The substantive part of this Report is divided into two parts. The first contained in the following section, summarizes the general regional aspects of the problem and suggested means to deal with it. The second part covers the specific problems encountered in the individual Central American countries, the possible strategies and programs to be pursued in each for reducing post-harvest grain losses, and programs or projects to be initiated with the help of the external agencies. Panama, where an ICAD/LAC mission also worked, assigns priority to reduction of post-harvest losses in perishables, rather than in grains, as well as in a number of projects other than post-harvest technology. For that reason

no programs in food grain losses have been identified for Panama in this report. Subsequent to the final decisions by the agencies on the proposed programs for the Central American countries, IGAD/LAC will respond to any Panamanian request in the field of perishables, which requires a different methodology.

The Conceptual and Methodological Framework of Analysis

Before examining the specific characteristics of the post-harvest grain loss problem in Central America, there is need to set forth the conceptual and methodological framework within which IGAD/LAC has approached the problem. In this connection, the IGAD/LAC Coordinating Staff has drawn heavily on the methodological work already done by FAO, the Tropical Products Institute, and Professor Malcolm C. Bourne of Cornell University, who served as a Consultant to IGAD/LAC.

Post-harvest losses are defined as the quantitative and qualitative losses of a crop at any of the stages between harvest and delivery to the consumer. These stages involve eight principal types of operation: harvesting, threshing, cleaning, drying, storing, transport, processing, packaging, and distribution. These operations together comprise the post-harvest system.

The quantitative losses, i.e. the weight losses, are attributable to inefficient harvesting of the crop which results in substantial portions of grain left in the field; grain spillage or breakage during handling and transport; consumption of the crop by rodents, birds, and insects

during storage; inefficient processing and milling; and shrinkage due to moisture loss. The losses incurred at any one stage of operation may be related to and be aggravated by losses suffered at preceding stages. For example, improper handling or drying of the crop may cause breakage and brittleness, which may aggravate losses sustained during transport; or defective fumigation of the grain at the farm level may not fully destroy insects and microorganism which may continue to build and multiply during the subsequent stages of the post-harvest system.

The qualitative losses are less obvious and more difficult to measure, but they are equally important. These losses relate to reductions in nutritional content, appearance, edibility, and wholesomness of the grain, as well as seed viability. These result in lower prices obtained for a given crop weight by the farmer or in reduced satisfaction and nutrients for the consumer, whether the producer himself or others. Qualitative and quantitative losses are of course related to the extent that qualitative deterioration beyond a certain point signifies a weight loss as well. In the absence of over-all grading systems of crops, the qualitative losses cannot be measured in monetary terms.

The causes of post-harvest losses, both qualitative and quantitative, may be categorized into primary and secondary. The primary causes are:

a) biological and microbiological, which involves consumption and damage by insects, mites, rodents, birds, and larger animals, as well as by molds and bacteria;

b) chemical and biochemical, which relates to losses due to fat oxidation, enzime-activated reactions, and contamination by pesticides, fungicides, and other harmful substances, such as lubricating oil;

c) mechanical, which comprises bruising, abrasion, and spillage of the grain, as well as defective containers;

d) physical, which involves excessive or insufficient heat or cold and humidity; and

e) physiological, which pertains to changes in respiration and transpiration.

Some of these factors interact. For example respiration causes heat which accelerates chemical and biochemical changes and may reach the point where grains may harbor and eventually burn. In most instances, the primary factors operate simultaneously or sequentially in a mutually reinforcing manner.

The secondary causes are those that lead to conditions in which primary losses occur. These comprise inadequate harvesting or drying equipment or deficient protection against rains; inadequate on farm and commercial storage facilities; inefficient transportation which causes spillage, bruising, weather, and other damage; inadequate marketing system, which involves excessive length of the marketing period, improper location of silos, inadequate or badly distributed storage capacity, and excessive number of middlemen; and inadequate legislation or agricultural policies which can affect incentives to control losses or the eventual retention or rejection of a food for human use. It is evident that the more numerous the stages in the post-harvest system and the longer the period between harvest and consumption, the greater the losses tend to be.

This somewhat detailed discussion of the nature and ramification of the problem is intended to underline the fact that the post-harvest chain is an interrelated system in which individual causes interact and generally reinforce one another. Therefore, any effort, no matter how effective, to deal with one aspect of the problem at one stage of the post-harvest process may be nullified by failure to deal effectively with the problems encountered at previous or successive stages. This also involves questions of financial costs and returns. For example, if a highly elaborate system of silos is built, as has been the case in some Central American countries, but the grain entering the silo is insufficiently dried and infested with insects and micro-organism, the loss will be aggravated and the investment in silos will not yield the potential return.

It should be quite apparent from the foregoing that any effective effort to reduce post-harvest grain losses must be comprehensive, interdisciplinary, and based on a carefully worked-out sequence and pattern of activities. Domestic and external financial or human resources can easily be wasted by a fragmented or precipitate approach. Governments, therefore, and cooperating external agencies must develop together a comprehensive strategy for dealing with the problem, adopt the appropriate measures and policies, and build the institutional framework to carry them out. To do this,

they must evolve more accurate data for measuring losses, determining where and in what amounts they occur, and what the direct and indirect causes are.

The foregoing is not meant to imply that before anything can be accomplished, there is need to build a complete and accurate data base. This would delay action for too long. Data compilation can be a process that takes place simultaneously with other fundamental efforts, especially training and research, designed to make a start in coping with the problem. Moreover, in developing a strategy and a policy in Central America, as will be shown in later sections of this report, great care must be taken to avoid placing excessive stress on what may appear to be the most obvious need, namely the construction on a massive scale of on-farm storage facilities without at the same time strengthening and reorienting agricultural extension services, creating a better understanding on the part of the small farmer of the causes of crop loss and deterioration and how they can be overcome, sensitizing governments to the potentially high cost-benefit of launching a new post-harvest technology, assisting them in establishing appropriate institutional mechanisms, and adopting policies to induce the small farmer to protect his crop more effectively.

Thus, an essential and, at the beginning, a major ingredient of any post-harvest loss reduction strategy, must be training and research. Training must cover government technicians, extensionists, managers of

cooperatives, and small farmers. Research must be launched in measuring and identifying causes of post-harvest losses. It is on the basis of such on-going research that it will be possible to determine the need for specific types of on-farm storage facilities, appropriate methods and equipment for drying, feader roads, type and location of silos, special trainign, legislation, etc. Thus the initial purpose of any comprehensive program where none has existed before must be to assist local agencies to develop their own programs and strategies.

When viewed in this light and, as reflected in the types of programs identified or proposed for Central America, the size of programs and the amounts of external assistance that can be effectively absorbed at the beginning will necessarily be small. This however, does not mean that, therefore, such programs are marginal or unimportant. On the contrary, they may be decisive in widening the opportunity for the progressive investment of larger resources, both domestic and international, and the enlargement of programs and projects that can yield rates of economic as well as social returns. In this connection, the sharp initial focus on the small producer, operating individually or in a cooperative, and on the small rural community implies efforts that can reach considerably beyond protection of the harvest as such and involve the broader problem of rural modernization, marketing, and raising the income of the marginal farmer.

V. The Post-Harvest Loss Problem in Central Aemrica

Post-harvest losses in Central America affect all food grains, but since corn, beans, rice and sorghum comprise the food staple for the major part of the population of the region, the analysis of the problem is necessarily concentrated on these products.

Until relatively recently, the great bulk of efforts to expand the food supply in Central America, especially of the staple food grains, has been concentrated on increasing production. Substantial domestic and external financial resources have been devoted to bringing new land under cultivation; providing a more adequate agricultural infrastructure -roads, commercial warehousing, water and irrigation, electricity, health and educational facilities; establishing new training and research facilities; controlling plant and animal disease; improving seeds; and strengthening the institutional structure. As a result, the production of food grains in Central America has expanded impressively during 1965-1975. But the annual average rate of expansion for all food grains has been only slightly greater than the increase in population, with the result that, despite all efforts to raise output, income and nutritional levels on a per capita basis in the rural areas, remain among the lowest of the hemisphere.

It is only recently, especially since the 1973 food and oil crisis, that increased attention has been drawn to augmenting food supplies through the reduction of post-harvest losses and recovering what has been called "the hidden harvest". The steep rise in recent years in the prices of fossil fuels, agricultural machinery and equipment, and fertilizer as well as higher interest rates have pushed up the cost of bringing new land under cultivation. This has provided a new rationale for efforts to protect and preserve the crop once it is harvested. Some efforts in this direction have begun in all Central American countries and in Panama, but thus far no systematic or comprehensive programs have been devised in any of them. The international and regional organizations and financial institutions are only beginning to become alert to the problem and virtually no financing for any comprehensive post-harvest food grain program has taken place thus far.

There are several reasons why progress has been limited. First, the Central American farmer and governments are not yet sufficiently sensitized to the magnitude and complexity of the problem and the potential cost-benefit to be derived from a systematic effort to reduce losses. While in each of the countries of the region there are officials and technicians who are acutely aware of the need to concentrate on reducing post-harvest losses on a massive scale, the governmental machinery still places major stress on the pre-harvest problem of expanding output. This applies especially to the agricultural extension services. Second, there are few experts in the countries specialized in post-harvest technology, which in turn is a reflection of the fact that the basic methodology

for dealing with the problem is still being developed. Moreover, the way the Ministeries of Agriculture and other entities dealing with rural development are now structured does not lend itself easily to the kind of integrated systems approach that is required. Indeed, the existing institutional structure often encourages a fragmented approach whereby uncoordinated and unrelated programs are adopted in the various fields comprising post-harvest systems. Moreover, there is still a lack of appreciation of the immediate economic and social benefits accruing to the small farmer as a result of the reduction of post-harvest losses.

Finally, the Central American land tenure system, characterized by the prevalence of minifundia and rural bakwardness, represents an inhibiting element in the improvement of post-harvest technology.

Magnitude of the losses

In none of the five Central American countries are precise and up-to-date statistics on post-harvest grain losses compiled. Whatever data exist are based on limited samples and refer to quantitative losses only. Nor is any allowance made for special factors at the time the samples were taken, such as weather conditions, timing and size of the crop, insect, bird and rodent population, etc., all of which affect losses. In 1963 experts from the U.S. Department of Agriculture estimated food grain losses for Central America and more recently attempts have been made in Nicaragua, with the help of the Tropical Products Institute, to measure losses more precisely and on a more continuing bases. Some sporadic efforts have also been made in the other Central American countries.

Taking the various estimates, however, there is agreement that the post-harvest food grain losses -corn, beans, rice, and sorghum- fall within a range of between 15 and 30 percent. There are of course differences among products and countries. Thus, the losses are the greatest in corn which represents the bulk, about 50 percent, of the food grain crop and is grown mainly on small farms where damage to the harvest tends to be heaviest. About half the corn crop in Central America, on the average, remains on the farm where it is most subject to loss and deterioration because of deficient post-harvest techniques and facilities. In Honduras, where close to 70 percent of the corn crop goes into auto-consumption at the farm level, losses undoubtedly are near the top of the 15-30 percent range, while in Nicaragua where only about 30 percent of the crop remains on the farm, the losses are probably nearer to the bottom of the range. It is also important to note

that the hybrid corn variety, which is increasingly prevalent in Central America, especially Nicaragua and Costa Rica, is more vulnerable to post-harvest losses than the native variety.

Next to corn, beans account for the greatest losses of food grains. Losses are high mainly because of hardening due to inadequate storage and because a large proportion of the bean crop also remains on the farm, including the larger farms where coffe, sugar, cotton, and other products may be cultivated commercially and where beans are used to feed agricultural labor.

Post-harvest losses in rice are relatively small and are not believed to exceed 10 percent. This is explained mainly by the fact that the cultivation of rice is concentrated in the larger farms. Sorghum, likewise, suffers relatively low losses. It is used primarily for animal feed and is sold commercially for the manufacture of concentrates.

As regards the incidence of losses in individual countries, the available evidence suggests that they are highest in Honduras where on-farm storage is particularly inadequate and where the prevalence of subsistence farming with all its deficiencies is most widespread.

Post-harvest food grain losses in monetary terms (1975 prices) are estimated at around US$100 million annually. With 70 percent of the losses occurring at the small farm level (farms up to 35 hectares), the income reduction suffered by small producers amounts to around US$70 million. These figures represent approximately 13% of total income of about $530 million generated by small farms in 1975 in Central America.

Imprecise as some of these calculations are, they are suggestive of orders of magnitude which, in the absence of better data, justify the presumption that the real and monetary income losses due to faulty post-harvest systems are substantial, and in some cases outright staggering. In other words, one way of raising small and marginal farm income in Central America rather rapidly and without massive new investments in bringing new lands into cultivation may be through major improvements in post-harvest techniques. The foregoing data also suggest that there may be considerable pitfalls in measuring returns on investment on small farms in terms of the volume and value of the crop. Without taking into account the substantial post-harvest losses in weight and quality which significantly reduce the availability and nutritive content of food grains for consumption, the rate of return may be considerably overstated. Or, putting it differently, much of the agricultural inputs being used to increase production, both by governments and external agencies, may be wasted in view of the post-harvest losses that occur.

Causes and Location of Losses

As might be expected, the causes of post-harvest food grain losses in Central America are varied and occur to some extent at each stage of the marketing chain. Little research has been undertaken in Central America thus far in identifying these causes more accurately, how they interact, what their quantitative and qualitative impact is, and at which stage in the post-harvest process they occur. Obviously, such data are essential in determining the remedies that must be applied. For example, in Central America the small farmer loses a significant part of his crop on the field at harvest time because of inadequate methods and equipment for harvesting. But no systematic attempt has been made to measure these losses and to determine what improvements are required to reduce them. Nor has much work been done in determining how much damage to the crop is due to improper handling, stacking, and drying and the extent to which these deficiencies increase the vulnerability of the crop to insects, rodents, birds, fungi, etc. No program of experimentation apparently exists with regard to the possibilities of changes in the periods of planting and harvesting so as to reduce the risks of damage by weather and humidity. In Guatemala, the authorities are now considering moving crops to the higher altitudes where they may be less subject to the damaging effects of climatic and biological factors, as an alternative to building costly central or community storage facilities.

Likewise, virtually no systematic work has been done in evaluating crop damage and deterioration due to transport, deficient use of pesticides and fumigants, and faulty farm equipment. Because so little is known about the

relative importance of certain causes of post-harvest losses and their inter-action, there does not as yet exist a clear-cut idea concerning the design of on-farm drying and storage facilities needed, or the desirable capacity, whether for individual farm use or for community or cooperative use. In Honduras the authorities incline more toward the construction of storage facilities for cooperatives and small farm communities, while in El Salvador individual storage bins are preferred. But in neither case has the issue been fully analyzed.

In the case of Nicaragua the IGAD/LAC mission was able to make a tentative evaluation of the relative importance of various causes of post-harvest losses. This was possible mainly because the Nicaraguan authorities, with the assistance of the Tropical Products Institute, had begun to study the problem more intensively in recent years. One may safely assume that the preliminary findings for Nicaragua would also hold for the other Central American countries.

According to these studies, about two-thirds of the quantitative post-harvest loss in corn is attributable to insects, 10 percent each to rodents and birds and breakage, and about 7.5 percent each to spillage and micro-organisms. In the case of beans, insects also account for roughly two-thirds of the weight loss, but while rodents are less important than in the case of corn, the damage inflicted by micro-organisms is greater. In the case of sorghum half the weight loss is attributable to insects. While in the case of rice the proportion is one third. Weight loss by micro-organisms and breakage tends to be somewhat higher in these two commodities than in corn

and beans, while the effect of rodents is significant in the case of sorghum.

The foregoing data suggest that insect damage is by far the most important single cause of post-harvest food grain losses on Central America. Since the greatest losses also occur at the farm-level, it may be assumed that it is here also that the greatest incidence of insect damage occurs. What these data do not reveal, however, is the extent to which the high intensity of insect damage is the result of other factors, such as breakage or damage to the hull which exposes the crop to humidity and micro-organisms which may attract insects.

Measures of the relative importance of various factors resulting in the qualitative deterioration of the crop do not exist. But there is agreement that humidity, fungi, toxins and other types of contamination play a major role.

One may conclude that the relative incidence of the various factors resulting in post-harvest grain losses reflect the fact that a substantial part of the crop is stored and consumed at the farm level. Because of the prevalence of minifundia and the poverty and backwardness of the small farmer the crop loss and deterioration after the harvest assumes major proportions. Insufficient and often improperly trained extensionists contribute to the problem. A further aggravating factor is the inability of the farmer to reach or to be reached by government entities which purchase the crop at support prices. This forces the small farmer to hold his crop for longer periods or to sell to the trucker or the local middleman where grain losses, although less, also occur.

Institutional Framework

In Central America there now exists a proliferation of institutions at the national and regional level dealing with various aspects of rural development. Apart from the Ministries of Agriculture, which are responsible for the formulation and implementation of over-all agricultural policy and generally for extension services, in most countries specialized institutions operating under the Ministries of Agriculture or independently have been established, notably in the field of agricultural technology, such as in Guatemala, Nicaragua and El Salvador; marketing; rural development services to the small farmer, as INVIERNO in Nicaragua, and more recently agricultural training, as in both Nicaragua and El Salvador. The provision of credit is dispersed among several private and governmental institutions; only in Nicaragua is there a special credit institution, INVIERNO, geared to provide credit to the small farmer. In addition, there are of course the national planning entities, the Ministries of Health, Education, Public Works, with all their satellite institutions, as well as other agencies all of which also have certain responsibilities in the agricultural sector and in rural development. Although, on the whole, these institutions individually all operate rather effectively, there exists a considerable overlapping of functions, compounded by differences in policy emphasis or orientation and inter-institutional rivalries and conflicts.

Despite the wide spectrum of specialized ministries and agencies that has evolved to meet the needs of rural development, the Central American small farmer is still not adequately reached by any of them. Partly this is a

reflection of the limited human and financial resources with which some of these agencies operate. Partly it is due to a certain bias on the part of official entities and external financing agencies in favor of large "impact" projects, which are not found at the level of the small farm community. The Central American marketing entities, for example, generally have emphasized the construction and improvement of large, central storage facilities, even though many of them operate below capacity because of road and transportation problems which prevent the crop from reaching the silos and middleman who often buy the crop in advance and store it in their own facilities.

The Central American agricultural credit institutions, likewise, have preferred to make bigger loans to the larger and more credit worthy farmers, than to the subsistence farmer. Loans have been provided to bring new land under cultivation and produce a crop which will provide the means for repayment, rather than to assist the farmer in both producing and preserving his harvest. The various entities responsible for research and the development and application of new agricultural technology also have been oriented more toward the problem of increasing yields by developing new seeds, experimenting with various types of fertilizers, and generally improving pre-harvest rather than post-harvest technology. Only in Nicaragua has a start been made by SEPRAL in dealing more systematically with the problem of post-harvest losses.

These short-commings are, of course, a reflection of the intensely production and productivity oriented agricultural strategies pursued by the Central

American countries throughout the past two decades. But with the increased interest in the region in coping with the post-harvest grain loss problem, there is unquestionably a need for some institutional innovation and experimentation. Since the post-harvest loss problem involves primarily protection of the crop at the level of the small farmer, the institutional structure must become geared to reaching him directly. This relates particularly to the marketing boards and marketing agencies which at present purchase not more than 20-30 percent of the part of the crop which is sold by the small farmer commercially.

In this connection also, there is need for a national storage plan and policy that would be geared more adequately than now to reducing crop losses and deterioration at the small farm level and create a better balance between effective on-farm crop preservation and storage and central storage. The establishment and enforcement of quality standards must be an indispensable part of the work of the marketing and extension agencies.

The problem of reaching the small farmer in reducing post-harvest losses also relates to the structure and policies of the credit institutions. Massive amounts of agricultural credit have been dispensed in Central America in recent years, much by external loans. Since such credit has not reached the small farmer in sufficient volume and on appropriate terms, new policies, institutional mechanisms, and procedures will have to be devised to correct the situation. By the same token the recently created agricultural training institutions in Nicaragua and El Salvador as well as those to be created elsewhere in the region, will have to sharpen their

[illegible]

focus on the type of training needed to enable the farmer to understand the causes and effects of post-harvest losses and how to deal with them more effectively.

Apart from the need for certain basic shifts in policy and methods of operations by the various institutions dealing with rural development so as to cut post-harvest grain losses, there is also a need for these institutions to view post-harvest technology as a system requiring an interdisciplinary and highly coordinated approach. Improvement of post-harvest technology cuts across the spheres of responsibility and competence of all agencies engaged in rural development. This will require fundamental political decisions, top-level direction so as to ensure effective coordination, sensitizing public officials to the post-harvest problem,and the provision of specialized training for those who will train, instruct and motivate the small farmer. Such institutional adaptations will be fundamental in evolving and putting into operation a comprehensive strategy for dealing effectively with the post-harvest problem in Central America.

