A METHODOLOGICAL BASIS FOR THE EVALUATION OF MARKETING LOSSES OF FOODS IN DEVELOPING COUNTRIES

By Carlos A. da Silva

A Plan B Paper

Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of

MASTER OF SCIENCE

Department of Agricultural Economics

Winter 1979

Dedicated to

Arthur A. da Silva (in memoriam)
and
Dulce B. da Silva

ACKNOWLEDGEMENTS

I wish to express my most sincere appreciation to the members of my guidance committee: Dr. Darrell Fienup, my major professor, and Dr. Michael Weber, for their support throughout my program of studies and for their comments and suggestions in the preparation of this paper. Thanks are also due to Dr. John Allen for his participation in my examining committee and for his helpful review of this work.

I should also acknowledge the financial support provided by the Brazilian Ministry of Education, through the PEAS program, and by the Federal University of Vicosa (UFV), through its Department of Food Technology.

Finally, I wish to specially thank Dr. Adao Pinheiro, former PEAS coordinator at UFV, and Dr. Manoel Diaz, former MSU consultant at UFV, for their efforts in demonstrating the relevance of the study of Food Marketing. Without their support, it would have been impossible for me to pursue my educational goals.

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued . . .)

I. INTRODUCTION AND PROBLEM SETTING

The shortage of food for a substantial proportion of the world's population is a problem which has been challenging our society for a long time. In the 1972-1974 period an estimated 1.3 billion people subsisted in less developed countries with dietary energy supplies under the minimum nutritional requirements, and the current outlook is for a widening gap between needs and food supplies (22).

Although progress has been made in production oriented research, such as the development of high yielding crop varieties and of better ways to control pests and diseases, there is still a need for additional means to increase the world food supply.

Bourne (10), pointed out that one of the dimensions for providing more food to the ultimate consumer has been largely overlooked. Production oriented research has dominated the literature concerned with the world food problem, while marketing aspects have been given very little attention.

The task of providing more food is not completed at the moment of harvest. Food has to be moved through the various stages of the marketing chain until the household is reached, and each of the many functions involved in food

marketing is a potential area for losses.

Post harvest food losses can account for sizeable reductions in food availability, and ways to minimize these losses have now become a major issue among researchers and institutions concerned with this problem area.

Accurate assessments of the magnitude of losses in food marketing systems are not available for most commodity groups, but there is a consensus that the amount lost is substantial. Based on a variety of sources, the FAO estimated that "for food grains, the overall losses are probably in the range of 10 percent to 20 percent, for semi-durable root crops probably somewhat higher." (21) Other sources present different ranges of estimate, depending on product, causes, areas and other pertinent factors (3,7,10,11,12,14,15,16,17,31,36,40,41,42,45,46,61,62,63,65, 67).

Reduction of food losses is an area with great potential for increasing food availability. It is estimated that a reduction of grain losses by 50% would provide enough food for an additional 500 million people (21,15). Considering that losses are also substantial for other food products, the relevance of their minimization can easily be felt.

Despite the growing interest in the problem, corrective action has been precluded to a great extent by

the virtual nonexistence of information on the nature and extent of food losses in developing countries. The need for a workable approach to the generation of such relevant data is therefore recognized as a major prerequisite to effectively design loss minimization programs.

Objectives

The objectives of this paper are as follows:

- To define the problem and its relevance for developing countries.
- To identify the current lines of research in the problem area.
- To review the relevant literature on the methodological aspects of loss assessment studies.
- To outline the basic elements to be considered in the design of food loss assessment surveys as an initial step in the establishment of loss reduction programs.

Basic Concepts

Many authors concur that one of the key reasons for the diversity of estimates in regard to the magnitude of food losses in marketing systems is the diversity of concepts and procedures adopted in the literature (4,10,17). Hence, it is important to precisely define the terms and concepts involved in this paper.

A "loss" will encompass any modification in the characteristics of food products so that their edibility

or wholesomeness is reduced or the products turn unfit for human consumption.

The term "post harvest food losses" will be used interchangeably with "food losses in marketing systems." Losses occurring from the completion of harvest until the moment in which the consumer takes possession of the food product are considered post harvest food losses. Some authors also consider losses at the household as an integral part of the problem (14,63,67), but for the purposes of this paper, those will be considered as "consumer losses" and are not included in our definition.

Classifications by type and cause of losses, have also been attempted in the literature (4,10,57). Of relevance for this work are 1) physical or quantitative losses, which refer to changes in weight or volume of foodstuffs, and 2) qualitative losses, which are related to the downgrading of the products considered and the associated effects on their economic value. Losses in the nutritional value of food products will not be appraised separately, given the complexity involved in measurements and the fact that they can be regarded as a product of both quality and quantity losses (15). A classification by cause is not appropriate at this stage, for it would be difficult to provide an all encompassing generalization. As will be seen later in this report, such a classification scheme is usually done at advanced stages in the research process.

