

## Chapter 2

# Preserving Food After Harvest is an Integral Component of Food Security

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### 2.1 Introduction

The projections of increasing world population for the next 40 years and possible reductions in agricultural productivity because of climate change, water shortages, and other factors have propelled food security into the forefront of concern on the world stage. The first step in these discussions is to define exactly what is meant by the term “Food Security.”

The Food and Agriculture Organization (FAO) of the United Nations definition is: “Food security exists when all people, at all times, have access to sufficient, safe, and nutritious food to meet their dietary needs and food preferences for an active and healthy life” (FAO 1996).

The United States Department of Agriculture gives a more detailed definition as follows: “Food security for a household means access by all members at all times to enough food for an active, healthy life. Food security includes as a minimum (1) the ready availability of nutritionally adequate and safe food, and (2) an assured ability to acquire acceptable foods in socially acceptable ways (that is, without resorting to emergency food supplies, scavenging, stealing, or other coping strategies)” (USDA 2014).

Hundreds of millions of people do not have security as defined above and the number will increase in the future unless major investments are made to improve the situation. The major causes of food insecurity are:

1. Poverty
2. Losses in seasonal crops after harvest
3. Population and Urbanization—distance and time from farm to fork becomes longer

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M.C. Bourne (Deceased)

4. Disasters—floods, drought, pests that lower productivity
5. Health—sick people cannot work hard
6. Wars and Conflicts
7. Gender Inequity

Item number 2 in the above list—losses in seasonal crops after harvest—is the sector in which food technologists have the knowledge to make a major contribution to resolving the problem of food insecurity. The International Union of Food Science and Technology (IUFoST) at the 15th World Food Congress held in Cape Town in August 2010 explained the situation in the following words: “We accept that the problem of food insecurity has huge political and economic dimensions and will not be solved by food science and technology alone or even by science alone; but it will certainly not be solved without the contribution of science and of food science and technology” (IUFoST Cape Town Declaration 2010). Food technology is a central component but not the only component in resolving the problem of food insecurity.

## 2.2 Role of Food Technology

Food technology has two main branches:

1. **PRESERVATION TECHNOLOGIES** stabilize, safeguard, and maintain the harvest from land and sea in a condition suitable and safe for human consumption. Examples for foods that spoil quickly are drying, canning, refrigeration, freezing, and preservatives. For stable foods such as cereal grains, the main preservation technology is adequate drying to prevent mold growth. Control of insects and designing storage structures that prevent entry by rats, mice, and other vertebrate pests are also important technologies for stable foods.

This is the sector where food technology can make a large contribution to reducing food insecurity. Huge quantities of food already harvested are not eaten because the food is lost or becomes inedible. The causes of the postharvest losses are well known. Technologies to prevent the spoilage vectors are also well known in the food science community.

The causes of food losses depend on the type of food and are summarized below:

CEREALS—fungi, insects, vertebrates, poor milling

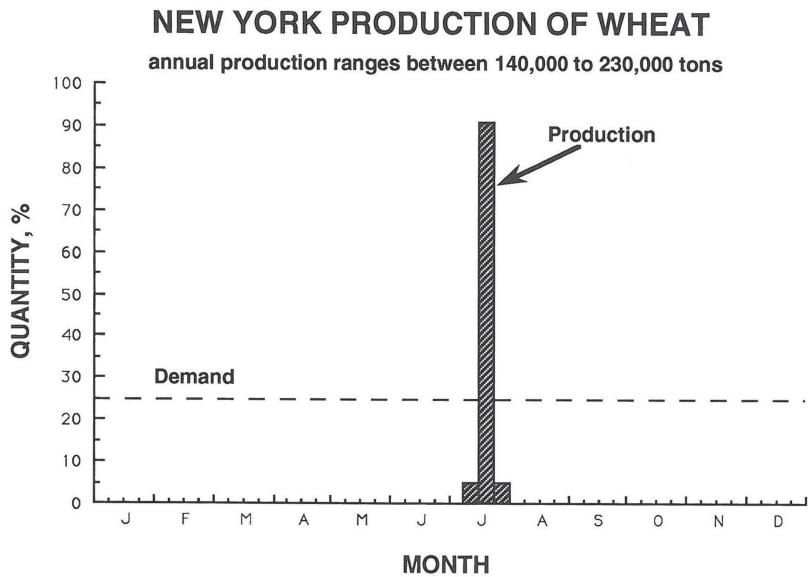
FRUITS and VEGETABLES—bruising, rotting, senescence, wilting