V. The Proposed Program for Central America

A. Main Elements of the Program

The ICAD/LAC mission has identified a program for each of the five Central American countries which is contained in the individual country reports. These programs are all based on the same fundamental concepts and have common characteristics. The differences reflect variations in emphasis, scope, and priorities in line with the needs and realities of each country.

The fundamental purpose of the proposed program is the development in each country of an effective strategy, policies and concrete activities for dealing with the problem of post-harvest grain losses and to provide appropriate international assistance in meeting this objective.

In developing a comprehensive national program, there is need in the early stages to proceed by carefully planned and well synchronized stages, and to assure that external technical and financial assistance is provided on a scale that will enable the countries to absorb it effectively. Since much experimentation, training, and research is needed before any massive national programs can be launched, the size of the proposed programs is necessarily small. The objective of the external assistance component is to establish the bases and experience on which expanded efforts can be undertaken progressively at the end of the first, second or third year of operations. At the end of the second year of implementation of the program, an assessment of its effectiveness should be made, with a view to correcting any inadequacies and planning for its amplification.

The program does not set any fixed target for harvest loss reductions, although it is expected that such losses will begin to be reduced significantly after the fourth or fifth year due to the multiplier effect produced by a simultaneous program of action in research, training, extension and credit.

The largest program, about US$2.4 million, is contemplated for Nicaragua where considerable work in post-harvest technology is already being done and where more than 50.000 production units are to be covered by the investment program, compared to 20.000 each in El Salvador and Costa Rica and 40.000 in Guatemala. The figure for Honduras has not been determined as yet, mainly because the primary need is training and research/extension.

The foregoing cost data are not based on precise calculations, but are indicative of orders of magnitude. As yet no attempt has been made to determine the amounts to be financed out of local resources, but it is doubtful whether the proportion can exceed 25-30 percent. The purely economic rates of return of the investment as calculated in the individual country reports which follow, fall within a range of between 22 and 27 percent. It is clear, however, that the social impact which is not easily measurable, will be considerably more significant. By attacking the problem of post-harvest losses a meaningful attack can also be made on the broader and pressing problem of rural modernization. A meaningful start on a post-harvest loss reduction strategy, with the focus on the small farmer, may help to convert the rhetoric of rural development into reality.

DOCUMENT VI - G

THE ESTIMATION OF POST HARVEST LOSSES IN DURABLE COMMODITIES -BASIC PRINCIPLES*

By:

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*Prepared for the Seminar on the Reduction of Post-Harvest Food Losses in the Caribbean and Central America. Santo Domingo, D. R. August 8-11, 1977.

TABLE OF CONTENTS

COMMENTS ON INSECT-CAUSED POST HARVEST CROP LOSS ASSESSMENT

There has been a recent questioning of the programs aimed to provide enough od for the hungry masses of the world. It has been re-stated lately (Moore ippe and J. Collins 1976) that increasing food production alone, without anges in the mechanisms of distribution, will not accomplish the desired al of an adequate food supply for the world's population. Alternative proaches to solve this problem vary from changes in the existing social ructures and economic systems to the improvement of marketing systems.

One way to reduce the post harvest insect-caused crop losses is to improve rketing systems. There is a considerable amount of information about the ys insects can cause post harvest crop losses, and methods to reduce these sses, in developed countries. Much less information of this nature is ailable for Latin American countries, and there is a growing need for it.

It is beyond the scope of this presentation to dwell on the specifics post harvest insect-caused crop losses. Instead, I prefer to comment on o aspects:

A. Pre-harvest insecticide applications on food crops and their relation to post harvest crop loss assessments.
B. The need to relate the pre-harvest and post harvest insect pest complexes.

Pre-harvest insecticide applications on food crops and their relation to post harvest crop loss assessments.

Several post harvest crop loss studies have been done starting at, or ter, the crop harvest, using the following methodology. A quantitative sessment is done at harvest time using visual macrocriteria such as "rotten", isect damaged" non-marketable units. The assessment gives the number aged, non-marketable units (fruits, heads of cabbage, kg. of potatoes, etc.). imilar assessment is done in the market at the retail level (Fig. 1).

The methodology just described is an acceptable first approach that vides valuable information about post harvest crop losses. It is, however, y general and can be improved.

Insecticides, in varying degrees, are included in the package of agronomic practices that make crop production possible. It is to be expected that, because of long residual action, excessive dosages, repeated applications, spraying too close to harvest (acting alone or in combination), many insecticides remain on the crops until harvest or even beyond. Food with excessive insecticide residue levels is not fit for human consumption and must be considered as a loss in post harvest crop loss assessments.

If only macrocriteria are utilized to evaluate post harvest crop losses and the evaluation is done starting after harvest, ignoring the long term consequences of pre-harvest insect pest control (Fig. 1), insecticide residue levels are not being measured. One way, then, to improve post harvest crop loss assessments is to include the food with excessive insecticide residues in the category of "losses". The scope of the resulting post harvest crop loss studies will be broader, more inclusive, and will have to consider some pre-harvest practices like insect control measures and their consequences on food quality (Fig. 2).

The excessive use of chemical insecticides for insect pest control has been documented in Latin America (Carazo et al, 1976, Cermelly et al. 1972). Their is either no adequate legislation regarding insecticide residue levels in food crops, or the existing legislation is not enforced. This situation is particularly serious in horticultural crops.

Fig. 1. -Post harvest crop loss assessment without considering pre-harvest events.

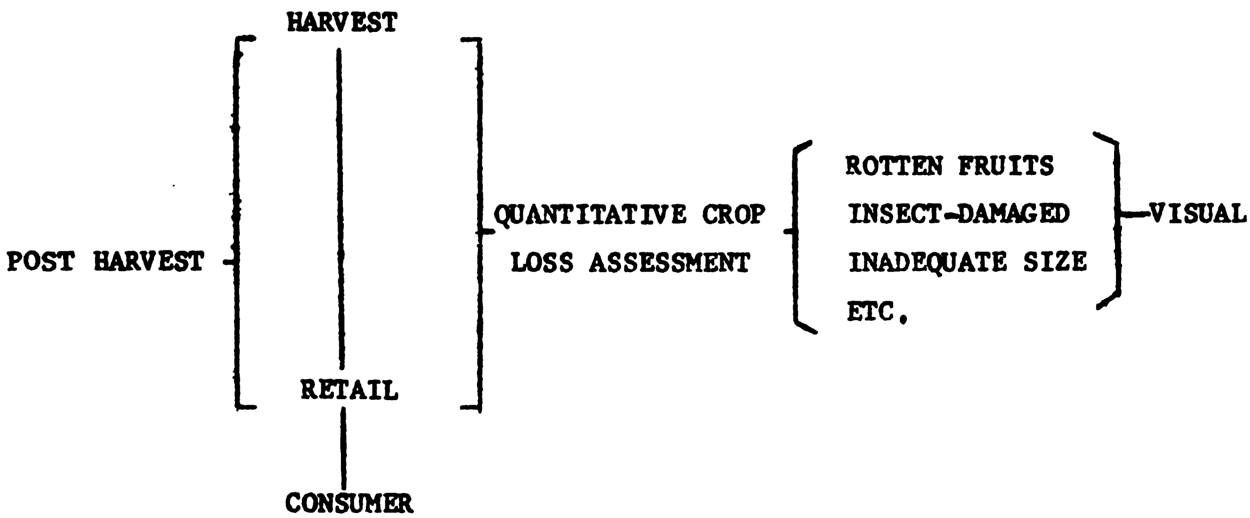
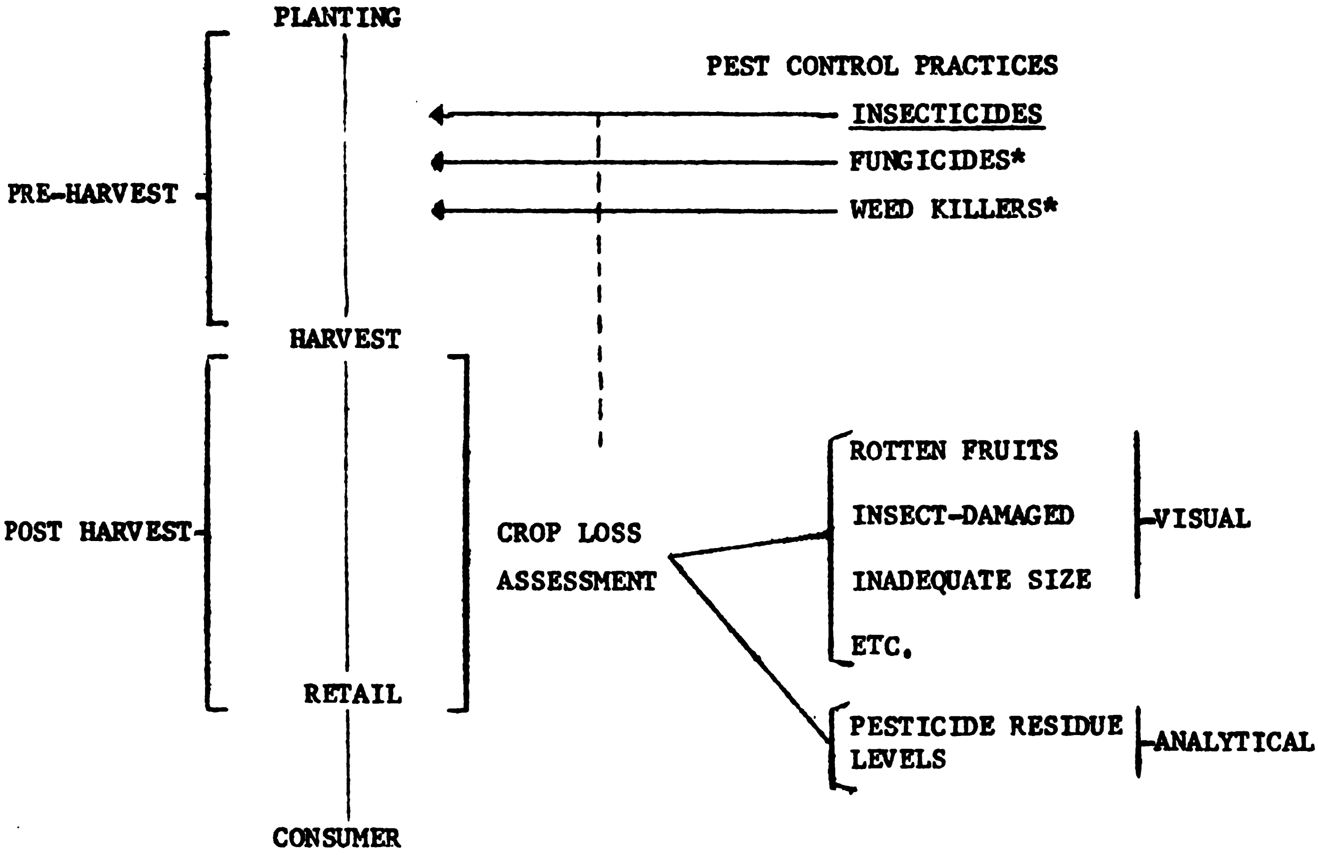


Fig. 2. -Post harvest crop loss assessment considering pre-harvest events.



* These pesticides should be considered, although not discussed in this paper.

Let us consider the insect control measures taken by a typical cabbage grower in one of the main horticultural areas (the Culata Valley) of the Dominican Republic. All the insecticide applications are done on a calendar basis regardless of economic injury levels or presence of damaging insect pest populations. The choice of insecticides to be sprayed is based on advice from fellow cabbage growers, pesticide salesmen and in a few cases government agronomists. The choice of insecticides is usually not the most advisable for the particular insect pest problem of the grower.

The main target of the insecticide applications is the diamond-back moth, Plutella xylostella (L.), which has in the Dominican Republic, as in many other countries, developed resistance to a wide variety of insecticides. The typical insecticide spray schedule of one farmer is described. For one month after germination, the cabbage seedlings are weekly sprayed with an insecticide mixture consisting of: 250 g of Dipel[1/] + 335 cc of Malathion[2/] + 335 cc of Gusathion[2/] in 209 l of water. After transplanting, the grower keeps spraying the same mixture of insecticides, varying only the total quantity applied/hectare. Six applications (2/week) are made during the 20 days following transplanting (early season). Sixteen applications (2/week) are made in the next 60 days (middle season). By this time, the cabbage has formed and closed its head, thus beginning the late season which lasts for 31 days. Nine more applications are made during this period. Table 1 summarizes the spray program described.

When the cabbage are ready to be harvested, the grower either brings them to the open market in Santo Domingo where he sells them to the retailer, or he sells them in the field to middlemen who in turn bring them to the city. Cabbage prices change rapidly and in many cases the grower prefers to keep the ready-to-harvest cabbage in the field, waiting for a higher price. In the meantime, he continues applying insecticides. If he gets a better offer for his cabbage, he immediately sells them, regardless of whether or not he has recently sprayed the field. One example of how fast cabbage prices at the producer level change in the Dominican Republic is shown by the fall of the price from $50/100 heads of cabage to $25/100 heads of cabbage in a period of 2 days (from July 12 to July 15, 1977).

1/ Bacillus thuringiensis.

2/ Organic phosphate (OP).

Table 1. -Insecticide spray schedule followed by a cabbage grower in the Culata Valley, D.R., 1977.

Stage	Insecticide[1/] sprayed/hectare		Number of Applications per week	total	total insecticides applied
Seedbed 30 days	Not measured, negligible compared to total amount sprayed		1	4	---------
Early season 20 days	Dipel	1.00 kg	2	6	6.00 kg
	Malathion	1,34 1			8,04 1
	Gusathion	1,34 1			8,04 1
Middle season 60 days	Dipel	4,00 kg	2	16	64,00 kg
	Malathion	5,36 1			85,76 1
	Gusathion	5,36 1			85,76 1
Late season 31 days	Dipel	2,00 kg	2	9	18,00 kg
	Malathion	2,68 1			24,12 1
	Gusathion	2,68 1			24,12 1

Days from transplanting to harvest: 111 days

Total applications: 32

Total insecticides per hectare:

Dipel 88.00 kg

Malathion: 117,92 1

Gusathion 117,92 1

1/ Insecticide mixture: 250 g of Dipel + 335 cc of Malathion + 335 cc of Gusathion in 209 1 of water.

It is very likely that cabbage grown under these circumstances reach the consumer with excessive insecticide residues. The amount of insecticides used during the growing cycle is excessive and the period for their breaking down inadequate (141 days).

The cabbage situation just described in the Dominican Republic is by no means unusual nor exclusive. Very high amounts of insecticides are used in Venezuela for tomato insect pest control (especially a Gelechiidae complex). Insecticide resistance is common in the tomato insect pests in the main Venezuelan horticultural regions (Lara, Carabobo, Aragua) and growers are hastening its development by the excessive insecticide usage. Examples of insecticide mixtures that are commonly sprayed (twice a week) for insect control are the following:

-0,5 l of Galecron[3] (Chlordimeform) + 0,5 l of Supracide[4] (Methidathion) in 200 l of water.

-0,5 l of Cyolane 250 E[5] (Phosfolan) + 1.0 kg of Phosvel[6] (Leptophos) in 200 l of water.

-1,0 l of Birlane[7] (Chlorfenvinphos) + 1.0 l of Dimecron[8] (Phosphamidon) + 1.0 l of Nuvacron[9] (Monocrotophos) in 400 l of water.

High insecticide residue levels on tomatoes grown under the circumstances described are to be expected. The tomato growing cycle is short (150 days) and spraying and harvesting often coincide with each other.

Besides the protection to the consumer, post harvest crop loss studies that consider excessive insecticide residue levels as losses could greatly benefit those of us working in integrated insect pest management during pre-harvest. Integrated insect pest management utilizes biological agents such as: insect parasites, predators, pathogens, in addition to insecticides and other practices for the sound management of insect pest populations. If crops with excessive insecticide residue levels are considered as "losses", the growers will be forced to seek and adopt alternative insect control measures and rely less on insecticides.

3/ Formamidine compound.

4, 5, 6, 7, 8, 9/ OP.

B. The need to relate the pre-harvest and post harvest insect pest complexes.

It must be realized that some post harvest insect pests are also pre-harvest pests. Some insects that are found causing post harvest food losses could have started the infestation before or shortly after harvest, depending on the circumstances. Many times harvested crops (especially fruits) carry insect eggs or larvae that are not easily seen. Other times harvested crops are left overnight in the field or in inadequate storage facilities allowing the insects to invade them. It is not until later that their presence, and damage, is noticed. Measures to reduce post harvest crop losses caused by these types of insects should start during the pre-harvest period. For example, the potato tuberworm Gnorimoschema operculella (Zeller) infests potato plants in the field and also infests potatoes in storage. Harvested potatoes left overnight in the field are a prime target for G. operculella moths to oviposit. When the potatoes are stored they are already infested and a serious post harvest loss can result. G. operculella moths can also enter inadequate storage facilities near potato fields and infest the stored potatoes. Measures to reduce post harvest potato losses caused by this insect could include aspects such as a reduction of the G. operculella population levels and the improvement of storage facilities.

Considering some aspects of the pre-harvest period of a crop in post harvest crop loss studies is advantageous not only when considering insects alone. Insects are associated in many ways with different decay-causing organisms. A better understanding of post harvest food losses caused by microorganisms could be obtained through multidisciplinary (entomological, physiological, microbiological, etc.) team work in post harvest crop loss studies. It must always be kept in mind that spoilage of food after harvest seldom, if ever, results from the action of a single variable.

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DOCUMENT VI - I

POST HARVEST LOSSES OF POTATOES QUANTIFIED DURING THE MARKETING PROCESS: FROM RURAL ASSEMBLY TO WHOLESALE AND RETAIL ASSEMBLY IN SANTO DOMINGO, DURING 1976*

By:

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*Prepared for the Seminar on the Reduction of Post-Harvest Food Losses in the Caribbean and Central America. Santo Domingo, D. R. August 8-11, 1977.

TABLE OF CONTENTS

I. INTRODUCTION AND OBJECTIVES

This summary is based on the study [1] of post-harvest losses of potatoes in the Dominican Republic carried out during the 1976 harvest in the region of San José de Ocoa. This is the first study realized in the Dominican Republic attempting to quantify post-harvest losses. It was carried out as part of a program between the Secretary of State for Agriculture and the Interamerican Institute of Agricultural Sciences (IICA) with the fundamental purpose of attempting to develop a methodology to quantify post-harvest losses in perishable commodities and identify projects to reduce such losses.

The specific objectives of the study are the following:

a) Evaluate in a preliminary manner post-harvest losses of potatoes which occur in the Dominican Republic.

b) Determine the effect which these losses may have on the economy.

c) Identify the main causes for the losses.

d) Identify possible alternatives for reducing the losses and lay the base for the preparation of projects to implement the reduction of such losses.

II. BACKGROUND INFORMATION

The study concerns Irish potatoes of the Kennebec variety cultivated in the area of San José de Ocoa during the 1976-1977 season. The total production in this area was estimated at 17,000 MT in 1975 produced on approximately 35,000 tareas [2] which represents 85% of the national production.

The following table indicates the estimated production and area under cultivation in the Dominican Republic in 1975-1976 and the principal production season.

1/ Estudio sobre Pérdidas Post-Cosecha de Papa en R.D., SEA/IICA Documento #24, Dic. 1976 69 páginas.

2/ 1 Tarea = 630 M^2; 1 Hectárea = 15.9 tareas

Table No. 1. Area and production of potatoes during 1975-1976 in the Dominican Republic.

ZONE	AREA (TAREA)	AVERAGE YIELD qq/Tarea*	MARKETABLE PRODUCTION qq/50 kg	PLANTING PERIOD	HARVEST PERIOD
Ocoa	7,769	10	77,690	Dic/75-Feb/76	Mar-Jun
Ocoa	25,000**	10	250,000	Abr-May/76	Jul-Sep
Ocoa	2,000	10	20,000	Jun/Jul/76	Oct-Dec
Constanza	3,750***	15	56,259	Dic/75-Jan/76	Apr-Jun
Higuey	975	10	9,750	Oct/Nov/75	Feb-Apr
Romana	1,000	17	17,000	Sep/Oct/75	Jan-Feb
Otras	300	10	3,000	Dec/Feb/76	Mar-May
TOTAL	40,794		433,690		

* These are the average yields which are marketed. They represent units of 50 Kgs of 110 lbs.

** Traditionally in Ocoa between 20 and 25,000 tareas are planted during the period April-May. The real areas planted depends on diverse factors including the results of the previous crop, weather and prices.

*** In Constanza new plantings of 2,000 tareas are estimated during the second semester. New plantings are also estimated for Higuey of approximately 1,300 tareas but these will not be harvested in 1976.

SOURCE: Diagnosis of the Marketing of Potatoes in the Dominican Republic SEA/IICA, Project Document No. 12, June 1976.

According to the diagnostic study in the marketing of potatoes in the Dominican Republic approximately 73% of the national production reaches the wholesale market through "acopiadores-camioners" (assembly truckers), 25% by the producers themselves,
and 2% by the Cooperative Santa Cruz.