II. THE RELEVANCE OF THE PROBLEM FOR DEVELOPING COUNTRIES

"The power of population is indefinitely greater than the power in the earth to provide a subsistance for man"

Thomas Malthus, 1798

When Malthus wrote his "Essay on the principle of population", the world's population was still below the one billion mark. Life expectancy at birth was about 40 years and the population growth rate was approximately .5% (39).

From the end of the 18th century to now, the world has four times as many people, life expectancy increased to 55 years and the population growth rate has gone up to 2.8% (32,39).

The pessimistic predictions of Malthus did not materialize as expected, given factors such as wars, pests, and other causes of population reduction. On the other hand technological advancements in food production and preservation, as well as the developments in international trade, further contributed to the amelioration of the international food situation.

Nevertheless, there are still large portions of the world population which are not adequately fed. The average figure provided in the preceding section may be misleading, given that no allowances were made for the uneven distribution

of resources in the countries used in the estimation. If these imbalances are accounted for, as much as 70% of the world's population will be found to subsist under inadequate levels of energy and protein intake (32,39).

The developing world is the most affected by the problems of famine and malnutrition. Even though improvements in population planning and food production programs have been goals in virtually all development plans, per capita food production in these countries has risen at an average of only .3 percent over the past two decades (15, 22).

Developing countries have for centuries depended on the traditional means of increasing food output through expansions in the area farmed. Rapidly growing populations and shrinking potential land area for agricultural uses, have now forced a quest for alternatives to increase their food supplies.

Even though technology may be available, capital shortages often preclude using high yielding crop varieties, fertilizers and other improved agricultural inputs on a large-scale basis. Furthermore, use of capital intensive food production technologies is often associated with high social costs.

Along with the problems in food production, developing societies are ironically facing the adverse consequences of the development thrust in marketing the scarce food resources available. As industrialization takes place,

rural exodus contributes to the proliferation of heavily populated urban areas, with all the associated infrastructural problems. Once relatively simple food marketing systems must be transformed into a complex body of activities and functions, to which the existing structure is not able to rapidly adjust. Transportation distances increase, intermediate stages are introduced and the task of coordination becomes extremely complex. The overall performance of these systems is often inadequate, with shortcomings ranging from excessive marketing costs to high levels of losses.

Food losses in marketing systems constitute a problem which contributes to even further imbalances between food needs and availability. Although not directly comparable, the estimates presented in Table 1 can give an idea of the magnitude of the problem in developing countries.

These estimates are just a small sample of the vast amount of food resources which are continuously wasted. It is known that food losses occur at all levels in the marketing chain for virtually all food products in a worldwide basis.

The monetary value of such losses is substantial. In India, for instance, the total loss of foods in 1974 represented a net loss of more than U.S.$1 billion at market prices, while in Tanzania corn losses alone in the 1974/75 period were responsible for additional imports totalling

TABLE 1. Estimates of marketing losses for selected food products

Product	Country	% of weight losses	Source
Grains	India	9.33	(36)
"	Trinidad	25 to 40	(4)
"	Brazil	15 to 20	(31)
Maize	Zambia	8 to 10	(3)
"	Tanzania	20 to 100	(17)
"	Brazil	15 to 40	(17)
Potato	Dom. Republic	1 to 50	(40)
Rice	Philippines	10 to 37	(10)
"	India	12	(31)
"	Sri Lanka	13.4 to 40	(17)
"	Bolivia	16	(17)
Sorghum	Rwanda	10 to 20	(17)
"	Sudan	6 to 20	(17)
"	Indonesia	4	(17)
Tomatoes	Guyana	15	(42)
"	Dom. Republic	14	(41)
Meat Prods.	Rwanda	.2 to 13	(17)
"	Philippines	5 to 20	(17)
"	Chile	50	(17)

U.S. $20 million (15). Durable commodities losses accounted for a decrease of 9 percent in the 1969 gross national product of Rwanda, and in Pakistan these losses amounted to a staggering U.S. $160.4 million (17).

Obviously, the economic implications of food losses are not restricted to a purely monetary dimension. The

following analysis of these effects in other major variables will better demonstrate the relevance of reduction of food losses in the developing world.

Benefits of food loss reduction

Any benefit stemming from a program of increases in food production will be largely offset by the losses in the marketing chain. In fact, an increase in food output has to be greater than proportional to a decrease in losses, if the same final results are to be achieved. To illustrate, the following formulation is proposed: If Q_t is the total amount of food produced, the total available for the ultimate consumer will be given by the expression $Q_t(1-i)$, where i is the percentage lost in the system. If Qt is to reach the consumer through an increase in production, the percentage increase j will have to be such that $Qt(1+j)(1-i)=Qt$. Hence:

$$(1+j)\ (1-i) = 1 \text{ and}$$

$$j = \frac{1}{1-i} - 1 \qquad (a)$$

From (a) we can infer that for any level of losses "i"; the offsetting increase in production "j" is necessarily greater. As an example, a 20% level of losses will require an increase in production of 25% to offset the amount lost.[1]

The above relationship is one of the many reasons why the concern with reduction of food losses has increased in

---

[1]An alternative formulation is proposed by Bourne (10).

the past few years. Yet, a number of additional benefits arise from their reduction.