ROOTS and TUBERS—bruising, rotting, senescence, wilting, sprouting, insects

MEAT, MILK, POULTRY, FISH—growth of microbes

DRY FISH—fungi, insects

2. **PROCESSING TECHNOLOGIES** convert edible food materials into another form with higher acceptability. People prefer to eat bread, spaghetti, cake, and many other delicious items rather than grains of wheat. They prefer to drink beer



**Fig. 2.1** Production of wheat in New York State. A year’s supply is harvested within 3 weeks and most of it in 1 week

rather than eat barley grains. They prefer tough cuts of meat to be converted into some kind of sausage. They like foods that have been processed to give a crispy texture and blends of ingredients that create creamy sauces.

Because of economic forces food science departments in developed countries put great emphasis on food processing technologies. Preservation technologies are well covered for highly perishable foods such as milk and meat, but stable commodities such as cereal grains get less coverage even though the technologies to control fungi, insects, and vertebrates are well known.

**2.2.1 Seasonal Crops**

Within a given region the daily demand for food is constant over the course of a year, but the supply of food for that region is very uneven throughout the year. Food preservation, storage, and transportation are the mechanisms humankind uses to match the very uneven day-to-day supply of food with the even day-to-day demand for food. Matching the uneven food supply to the even demand is a problem the human race has had to face ever since the dawn of agriculture.

The nature of the problem is illustrated in Fig. 2.1 which shows the production of wheat in New York State for each month of the year. The farms in New York produce no wheat from January to June or from August to December. All the wheat is harvested in the month of July as shown by the vertical bar. In fact, 90 % of the

wheat is harvested in 1 week, usually the third week of July. However, the demand for bread, macaroni, donuts, and all the other nice foods made from wheat is very uniform throughout the year as shown by the dashed line parallel to the horizontal axis of Fig. 2.1.

Most of the world food supply is seasonal—cereals, legumes, fruits, vegetables, roots, and tubers produce a large crop over a short period of time and then nothing until the next crop matures. The time of year when the harvest is ready can be any month of the year depending on the climate and nature of the crop, but the pattern of a large harvest followed by a period of no harvest is the common feature. In some locations where climate and water supply permit there is more than one harvest per year. In those cases there are two or more peaks of production with nothing in between.

Foods from domestic animals are not seasonal. With good management the time of harvest can be controlled to become uniform throughout the year. Milk and eggs can be harvested daily. Animals and birds can be kept alive and slaughtered as needed. Some fish harvests are seasonal because wild fish cannot be managed like domestic animals.

Of the many factors that affect food security, one that is often overlooked is the need to prevent spoilage of food between the time it is harvested and the time it is consumed. This time can range from 1 day for highly perishable foods such as milk and meat to several years for stable crops such as cereal grains.

Many activities are required to convert mature agricultural products in the field into a form suitable for human consumption and to deliver it to the meal table in an acceptable form. There are many opportunities for food to be lost between harvest and consumption. These are known as *POSTHARVEST FOOD LOSSES*; they represent a loss of valuable nutrients and money, especially in developing countries where many are already undernourished and poor. Food must not only be produced, it must be delivered to the ultimate consumer in an acceptable form if it is to fulfill its nutritional destiny (Bourne 1984). It must also be fit to eat and safe to eat when mealtime comes.

## 2.3 Historical Development

How attention to reduction of food losses as an essential component of food security developed will now be discussed in three parts: (1) before 1975, (2) 1975–2010, and (3) 2011 and into the future.