In the wholesale markets some 99% of the production is marketed by wholesaler and commission agents. At the retail level the product is distributed in the following manner:

- 48% retailers in public markets
- 25% through supermarkets
- 20% through mobile vendors
- 5% used by industries

III. METHODOLOGY

3.1 General Survey and Analysis of the Marketing Channel

The study began with the identification and survey of all the stages in the marketing of the product beginning with the retailer and following the channel in reverse to the producer. This survey provided information on the following aspects:

- Visual examination and interviews provided information on the type of losses and their respective causes.
- The identification of all the steps in the marketing channel[1/]
- The points in the marketing channel most suitable for taking samples and the types of sample required.
- The identification of the participants in the marketing channel and the identification of producers and intermediaries willing to collaborate with the study.

1/ Ver diagrama del Flujo.

3.2 Sample

Given the previous mentioned information the next step was to take the samples in the manner and at the points identified. The sample was taken without changing the traditional movements through the marketing channel, always using the criteria of the marketing participant for the determination of post-harvest losses.

Samples were taken at the following points in the marketing channel:

- Immediately after harvest so as to detect losses at the farm level.
- During the storage in the rural assembly centers.
- During the delays of one to two days occuring at the wholesale markets.
- After the produce has reached the hands of the retailer.

The losses that were detected in the rural storage points were those which occur due to loss of weight caused by dehidration and for the removal of potatoes having infections. The losses were quantified in three typical rural warehouses, two with metal roofing and one with corrugated tar paper roofing (Table No. 2). In each warehouse four sacks containing 8000 grms of potatoes each were placed in different sections of the warehouse, at the upper level of the stored produce. The losses caused by dehidration (3.7%) were determined after 15 days which is the average time the produce is stored according to local sources. Infected potatoes were quantified at 19% of the total sample.

To quantify the losses at the wholesale level a study was made of the losses occuring during transportation of the product from the farm to the wholesale market. The sample group (sacks of potatoes) were weighed, observed and marked before loading on the trucks in the rural areas. Later in the wholesale market the sacks were identified and reweighed and evaluated as they passed unto the retail level, after being at least one day in the wholesale market. (Table No. 3).

To detect losses at the retail level another methodology was used, evaluating the losses by unit rather than volume. This was done so as to facilitate the collection of data and basically because it was easier to count than to weight. The use of this procedure assumes distribution of similar weights in the losses and in the total sample. The results of this sample are presented in Table No. 4.

Table No. 2. Losses of Potatoes due to Dehidration during storage for 15 days in the Rural Zone of San Jose de Ocoa

No. of Samples	Warehouse 1				Warehouse 2				Warehouse 3			
	1	2	3	4	1	2	3	4	1	2	3	4
Original weight (grams)*	8800	7864	7412	8570	7138	6764	7058	7278	8106	8736	8592	7284
Weight after 15 days	8546	6812	7038	8386	6826	6396	6618	7076	7844	8420	8324	7034
Weight losses (grams)	254	1052	374	184	312	368	440	202	262	316	258	250
Percent loss	3	13	5	2	4	5	6	3	3	4	3	3

* Potatoes harvested during last 24 hours
Average loss after 15 days (eliminating sample 2 from warehouse No. 1): 3.72%

Standard deviation 1.18% Coefficient Variation 32%

SOURCE: Experiments of this study, August/76.

Table 3 Losses due to Potato Dehidration and Infection at the Modelo Market (Roofless Storage 24-48 hours) (Sample of 2,604 kilograms)

Sample Original Weight Kg.	Weight 24-48 hours later kg.	Losses Kg	%
91	86	5	6
89	83	6	7
79	74	5	6
86	80	6	7
89	80	9	10
85	78	7	8
80	75	5	6
86	76	10	12
87	77	10	12
90	80	10	11
84	80	4	5
87	81	2	2
84	79	5	6
81	77	4	5
80	76	4	5
89	83	6	7
87	81	6	7
81	78	3	4
77	75	2	3
86	76	10	11
84	74	10	12
84	75	9	11
85	75	10	12
85	80	5	6
75	69	6	8
83	75	8	10
83	73	10	14
80	78	2	2
83	79	4	5
78	76	2	3

Average: 7.5%
Standard Deviation: 3.26%
Coefficient of Variation: 43%

SOURCE: Experiments of study, August/76

Table 4 Potato Losses at Retail Market in the Capital

Sample No.	Sample Size Units	Number of Units Loss	Percent Losses
1	748	51	6.8
2	676	16	2.4
3	713	8	1.1
4	581	24	4.1
5	679	20	2.9
6	746	28	3.7
7	624	19	3.0

Average: 3%
Standard Deviation: 1.84%
Coefficient of Variation: 62%

SOURCE: Investigations of this study, September, 1976

IV. PRESENTATION OF RESULTS

The results are presented for each of the experiments realized and mentioned in part three of this document; in addition the total losses have been summarized in another table. Table No. 5 summarizes the losses at three levels including rural assembly, wholesale markets, and retail markets. The results shown are estimated assuming that the produce is stored for a maximum of fifteen days in the rural areas before passing on to Santo Domingo.

Other alternatives that were identified for marketing the potatoes include those of:

a) direct marketing, which is that directly from the farm to the wholesale market without been stored in rural areas.

b) marketing which includes medium or long term storage exceeding 15 days in the rural area.

Table 5 Estimation of Post-Harvest Losses of Potatoes Projected to a National Level, Under Conditions of Short Term Storage (Less than 15 days) 1/

Steps and Causes of Losses 2/	Marketing with short term storage			
		%		qq 3/
Rural Assembly:		22.7		89200
Dehidration	3.7		13500	
Infections	19.0		69400	
Wholesale Markets				
All Causes		7.5		21200
Retail Markets				
All Causes		3.7		7800
T O T A L		31.0 4/		118200

1/ Based on the 1976 harvest in San José de Ocoa which represents more than 80% of national production.
2/ Losses were analyzed at three steps of the marketing channel: rural assembly, wholesale markets, and retail markets. Samples were also taken during the first stages of harvest and on-the-farm assembly where additional losses due to physiological damage, insects, size and mechanical damage were identified. These losses were estimated at 24% of the production, however, they are not included here because the samples taken were too few in number and thought to be unreliable. Losses at this stage should be studied in more detail including a larger number of producers and at different times during the harvest so as to obtain data more representative.
3/ These are estimates of total losses, projecting the sample to a national level.
4/ Pondered average.

V. ECONOMIC EVALUATION OF POST-HARVEST LOSSES OF POTATOES

So as to obtain a minimum estimate of post-harvest losses of potatoes it has been assumed that the potatoes are marketed only under conditions of short term storage. It should be understood that part of the crop (the percentage has not been determined) is stored over a medium or long period (two weeks to three months) which means greater losses than estimated here.

The evaluation is made based on the estimated 1976 production of 434,000 qq, deducting 20% 1/ of the harvest at the farm level, which is considered not marketable and remains in the rural area. The estimation of the value of the losses is based on a price of RD$7.00 for 110 pounds at the rural assembly level, RD$8.00 at the wholesale level and RD$8.50 at the retail level. As can be seen in Table No. 6 the value of losses can ascend to RD$843,000 in the case of alternative No. 1 where 10% of the marketable product goes directly from the farm to the wholesale market and 90% is stored in rural areas for less than 15 days. If we were to include the value of the losses rejected at the farm level and the losses incurred over long term storage (estimated as high as 50%) the value of the annual losses would be in excess of RD$1,000,000.

Table 6 Estimation of Post-Harvest Losses of Potatoes in Economic Terms for the Dominican Republic

Alternatives	Percentages Marketed: Direct Marketing % of production	Percentages Marketed: Short Term storage % of production	Value of Losses * (RD$)
1	10	90	843,000
2	30	70	621,000
3	50	50	468,000
4	70	30	317,000

* Based on 347,200 qq of potatoes marketed in 1976.

1/ Percentage of the production going for on-the-farm consumption, seeds and general losses.

VI. METHODS PROPOSED FOR THE REDUCTION OF LOSSES

6.1 Reduction of losses caused by mechanical damage

6.1.1 During the harvest:

-Avoid early harvest allowing the potatoes to develop a thougher outer layer.

-Identify new varieties more suitable to the conditions of the country.

6.1.2 Loading and Unloading

Introduce methods to reduce the rough handling that the potatoes suffer:

-Marketing of potatoes in smaller sacks.

-Use of inclined plains in the loading of potatoes onto the trucks in rural areas and the use of hand carts in the movement of potatoes at the wholesale market.

-The use of shock absorbers (padding) to reduce the damages to the product in those cases were rough handling is unavoidable.

6.1.3 Type of packing

-Study the possibility of introducing more protective containers to replace the presently used sacks, at least at crucial points of the marketing system.

-Eliminate the practice of placing the best and largest potatoes at the top of a sack where are likely to receive the most damage.

6.2 Reduction of Physiological Damages and Infections

6.2.1 Delays:

-In the wholesale market: Create a wholesale center for potatoes where satisfactory sanitary conditions can be maintained and where the produce can be protected from the direct rays from the sun.

-In the retail market: improve the design of the tables used for retailing the product so as to improve sanitary conditions.

-In the warehouses: Study the possibility of curing the product before storing and employing fumigants and growth controlers.

-During marketing: Reduce the number and the duration of the delays which occur at the different points of the marketing channel.

6.2.2 Pre-harvest Factors:

-The principal problem identified was that of the seed. The use of pre-selected seeds could reduce in significant amounts the causes of post-harvest losses.

-The losses due to size and greeness could be reduced by improving production techniques such as the proper use of fertilizers, (combined with lime in the mountainous areas) and proper covering of potatoes by mounding.

6.3 Possible Program for Reducing Losses

The problems identified related to post-harvest losses of potatoes, possible corrective actions and requirements in professional personnel to realize the corrective actions are summarized in Table 7.

In analyzing this Table it becomes obvious that the principal problems are those related to rural storage, the types of containers, transportation at the farm level, delays occuring at the wholesale market and seed quality.

The corrective actions to eliminate or reduce these problems can be expressed in possible projects which include the following:

6.3.1 Rural Storage Project

6.3.2 Project to Improve the Quality and Type of Container

6.3.3 Project to Improve Extension among Potato Producers (Seeds, etc.)

6.3.4 Improved Wholesale Market Infrastructure.

PROGRAM FOR REDUCTION OF POST HARVEST LOSSES

Product: Potatoes

PROBLEMS AND CAUSES		CORRECTIVE ACTIONS *														PROFESSIONAL REQUIREMENTS **								
		Applied Investigation /Transfer of Technology		Training -Courses - In service		Extension			Publications		*** Institutional Aspects		Infrastructure	Agroindustry		Agronomist	Economist	Food Technologist	Anthropologist	Entomologist	Food Pathologist	Extensionist	Ag. Technician	
GENERAL	SPECIFIC	General	Specific	Technicians	Producers	Producers	Intermediaries	Consumer	Direct	Indirect	Public	Private												
1. Mechanical Damages a) Rough handling Harvest			X													✓								
Packing	on the farm		XXX	X		XX	XX			XX	XX	XX					✓	✓	✓			✓	✓	
Transportation	farm – assembly center		X	X		XXX	XX			XX	XX	X					✓	✓	✓			✓	✓	
Storage										XX	X											✓		
Wholesale										XX	X		X				✓	✓				✓		
Retail																								
b) Container Poor design	insufficient protection from propylene sacks		X			XX	XX		XX		XX	XX					✓	✓						
Poor finish																								
Other																								
2. Physiological Damages a) Storage	rural assembly		XXX	XX	XXX	XXX	XX		XXX		XX	XXX	XXX			✓	✓	✓	✓			✓	✓	
b) Early harvest	harvest too early or too late		X	X						X	X											✓	✓	
c) Delays.	wholesale markets		XXX				XX					X	XX				✓	✓				✓		
3. Infection a) Micro-organisms	during storage during delays		XX	X		X	X		XXX		X										✓			
b) Insects	pre-harvest problem		X	X		XX				X	X									✓				
4. Excess Supply	during certain periods		X			XX		X		X	XX	X	XX	X		✓	✓					✓	✓	
5. Loss Nutritive Value																								
6. Seed Quality	inadequate storage		XX			XXX			XXX		XXX	XX	XX			✓					✓	✓	✓	
7. Lack of Information	concerning seeds, use of fertilizers, storage techniques									XX	XX											✓	✓	

* Indicate priority using from one (low priority) to three marks (high priority)

** Using footnotes one can complete the information indicating the names and number of professionals required and the names of the responsible institutions.

*** In this case one should try to define with precision the institutions with more responsibility. It is

DOCUMENT VI - J

STUDY OF POST HARVEST LOSSES OF SALAD TOMATOES IN THE DOMINICAN REPUBLIC*

By:

Gilberto Mendoza

*Prepared for the Seminar on the Reduction of Post-Harvest Food Losses in the Caribbean and Central America. Santo Domingo, D. R. August 8-11, 1977.

TABLE OF CONTENTS

STUDY OF POST HARVEST LOSSES OF SALAD TOMATOES IN THE DOMINICAN REPUBLIC

SUMMARY

I. INTRODUCTION AND OBJECTIVES

This document is a summary of a study of post harvest losses of salad tomatoes in the Dominican Republic 1/, realized by the Integrated Marketing Project SEA/IICA. This summary has been prepared especially for the Seminar on the Reduction of Post Harvest Food Losses in the Caribbean and Central America.

The objectives of this study include the detection of salad tomato post-harvest losses in the internal marketing system, the identification of the causes for these losses and the alternatives to reduce them. Another objective is to develop a methodology to investigate post harvest food losses applicable to various products in other countries in the Caribbean and Central America.

II. GENERAL CHARACTERISTICS OF THE PRODUCT

The study concerns salad tomatoes which is one of the more important vegetable crops in the country, important not only because it is produced by small farmers and uses a high concentration of manual labor, but because it is an important crop for popular consumption and has excellent potential for exportation.

The following table summarizes the situation of the product according to production and apparent consumption through 1974.

TABLE No. 1: Production and Apparent Consumption of Salad Tomatoes in the Dominican Republic 1970 1974.

YEAR	PRODUCTION (Tons)	MARKETING LOSSES (Tons)*	EXPORTATION (Tons)	POPULATION (000)	APPARENT CONSUMPTION Per Capita Pds./Year
1970	17,000	2.380	1,094	4,062	7.32
1971	17,000	2.380	2,107	4,182	6.58
1972	18,000	2.520	1,584	4,305	7.10
1973	18,000	2.520	1,249	4,432	7.06
1974	20,000	2.800	1,412	4,562	7.61

SOURCE: SEA/IICA Diagnosis of the Marketing of Tomatoes in the D.R. Document No. 12

* 14% of the production quantified in this study.

1/ Estudio sobre pérdidas Post Cosecha de tomates en R.D. Mansfield G., Jimenez, F., Pérez, J., Mendoza, G., SEA/IICA, Departamento de Economía Agropecuaria, SEA, Santo Domingo, R.D.

Although the apparent consumption per capita on a national level is quite low, it is importante to point out that the largest part of the consumption of this product is in the urban areas (46 percent of the national population is urban and 54 percent is rural). In the rural areas, tomatoes are consumed mainly in the form of canned tomato paste.

The largest part of the national production of salad tomatoes comes from small producers having less than 25 tareas 1/.

The total production of the salad tomato crop is destined for commercial purposes, with the exception of that percentage which is lost during the harvest and is analized below. The level of fresh tomatoes consumed by growers is very very low.

The supply of tomatoes is noticeably seasonal. The most common months of production are from January to June. During the second semester of the year the harvest is reduced· there is a noticeable scarcity of tomatoes during the period of October to December due to the reduced production of the crop in the southern part of the country.
The varieties most commonly grown in the Dominican Republic are AC/52, AC/55, OTIN, Manzano, Manalucie and Floradel.
In the marketing of salad tomatoes, very few intermediaries intervine at the farm level, this differs substantially from most of the other agricultural crops. Salad tomatoes are taken directly from the farm by the producer, or one of his friends, in a pickup truck directly to the wholesale market of the capital Santo Domingo. In this market the product is delivered to a wholesale commission agent who takes charge of the sale and charges a commission for each unit (huacal) sold.
The wholesaler sells the tomatoes to the retailer subsystem. The retailers of the public markets estimate that they channel 55% of the demand in the capital, the 'tricicleros' or mobile retailers channel 20%, the supermarkets and food stores handle 10%, with the remaining 15% going directly for institutional consumption (hotels, hospitals, etc.) and other.

The exporters handle approximately 7% of the national production (1974), and in these cases rural assembly agents are used.

The movement of salad tomatoes through the internal marketing system is done in wooden crates (huacales) with a capacity of approximately 70 pounds net weight. These wooden crates are the same as the ones used to import seed potatoes. For export purposes paper cartons with a capacity of approximately 30 pounds net weight are used.

1/ Tarea = 630 m^2· 1 Hectarea = 15.9 Tareas

III. SUMMARY OF THE METHODOLOGY

More detailed information on the methodology used in the post harvest studies is included in other documents which have been distributed in this Seminar 1/. A brief summary of the methodology employed in this case follows:

The study is carried out in three fases which are:

A) General Survey and Analysis of Marketing Channel

A general study of all of the steps and movements which the product follows from harvest time to final consumption is made. At the same time a diagram of the marketing channel (see diagram No. 1) is made using a system of flow charts with conventional symbols, with the purpose of detecting the "key" points where samples should be taken so as to quantify the post harvest losses.

In addition, all of the variables which may affect the quality and life of the product are measured, for example: temperature, relative humidity, stacking procedure, height of stacks, storage practices, length of the delays and conditions at different points of the marketing channel, etc.

B) Pre-Sample

This step is carried out at the same time as the previous one and consists of random samples to detect the principal causes of the losses, determine the coefficients of variability of the detected phenomena and evaluate the sample methods selected. This permits the definition of a final plan for the samples and study.

C) The Sample

The pre-sample and the general survey will permit the realization of a sample in the most practical and direct manner possible, depending on the levels of accuracy of the information desired. In the case of salad tomatoes samples were taken at the following levels:

1- <u>Farm Level</u>

Gardens in plain production	48 samples of 6 to 8 Kgs. each
Gardens in final stage of production	58 samples of 6 to 8 Kgs. each

2- <u>Retailer Level</u>

9 samples with a total of 1135 Kgs.

1/ SEA/IICA Bases for a Methodology for studying post harvest losses of Agricultural products, July, 1977.

The samples consist of the selection of typical marketing agents and the verification of the operations of handling and buying and selling in the traditional manner, but without the influence of the investigator, except to note the procedures used and to quantify the losses and the conditions (handling, temperature, humidity, time, etc.) in which such losses take place. The classification of the losses are undertaken using the criteria of the traditional commerical practices which is to say the practices normally followed by the producers, the intermediaries and the consumers.

The losses which appear in this document are those which were quantified according to the criteria of the participants in the marketing system and the desires expressed according to prices paid for the different qualities of the product 1/.

IV. ANALYSIS OF THE LOSSES AT DIFFERENT LEVELS

4.1 Farm level

Of the various levels studied (farm - wholesaler - retailer - exporter) the analysis of losses began at the farm level where the methods of harvest and handling where examined and losses were calculated. The losses at this level were quantified for produce in plain production and produce in the final stages of production, because the presample detected considerable differences between these two stages. The results of these samples are presented in Tables 2 and 3.

To determine the causes for the losses at the farm level, six samples were classified and the results are shown in Table 4. Due to the fact that excessive maturity was detected as one of the predominant factors causing losses at this level, a sample of 147 tomatoes classified as rejects were reclassified according to their state of maturity. The results of this examination are shown in Table 5.

1/ There are some cases which are difficult to quantify. For example the very ripe tomato, in relatively good condition and acceptable size is not denied by the consumer, however, it is classified as second quality at the farm level. This tomato has a value equivalent to only 50-60% of the price of the tomato of similar quality but still in the early stages of maturity. This means a partial loss to the producer, but it can not be classified as a complete loss.

TABLE NO.2: POST HARVEST LOSSES IN CLASSIFICATION OF SALAD TOMATOES AT FARM LEVEL: TOMATOES IN FULL PRODUCTION

Sample No.	Sample Wt (Kgs)	Losses (Grams)	Percent Losses
1	6.8	430	6
2	6	448	8
3	6	388	7
4	7	564	8
5	7.5	568	8
6	8	498	6
7	8	814	9
8	7.5	74	1
9	8	220	2
10	8.5	-	0
11	8	352	4
12	7	237	3
13	7.5	43	0.5
14	7	88	1
15	7.5	300	4
16	7	350	5
17	8	136	2
18	7	206	3
19	7.5	184	3
20	7	636	9
21	8.5	612	7
22	6	756	13
23	7	914	13
24	6.5	584	9
25	7	192	3
26	7.5	140	2
27	7.5	736	10
28	7.5	530	7
29	7.0	664	9
30	7.5	804	11
31	7	40	6
32	8	464	6
33	7	-	-
34	7	1,056	15
35	6	864	14
36	7	846	12
37	6	216	4
38	9	588	7
39	6.5	520	8
40	8	180	2
41	6	276	5
42	6	200	3
43	6	240	4
44	13	756	6
45	15	1,040	7
46	16	716	4
47	23.5	1,000	4
48	14.5	500	3

Average losses in sample 6%; standard deviation 3.8%; coefficient of variation 63%

The samples were taken at Vicente Noble during 7-20-76 and 11-27-76 (samples 1 to 36) and in Jarabacoa 12-19-76 (samples 37 to 48)

Source: Experiments of this study.