Because they represent a direct reduction in food supply, food losses will mean higher food prices at the consumer level. Given the low price elasticities for food products, this shift in the supply function will clearly have adverse effects on consumers. On the one hand, it is likely that the already inadequate diets of the less privileged will be further affected as less income becomes available for consumption of more expensive protein rich foods, particularly the ones of animal origin. On the other hand, as more income is spent on food, demand for nonfoods is also negatively affected.

If a program for loss reduction is effective, lower food prices can be expected and real income will increase as well. As Harrison et al. (27) have shown, a 10 percent food price reduction in Colombia would not just increase the amount of food consumed, with probable improvements in the average diet, but would also increase nonfood expenditures by 30 percent, for the lowest income groups. The multiplier effects of both expanded demands are obvious.

From the producer's side the situation is similar. By and large, food losses will mean lower returns to producers, with consequent disincentives to efforts towards expansion of output.

If a farmer knows from experience that a given part of his output will be wasted before he is able to market or

consume it, it is then likely that this expectation of loss will affect his production decisions. A rational farmer would not expand his output beyond the perceived level of the post harvest system's capacity of absorption.

Furthermore, the absence of adequate post harvest infrastructure leads producers to the common practice of "rushing" the marketing of their output as a hedge to losses which are expected to occur if sales are distributed over time. Such practices are often responsible for "flooding" the market, which brings farm prices to minimum levels (15). Reduction of producer losses through provision of adequate facilities can thereby minimize the effects of this additional source of disincentive to production.

Producers also are potentially affected by expectations of loss at later stages in the food chain. Given market imperfections, bargaining power of middlemen is usually greater than producers. Thus, if losses are expected at intermediate levels in the marketing channel, then prices paid to producers are likely to be adjusted by middlemen so as to make up for the leakage in the system.

Marketers decisions are as much affected by food losses as producers. Particularly in developing countries, where price policies are usually designed to keep food prices to consumers at low levels, product losses represent an additional element of cost leading to reductions in operating margins. Since the improvement of operations of marketing firms is normally financed by equity capital or by credit from private

sources (27), shrinking margins pose a further disincentive to investments of this nature. Practices such as the one above discussed logically follow, as marketers strive to maintain adequate margins.

A reduction of the level of food losses at the distribution channel level, in addition to the benefits brought to marketing firms, would be likely to result in lower prices at the consumer level as well as better returns to producers, through a reduction of marketing margins.

Figure I shows the effect of food losses on retail and farm prices. Farm prices are determined by the intersection of the primary supply and derived demand curves, while retail prices are arrived at when derived supply intersects the primary demand curve. A marketing margin is defined as the difference between retail and farm prices, and it expresses the value added to the farm product through marketing inputs.

If we accept the proposition that food losses in the marketing process represent a direct increase in marketing costs (64), then, as unitary marketing costs are increased, derived demand and derived supply are decreased to the levels DD1 and DS1 in the diagram. Retail prices go up to PR1 and farm prices go down to PF1. As a consequence, the initial marketing margin MM would increase to MM1.

A reduction in losses would have the opposite effect. The lower marketing costs would shift the derived supply curve to the right, and a lower retail price PR1 would be established (Figure 2). Consequently, derived demand would be