### 2.3.1 Before 1975

The Tropical Products Institute founded in London in 1896 always had a strong interest in preservation and quality of foods in the colonies of the British Empire. It was renamed Natural Resources Institute in 1990 and moved from London to Greenwich

and is still a leading player in food security issues. Their library is probably the greatest single resource of knowledge on this subject.

The Food and Agriculture Organization (FAO) of the United Nations was founded in 1945 and has devoted much attention to food security issues. Its headquarters are in Rome and there are regional offices on every continent.

In the United States, the International Development Assistance Program, which began in 1950 during the Truman Administration, had food security as one of its high-priority objectives. The name was changed to United States Agency for International Development (USAID) in 1961 during the Kennedy Administration.

A number of other institutions, both public and private, established since 1960 have had food security as one of their major areas of interest. Reduction of postharvest losses of food, with emphasis on losses in developing countries where malnutrition and hunger are high has often been on their action agenda. However, most of these programs were sporadic and short-lived because they depended on the foresight and enthusiasm of one or two people on location in a developing country who saw the shocking rate of spoilage in food already harvested. The programs usually expired after the initiators of these programs completed their assignments and returned to their homeland. This piece-meal, localized approach occurred without much recognition at high policy levels.

### ***2.3.2 1975–2010***

The situation changed dramatically in September 1975 when the United Nations General Assembly meeting in New York passed the following resolution: “The further reduction of postharvest losses in developing countries should be undertaken as a matter of priority, with a view to reaching at least 50 % reduction by 1985. All countries and competent international organizations should cooperate financially and technically in the effort to achieve this objective.”

This resolution drew the attention of the highest levels of governments and donor organizations around the world to the problem of food losses and the contribution that reducing these losses can make to the improvement of the nutritional status of the poor. The resolution is realistic; it recognizes that food losses will never be reduced to zero but calls for efforts to reduce sharply the high levels of loss that presently occur. Note the focus on improving the food supply in developing countries at the highest policy level.

A result of the 1975 UN resolution was that many governments and other agencies made it a POLICY to include a postharvest food loss component in their foreign aid programs. The US Agency for International Development (USAID) initiated a number of programs including commissioning a report from the US National Academy of Sciences. This report was the standard reference in the field for many years and is still a valuable resource.

Governments in the European Union, Japan, Canada, and Australia, and a number of nongovernment organizations also initiated postharvest food loss programs.

**Table 2.1** Postharvest losses in the Philippines before the 1975 United Nations Resolution and 20 years later

	1974 (%)	1994 (%)
Range	10–37	11–32
Average	23.5	14.8

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FAO expanded its efforts in postharvest loss reduction. Many good programs were put in place, and substantial reductions in food losses were achieved in some developing countries.

One example is shown in Table 2.1. Postharvest losses of rice in the Philippines averaged 23.5 % in 1974. Thanks to the effort of many this figure fell to 14.8 % by 1994—a 37 % reduction from the 1974 figure. The efforts did not reach the goal of 50 % reduction called for by the UN resolution, but substantial progress was made.

### 2.3.2.1 Publications

A number of publications were produced that describe the problem and became a valuable resource to organizations planning a postharvest program. Some of the most notable are:

1. M. C. Bourne 1977 “Postharvest Food Losses—The Neglected Dimension in Increasing the World Food Supply” Cornell International Agriculture Mimeograph, No. 53, 69 pages. It is now available free online at: <http://ecommons.library.cornell.edu/handle/1813/28900>
2. US National Academy of Sciences 1978 “Postharvest Food Losses in Developing Countries,” 199 pages. The Academy also published a 350 page bibliography on postharvest food losses comprising approximately 2100 entries. This is the most complete compilation of literature up to 1978.
3. Food and Agriculture Organization 1981, “Food Loss Prevention in Perishable Crops”, 72 pages, FAO Agricultural Services Bulletin 43. This publication is the result of an expert consultation jointly organized by FAO and the United Nations Environment Program. It describes the importance of fruits, vegetables, roots, and tubers, the technologies that prolong shelf life and gives 14 recommendations for policy makers, planners, development corporations, and potential investors in developing countries.
4. United Nations Environment Programme 1983, Industry and Environment Guideline Series “Guidelines for Postharvest Food Loss Reduction Activities,” 47 pages. The Guidelines synthesized information and experiences in a concise form as an aid to policy formulation. It includes an appendix that lists 12 international organizations and 55 national organizations in 31 countries that have active programs in food loss reduction. Published by UNEP Industry and Environment Office, Paris.