TABLE NO.3: POST HARVEST LOSSES IN CLASSIFICATION OF SALAD TOMATOES AT FARM LEVEL: TOMATOES IN FINAL STAGES OF PRODUCTION

Sample No.	Sample Wt(Kgs)	Losses (Grams)	Percent Losses
1	7	1,114	16
2	7	1,026	15
3	7.5	1,140	15
4	7	1,360	19
5	7.5	1,451	22
6	9	1,456	16
7	9	558	6
8	8	1,774	22
9	8	1,910	24
10	8	1,752	22
11	7.5	2,180	29
12	6	1,916	32
13	7.5	274	4
14	6	1,760	29
15	7	722	11
16	7.5	940	13
17	6	1,162	19
18	7	924	13
19	7	1,494	21
20	7	940	13
21	7	988	14
22	8	492	6
23	7	1,370	20
24	6.5	720	11
25	7.5	1,188	16
26	7	1,524	22
27	6.5	656	10
28	7	1,664	24
29	7	660	9
30	6.5	476	7
31	6.5	800	12
32	7	1,798	26
33	7	1,896	27
34	6.5	1,174	18
35	6.5	1,168	18
36	6	1,248	21
37	7.5	2,122	28
38	7.5	1,478	20
39	7.5	2,168	29
40	6.5	1,456	22
41	7.5	1,094	15
42	7.5	2,324	31
43	7	2,452	35
44	7.5	1,452	19
45	7	2,134	30
46	8	2,366	30
47	7	1,304	19
48	7	1,944	28
49	8.5	1,824	21
50	6	834	14
51	6	1,948	32
52	5	2,298	46
53	6	3,200	53
54	4.5	1,826	41
55	9	3,764	42
56	4.5	1,796	40
57	8	2,154	27
58	6	1,204	17

Average losses 22%; standard deviation 10%; coefficient of variation 50%. The experiments were realized at Vicente Noble 7-20-76 (sample 1 to 28); Constanza 11-7-76 (sample 29 to 48) and Jarabacoa 12-19-76 (samples 49 to 58)

Source: Experiments of this study.

Table No. 4: Types of Losses of Tomatoes during classification at the Farm level

Cause of Losses	SAMPLES 1		2		3		4		5		6		TOTAL	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Physiological Cracking 1/	38	70	6	30	-	0	-	-	3	33	9	34	56	43
Size 2/	5	9	8	40	6	75	10	83	-	-	3	11	32	25
Infection 3/	3	6	2	10	1	13	1	8	1	11	1	4	9	7
Other Physiological losses 4/	6	11	1	5	-	-	-	-	1	11	1	4	9	7
Insect Damage 5/	2	4	-	-	-	-	-	-	-	-	11	42	13	10
Mechanical damage 6/	-	-	2	10	1	13	1	8	1	11	-	-	5	4
Others	-	-	1	5	-	-	-	-	3	33	1	4	5	4
TOTAL	54	100	20	100	8	100	12	100	9	100	26	100	129*	100

1/ This occurs when the fruit reaches maturity and is caused by differences in the velocity of expansion of the internal tissues in relation to the external tissues.

2/ Tomatoes with a diameter less than 2 inches.

3/ Tomatoes infected by microorganisms.

4/ Principally tomatoes with anormal coloration and diformaties.

5/ Tomatoes with holes caused by insects.

6/ Tomatoes brused during harvest.

* Number of tomatoes in total sample.

SOURCE: Experiments made in Vicente Noble 7-2-76.

Table No. 5: Types of Tomato Losses at the Farm level according to level of maturity.

Grade of Maturity	Number	Percent 6/
Ripe 1/	62	42
Half ripe 2/	43	29
Partially ripe 3/	28	19
Starting to ripe 4/	11	8
Green 5/	3	2
TOTAL	147	100

1/ Tomatoes completely red without any sign of green.

2/ Tomatoes with some signs of greeness in the region opposed to the stem when observed from above.

3/ Tomatoes which have a redish color wisible without difficulty in the region opposed to the stem when observed from above.

4/ Tomatoes in which a redish color is slightly visible in the region opposed to the stem when observed from above.

5/ Tomatoes in which there are no visible signs of redness.

6/ Percentages of different levels of maturity.

SOURCE: Experiments realized in Vicente Noble, 7/20/77.

4.2 Wholesale level

Moving on to the second step, or that of the wholesalers, samples were taken to identify losses caused by transporting the product from the farm to the wholesale market and by the handling at the wholesale level.

Table No. 6 presents the results of the investigation. Due to the fact that the tomatoes are in the hands of the wholesalers only a very short time and the wholesalers do not reclassify the product but pass it on to the retailer in the same form in which it was received from the farm, at this level of study no losses were quantified. The losses caused by handling type of packing and transportation are transferred to the retail level.

Table No. 6: Mechanical Damages occuring to Tomatoes from Vicente Noble during the Packing and Transport to the Capital.

TYPE OF DAMAGE	LOCATION OF THE DAMAGE IN THE CRATE					
	UPPER PART		MIDDLE PART		LOWER PART	
	No.	%	No.	%	No.	%
Without damage 1/	34	16	16	11	10	6
Light damage 2/	74	36	64	45	78	52
Medium damage 3/	64	31	50	36	45	30
Major damage 4/	30	14	7	5	8	5
Serious damage 5/	6	3	4	3	11	7
TOTAL	208	100	141	100	152	100

1/ No observable mechanical damages.

2/ Bruses of a daimeter less than 1/4 inch.

3/ Bruses with a daimeter between 1/4 and 3/4 of an inch.

4/ Bruses with a diameter of more than one inch.

5/ Cuts which have broken the skin.

NOTE: These damages were identified by the investigators however this does not always signify rejects or losses.

SOURCE: Experiments carried out during the study.

4.3 Retail level

At the retail level samples were carried out with the participation of diverse types of retailers who colaborated with the study without modifying their methods of sales, time in handling etc. The results of the samples and the classification of the principle types of losses found are presented in Tables 7 and 8.

Table No. 7 Tomato losses quantified at the Retailer level in Santo Domingo

SAMPLE No.	WEIGHT OF THE SAMPLE (KGS)	WEIGHT OF THE LOSSES (KGS)	% LOSSES 1/
1	209.0	19.1	9.0
2	163.5	17.3	10.6
3	157.5	8.9	5.7
4	659.0	69.1	10.4
5	159.5	15.7	10.0
6	308.5	19.3	6.3
7	38.0	4.2	11.0
8	68.5	3.7	5.4
9	1135.0	123.4	11.0

1/ Average 8.8%; standard deviation 2.35%; coefficient of variation 26%

Table No. 8: Classification of the Losses at the retail level in sample of 348 Tomatoes

TYPE OF LOSSES	PERCENT
Mechanical damage 1/	83
Insect damage	3
Physiological damage	3
Losses due to infection 2/	2
Other losses	9

1/ Those tomatoes whether infected or not with signs of having suffered mechanical damage.

2/ Tomatoes infected for other causes distinct from mechanical or insect damage.

SOURCE: Experiments realized during the study.

One of the more interesting observations in the study of losses at the retail level was that, contrary to popular belief no losses were identified among the mobile retailers (tricicleros). Apparently due to the fact that the mobile retailers usually sell all of their tomatoes (approximately 70 lbs.) during a period of 6-8 hours which does not give the infections carried by the tomatoes time enough to develop. Other retailers usually require two to three days to sell their respective volume of tomatoes (100-200 lbs.) and the corresponding losses are considerably higher.

4.4 Exporter level

The losses and damages that occur at the level of the exporter were not directly quantified. In this case the exporters facilities were visited and inspected and based on interviews with the same exporter and the observed conditions losses at this level were estimated at one percent.

V. PRESENTATION OF FINAL RESULTS

5.1 Evaluation of physical losses.

The results projected to the national level, which are consolidated in Table 9, summarize the losses at the farm level and the retail level. As was mentioned, it proved impossible to quantify losses at the wholesale level because of the producers habit of delivering his produce directly to the wholesale market himself, where the product is sold through a wholesaler commission agent and no classification steps take place.

Estimates were made as to the quantity of total losses on a nation wide level reasoning that the areas studied are representative of the major regions of production.

Table No. 9· Post Harvest losses of salad Tomatoes projected to the National level based on investigations carried out in Vicente Noble, Jarabacoa and Constanza.

DAMAGES AND CAUSES	% OF THE HARVEST WHICH IS LOST		VOLUME OF LOSSES 1/
Farm level		6.0	28,000
Physiological damages	2.6		12,100
Size	1.5		7,000
Insects	0.6		2,800
Infections	0.4		19,000
Others	0.9		4,200
Retail level		8.8	38,500
Mechanical damages	5.8		25,400
Others	3.0		13,100
TOTAL		14.0 2/	66,500

1/ Estimation of losses on a national level in hundred weight based on 1974 production of 466,000 quintales.

2/ Pondered average: this can be considered minimum losses as data used is from losses of tomatoes in plain production. During final stages of production losses increase greatly.

SOURCE: Investigations carried out in the study.

5.2 Economic evaluation of the losses

At this point an economic evaluation of the losses occuring at two levels can be made: a) Micro or that of the average producer and b) Macro or the nation wide losses of the product.

In the first case it has been estimated that the losses to an average sized producer (25 tareas) at the farm level would represent a reduction in the net return to this producer of RD$775.00 over a six month period.

In the second case on a national level the post harvest losses of salad tomatoes were estimated at RD$775,000 1/ per year calculated at internal market prices at the date of study.

1/ US$1= RD$1

VI. CONCLUSIONS

The conclusions are presented in two parts:

a) Methods for the reduction of post harvest losses, and

b) Bases for a program of reduction of post harvest losses.

6.1 Methods for the reduction of post harvest losses

At this point we can summarize some simple methods for reducing losses caused by mechanical damage and others that occur due to physiological damages and infections.

6.1.1 Concerning the reduction of losses caused by mechanical means the following recommendations are made:

a) At the farm level

- Selection of varieties that mature uniformally so that there are fewer ripe tomatoes at the time of harvest.
- Assure that the containers used for the collection of the product from the field are free of sharp edges which can damage the product as it is harvested.

b) For loading and unloading:

- Utilize mechanical aids such as small carts to avoid the rough treatment received when handled manually.
- Reduce the average weight in the tomato crates (huacal) from the traditional 35 40 kgs. to a more reasonable weight of 15 20 kgs.

c) During the transportation

- Improve the design of the crates adapting them to the means of transportation.
- Introduce methods of stacking the crates so as to reduce vibrations.
- Improve the packing technique so that the product remains firmally in place and does not rotate or rub against other fruits.

d) Improvement of the container.

- Standarize the construction of the crates based on a design to reduce mechanical damages.
- Study the economic feasibility of utilizing the wooden crate produced locally by Puerto Plata Industrial, C. x A.

6.1.2. To reduce losses due to physiological damages and infection the following recommendations are made:

- Try to organize the marketing channel so as to avoid unnecessary delays.
- Improve and maintain the sanitary conditions of the surfaces which the tomatoes touch and the areas where the tomatoes are classified and packaged.
- Store the produce so as to avoid direct sun light when unavoidable delays in the marketing channel occur.
- To avoid infection during the delays at the farm level, the product should be harvested after the morning mist has evaporated.

6.2 Bases for a program to reduce post harvest losses in salad tomatoes.

- Up to this point we have been able to identify and quantify the principal losses in salad tomatoes in the internal marketing system. Also, as has been mentioned above, it has been possible to identify diverse alternatives for reducing these losses. If we analyze the principal causes for the losses from the point of view of possible corrective actions, as we have done in Table No. 10, it is possible to define a program for the reduction of post-harvest losses for salad tomatoes.

In Table No. 10, we can identify four projects which combined represent a possible program for the reduction of post-harvest losses in salad tomatoes.

Project No. 1:
The project of highest priority in this program is that to improve the traditional system of packing salad tomatoes in homemade crates so as to eliminate specific problems such as lack of stardarization, poor design, excesive capacity and in general an inadequate packing system. This project will require a minimum infrastructure to produce improved crates. It will also require activities in training, extension at the producer and intermediary levels, improved communication and transfer of technology.

PROGRAM FOR REDUCTION OF POST HARVEST LOSSES — Product : Salad Tomatoes

PROBLEMS AND CAUSES		CORRECTIVE ACTIONS *															PROFESSIONAL REQUIREMENTS **								
		Applied Investigation /Transfer of Technology		Training -Courses - In service		Extension			Publica-tions		*** Institutional Aspects														
GENERAL	SPECIFIC	General	Specific	Tech-nicians	Producers	Producers	Inter-mediaries	Consumer	Direct	Indirect	Public	Private	Infrastructure	Agroindustry		Agronomist	Economist	Food Technologist	Anthropologist	Entomologist	Food Pathologist	Extensionist	Ag. Technician	
1.Mechanical Damages a) Rough handling Harvest	inadequate type container		X			XX			X		X											✓	✓	
Packing	excessive capacity		XXX			XX	XX		X		XX						✓	✓				✓	✓	
Transportation	poor stacking						XX		X		X							✓				✓		
Storage	-																							
Wholesale	inadequate packing		XXX				XX		X		X						✓	✓				✓		
Retail	too much handling by consumers		X				X	X	X		X							✓				✓		
b) Container Poor design	internal surface poorly designed		XXX	XX		XX	XX		XX		X	X	XX				✓	✓				✓		
Poor finish	lack of standardization		XXX		XX	XX	XX		XX		X	X	XX			✓	✓	✓				✓		
Other	excessive capacity		XXX		XX	XX	XX		XX		X	X					✓	✓				✓		
2.Physiological Damages a) Storage	—																							
b) Early harvest	lack of uniformity in ripeness		XX			XX					XX					✓				✓	✓		✓	
c) Delays.	too much sun wholesale market		XX				XX		X		X	X	XX				✓	✓	✓					
3.Infection a) Micro-organisms	lack of hygiene		X				X	X	X		X	X									✓	✓		
b) Insects	-																							
4.Excess Supply	—		X			X			X		X					✓	✓					✓		
5.Loss Nutritive Value	possible contamination insecticides		XXX			XXX			X	X	XXX	X					✓	✓	✓	✓		✓	✓	
6.Seed Quality	lack of investigation selection of seeds		XX								XX													
7.Lack of Information	concerning seeds and possible markets		X			XX	X			X	XX											✓	✓	

* Indicate priority using from one (low priority) to three marks (high priority)

** Using foot notes one can complete the information indicating the names and number of professionals required and the names of the responsible institutions.

***** In this case one should try to define with precision the institutions with more responsibility. It is recommended the use of footnotes to complete the information concerning institutions and possible actions.**

Project No. 2

This project is basically one of investigation to quantify the losses in nutritive value caused by excesive use of insecticides, identification of improved varieties of seeds and varieties of tomatoes with uniform maturity. It will also have its complementary action in extension at the farm level and institutional support (basically pre-harvest activities).

Project No. 3

This project is focused at the problem of delays at the wholesale market level. It will include minimum infrastructure in the marketplaces to protect the product from excesive sun light and perhaps cold storage facilities. It will have activities in extension at the intermediary level and pilot projects in investigation and transfer of technology.

Project No. 4

The orientation of this project is that of extension at all the levels (producer, intermediary, consumer) to solve specific problems such as inadequate containers used during harvest, deficient stacking methods used during transportation and in the marketplaces, improved information about seed. varieties, alternative markets, sanitation problems and excesive handling of the tomatoes by the retailers and the consumers.

DOCUMENT VI - K

SUMMARY OF STUDY OF POST-HARVEST LOSSES OF CASSAVA IN THE DOMINICAN REPUBLIC*

By:

Romero Tejada

*Prepared for the Seminar on the Reduction of Post-Harvest Food Losses in the Caribbean and Central America. Santo Domingo, D. R. August 8- 11, 1977.

SUMMARY OF STUDY OF POST-HARVEST LOSSES OF CASSAVA IN THE DOMINICAN REPUBLIC 1/

I. OBJECTIVES OF THIS STUDY

The objective of this study is to identify and to measure the losses of cassava roots between the moment they are harvested to the time they are consumed by families. An economical evaluation of the losses is included and suggestions are made as to how to reduce them, from the point of view of the farmer as well as from the point of view of the Secretary of Agriculture.

II. PRODUCTS BACKGROUND

The sowing of cassava is distributed throughout the national territory with the Northern region being the one with the major production. Espaillat and La Vega provinces produce the majority of the regional total. La Vega province is the largest producer in the whole country, even above Espaillat province (Moca) which is considered popularly the main producer. The region with the lowest production and yields per tarea 2/ is that of the south.

Planting and harvest of cassava is carried out during the whole year principally because the sowing time varies from one region to the other due to climatic conditions and the different varieties cultivated.

1/ Prepared by Romero Tejada R and Wilfredo Moscoso, Food and Economics Investigations Center, Superior Institute of Agriculture. Santiago, for the Seminar on the Reduction of Post-Harvest Food Losses in the Caribbean and Central America, August 8-11, 1977 .

2/ Equals 629 square meters.

For the evaluation of post-harvest losses of cassava in this study the area including the provinces of Santiago, Samaná, Moca and La Vega, were considered. In 1976, this region had 209,334 "tareas" 1/ planted in cassava with a production of approximately 2,131,126 "quintales" 2/ equal to 56.85% of the national production. The varieties most extensively cultivated in the studied area are: Zenón, Sanjuanera, Machetazo and Jíbara Prieta. All of them have white flesh with a dark outer layer, except the Machetazo variety which has a light colored outer layer.

From 75% to 88% of the total production is sold to truck drivers. An average of 19% of total production is not suitable to move into the regular marketing channels; these rejects (raviaas) are used either as payment for the hand labor, sold at reduced prices or used for animal consumption.

Some 98% of the marketable cassava is consumed in the Dominican Republic, the remaining (2%) is for exportation to Puerto Rico or Miami. The main part of national consumption is in fresh form. Other principal uses are: "casabe" 3/ and flour.

III. APPLIED METHODOLOGY

3.1 Farm Sampling. In the realization of this sample, 18 observations were made corresponding to eight farms with planted area varying from 3 to 200 "tareas". The observations were made at random in the field. The farmers were allowed to clasify the products in accordance with their traditional methods.

1/ Tarea equals 629 square meters.

2/ Quintal equals 100 pounds.

3/ Cassava bread or cakes.

Once the clasification was made, the next step was the weighing and counting of the different types of cassava, and the evaluation of the losses and their causes.

In obtaining the statistical data, each observation considered the number of cassava roots as well as their weight, where the total amount of the product, prior to the clasification, was considered 100 percent. The losses were measured in relation with this total.

3.2 Transport Sampling. This refers to that part of the marketing system between the delivery of the product in "cerones"1/ to the truck driver, up to the selling of the product to the wholesalers and retailers in the Central markets of Santiago and Santo Domingo. For these samples, three vehicles were selected and 28 observations were evaluated, distributed throughout the load in such a way that they were representative of the different areas (top, middle, bottom) of the transported volume. Polipropilene bags were used (same bags used in the commercialization of onion) during transportation. These bags were numbered and weighed. The weight fluctuated between 12 and 36 pounds per bag. At the moment of the sale each bag was weighed again and a new counting of cassava roots was made, whole and in pieces, and comparisons were made with the amount registered at the moment of loading at the farm level.

3.3 Sampling at the wholesaler's level. An agreement was made with wholesalers (stand owners) in central markets. Whereby they would allow observations to be made during the sales transactions and permit control of the product while it was in their hands. The initial weight of the purchased product was registered, and every 24 hours losses, as a result of

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1/ Type of sack or basket with a capacity equivalent to 55 kilos.

classification and physiological damages, were quantified. At the same time, the susceptibility to deterioration of the different varieties of cassava was observed. The product remained at the wholesale level during a relatively short period of time varying from 24 to 48 hours.

3.4 Sampling at Retailer Level. The different types of retailers considered here included: Small retailers, grocery stores, mobile vendors (tricicleros), pedlars and stand keepers at central markets. Agreements were made with the individual retailers whereby they would allow the investigators to study the movement of the produce from purchase from wholesalers to the sale to consumers.

A total of 23 retailers were selected and daily samples were taken for a week with two repetitions. Each retailer saved for the investigators the cassava rejected by the consumer for reason of low quality. In the same way, they also kept apart the cassava which was spoiled before being offered to customers. At the end of each day the product was weighed, losses were quantified and variations in cassava quality were observed.