FIGURE 1. Effect of food losses in farm and retail prices

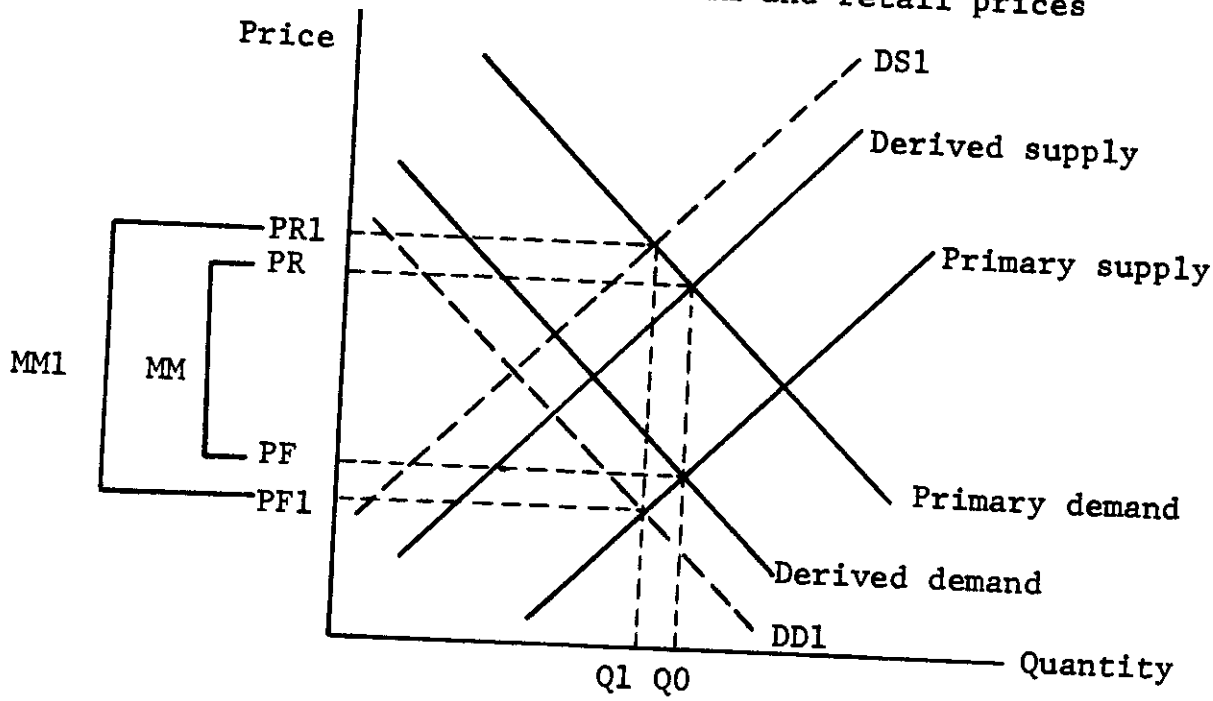
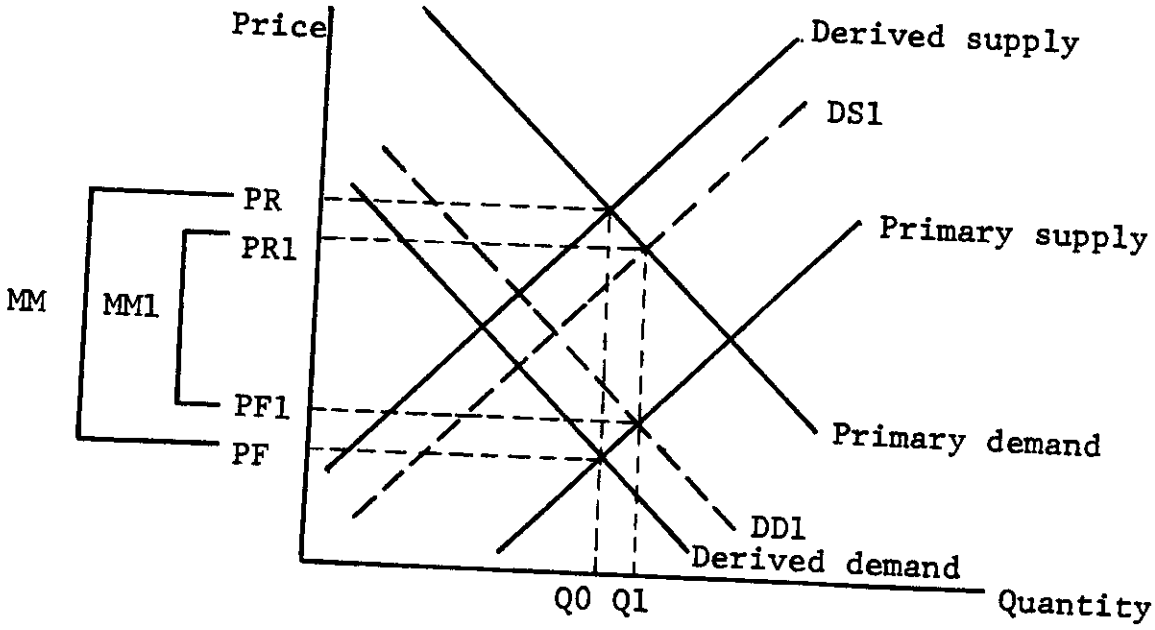


FIGURE 2. Effect of food losses reduction in farm and retail prices.



shifted upwards, and a higher farm price PF1 would be determined, thereby bringing the initial margin MM to the lower level MM1. Obviously, the magnitude of change will be determined by the elasticities of the relevant functions.

To the economy as a whole, food losses represent a direct reduction in gross domestic product. They may also represent a serious drainage in the reserves of foreign exchange, if greater levels of imports are necessary to offset food deficits which may be caused by such a reduction in output. As an example of this relevant aspect, the FAO estimates that a reduction of 50% in losses of food grains in developing countries by 1985 would represent total savings in imports of approximately 7.5 billion dollars (21).