5. US National Academy of Sciences and China State Science and Technology Commission, "Postharvest Food Losses in Fruits and Vegetables," 1986, 188 pages. Published by National Academy Press, Washington, D.C.

The above are a sampling of the most influential documents resulting from the 1975 United Nations Resolution. There are many more including some in languages other than English.

### **2.3.2.2 Education**

A number of programs to train people on the causes of postharvest losses and the technologies available to prevent these losses were put in place in many countries.

In 1977, Cornell University instituted the course Food Science 447 "International Postharvest Food Systems." This interdisciplinary course described the causes of postharvest food losses and methods available to reduce the losses. It was designed for all seniors and graduate students who were interested in storage and preservation technologies for unprocessed or minimally processed food commodities (cereals, dry legumes, roots, tubers, vegetables, fruit, fish) in the U.S. and overseas. The course was of special interest to students who had worked in, or planned to work in developing countries. This course was offered for 25 years.

## **2.4 2010 and the Future**

More than 35 years have passed since that 1975 UN Resolution was adopted. The scientists who carried out those postharvest activities in the field have retired as have the policy makers of that generation. Most of the excellent programs of the late 1970s and 1980s have expired and not been renewed. Policy has moved away from the initial focus on preserving raw agricultural commodities to include all activities from harvest to consumption with greater attention given to processing technologies that convert raw products into foods ready to eat. The programs that are still active have generally shifted emphasis from reducing losses to improving the quality and safety of foods exported from developing countries to developed countries. It seems that postharvest has fallen from the policy agenda of most governments and donor agencies.

An International Congress entitled "SAVE FOOD" was organized by the Food and Agriculture Organization, May 16–17, 2011, at the International Packaging Industry Fair Interpack 2011 in Düsseldorf, Germany and the proceedings published by FAO with the title "Global Food Losses and Food Waste." It is based on studies carried out by the Swedish Institute for Food and Biotechnology (SIK) at the request of FAO. The study highlights the losses occurring along the entire food chain, identifies causes of food losses and possible ways of preventing them. Considerable data on losses from agricultural production, postharvest handling and storage, processing and packaging, to distribution and consumption are given.

**Table 2.2** Comparison of United Nations 1975 resolution and the Food and Agriculture Organization Congress 2011 report

UN 1975	FAO 2011
Postharvest food loss	Food loss and waste
Developing countries	Developed and developing countries
Motivation	Motivation
1. Improve nutrition of poor	1. Reduce stress on environment
Seasonal crops (cereals, roots, tubers, vegetables, fruits, fish)	2. Improve nutrition of poor
	All foods (meat, poultry, fruits, vegetables, fish, roots, tubers, cereals, oilseeds, dairy)

It is noteworthy that “food waste” was added to the established phrase “food loss.” The differences between the 1975 UN resolution and the 2011 FAO report are summarized in Table 2.2. The major changes are that great attention is now given to reducing waste, especially in developed countries, that all foods get attention, and the main motivation is to reduce stress on the environment.

The major causes of food waste are:

1. Demand for perfect appearance and convenience.
2. People in developed countries can afford to discard food because it is abundant and low in cost relative to income.
3. Production exceeds demand.
4. Food is unsafe or suspected of being unsafe.

These causes are completely different from the causes of food losses shown in Sect. 2.2, point 1. Unlike food loss reduction technologies where food science has the major role, reducing waste requires modification of human behavior, an area in which food scientists have no expertise except for item No. 4, food safety.