3.5 Sampling at Consumer Level. This part covers from the purchase of the product by the consumer to its definite consumption in the homes. Some 105 observations were made from among 25 consumers of different socio-economic classes and located at different distances from retail stores. The sampling included those persons who consume the product immediately after purchasing as well as those who refrigerated it for a short period before use. The cassava

was weighed at the moment of purchase and agreements were made with the consumers whereby they would save the pieces and parts of pieces not fit for consumption. These were later qualified and the losses determined.

IV. ANALYSIS OF LOSSES AND CAUSES ORIGINATING THEM

4.1 Producer Level. Losses at the farm level are evaluated considering only the cassava that is not sold to the truck driver and/or exporter.

Table 1 shows the percentages of cassava that leaves[1/] the farm destined for the local market as well as for exportation. It shows, also, the percentage of cassava that is damaged before leaving the farm. These damages are not so serious as to require an inferior classification thus the farmer is not penalized price wise. It should be noted that of the cassava destined to local markets, only 79% of the harvested amount is sold,[2/] whereas of the cassava for exportation, 86% of the amount harvested is sold. The cassava for exportation purposes also has less damage than that destined for the local market. Both comparisons are indicative of the greater care taken in the handling of cassava for exportation purposes.

In Table 2 we can observe the percentage of losses occuring during harvest and the reason causing the losses. It can also be noted that the total losses occuring during harvest are on the order of 8.81%, with mechanical damages being the principal cause of these losses (57.43% of the harvested cassava, is categorized as "tails" (small roots). These "tails" are not included in the previous table because they

1/ That which does not leave the farm is considered losses at this level Losses can be subdivided into natural losses (units too small for market) and losses which can be reduced.

2/ 21% not sold.

Table 1. Percent Marketed, Destination and Quality of Cassava Harvested expressed in percentage terms.

	Destined for local market				Destined for export				
Observations	Sold tru truckers (1)	Whole Units (2)	With mechanical damage (2)	Observ-ations	Sold for Export	Sold tru truckers	Total Sold (1)	Whole Units (2)	With mechanical damage (2)
1	78.10	29.91	70.09	1	55.70	19.30	75.00	55.70	44.30
2	84.66	47.77	52.23	2	71.55	8.48	80.03	71.55	28.45
3	83.76	44.62	55.38	3	77.68	13.70	91.38	77.68	22.32
4	75.06	36.36	63.64	4	79.38	10.48	89.86	79.38	20.62
5	74.09	58.87	40.13	5	74.19	11.84	86.03	74.19	25.81
6	74.55	44.35	55.65	6	62.07	20.91	82.98	62.07	37.93
7	76.02	45.38	54.62	7	72.13	20.17	92.30	72.13	27.87
8	80.76	45.00	55.00						
9	84.04	51.35	48.65						
10	79.31	43.48	56.52						
11	78.19	33.30	66.60						
Pondered Average:	79.26	43.99	56.01		72.48	13.88	86.36	72.48	27.55

(1) Percent of the total crop harvested

(2) Percentages of the cassava sold in (1).

Table 2. Losses of Cassava Occuring During Harvest by Type of Damage (in %)

Observations	Physiological Damaged	Insect Damaged	Mechanical Damaged	Losses by Classifica-tion	Total Losses
1	0	0.53	5.11	4.38	10.02
2	2.16	0	3.76	1.35	7.27
3	.45	0	4.59	2.37	7.41
4	0.26	8.36	5.07	6.49	20.18
5	0	0	4.57	2.66	7.23
6	0.59	0	5.26	3.80	9.65
7	1.01	1.26	4.37	.81	7.45
8	1.87	0.69	3.79	1.00	7.35
9	0.51	0.53	4.51	2.00	7.55
10	0.25	0	7.89	1.32	9.46
11	0.12	0	6.77	0.54	7.43
12	0	0	4.12	2.82	6.94
13	0	0	4.21	1.87	6.08
14	0.76	6.13	4.05	6.73	17.67
15	0	3.73	8.51	11.64	23.88
16	0	0	2.55	3.03	5.58
17	0	0	4.71	5.28	9.99
18	0.34	0	6.21	6.89	13.44
Pondered Average:	0.54	0.86	5.06	2.35	8.81
Standard Deviation:	5.20				
Coeficent of Variation:	59%				

are considered "natural losses" that would happen in any case of all varieties of cassava.

It can be noticed in observations numbers 4, 14 and 15, that damages caused by insects are considerable greater than in others. This is due to the fact that the observations were made in the section called Las Galeras in Samaná, where the insect Phyllophaga spp (cigarra) strongly attacks the cassava plantations. The average percentage of cassava affected by this insect in Las Galeras was 6.07% contrasting with 0.20% in other studied areas.

4.2 Transport to Market. The magnitude of damages occuring during transportation can be noted in Table 3. The damaged produce are not considered a total loss because the damages do not affect the product value at selling time.

Damages are classified in the Table according to the position of the samples in the load. The cassava transported in the lower part of the load, suffered greater damages than that transported in the middle and upper part, due of course to the fact that it bears the greatest weight. The samples showed damages of 11.32% for that transported in the lower part of the load, 7.89% for that transported near the middle and 1.83% damage for the cassava near or on top. According to this study the average loss in weigh was on the order of 0.53% of cassava which arrived to market within 24 hours of harvest time. Some 50% of the observations that showed weight loss were located in the upper part of the load due most likely to the dehydration caused by wind and sun.

Table 3. Damages Occuring During The Transport of Cassava Between the Farm and the Wholesale Market.

Number of Trips	1	2	3	Total
Total Number Units of Cassava	112	189	81	382
Total Number Tubers in upper part of load	29	50	30	109
Number of Tubers Damaged	0	2	0	2
% of Tubers Damaged	0	4	0	1.83
Total Number Tubers in Middle part of load	33	60	21	114
Number of Tubers Damaged	2	5	2	9
% of Tubers Damaged	6.06	8.33	9.51	7.89
Total Number Tubers in Lower part of load	50	79	30	159
Number of Tubers Damaged	4	11	3	18
% of Tubers Damaged	8	13.92	10	11.32
Total Number Tubers Damaged	6	18	5	
Total % of Damaged Tubers	5.36	9.52	6.17	

Average Losses: 6.65%

Standard Deviation: 4.38%

Coeficient of Variation: 65.86%

4.3 Wholesaler Level. Due to the relatively rapid marketing (4-6 hours) and to the practice of not classifying the cassava during sale at the wholesale level, the registered losses at this point are not considerable. Neither were any losses registered among the truck drivers (wholesalers) who sell both at the wholesale and retail levels.

The result of 40 observations made at this level showed losses of only 1.32%.

Twelve observations were made during the study to identify the most important causes of deterioration caused up to this level. According to the data, 0.88% of the cassava spoils because it is in too small pieces for selling purposes, 1.95% shows primary deterioration (presence of black/blue grooves on the vascular system) and 0.32% shows secondary deterioration caused by a pathogenic agent or physiological reactions which induce fermentation or softening of the roots.

To these losses we must add those caused by dehydration. Experiments show that weight losses can rise to 4.39% and 6.32% of the original weight of cassava stored at room temperature during one or two days respectively. When roots were kept covered by damp bags, weight losses were less, rising only to 0.31% and 0.74% during one or two days of storage respectively.

4.4 Retailer Level. The result of 74 observations made at 23 retailers showed total losses at this level of 3.91%. We must add, however, losses caused by dehydration due to heat. These losses are estimated at 1.8% and 5.6% for 24 and 48

hours of storage respectively, at room temperature. Comparing losses corresponding to the different and most common varieties of cassava in the studied regions, we found losses of 6.67%, 4.53% and 2.85% for the varieties Zenón of Samaná 1/, Zenón and Sanjuanera, respectively.

4.5 Consumer Level: The average losses observed during this phase of the study was 3.90% of which 41.89% corresponds to Zenón of Samaná, 31.82% to Sanjuanera and 26.29% to Zenón variety. This relation shows that Zenón variety is the one less likely to suffer damages and the one that maintains its quality for a longer period of time.

4.6 Exporter Level. For cassava for the export market, the transport system was analyzed from the farm to the washing (bulking) point. In experiments realized it could be noted that losses of weight reduction and mechanical damages were insignificant due mainly to the fact that the distance covered is short and the washing places are located near the production center. Furthermore, since cassava is transported in "cerones" (type of basket), it receives less abrasion than if it were transported loose. Losses as a consequence of mechanical damages and reclasification were 1.11%.

V. GENERAL EVALUATION OF LOSSES

5.1 General Summary

Table 4 presents a summary of the post-harvest losses of cassava. The total losses which appear in this table are based on 3,766,000 "quintales" which was the estimated real production of cassava in 1976.

1/ Variety of Zenón Cassava Cultivated in Samaná.

Table 4. Summary of Post-Harvest Losses of Cassava in the Dominican Republic

Steps	Percent Losses	Total Losses (qq)1/	Price RD$/qq 2/	Value of Losses RD$/1976	Quantity going to Market (qq)
Producer	8.81	331,785	7.91	2,624,419	3,434,215
Transport	0.532	18,270	8.60	157,122	3,415,945
Wholesale	1.32	45,090	9.95	448,646	3,370,855
Retail	3.91	131,800	11.50	1,515,700	3,239,055
Export	1.11	836	7.91	6,613	3,238,219
Consumer	3.90	126,323	11.50	1,452,715	3,111,896 3/
T o t a l	17.37 4/	654,104		6,205,215	

1/ Using the real estimated national production of 3,766,000 qq in calculating losses. One qq = 100 pounds.

2/ Average prevalent prices during the period march-may, 1977, date of study.

3/ Production finally consumed.

4/ Pondered average.

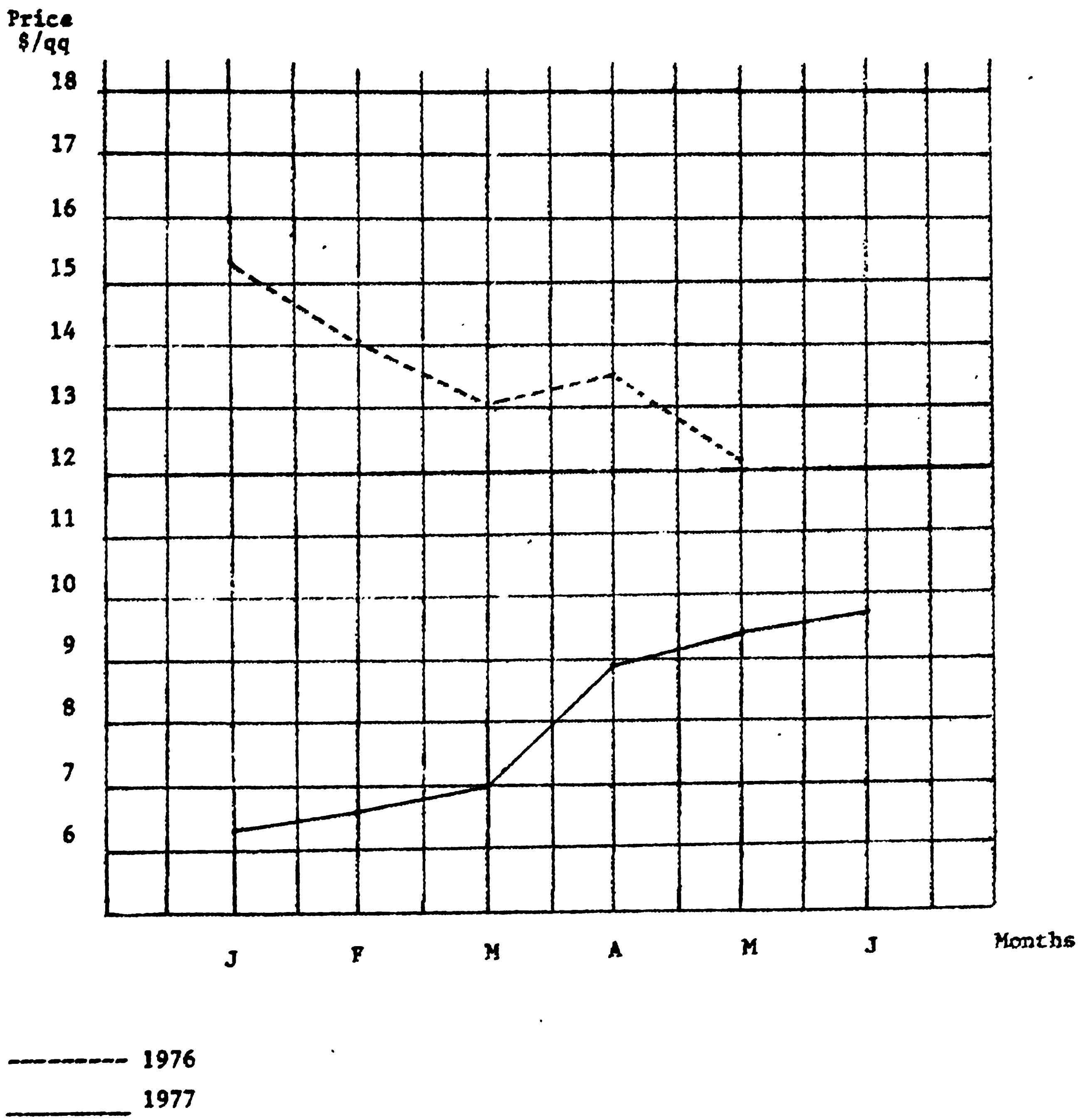
The 8.81% of losses occuring at the producer level were applied to the total 1976 production. At the wholesaler level, the percentage loss (1.32%) is applied to the total production less the losses at the producer level and during transport --this results in 45,090 "quintales". The same procedure was used to calculate total losses up to the retailer and consumer level. That is, losses were computed considering the fact that the total marketed volume decreases as the product goes through the marketing system. The estimated total of post-harvest losses was calculated at 17.3%, the pondered average.

As graph No. 1 indicates, there is a rising tendency in the market on cassava prices this year. Based on the behavior of the farmer and the merchants --trying to obtain the greatest profits possible, it is felt that post-harvest losses vary inversely with market prices. That is, the higher the price for cassava the more insistent the persons are in selling the largest volume possible, and the most rapidly possible, thus reducing losses.

When cassava is cheap, there is less care in the handling of the product and delays increase, thus increasing losses.

If this hypothesis is true, the measured losses of this study would lightly underestimate average losses. The logic of reasoning also suggests that post-harvest losses act inadvertently as a mechanism that slightly contributes to stabilize cassava prices. This does not justify that some kinds of measures should not be taken to reduce post-harvest losses. Among the suggestions given in this study are those of storage and proccessing that could reduce losses and at the same time contribute to

Graph No. 1 Prices of Cassava in the Santo Domingo Wholesale Market during the months of January to May 1976-1977.



stabilize prices, if they are handled precisely with this purpose in mind.

5.2 Microeconomic Evaluation

For this evaluation, we can describe the situation for a typical farmer in the studied area. This man cultivates about 30 "tareas" generally without irrigation and with only one harvest annually, (10-12 months). The following is a summary of the evaluation:

Cultivated area	30 "tareas" 1/
Productivity	10.87 qq/tarea 2/
Losses during harvest	8.81%
Production cost by "tarea"	18.97 3/
Harvesting costs 4/	0.56 qq
Sale price to truck driver	$7.91
Net profit with losses of 8.81% 5/	1,616.57
Value of post-harvest losses	224.40

If we assume that the production time of the crop is from 10 to 12 months, in the case of sweet cassava, the monthly income for this average farmer will vary from 134.71 to 161.65. The growing of cassava is profitable (at prices already indicated) because as one may observe in the previous analysis, the costs are only 45% of the net benefits. Post-harvest losses of 28.73 "quintales" represent a reduction for the average farmer of $224.40 in his net income on this annual crop.

1/ Equals 629 square meters.

2/ Hundred weight per tarea.

3/ Secretary of State of AGriculture, Division of Rural Administration.

4/ Divided in the following way:

Harvesting	0.31
Selection & packing	.15
Transport on the farm	.10
	0.56

5/ The calculation of net income can be generalized in the following model, which does not consider economies of scale: T-Cultivated Land; P-Productivity; R-Losses during harvesting; c-Production cost per "tarea"; r-Harvesting costs; p-Sale price to truck driver.
Net Income = (p-r) (TP-RTP)-Tc
Note that R = f (p,M) where M refers to general practices in handling product.

It should be noted that part of the losses at the farm level (rejects, small pieces, etc.) are consumed, since the producer may use them for payment or give them away for human and animal consumption.

5.3 Macroeconomic evaluation

The objective of the macroeconomic evaluation is to estimate the magnitude of losses on a national scale. The calculation implies that this study realized in the provinces of Moca, Santiago, La Vega and Samaná, which accounts for some 56.85% of the national production, can be inferred to the rest of the country. These losses are measured, considering prices at each step of the marketing process as of the period between January and March of 1977.

It can be observed in Table 4, that the total estimated value of losses of cassava in the Dominican Republic in 1976 was on the order of RD$6,205,215 of which RD$2,624,419 (42%) occur at the farm level, and RD$1,452,715 (23%) at the consumer level. In this last case it is important to note that observed losses are transferred from retailer to consumer: the retailer's margin incorporates marketing losses.

The sale price of cassava roots breaks down as follows:

Producer sale price	$ 7.91
Wholesaler sale price	9.95
Retailer sale price (consumer in Santiago)	11.50

This means that the producer receives 69% of the final price paid by the consumer, while the retailer receives 13.5%. 1/

1/ This is a retailer's gross margin for the product sold in Santiago. The marketing margins for cassava in Santo Domingo were: (according to SEA Department of Agricultural Economics) Producer, 60% of final price, truck driver, 13%, wholesaler, 7% and retailer 20%. Santo Domingo is the largest cassava consumer (it has 20% of national population).

VI. POSSIBLE METHODS FOR REDUCING POST-HARVEST LOSSES IN CASSAVA

Different methods for reducing losses are enumerated here, each one of them is described in detail in the original text.

6.1 To Reduce Losses in Post-Harvest Handling

6.1.1 Avoid the mechanical damages which occur during harvest since these are the points at which the pathogenic agents enter the produce.

6.1.2 Avoid high temperatures (29-32°C)during harvest which accelerate product deterioration. This can be achieved by storing the product in improvised shelters on the farms.

6.1.3 Promote the use of more resistant varieties such as Sanjuanera or Zenón variety (see page 11)

6.1.4 Curing the cassava by storing it for 3 to 5 days at high temperatures (25-40°C) and high relative humidity (80-85%).

6.2 To Reduce Losses in Conervation and Processing

6.2.1 Study the economics of installed refrigeration. This method is expensive but assures the best conditions of storage.

6.2.2 Develop a program of Country Silos - This method implies a great deal of work, but brings good results as 75% of the roots can last up to a month or more.

6.2.3 Storage in boxes with sawdust at 45-55% of humidity. On experiments realized at CIAT, more than 75% of treated roots remain in good conditions after a month of storage.

6.2.4 Transformation of cassava into cakes. If the cassava is processed near its place of origin and soon after harvest

losses will be minimized by eliminating delays.

6.2.5 Manufacture of pellets and chips. This is a simple practice but it prolongs the product's life after it is dry. Pellets and chips are used for animal feeding.

6.2.6 Diverse methods of freezing or industrializing for human and animal consumption.

DOCUMENT VI - L

POTATO STORAGE

AS PART OF A TOTAL POTATO PRODUCTION PROGRAMME

WITH SPECIAL REFERENCE TO

SOUTH KOREA *

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* Th:' paper formed the preface to a consultancy report on "Potato storage in the Republic of Korea" prepared by the authors in September-October 1976 for the Interdisciplinary Potato Research Team, Crop Improvement Research Center, Office of Rural Development, Suweon, Korea. It is reproduced here without modifications and with their permission and that of the International Potato Center, Lima, Perú.

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The impact of research and development on the production of utilisable potatoes.

The limitations of placing all our research and development efforts into simply increasing field production (eg tons/ha) can be seen by studying table one, from which it can also be seen that a similar effort in reducing post-harvest losses results in a larger net production. For example it is seen that exactly the same final net production is obtained by reducing post-harvest losses by 15% as is obtained by increasing field production by 20%. While in many cases it may also be simpler to reduce post-harvest losses than it is to increase field production it is not suggested that all our effeorts be placed in this field but rather that we try to develop a fully integrated approach in our research programmes. This in many cases necessitates a new look at the composition of our Interdisciplinary Research (I.D.) teams and almost always a broadening in approach to our established members. Thus our newly formed I.D. Team will be composed of post harvest scientists and technologists in addition to our field production specialists and additionally our field production specialists will be made aware of the important role which they can play in reducing post-harvest losses and so increasing total production.

Aims of the "Total Production" I.D. Team

The aims of our newly formed "total production" I.D. Team may simply be stated as to undertake the necessary research and development to make available at all times a sufficient supply of potatoes to meet the requirements. Our total requirements must be considered in terms of fresh human consumption, seed, processing for human and animal feeds, industrial usages, and export requirements.