In short, many benefits may be derived from reducing food losses in developing countries. But there are also costs associated with reduction of food losses, and policies aiming at this goal must not overlook cost-benefit considerations.

The economic aspects of the reduction of food losses are many. Schermerhon (54) has shown that from the individual producer or marketer standpoint, there is an optimum level of losses beyond which the further cost of reduction is not compensatory. As an example, he shows that for lettuce in the U.S. at least 35 percent can be lost before the cost of a virtual elimination through air transportation would be economically feasible. By the same token, he points out that the additional energy used in reducing losses through extended

refrigeration, faster transportation or means alike, may outweigh considerably the benefits brought by the amount of food for which losses were avoided.

Accordingly, accepting that losses can be reduced by means of improved practices or technologies which are currently available, the question of whether or not to minimize waste in the food system is continually answered by its participants on the basis of their perceived costs and returns (57).

In the absence of effective coordination mechanisms, the adoption of innovative techniques which may be beneficial for all elements in the system, but are not necessarily economical for any participant acting individually, is therefore precluded. A typical example of such a case is the use of inadequate containers for perishable produce in certain areas of Latin America. Even though more appropriate containers are available, it is often difficult to induce their adoption into the normal marketing process, for ". . . the change generally must be made at the distribution channel level and is not something that can be adopted by any single participant." (27)

It is then clear that the desirability of programs to minimize wastage of foods in the marketing system will be better shown at the overall system's level. Furthermore, food loss reduction programs in developing countries will prove even more desirable if measures other than private profitability criteria are adopted as indicators of effectiveness of investment.

Since the usual measure of efficiency of public investments tends to reflect only the financial cost of accomplishing a pre-specified goal, additional elements which may have substantial importance are seldom accounted for in a proper way.

Greely (23), has shown the appropriateness of incorporating the effects of employment, distribution and balance of payments in the analysis of food loss reduction programs in a social cost/benefit framework. By expressing these elements in terms of social accounting prices, social cost/benefit ratios can be computed and these will certainly demonstrate the relevance of food loss reduction programs as dynamic factors towards the development goal.

III. CURRENT LINES OF RESEARCH IN THE PROBLEM AREA

Even though research in some of the more specific aspects of food losses have been carried out since the early years of this century, it was not until the mid-seventies that the problem began to receive the attention of researchers and international organizations in a widespread basis.

Recent interest in the issues related to this problem area can be credited to the resolutions of the 1975 United Nations General Assembly. The Assembly, adopting a proposal of the United States Secretary of State, set in this year a goal to eliminate half of the world food losses by 1985 (15, 21,10).

Yet, in spite of the increased amount of resources and efforts being spent in the different dimensions of the problem, research in the area of food losses can still be considered incipient, with the majority of work being done for some major food grains.

Historical Perspective

Most of the pioneering work found in the literature is concerned with on-farm storage of food grains, which for many authors is the link in the post-harvest chain where losses are likely to be greatest. These early works were

primarily focused on biological aspects of the problem, particularly with ways to control insect and rodent infestation in stored crops.

An excellent account of the literature in post-harvest losses was published by Adams in 1977 (1). An examination of this work demonstrates the emphasis given to the above mentioned variables.

Although the attention on food grains was continued in the more recent literature, the U.N. challenge has been answered by the international organizations and development agencies with a somewhat more diversified research agenda. By the same token, the concentration of efforts in a few African and Asian countries has been expanded to include other areas of the developing world.

The traditional approach to research in food losses, whereby the problems were analyzed within the boundaries of an investigator's scientific background, has now been replaced by an increased stress on multidisciplinary work. Such recognition of the many dimensions involved in the analysis of the issues related to post-harvest food losses is perhaps the major contribution of the recent literature.

The current lines of research in this area are identified in the remainder of this section.

The Role of the FAO

The Food and Agriculture Organization of the United Nations (FAO), is the leading institution conducting research

on the minimization of post-harvest food losses.

The U.N. agency characterizes its activities in the area as ". . . advisory, training, applied research, and field activities directed at improved storage practices on farms, improvements in milling technology, extension system, off-farm storage and the strengthening of technological institutions" (21) The stress on losses at the farm level is justified by FAO on the grounds that subsistance farming is still responsible for up to 70/80 percent of the food output in most developing countries (16).

Research on the off-farm levels of the post harvest chain has not yet been explicitly carried out by the FAO. Nonetheless, elements of food losses reduction are obviously present in most of the traditional efforts of the agency towards the improvement of food marketing systems in developing countries.

The budget for the agency's activities in the area of concern, which are carried out through the "Post-Harvest Food Loss Reduction Program", has increased from $2.5 million in 1976/77 to the current $10 million figure (15,43). Clearly, the amount of resources being allocated by FAO, to the area will be increased substantially, if proper account is given to the many ongoing projects with loss reduction components.

Another major role played by the agency is the close collaboration with bilateral agencies, done mainly through exchange of informations.