Also, the emphasis has moved from staple seasonal crops such as cereals to foods of animal origin. A rough comparison of this change is shown in Table 2.3 where the number of references cited in the 2011 FAO report is compared with the number of pages devoted to each food in the 1978 National Academy of Science report as mentioned in Sect. 2.3.2.1. Although this is an “apples versus oranges” type of comparison it clearly demonstrates the change in emphasis between 1975 and 2011.

Extensive tables in the 2011 FAO report show that the highest food *losses* occur in developing countries and the highest food *waste* in developed countries. Food waste is low in developing countries and food losses are low in developed countries. This is demonstrated in Table 2.4, which summarizes extensive data prepared by SIK and published in the FAO report.

While we need to reduce food waste in rich countries, we must not forget the hundreds of millions who are malnourished and poor. In October 2012 FAO reported that 868 million people are hungry, that is 12.5 % of the world’s population. The mortality and morbidity rates are still very high in LDCs and stunted growth is considered normal.



**Table 2.3** Comparison of commodity emphasis between 2011 Food and Agriculture Organization Congress and 1978 National Academy of Sciences report

	Number of references in 2011 FAO report	Number of pages in 1978 NAS report
Meat and poultry	30	0
Fish	16	17
Dairy	3	0
Cereals	6	60
Fruits, vegetables, roots, tubers	31	27
Oilseeds	2	0
Unclassifiable	38	

**Table 2.4** Summary of food loss and waste from Food and Agriculture Organization Congress 2011

	Postharvest and storage (%)	Distribution (%)	Consumption (%)
Europe and Russia	4–9	2–10	17–25
N. America and Australia	2–10	2–12	27–30
S and SE Asia	7–19	2–11	1–7
Sub-Saharan Africa	8–18	2–17	1–5

Figure 2.2 shows the tragedy of severe malnourishment, a 30-month-old girl who weighs 5.5 kg. Note the skinny legs and arms, distended abdomen, and lethargy. There are still many thousands of children such as this who die every year.

A more serious problem of malnourishment is the stunted growth that results from insufficient food. Figure 2.3 shows two boys the same age. The boy on the left grew up in a developed country and weighs 33.6 kg (74 lb), while the boy on the right weighs 25.4 kg (56 lb) and is not as tall as the boy on the left. There are many millions of people like this whose stunted growth affects their whole life span.

How did that 1975 UN Resolution (shown in Sect. 2.3.2) that resulted in many postharvest loss reduction activities, come to be passed?

The answer is that the US Secretary of State, Dr. Henry Kissinger, in an address presented at the 7th special session of the United Nations General Assembly on September 1, 1975 in New York said, “Another priority in the poorest countries must be to reduce the tragic waste of losses after harvest from inadequate storage, transportation, and pest control. There are often simple and inexpensive techniques to resolve these problems. Investment in such areas as better storage and pesticides can have a rapid and substantial impact on the world’s food supply; indeed, the savings could match the total of the food aid being given around the world. Therefore, we urge that the Food and Agriculture Organization, in conjunction with the UN Development Program and the World Bank, set a goal of cutting in half these post-harvest losses by 1985, and develop a comprehensive program to this end.”

The resources allocated to postharvest food loss reduction from the mid-1970s to 1990s were a direct result of the speech Dr. Kissinger made to the United Nations

**Fig. 2.2** A 30-month-old child suffering from severe malnutrition (Photo from M. C. Bourne file)



**Fig. 2.3** Height and weight of a boy who grew up in a developed country (LHS) is significantly greater than for a boy of the same age who grew up in a developing country (RHS) (Photo from M. C. Bourne file)



General Assembly in 1975. Significant resources for postharvest food loss reduction in 2012 and forward are unlikely to be assigned until they become government policy again. I fear that resources devoted to improve the nutritional status of the poorest who suffer the most from food insecurity will not increase until postharvest food loss reduction becomes a high-priority issue for world leaders again.

Where do we find a prominent person who will make a similar speech to the one made by Dr. Kissinger to the United Nations or a similar prestigious organization that will trigger the allocation of significant resources by governments and donor organizations to reducing postharvest food losses in developing countries? Efforts to increase food security will be crippled unless a postharvest component is included in the programs.

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