If we greatly simplify the position with regard to total requirements and consider these to be constant and stable throughout the year then we can simply represent our aims graphically as in figure 1. Our total requirements will in fact approach nearer to a straight

line pattern where potatoes are being consumed as a staple food and probably vary over a much greater range where they are consumed as a vegetable and in all cases our requirements will vary and be influenced by many other factors such as the availability and cost of alternative food stuffs.

It is thus seen that it is fairly important that we should, early in our development programme, arrive at reasonable estimates of our total requirements and requirement patterns. To achieve this it is frequently necessary to undertake extensive "consumer" and marketing studies.

Achievement of our aim : Supply = Requirement

Again, let us for simplicity consider that our requirements are constant and stable throughout the year, then we can achieve our aim by one of two means :

A. Continuous production
B. Periodic production plus storage.

A. Continuous Production : this requires the existence in the country of a continuous "growing season" or alternatively varieties adapted to produce under different climatic seasons etc. and also the continuous availability of "suitable" land or again varieties adapted to produce in widely differing soil types and geographic zones. Here the role of our production scientists in the I.D. Team is obvious and while it is realised that in Korea there are severe restraints imposed by the severe winters and the requirements of the important rice crop it is nevertheless believed that greater consideration needs to be given to this approach to avoiding the need or at least reducing storage requirements. It is probable that by the careful use of varieties and available land a supply of fresh potatoes could be made available over a greater period of the year than they are at present in Korea.

B. Periodic Production plus Storage. Depending on the number, frequency, and magnitude of the production periods different storage patterns have to be developed in order to arrive at a continuous and even supply of the produce. Figure 2 illustrates two simple situations : a) a single production period followed by a long twelve month storage period and b) two equal six montly production periods each followed by a six month storage period. However, even in these two simple examples it is readily seen that the different storage periods required to maintain a continuous supply of produce will have very different storage requirements. Let us now consider a somewhat more complex situation as illustrated by the production pattern in Korea where we have two unequal production periods unequally distributed through the year. It is seen in Figure 3 a. and b. that if we follow a similar storage pattern to that used in the previous examples we end up with a continuous but uneven supply. This situation may be acceptable where our demand/requirements are much greater than our total production (Figure 3c) but it is obviously unacceptable when our total annual production is equal to our requirements as we will have surpluses at certain periods of the year and shortages in others (Figure 3d). Figure 4 therefore illustrates two possible alternative storage patterns to overcome this problem and produce a continuous and even supply. For alternative A to be successfull, however, it is probably necessary to introduce some price control, particularly during months 11, 12, 1, 2, and 3 when the fresh or only recently stored fall crop would be competing on the market with the long stored spring crop. For alternative B to be successful legislation would be required to make it obligatory to store and hold all the fall crop until the stored spring crop has been completely utilised. This again points to the broad approach which is required to arrive at the most appropriate storage pattern. And also the different storage patterns have different storage requirements.

Storage Requirements

The two major requirements of a system of storage are a) that it should allow a weight of saleable potatoes as near as possible to the weight of

potatoes placed in store to be available following the required storage period and b) that these should be of acceptable quality to the consumer. The storage method or methods chosen to meet these requirements should naturally be selected to yield maximum returns on the investment made and different techniques will be more or less appropriate in different circumstances.

In Korea we have very obvious differences in requirements for the winter and summer storage periods. The requirements for the winter storage period are relatively simple to achieve in a wide range of structures and much of the necessary technology is available and already being applied relatively successfully. It is much more difficult to meet the requirements for the summer storage period and so let us consider how we might select the best summer storage system.

The simplest technical answer is of course the use of refrigerated stores but this system may not necessarily yield maximum returns as refrigerated stores are both expensive to build, maintain, and run. Also, managerial problems frequently arise, particularly in those situations where the potatoes are produced by a large number of small growers. The extreme alternative to refrigeration is the use of simple farm stores, but similarly this system may not necessarily yield maximum returns particularly towards the end of the storage period when storage losses in such stores could be expected to be high. Perhaps therefore we should consider the development of an integrated storage system, different individual storage methods being chosen as those yielding maximum returns for differing periods within the total required storage period. An example of such an integrated system using simple farm stores, ventilated stores and refrigerated stores is shown in Figure 5. In this example we have an eight month total storage requirement which we achieve by storing 3/8 of our tonnage in simple stores which is supplied over the first three months, 3/8 of our tonnage in ventilated stores which is supplied during the second three month period, and 2/8 of our tonnage

in refrigerated stores which is not supplied until he final two months of the total storage period.

An Integrated Storage System

Before we can arrive at an integrated storage syster as illustrated in Figure 5 we need to know how long we can successfully and economically store potatoes in the different structures under the local prevailing enviromental conditions. This is the type of information which needs to be obtained and which is required before the most appropriate storage recommendations can be made.

In general terms we can say that the economic success of a storage system is determined by :

a) cost of store
b) storage profit (determined largely by the difference in the selling price of the potatoes at the beginning and at the end of the storage period) and
c) storage losses

It is not proposed here to discuss factors a) and b) except to say that due attention must be paid to the marketing and pricing framework in which we are working and obviously if the consumers require a continuous and even supply of potatoes then they must be prepared to pay for the cost of the storage pattern required to attain this.

Storage Losses

Storage losses generally when expressed graphically follow a sigmoid curve pattern and we should strive to obtain these curves for our different structures under local conditions. Information from these curves can then be used along with the appropriate economic data to derive our possible integrated system.

An example of such loss curves for different storage types is given in

Figure 6. From these curves and with the necessary economic data we can decide how long we can successfully use each of the storage systems.For example we might say, that knowing the pricing system in which we are working, that with simple stores that are very cheap to construct etc. that we can accpet a 20% loss in store and therefore we can see that we can successfully use simple stores for up to X months. Similarly with ventilated stores that are more expensive to build and run we may decide that we can afford a 10% loss in store and so we can use these stores for up to Y months. And finally with our expensive refrigerated stores we find that we can only accept a 5% loss in store and so they can be successfully used for Z months.

From this example therefore we would probably decide that maximum returns would be achieved by using simple stores for storage up to X months, by using ventilated stores for the quantity of potatoes required between months X and Y and only use refrigerated stores for that quantity of potatoes required beyond month Y.

Major causes of storage losses

In drawing up our storage loss curves we will note that quantitative storage losses fall broadly into three categories; those caused by a) diseases, b) water and respiratory loss, and c) by sprouting.

Losses caused by disease. Diseases are the most common cause of storage losses and can be sub-divided into two groups a) those diseases where infection of the tubers occurred in the field prior to the harvesting and b) those diseases where infection occurred at or after harvest time, frequently at the sites of mechanical damage. Examples of the first group include Light Blight, Pink Rot, and Brown Rot and possible control measures concentrate on control of the diseases in the field by means such as varietal resistance, chemical sprays, and appropriate cultural practices. Examples of the second group of diseases include Dry Rot, Gangrene, and Bacterial Soft Rots. A reduction in the incidence of these diseases may be

achieved through such control measures as varietal resistance, careful harvesting and handling to reduce mechanical damage to a minimum, possible post-harvest application of fungicides, good higiene eg. store disinfection, and successful and timely CURING.

Before considering water and sprouting losses let us look briefly at the important process of CURING. Curing is a wound healing process which also favours the general thickening and hardening of the periderm/skin. It involves suberisation of the cells adjacent to cut surfaces followed by the formation of wound periderm/cork/skin. Curing should be undertaken as soon as the potatoes have been placed in storage (or temporary storage) and immediately following any handling operations. Successful curing controls many post-harvest diseases by providing a physical barrier which potential wound parasites are unable to penetrate, thus, it will be of little value unless undertaken immediately after handling operations as otherwise the pathogens will have become established in the wound before the periderm is formed. Similarly curing must not be considered as a "once and for ever" process, it needs to be repeated following each handling operation. This obviously means that once harvested we should derive systems of reducing the number of handling operations to a minimum. Successful curing can be achieved over quite a wide temperature range between 8°C and 20°C with a possible practical optimum at around 15°C, but requires a high relative humidity of at least 85% R.H. It is to be noted however that few studies have been conducted on the curing of potatoes at temperatures in excess of 20°C. In general it is as well to maintain the relative humidity as high as possible but avoiding condensation of free water on the tubers. These conditions required for curing can generally be readily obtained; the high respiration rate of freshly harvested potatoes causes a rapid rise in temperature as soon as ventilation is restricted and water evaporation from fresh wounds and from adhering moist soil etc. soon results in a high relative humidity. Different

varieties differ in the rate at which curing occurs and also different types of wounds heal at different rates but in practice a period of 10 to 14 days is suggested.

A reduction in water and respiratory losses is also achieved by successful curing as water loss from tubers is much greater through open wounds than it is through intact periderm and similarly damaged tubers have a higher respiration rate than either undamaged or cured tubers. Water loss may also be kept to a minimum by maintaining a low Vapour Pressure Deficit (ie drying power) in the ventilating air. At any given temperature the V.P.D. decreases with increasing relative humidity and at any given relative humidity the V.P.D. increases with increasing temperature. Thus the lowest V.P.D. may be obtained at low temperatures and high relative humidities. However, if it is not possible to obtain low temperatures, the relative humidity of ventilating air must be maintained as high as possible so as to keep the V.P.D. and thus water loss as low as possible.

Sprouting losses may most simply be kept to a minimum by selecting varieties for storage which have a long dormancy and slow subsequent sprout growth. If however, long dormancy and slow sprouting varieties are not available, sprouting may be controlled by careful manipulation of storage temperature or by the use of sprout inhibiting chemicals. It has been shown that little or no sprouting or sprout growth occurs at temperatures below 4°C although again little is known about the effects of temperatures above 25°C on dormancy and sprout growth. Chemical methods to suppress sprout growth are available and are in use commercially. Most of the suppressants employed are active in the vapour phase; they may be dispersed on an inert filler which is dusted on the potatoes as they are put in store, or are mixed with the tubers in a granular formulation, or alternatively the active chemical may be vapourised and blown through the stored tubers. Chemicals used for sprout control include

the methyl ester of α Xaphthaleneacetic acid (XPNA), tetrachloronitrobenzene (tecnazene, "fusarex"), isopropyl N-phenylcarbamate (propham, IPPC), isopropyl N- chloro-phenyl carbamate (chlorpropham, CPPC) and 3,5,5- trimethylhexan-1-ol (nonanol) and maleic hydrazide (MH). All the above chemicals with the exception of tecnazene are reported to inhibit the development of wound cork (curing). So, although the gross water loss associated with sprouting may be prevented by the application of suppressants, weight and disease loss may often still be disappointingly high because of the greater loss from unsuberised wounds and tuber skin surfaces. Inhibitors therefore should only be applied some weeks after harvest when curing is complete. In simple stores such a delayed application of inhibitors is not generally possible and so a dilema arises between the need to cure the tubers and the need to control sprout growth. It is believed that curing is of such paramount importance to successful simple storage that if we are to use such stores we will in general be limited to a storage period equal to the dormancy period of the particular tubers being considered for storage. It is considered that further information on the use of tecnazene in simple stores and on the behavior of the other sprout inhibitors at higher storage temperatures than is generally utilised would be extremely useful. Although the sprout inhibiting properties of tecnazene are not so strong as say CIPC, it is reported not to inhibit curing and also to have some fungicidal properties, particularly against the Fusarium species causing dry rot. The use of chemical sprout inhibitors gives rise to the presence of residues of the chemical in the tubers, which are the subject of legislation in most countries. All the substances listed above have been accepted by some but not necessarily all of the responsible authorities. In addition to chemical methods of sprout suppression, gamma-irradiation has successfully been used but it is considered unlikely to be economic in many situations.

From the examples given on how storage losses may be kept to a minimum it is possible to see the important role which the field

production scientists together with post-harvest technologists can play in reducing post-harvest losses. For example, greater total available production may be achieved by selecting a variety with slightly lower yield in terms of tons per hectare but with good storage characteristics than will be achieved by simply selecting the highest field yielding variety irrespective of its storage characters. And similarly the pataologist may be more profitably employed in studying means of reducing post-harvest diseases than concentrating all his efforts on producing a perfectly clean field crop. Similarly agronomic practices should take into account their influence on post-harvest life of the potatoes and shouldn't only be designed to maximise field yields.

Conclusions

In conclusion it can be seen that the storage method or methods chosen to meet the many storage requirements are inevitably a compromise between many different factors. Some of these factors, both social, economic, and technical have been briefly illustrated above while other important factors such as tuber quality, storage pests, storage engineering and processing have not been mentioned.

It is considered that processing should be regarded as an aid to storage and not an alternative to storage. A processing plant, no matter how simple, will in general be more economic the greater number of days it is kept operational, i.e. it needs a constant supply of raw materials which in most cases as we have seen will require storage facilities.

If we are to try to draw any specific conclusions from all the above it must first be to say that these notes are not intended as a complete commentary on potato storage in Korea but simply are an attempt to stimulate further thought and discussion on the broad approach which is believed to be necessary to solve potato storage problems. Coupled with this attention can be drawn to what is called the Total Production I.D. Team. In other words the I.D. team should be looking at the means of increasing the

total quantity of supply of potatoes to the consumers and not simply at increasing yields in terms of tons per hectare which are then simply handed over to some different storage and utilisation group.

On the slightly more technical side it is believed that it is important to realise that the most efficient method of potato storage is not absolute but is relative to a large number of continuously changing conditions and factors some of which have been very briefly discussed. Therefore we need to maintain a flexible approach to our problems which can change as factors such as availability of capital and different potato varieties etc. also change. Finally the importance of successful and timely curing must be re-emphasised, a factor which is considered to be of paramount importance to the success of any storage method and pattern that is finally selected.

Table 1.

The importance of an integrated approach to increasing total potato production

A. Present Total World Potato Production (million MT)

i.	Field production (FAO, 1974)	294	(100)
ii.	25% Post-harvest losses (Coursey and Booth, 1972)	73	(25)
iii.	Net production	220	(100-25=75)

B. Possible Total World Potato Production following Research and Development

1. to increase field production by:

5%	10%	15%	20%
(105-25% = 78.75)	(110-25% =82.5)	(115-25% =86.25)	(120-25% =90.0)
231.5	242.6	253.6	264.6

2. to reduce post-harvest losses by:

5%	10%	15%	20%
(100-20% =80.0)	(100-15% =85.0)	(100-10% =90.0)	(100-5% =95)
235.2	249.9	264.6	279.3

3. to both increase field production and reduce post-harvest losses by:

5%	10%	15%	20%
(105-20% =84.0)	(110-15% =93.5)	(115-10% =103.5)	(120-5% =114)
247.0	274.9	304.3	335.2

gure 1.

Aims of "total production" I.D. Team

Supply = Requirements

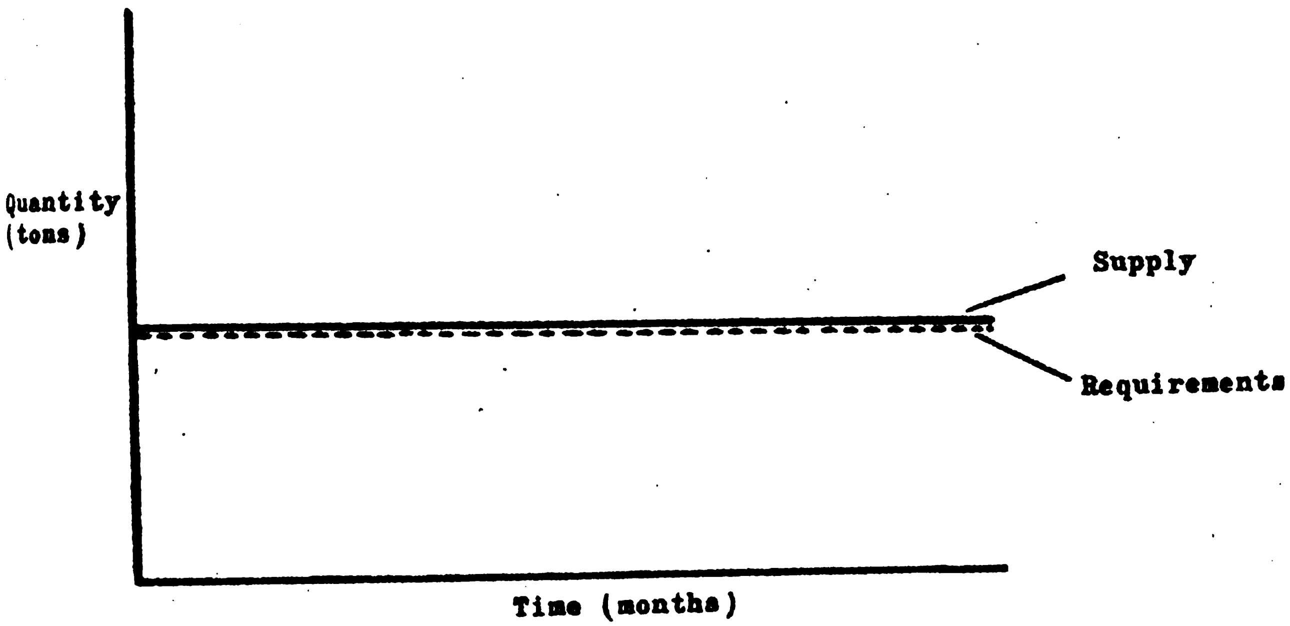
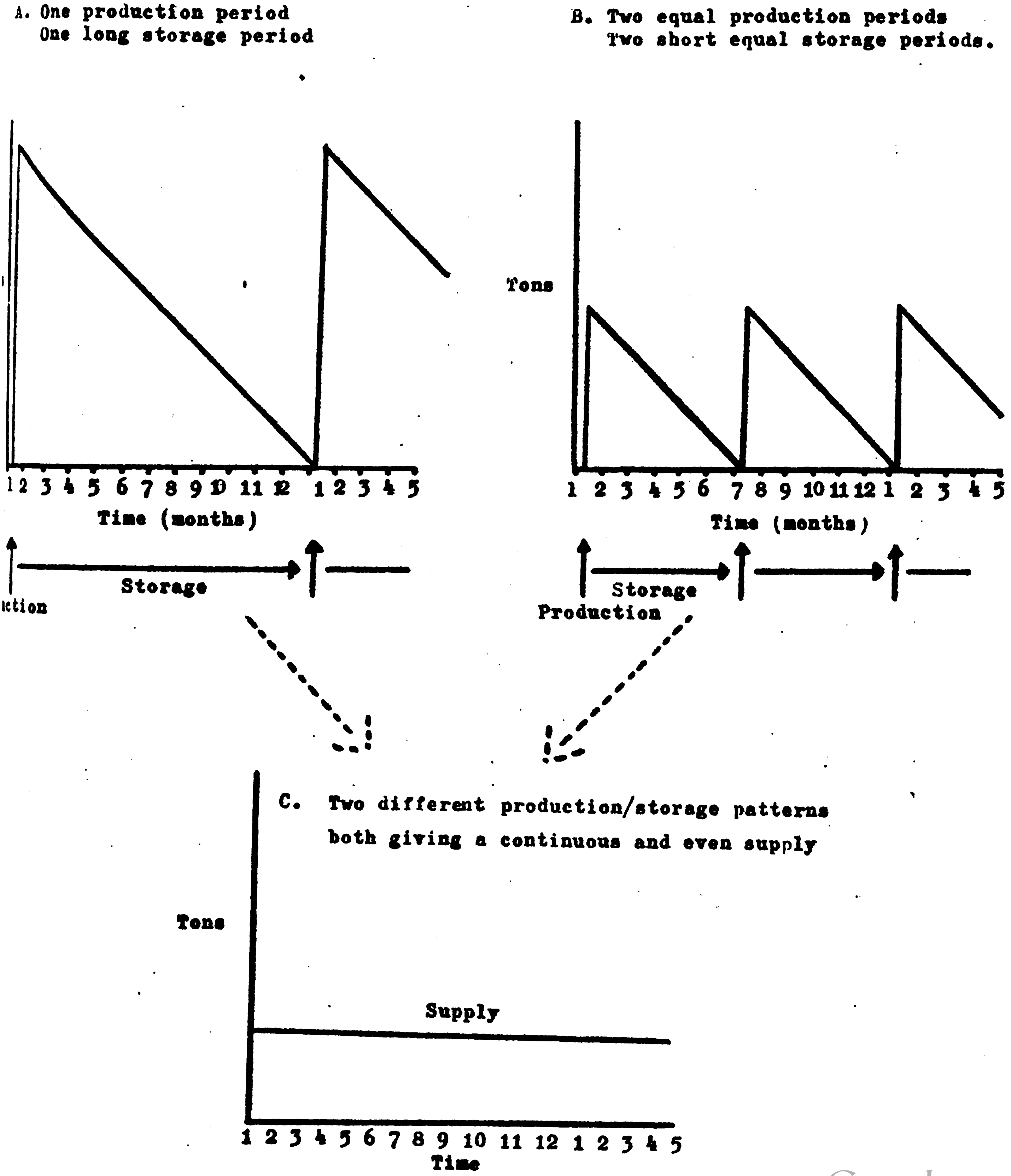


Figure 2.