An evaluation of the overall performance of the organization's activities in the area cannot be done at present, since most of its research work is in an early or intermediate stage.

Additional lines of research

In addition to the work being developed by the FAO, some different lines of research are currently in the programs of several major international organizations.

On the basis of the literature reviewed in this report, a summary of the identified areas of work of these organizations is presented in the following table.

TABLE 2. Major lines of research in the area of post-harvest food losses*

Agency**	Area of Activity	Scope of Research
InterAmerican Institute for the Agric. Sciences	Latin America	Loss assessment studies, standardization of procedures, training programs, technical assistance, etc.
USAID	World Wide	Projects with some storage elements, contracts with universities and professional societies for development of technical assistance, etc.

TABLE 2 (Continued . . .)

Agency**	Area of activity	Scope of research
Tropical Science Institute-London	World Wide	Development of methodology for grain losses surveys, assistance for improvement in basic marketing of food grains.
League for International Food Education	World Wide	Contract with American Association of Cereal Chemists (AACC) and the Committee in Improving Nutrition (COIN) for the development of a post-harvest grain loss assessment methodology.
USDA	U.S.A.	Assessment of losses of perishables in major urban areas.
National Science Foundation	U.S.A.	Contract with MSU for a comprehensive loss assessment study for some food products in the U.S.
International Group for agricultural development in Latin America	Latin America	Identification of food losses as a priority area for intervention in Latin America
Institute of Development Studies-Sussex, England	World Wide	Economics of food losses reduction.
International Development Research Center-Canada	World Wide	Application of systems concepts to post-harvest technology.
World Bank	World Wide	Financing of agricultural development projects with storage and processing components.

TABLE 2 (Continued . . .)

Agency**	Area of activity	Scope of research
Group for assistance on the storage of grains in Africa-GASGA***	Africa	Technical assistance on improvement of grain storage

* As identified in the literature review of this report.
** For F.A.O., see preceding discussion.
*** Encompasses six major international agencies.

Further interest in the area of food losses is recognized by the variety of articles published in the professional literature in the more recent past (13,26,28,48,58,59). Nevertheless, most of these works have as objective, the promotion of awareness of the issues, rather than the development of any definite proposal for corrective action. On the other hand, it was also possible to identify an overall commitment from national governments to support loss reduction programs at their countries (11,13,42).

Further Needs

From the foregoing discussion, it is clear that reduction of food losses has become a major area of interest in recent years. However, a more detailed analysis of the specific projects in the identified lines of research will indicate that there is still a gap between research needs and current action.

Particularly, it was recognized that in contrast to the vast amount of work done for food grains, research on more perishable food products is almost nonexistent, with just a few studies for fresh produce available for Central and South America (12,40,41,61,62,65). Surprisingly, even the FAO acknowledges that losses of perishable vegetables, meat, fish, dairy products and the like are higher than the ones for grain staples in developing countries (17,21).

On the other hand, it seems that a lack of integration among concerned agencies has led to an overemphasis in some aspects of the problem. An example is the identification of at least four independent agencies working towards the standardization of procedures for assessment of grain losses. Despite the claims of cooperation, it is hard to conceive that substantial duplication does not exist.

Clearly, the excessive stress in a given dimension of the problem drains substantial amounts of resources which could have alternative uses. The methodological question, although important, should not be an excuse for delayed action. As will be seen in the next sections, sufficient methodological basis for the identification of a workable approach for the design of loss reduction programs already exists. A shift of emphasis to more applied lines of research is therefore another need in this problem area.

IV. METHODOLOGICAL ASPECTS OF FOOD LOSSES ASSESSMENT SURVEYS

As mentioned earlier, the lack of information on the nature and extent of marketing losses of foods in developing countries is one of the major barriers to the design of policies leading to improved performance levels. Knowledge on the magnitude and causes of those losses has thereby to be obtained as a basic input for corrective action.

In this section, a review of the methods whereby such knowledge is obtained is carried out, and its purpose is to identify a workable approach to the process of designing loss reduction programs.

Conceptual Basis

Surveys aiming at the estimation of levels of food losses in marketing systems can be characterized both in regard to the comprehensiveness of their coverage and in regard to the research approach adopted. The former relates to the steps in the marketing chain for which estimates were made, whereas the latter refers to the data collection methods utilized.

Since these two characteristics are among the basic determinants of the reliability of research estimates, the above classification is proposed and used as a basis in the forthcoming discussion.

"Stage specific" vis a vis "Sytems oriented" Studies

Most of the loss assessment studies found in the literature are restricted to estimates at a given stage of the food marketing chain. Losses are estimated for transportation, storage at different levels, processing, retailing or wholesaling without any regard for the remaining stages in the channel.

Notwithstanding the usefulness of the estimates arrived at under this approach for corrective action at the micro level, the failure to consider the relationships between the different stages in the marketing process often constitute a hindrance for the design of effective, more comprehensive policies.

The interaction among the many steps in the marketing chain become particularly relevant when the problem of food losses is being considered. A typical example of their importance are the delayed effects of improper procedures at early marketing stages in many food products. A physical or physiological injury on certain vegetables, for instance, is an essential precondition for the development of diseases which will not be detected until the product is in the last stages of the channel (52,53). If a survey is designed to evaluate losses at the early stages, it is clear that the problem will not be identified. On the other hand, surveys at the last stages would probably consider the disease as the cause of loss, even though the primary cause is in fact the injury.

Clearly, the benefits stemming from a group of scattered and non coordinated corrective policies resulting from "stage specific" studies are hardly as high as those for macro, systems oriented programs.

To avoid these shortcomings, a systems approach to the problem of food losses was proposed by Spurgeon (60). By pointing out the excessive concern with individual components of the post harvest grain systems in Africa, Spurgeon discussed the difficulties in attaining adequate levels of performance under piece-meal programs designed by experts or government officials which ". . . tend to look exclusively for improvements in their own specialties. . . (or) are most concerned about the aspects involved in their own ministries" (60).

The relevance of a systems orientation to loss assessment surveys which will ultimately be the basis for the design of corrective policies is recognized in the most recent literature.

The work being carried out in Latin America by the InterAmerican Institute for the Agricultural Sciences (IICA), later reviewed in this section, illustrates the adequacy of the approach.

Major data collection methods and estimation procedures

A further distinction among food loss assessment studies can be made in regard to the means employed in the

generation of the relevant data.

Although most studies rely on direct measurements to evaluate the levels of losses, alternative methods such as questioning, physical simulation of marketing conditions or combinations of these approaches are also used to a lesser extent. Yet, estimates from experts and extrapolations based on proxies have been proposed by some authors (2 ,36).

Direct measurements are done in a variety of ways, depending on the type of product or another appropriate factor. Products are generally sampled and weighed or counted before and after a given activity is performed, and losses are estimated by the absolute difference in measurements.

Alternative ways of estimating percentage loss in food grains were reviewed by Kryshnamurty (36). The method proposed by Srivastava et al. used the following formula for calculating the actual percentage loss in grains:

$$\text{Loss } \% = \frac{n - n_1}{n_2} \times 100, \text{ where:}$$

n_1 = weight of the number of damaged grains in 100 grains
n = weight of equal number of healthy grains
n_2 = weight of 100 healthy grains

When the loss is caused by insect infestation, the following formulas were proposed by Zutzhi and Karan Singh et al. respectively:

$$LP = IP \frac{(UK - \overline{IK - K}}{UK}, \text{ where:}$$

LP = actual percent loss in weight

IP = percent infestation

UK = weight of equal number of uninfested kernels

IK = weight of equal number of infested kernels

K = weight of kernels from equal number of infested kernels that would yield no flour

$$Pn = \frac{IK \times 100}{TK} \qquad LP = \frac{UK_1 - IK \times 100}{UK},$$

where:

Pn = percentage of infested kernels

TK = total number of kernels in 50 gm sample

IK = number of infested kernels in 50 gm sample (Pn formula)

LP = actual percentage loss in weight

IK = weight of equal number of infested kernels (= Pn)

UK_1 = weight of equal number of uninfested kernels (= Pn)

Weight losses in any sample of grains were suggested by Krishnamurty to be computed according to the formulation below.

$$\% \text{ Loss in weight} = (w + g + m) - \frac{100}{S}(wl + gl + ml),$$

where:

S = weight of 100 good kernels in grains

w,g,m = % (by number) of weevilled, germ eaten and moldly grain.

wl,gl,ml = weight of w,g,m, numbers of weevilled, germ eaten and moldy grains in grains.

Adams (3), utilized an alternative formulation to estimate weight loss in samples of stored grains:

$$\% \text{ weight loss} = \frac{(UNd) - (DNu)}{U\ (Nd + Nu\ )} 100, \text{ where}$$

U = weight of undamaged fraction of sample

D = weight of damaged fraction of sample

Nd= Number of damaged grains

Nu= Number of undamaged grains

This method, and systematic weighing of samples of 100 grains over the storage period constituted what he described as the gravimetric methods for loss estimation. The volumetric method, also utilized by Adams (3), consists in the weighing of standard volumes of grain measured by standard procedures.

Unlike the many approaches adopted for food grains, vegetables, fruits and root crops have been assessed for losses through direct measurement by conventional weighing or unit counting. The former is straightforward. Counting is a method which presupposes uniformity in size among the food products sampled. Thus, the number of units in a sample is counted and those which are unsuitable for consumption are considered losses. The percentage of lost units in the total sample is then considered as an estimate of the level of losses.