Periodic production plus storage patterns



Periodic Production and Storage Patterns

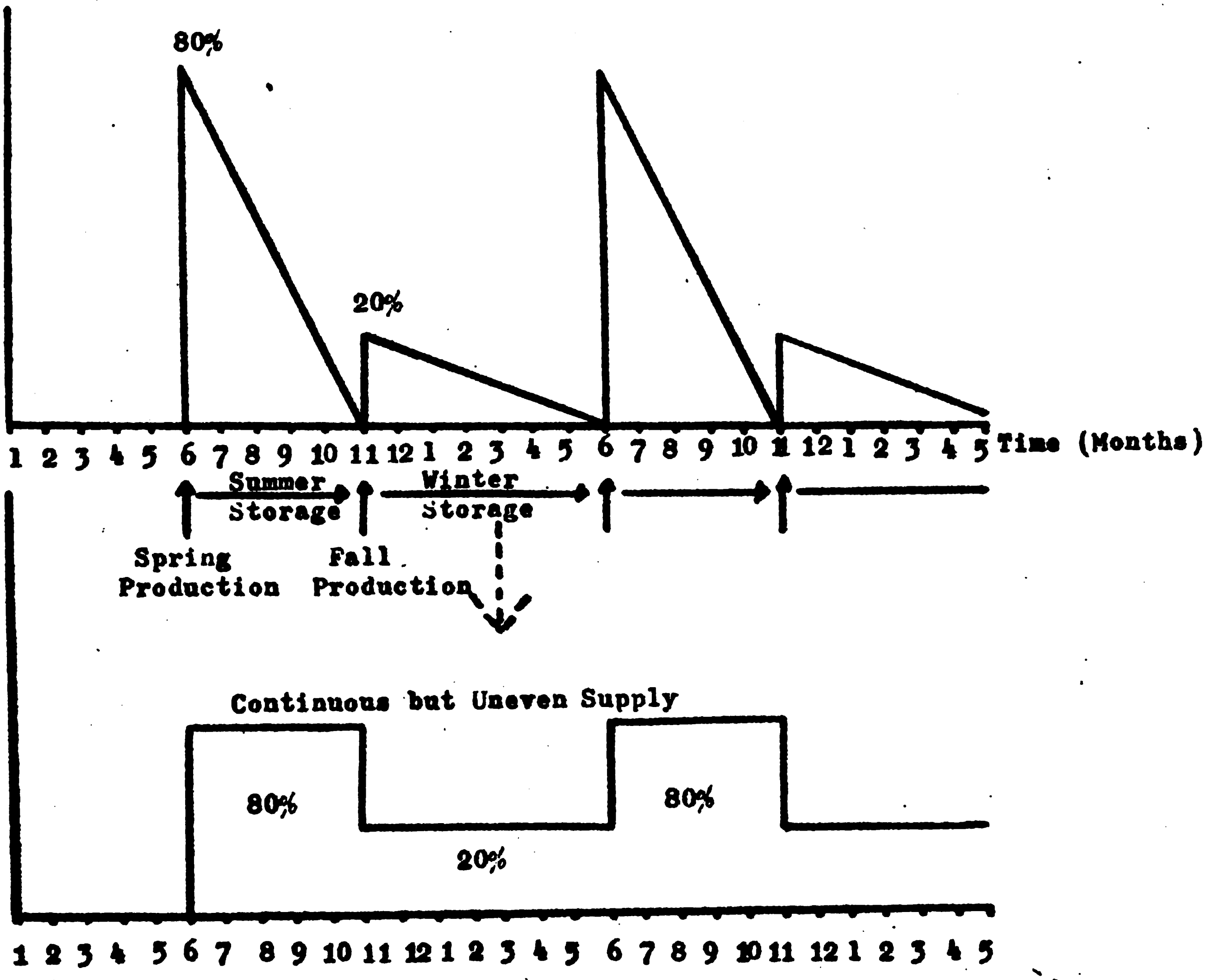
C. Two unequal production periods
Two unequal storage periods

eg. Korea where 80% of production
is Spring Crop and
20% the Fall Crop

3A.

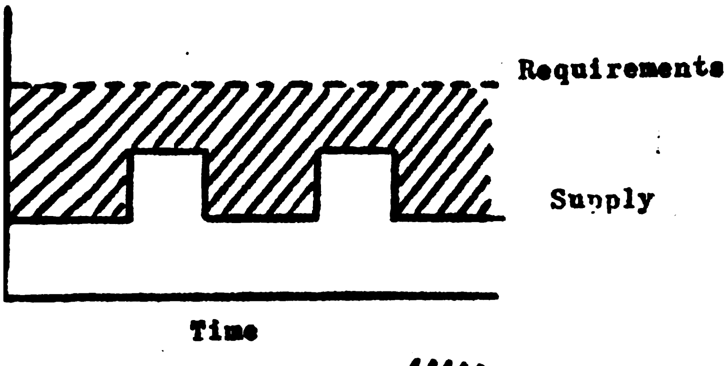
3B.

Tons.

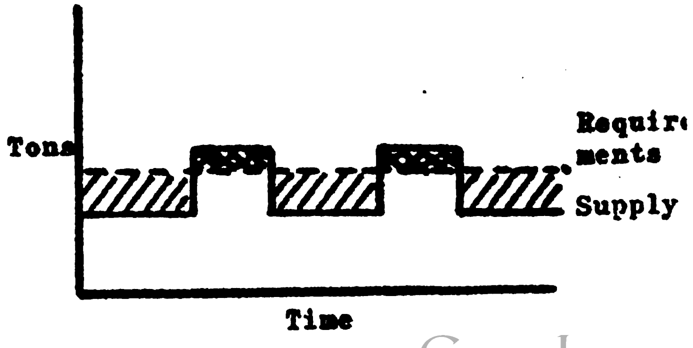


80% of Total production available over 5 month period
20% of Total production available over 7 month period

Total Production lower than requirements



3D. Total Production equal to requirements

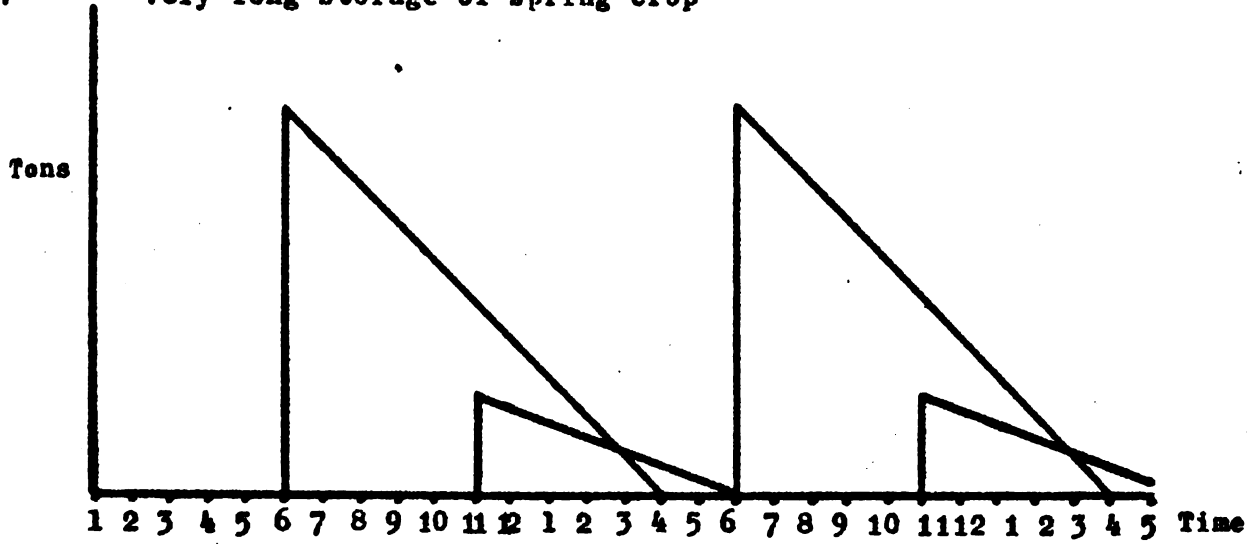


///// —Shortages —Excess

gure 4.

Possible alternative storage patterns to produce continuous and even supply .

A. **Very long storage of spring crop**



B. **Shorter storage of spring crop plus holding of fall crop**

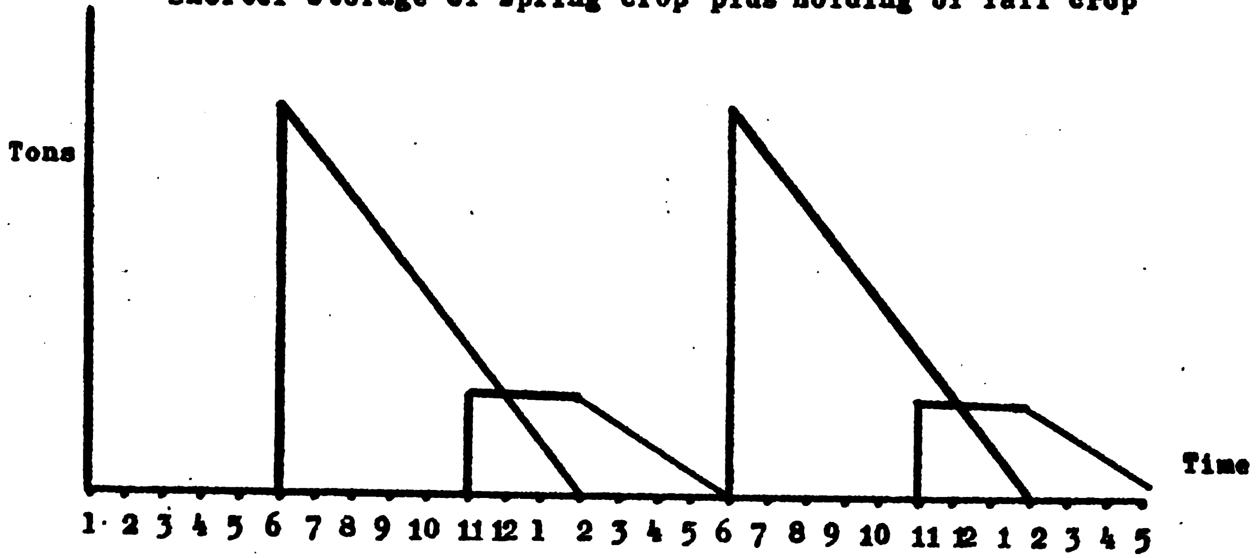
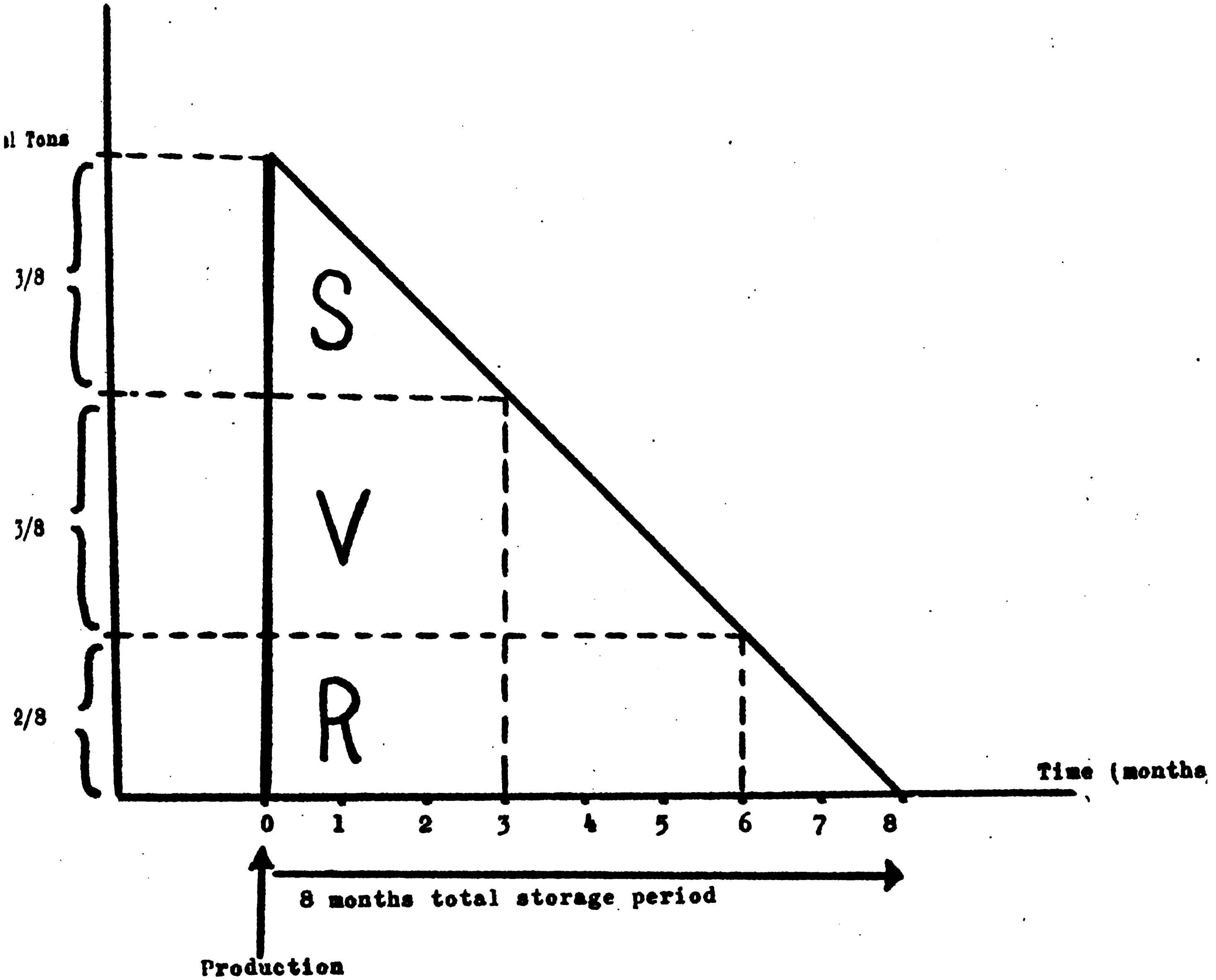


Figure 5.

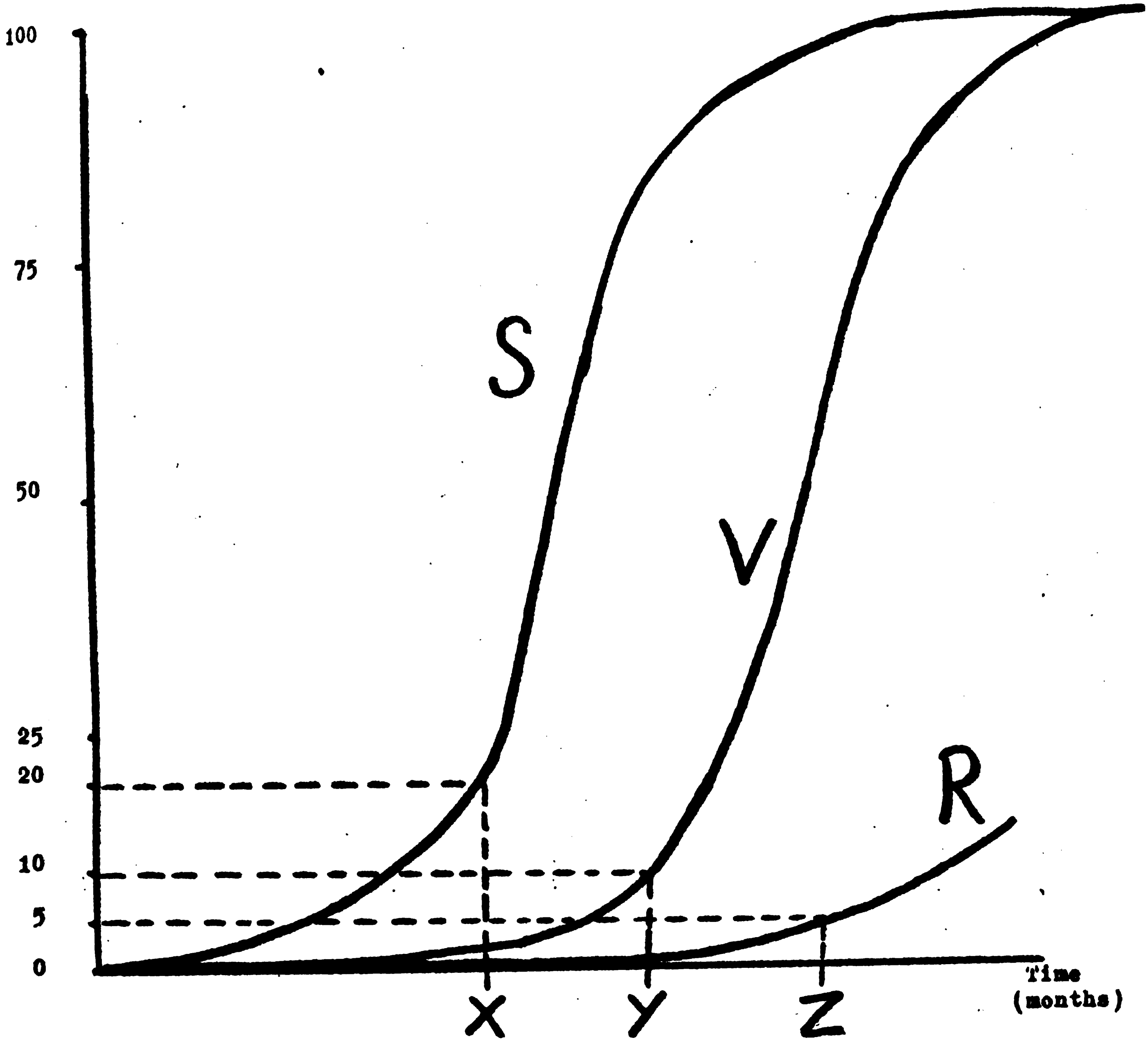
An example of an integrated storage system



S- Simple Stores, used for first 3 months
V- Ventilated Stores, used for up to six months but potatoes only made available in months 4,5, and 6
R- Refrigerated stores, used for up to eight months but potatoes only made available during final two months.

gure 6.

Examples of storage loss curves and their use in devising an integrated storage system



Within a given pricing system we may decide that

i. in Simple farm stores we can accept a 20% loss, therefore utilisable for X months

ii. in Ventilated stores we can accept 10% loss, therefore utilisable for Y months

iii. in expensive Refrigerated stores we can only accept 5% loss, therefore utilisable for Z mo-

DOCUMENT VI - M

TRANSFER OF POST-HARVEST TECHNOLOGIES TO SMALL FARMERS*

By:

Michael J. Moran

*Prepared for the Seminar on the Reduction of Post-Harvest Food Losses in the Caribbean and Central America. Santo Domingo, D. R. August 8-11, 1977.

TRANSFER OF POST HARVEST TECHNOLOGIES TO SMALL FARMERS*

INTRODUCTION

The post harvest system needs to be tailored to the needs of the people it serves. One of the key groups should be the small farmers. Identifying their problems is relatively simple. Understanding the reasons for these problems ~~are being resolved~~ and identifying workable ways to encourage farmers, technicians, private business and policy makers to start resolving them is more difficult. There is no simple "100 meter dash solution". The transfer of post harvest technologies is a process, not an event.

Professional development technicians and politicians are now paying increased attention to the problems of small farmers, realizing that a poverty environment only fosters malnutrition and weakens the entire social structure. Three main factors have reinforced the interest in programs to increase the small farmer's production and productivity thus giving him more purchasing power. These factors are:

- Most farms in Latin America and the Caribbean are operated as small holdings.[1/]
- Small farmers are major producers of food crops.
- Increasing evidence shows that small farmers can be as efficient per unit of capital investments as large units due to the intensity of labor inputs from the farm family.[2/]

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* Post harvest food loss here is viewed as an integral part of the agricultural and food marketing system. According to the National Academy of Sciences Post harvest is the time after separation from the medium of immediate growth or production of the food. It ends when the food enters the process of preparation for final consumption.

1/ For example, according to an analysis made by the National Bank of Mexico, 52 per cent of the 2,816,000 farm units in Mexico are classified as subsistence farms.

2/ See Peter Dorner and Donald Kanel, "The Economic Case for Land Reform", AID Spring Review, June, 1970.

The area concerned in this paper is the transfer of post harvest technologies to small farmers as part of the total rural development effort, with attention being called specifically to some of the related major policy implications and issues involved. Whatever arrangements are made for promoting the study and dissemination of information and technologies, a further problem to be seriously considered is the mechanism and policies by which technology is transfered to the small farm level.

THE SMALL FARMER AND POST HARVEST FOOD TECHNOLOGIES

The small farmer is typically identified as one of two main subsectors within the rural sector. The other, the large commercial farmer, has dominant access to land, capital markets, technology, government support services and fiscal incentives. The channels of this commercial subsector tend to modernize by capital intensive programs such as agroindustry complexes, large wholesale markets, supermarkets seeking vertical integration and modern storage facilities.

The small farmer is characterized as having limited access to productive services, technical assistance, income streams and political influence in his society. The composite of these variables restricts the size of his farm and his ability to influence the resource allocation process of goods and services in both the product and factor market. Governmental support is needed to help him break out of this low income and productivity equilibrium level.

There are many complicated reasons for this duality in the rural sector, such as the type of technological production and marketing packages being produced and delivered to the small farmers and the existing imperfections in the land and capital markets.

The job of improving the welfare of the small farmer through transfering technologies to reduce post harvest losses is very difficult. The prevailing production and distribution practices need to be studied and eveluated in order to determine

from analysis of field situations what innovations might yield the best economic results for the farmer, and what are the alternatives and their cost-benefits.

Overall, the small farmer at the first instance, does not appear to be a likely candidate to adopt innovations, assuming they can be made available and are appropriate, for he simply cannot afford to risk losses in crop production.

For example, a poor farmer who has been persuaded by a well-intentioned government extension agent to buy a small insecticide sprayer or a small scale on-farm storage facility must be convinced that it will bring in *significant* increased benefits in the short run. For it breaks down or proves to be non-competitive with existing traditional methods he will have not only lost his capital investment but also much of his confidence in new technology and in the "wisdom" of the extension agent.

David Hopper points out that if new technologies do add greatly to yield and the yield can provide a profit beyond the enhanced cost of the new methods, and if the farmer has access to the appropriate production factors he needs in order to apply these methods effectively, then "aggressive" innovations will follow. 3/

Recent thinking has suggested that the low adoption rates result from the new technology being *inappropriate* for small farm situations. According to Zandstra, Swanberg and Zulberti, "it may be erroneous to seek only to maximize production per hectare, and to consider that other production factors exist in unlimited quantities, and at fixed prices. Such an approach assumes that economic, social, cultural, and political infrastructure can and will automatically

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3/ Hopper, D. "The Development of Agriculture in Developing Countries", *Scientific American*, September 1976.

adjust to the requirements of the new technology. In practice this does not often occur".4/

More recently, an alternative approach has gained some acceptance, namely that of adjusting production and distribution technology to the social and economic system currently encountered in rural areas.5/ This approach has emérged as a result of the recognition that modern production and distribution may unfortunately increase the disparity in welfare levels between the commercial and non-commercial farmers rather than close the gap.6/

According to some experts, the labor intensive technology and performance of small units employing a combination of traditional and intermediate or appropriate technology generally compares favorably with large-scale units on the efficiency indicators, such as capital (outputs) yields per area of land.7/ Experience has shown that social or cultural acceptability is often a major factor in the success or failure of an innovation, but because it is so subjective and ill-defined there is a tendency to pursue the more "rational" criteria of engineering efficiency or economic viability.

4/ Zandstra, H. G., Swandberg, K. G. and Zulberti, C. A. Removing Constraints to Small Farm Production: The Caqueza Project, published by the International Development Research Center, Ottawa, Canada, 1976

5/ The following institutions are examples of this new approach towards low cost more labor intensive technology: ITDG (London), OECD (Paris), Brace Research (Quebec), VITA (Maryland), CENDES (Quito), CEMAT (Guatemala) and others in Ghana, India and U.S. and Europe.

6/ Araujo, J.E. Participative Technical Cooperation, paper prepared for the Conference on "New Approaches to Technical Assistance in Accelerating Agricultural Development", held in Munich, April 26-28, 1977

7/ Overseas Development Council/International Labor Organization. Employment, Growth and Basic Needs. 1977.

If new technology is to succeed it must be economically, technically and culturally "competitive" and possess an evolutionary capacity to keep on improving.[8/]

Gittinger points out that "intangibles" related to better life for rural people such as income distribution are real and reflect true values.[9/] However, they do not lend themselves well to evaluation, although an attempt is sometimes made. In many cases economic and financial analysis are viewed as an inappropriate tool to use for dealing with intangible effects.[10/]

STRATEGY CONSTRAINTS AND ITS REASONS

The change embodied in post harvest technologies together with the accompanying institutional and complementary inputs, may have a number of significant effects on the economy, specific regions, and specially the farmer and consumer. Changing technology creates new possibilities for some agricultural products, makes others obsolete effects markets, alters cost-price relationships, influences the amount and condition of employment and makes new non-agricultural industries feasible.

Most recent efforts in post harvest methods tend towards off-farm technologies such as bulk storage operated by the government in support of purchasing and selling, stabilization and or reserve programs.[11/] There appears to be a lack of attention for on-farm related post harvest technologies and the coordination and organization factors of the food system: Possibly because bulk storage methods are considered more effective in controling losses and more efficient from an economic standpoint.

8/ OECD: Appropriate Technology: Problems and Promises, edited by Nicolas Jequier Paris, 1976.

9/ Gittinger, P. Economic Analysis of Agricultural Projects, 1977

10/ Ibid.

11/ Kansas State University. Status of Grain Storage in Developing Countries. Special Report Nº 3. Revised July, 1975.

Some Latin American and Caribbean countries have made attempts to implement small farmer marketing and post harvest food loss program activities (i.e. Brazil, Colombia, Dominican Republic, Honduras, Costa Rica, Haiti, etc.) Recently a major seminar involving 14 Latin American and Caribbean countries was held by the Inter-American Institute of Agricultural Sciences (IICA) to discuss and analyze small farmer marketing strategies and related post harvest food losses.12/ Many of the post harvest food loss activities are "add on" to other agricultural integrated projects or food marketing improvement projects. According to one bibliography study on farm storage in developing countries, not much progress has been made between the early 1960's and the present as reflected in articles dealing with or calling for an improvement in on-farm storage methods.13/ Of particular importance is the need for economic research in this area. For example, improved drying and disinfestation methods at the farm level may be priority entry point in the post harvest system because the most important time to improve storage is at the beginning, for pest damage multiplies as the food passes through the food marketing system. Also, small farmers may have greater long-run potential than a completely integrated operation, especially in areas where there is significant land pressure. According to one major research report on Central America agribusiness management "as increasing concern is expressed at the political level regarding rural-income distribution problems, government credit and infrastructure may be heavily weighted towards such procurement practices", (refering to small farmers).14/

12/ IICA, Seminario Latinoamericano sobre Estrategias de Comercialización para el Desarrollo Rural, San Jose, Costa Rica, 25-28 de abril, 1977.

13/ Buckley, B. Farm Storage in Developing Countries: A Partially Annotated Bibliography, Agricultural and Rural Development Sector, World Bank, 1975

14/ Goldberg, R. Agribusiness Management for Developing Countries - Latin America, 1974

SOME MAJOR POLICY ISSUES

1. Political Committment and Professional Understanding

Government policy makers and professional developers jointly need to have a committment and understanding of the policy options and issues to be derived from a realistic and effective effort to increase food supplies. Both experience and research need to be adequately identified to assist the policy makers in appraising development implications of action programs. Otherwise, it is highly unlikely that the necessary political and institutional support will be obtained to assure the desire impact of post harvest food loss program on small farmers.

One key consideration is to recognize that the performance of the total food system can either enhance or limit the potential performance of the post harvest food subsystem. A great deal of effort and resources are presently being directed to engineering and technological problems. The socio-economic and cultural aspects and the coordination and organization activities are sometimes more important than the new "hardware" itself.

2. Resource Allocation

There exist resources within the countries and in international agencies, but how can they be brought to bear on this problem? There are many competing rural development programs and projects to affect the resource allocation process.

Most government institutions have tended to prefer direct forms of food marketing improvements, characterized by infrastructure build-up.

There has been a traditional physical facilities (off-farm) bias inherent in most development planning. Large investments have been made in these facilities by national and international agencies. One major research project concluded that "it is relatively easy to generate enthusiasm for a $50 million project to build a network of public owned-storage facilities, but hardly anyone is interested in a $2 million supervised credit and training program designed to improve managerial competence among marketing cooperatives and private intermediaries.[15/]

3. Integrated Effort

The needs and risk factors of the small farmer have to be resolved on a broad bases. Specific field projects are necessary, but the costs for improvements compared to market cost and other alternatives need to be considered. Also the cultural and social aspect is important.

4. Regional Cooperation

Technical contacts among individuals, developing countries and their institutions need to be promoted. Much duplication of activities may occur if there is no cooperation. Closer working relations with counterparts in neighboring countries may spread out the cost and accelerate the strengthening of national institutional capabilities.[16/]

15/ Harrison, K., Henley, D. Riley, H. and Schaffer, J. Improving food Marketing Systems in Developing Countries: Experiences from Latin America, LAMP/M.S.U., Research Report nº 6.

16/ An example of this would be the recently created food technology information service between Andean countries, Mexico and Central America, that will speed up communications among the different institutions should lower the cost of maitenance of such a system. See final Report, Grant Nº AID/ta-G-1238 LIFE-IFT, Nutrition Food Technology Study for Latin America, 1977.

5. Technical Cooperation

Many national and international agencies or institutions are providing technical cooperation to assist in the process of reducing post harvest food losses to small farmers. This is a long term process and continuity of the cooperation is vital. Few agencies may have the necessary committment and continuity to meet this task. (See list of institutions in Appendix).

6. National Institutional Strengthening

The institutions and organizations selected to improve food marketing and post harvest preservation are those involved in using their own resources and providing services plus coordinating and promoting both public and private sector efforts (e.g. Ministry of Agriculture - Extension and Credit, food technology institutes, marketing agencies, etc.) Strengthening these organizations entails 1) permanent adaptations of their objectives to the problem at hand and 2) better allocations of resources among different organizations and 3) improved coordination within the institutional system.

CONCLUDING COMMENTS

The problem of increasing income, food production and providing better nutrition on small farm holdings must be approached from a base of the existing farming system in terms of applying appropriate and practival post harvest technological innovations. This means direct association and discussion among agricultural professionals, technicians, change agents and the farmers, in order to:

1. Obtain information on the existing post harvest food system and understand the farming system.
2. Learn about the farmers priorities in his decision-making.
3. Determine innovations which might be helpful in improving his well-being given his present resources and knowledge base.
4. Implement collaborative on-farm testing of technology, which is likely to be adopted and
5. Improve problem identification of post harvest technologies which need supportive off-farm investigation.

The small farmer processes a store of knowledge related to the whole farm operation involving many activities and components which are fequently ignored, yet influenced innovations and modifications that have some impact on his welfare.

SUGGESTED ACTION PLAN

1. To develop and test methodologies for analyzing small farmer systems as they relate to post harvest technologies.
2. To identify and test with selected small farmers innovations or changes in present post harvest practices that might improve food supplies and net returns to the small farmer.
3. To assist in the training of interdisciplinary teams of agricultural professionals concerned with improving post harvest food technologies and its application on the small farmer. This would be part of a strategy to build national institutional capabilities in this field. An improved agricultural extension or technical assistance system is considered an essential element to transfer appropriate post harvest

technology to the small farmer. The system of training and visit[17/] has experienced some success in improving productivity of the small farmer using low-level technology and traditional methods.

4. To analize the efectiveness of different methodologies for working with small farmers and their impact on increased output and farmer welfare.

17/ Benor, D. and Harrison J.Q. Agricultural Extension: the training and visit system, World Bank, 1977

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PARTIAL LIST OF INSTITUTIONS OFFERING TECHNICAL ASSISTANCE, RESEARCH, TRAINING AND INFORMATION ON POST HARVEST LOSSES AND RELEVANT APPROPRIATE TECHNOLOGY

Inter-American Institute of Agricultural Sciences (IICA). Presently has one of the largest agricultural and food marketing technical cooperation programs in Latin America and the Caribbean. Recently started a permanent program of Post Harvest Food Losses. Currently has 14 full-time Senior Advisors located in 11 different countries.

IICA/PNCA (Programa Nacional de Capacitación Agropecuaria) offers courses in grain storage and conservation and grain silo. Also has generated a considerable amount of documentation of this subject matter.

Tropical Products Institute, London. Maintains a complete file of published articles concerning storage of cereals and export of tropical crops.

Kansas State University, Food and Grain Institute, USA. Carries out research, conducts training courses and responds to technical assistance inquiries. Also has published over 60 documents on food grain drying, storage, handling and transportation, including information on these functions in at least 13 Latin American and Caribbean countries. Drying technology concept is particularly good.

Food and Agriculture Organization (FAO). Has worked in marketing and post harvest losses for many years. Presently in the process of organizing a major effort in reducing post harvest losses.

International Development Research Center (IDRC), Canada. Conducts applied and adaptive research in cooperation with national institutions. Recently published David Spurgeon's Hidden Harvest a systems approach to post harvest technology.

League for International Food Education (L.I.F.E.) USA. One of their main functions is to sponsor, coordinate and provide information on post harvest losses. Recent efforts include a project entitled "Post Harvest Grain Losses: Development of an Assessment Methodology". Also a study just completed entitled "Nutrition Food Technology Study for Latin America with the Institute of Food Technologists (IFT).

Agency for International Development (AID). Has had extensive and varied activities in the post harvest food loss reduction area over the past ten years. Many of these activities are complimentary "add on" parts to other programs. Recently AID has contracted a full-time person to coordinate the post-harvest food loss reduction activities within the Agency.

IGAD/ALC (International Group for Agricultural Development in Latin America and the Caribbe). A coordinating and promoting group made up of international financing and technical organizations. Post harvest losses was identified as one of the major programs that it should concentrate on at the present time.

Canadian International Development Agency (CIDA). Has had varied activities in the post harvest food loss reduction area over the past years. Has recently expressed increased interest in this area.

World Bank. Currently supporting efforts of Professor Ricardo Amson, Instituto de Tecnología de Monterrey, in his studies on small farm grain storage in two micro regions in Mexico, and small farmer fruit and vegetable production and marketing project in six additional micro regions in Mexico.

National Academy of Sciences. Presently conducting a major research project world wide on post harvest food losses.

Inter-American Development Bank (IDB). The Inter-American Development Bank has had extensive project activities in the field of agricultural marketing and agri-business. Many of these activities have dealt with post harvest loss problems.

CIAT. This Center carries out research and training activities to develop skills in the development and delivery of technology at the national level. Emphasis is on new technology that is economically viable, socially acceptable and bioligically suitable under the conditions of low resource farmers.

DOCUMENT VI - N

ELEMENTS OF REGIONAL PROGRAM TO REDUCE POST-HARVEST FOOR LOSSES*

By:

Jerry La Gra

*Prepared for the Seminar on the Reduction of Post-Harvest Food Losses in the Caribbean and Central America. Santo Domingo, D. R. August 8-11, 1977.

TABLE OF CONTENT

Page

ELEMENTS OF A REGIONAL PROGRAM TO REDUCE POST-HARVEST FOOD LOSSES

I. INTRODUCTION

One of the objectives of the Seminar is to:

> Prepare the bases for a multi-national program for the preparation of national projects to reduce post-harvest food loses in countries of the Caribbean and Central America.

Here in the Dominican Republic we have been actively involved in a program to reduce post-harvest food losses in agricultural commodities for aproximately one year. In July of 1976 IICA contracted a consultant 1/ in food conservation to help organize a study of post-harvest food losses in perishable commodities in the Dominican Republic as part of the SEA/IICA 2/ Integrated Marketing Project. This consultant spent approximately 10 days in the Dominican Republic surveying the marketing system for potatoes and salad tomatoes, identifying key participants in the system, as well as possible causes for food losses. During the last day of this consultation an inter-institutional seminar was organized and technicians from key institutions, responsible for and interested in reducing post-harvest food losses, were invited. During this seminar, a procedure for studying and quantifying post harvest food losses in perishable crops in the Dominican Republic was outlined. At that point it became clear that there existed a basic need for a systematic methodology for identifying and quantifying post-harvest food losses and identifying, preparing and evaluating projects to reduce such losses. It also became clear that such a methodology did not exist, either in Latin America or the Caribbean. Immediately following the one day seminar, projects were prepared to quantify post-harvest losses in the case of potatoes and tomatoes. These two studies were carried out during the five month period, August to December 1976.

1/ Rafael Amézquita, food tecnologist from Colombia. As of January 1977, Mr. Amézquita was employed by IICA as specialist in the reduction of post-harvest food losses in the office in Mexico.

2/ Secretario de Estado de Agricultura (SEA)
Instituto Interamericano de Ciencias Agrícolas (IICA)

The results of these studies have been published as documents numbers 24 and 27 of the SEA/IICA marketing series and summarized at this Seminar. During these two studies, the original methodology was applied, evaluated and refined. In January of 1977, technicians from the Instituto Superior de Agricultura (ISA) expressed considerable interest in carrying out similar studies on other commodities. An agreement was reached between ISA and SEA, whereby the SEA/IICA Integrated Marketing Project would finance the operating costs of the study of post-harvest losses of yuca (casava). Simultaneously with the realization of these three studies, INESPRE 1/ was carrying out studies of its own, in the cases of post-harvest losses of potatoes, onions and garlic. Some of these studies organized or supervised by INESPRE have also been summarized during this Seminar. They have been unique in that the basic research has been undertaken by university students, supervised by university professors and INESPRE technicians.

We can summarize these esperiences by saying that in a period of only one year considerable effort has been applied in post-harvest food losses research in the Dominican Republic and that these efforts have resulted in the preparation and testing of a basic methodology which has proven to be simple, practical and valuable in identifying and preparing projects to reduce post-harvest food losses. An interesting point is that these efforts have been carried out with basically local available resources and at a very reduced cost.

The success of this program can be traced directly to the following elements:

1) Institutional interest in reducing food losses.
2) Existance of a few well trained experts in diverse post-harvest problem areas.
3) The availability of minimal financial assistance, and
4) The communication of experiences and methodologies from other countries.

1/ Instituto Nacional de Estabilización de Precios.

4.2 Basic Objectives

The basic objectives of a Regional Program to reduce post-harvest food losses would be the following:

1) Standardize the methodology used for quantifying post-harvest food losses and identifying and preparing projects to reduce losses.
2) Facilitate the exchange of experiences and information.
3) Facilitate the identification of sources of financing for specific projects.
4) Optimize the use of available human and financial resources.

The basic objective of a Regional Program at the country level, would be:

1) Train local technicians in the methodology for preparing integrated projects to reduce food losses.
2) Define programs and projects on a product basis which would reduce food losses and improve conditions at the farm level, especially for the small scale producer.

V. ESTIMATED COSTS OF A REGIONAL PROGRAM (one year)

5.1 Costs for one country

Assuming that little basic information is available on the products to be studied, thus requiring preliminary studies of the marketing systems, the costs will be substantially higher than was the case in the Dominican Republic. It is estimated that three products can be studied during a one year period at an approximate cost of $16,000 per product or $48,000 for the three products. In addition, approximately $10,000 should be added to this amount for the purchase of one all weather vehicle. Total costs to implement three programs to reduce post-harvest losses for three products, following the methodology proposed by IICA in this seminar, would be approximately $58,000 per country.

5.2 Costs for a Regional Program

The estimated costs to implement a Regional program to reduce post-harvest losses in the Caribbean and Central America, are summarized in Table 1. These costs assume the implementation of activities to reduce losses in 10 countries, the creation of a Regional technical assistance team and supervision by an international organization.

Table 1: Estimated costs to implement a Regional Program to Reduce Post Harvest Food Losses in TEN countries of the Caribbean and Central America.

TYPE COST	Local Currency (equivalent US$)	Dollar Costs USA	Total Costs
1. Implementation of three Programs each in ten countries $58.00/country	480,000	100,000	580,000
2. Travel expenses members technical assistance team* (30 visits $ 500)	-	15,000	15,000
3. Travel expenses supervisory group (60 visits $500)	-	30,000	30,000
4. Publication basic methodology (English, Spanish, French)	-	15,000	15,000
5. Overhead, Administration	-	25,000	25,000
6. Second International Seminar**	-	30,000	30,000
Total	480,000	215,000	695,000

* Teams include specialists from ten participation countries.

** At end of one year period.

5.3 Benefits of a Regional Program [1/]

The benefits of a Regional Program as outlined above would include the following:

1. Maximun utilization of existing national specialists.

2. Identification of pratical low cost projects which will allow an effective transfer of post harvest technology to the farm level (particularly the small scale farmers).

3. Identification and preparation of projects at relatively low costs.

4. Create conditions which will facilitate inter-institutional coordination.

5. Facilitate international communication of information and experiences.

5.4 Necessary steps in the implementation of a Regional Program.

1. Take decision at this Seminar that a REGIONAL PROGRAM to reduce Post-harvest Food Losses is possible and desirable.

2. Appoint a coordinating group to prepare final project proposal and seek financing.

3. Promote and obtain financing.

4. Select technical assistance team (members from each participating country).

5. Initiate one week workshops in each participating country to define application of proposed methodology.

1/ It is felt that bilateral activities to reduce post-harvest food losses would be much less effective.

6. Implement programs in each country which will result in the preparation of feasible bankable projects to reduce Post Harvest Food Losses.

7. Realize a second seminar such as this one to analyse and evaluate results of program in each country.