Direct measurements are often preferred over alternative data collection methods for they are likely to allow the highest levels of accuracy. However, the approach is costly,

cumbersome and it requires close cooperation from the participants in the food chain.

Questioning is an alternative which is particularly appropriate when high levels of accuracy are not a major concern, or when there is reason enough to believe that the respondents are sufficiently informed to generate reliable answers.

The method has been used in studies at wholesale and retail levels mainly due to its relatively lower costs. Cooperation is not as crucial as in the former case and samples can be substantially larger than the ones for alternative methods at a given cost.

But the main problem with questioning is the risk of biased results, for respondents may tend to over or underestimate the real extent of the problem. The prospect of governmental aid may elicit respondents to over stress the magnitude of their problems, whilst underestimation may be caused by subjective motives such as pride or fear of regulation. Thus, questionnaires should be designed in such a way that the answer sought is obtained by indirect means. Alternatively, cross checks may be included to verify the reliability of responses.

A further drawback of this method has to do with the wording of the questions. Unless the wording is such that terms and concepts are clearly understood in the same way by all the elements in the sample, the results will be of little value.

A third approach for the collection of data is the direct measurement of losses in simulated marketing environments. Functions such as storage or shelf display at retail can be simulated under controlled conditions and measurements are accordingly performed.

Even though this method avoids problems of cooperation of sampling elements and it is particularly convenient for complex measurements such as nutritive losses, the lack of variability among sampling units precludes the extrapolation of results to the actual system.

Nevertheless, the likely cost effectiveness of the approach has led researchers to its adoption for specific purposes (3,14,67).

Indirect methods for evaluation of losses in food products include the use of proxies and relationships with pertinent factors.

Krishnamurty (36) pointed out that estimation of losses based on food consumption data of insects has been proposed by researchers in the problem area. By calculating the daily intake of the damaging insects in a unit basis, extrapolation is allowed upon estimation of the insect population. The method can also be applied for damage caused by rodents or birds.

Adams (3) showed that the most used of the indirect methods is a factor relating damage to weight loss. Thus, a multiplier is determined, such as weight loss = 3 times the

damage, and estimations are in this way carried out.

Obviously, each of the approaches has its own advantages and shortcomings. Proper choice will be a function of both the research objectives and constraining resources.

Working examples of loss assessment studies

Given the diversity of procedures and approaches above identified, it becomes relevant to fully examine some of the few loss assessment studies available in the literature in regard to their methodological aspects. Emphasis will be given in the studies developed for nongrain foods and such an illustration will provide elements for the design of a general research methodology to be outlined in the next section.

Among the earliest surveys attempting to evaluate the extent of losses in marketing were the works developed by the USDA during a three year period in the areas of Chicago and Greater New York (14,67).

The surveys were separately conducted to assess the nature and the extent of losses in apples, potatoes, lettuce, strawberry, oranges and peaches at wholesale, retail and consumer levels.

Both studies adopted basically the same research approach. At the wholesale level, samples were drawn weekly from public servicing wholesalers or at distribution centers of large chainstore operations. The Chicago study also considered samples drawn every other week from an independent street wholesaler. The wholesaling samples, usually taken in

the common trading unit (box, fists, etc.), were taken to laboratories where analyses were performed upon arrival and after a simulated warehousing holding period. Losses were estimated by the application of ". . . a retail cull standard based on probable acceptance or rejection by the customer" (67), and they were usually expressed in percentages of lost weight. Internal damages, unless obviously apparent, were not accounted in the estimation, and eventual diseases were identified through routine laboratory procedures.

Sampling at the retail level was done in Chicago on a biweekly basis, while in New York samples were taken every week with the additional concern of assuring the selection to be from the same lots from which wholesaling sampling was originally done. A few cooperating chainstores and publicly served retail markets were continuously visited by research personnel and the retail operations were monitored for losses in a day long basis.

Measurement procedures differed in the surveys. In Chicago, waste and rejects from normal operations were gathered and taken to the laboratories for proper analysis. In New York most produce items were culled cooperatively with store personnel, culling losses were recorded and samples were taken to laboratories for analysis. Losses were also assessed in terms of percentage of lost weight.

The consumer sampling is not relevant for the purposes of this paper. Nevertheless, it is noteworthy of the fact

that all consumer evaluation was done through simulated holding conditions.

Clearly, the limitations on sample size and the uniqueness of the research approach adopted indicate that the research results should be regarded with caution. The validity of the results is likely to be much greater when identification of causes of losses are being considered than when the concern is with assessments of their extent.

Retail losses were also the concern of Brandt et al. (12) in their study in the city of Manaus, Brazil. The study had as objective the specification and quantification of the effects of selected variables on the level of losses in the retailing of lettuce, green peppers, tomatoes and cabbage.

Unlike the above discussed surveys, this work relied in a "one shot" survey for the generation of data. Questionnaires were submitted to 100 produce retailers in the market area of Manaus and the whole data collection task was completed in a short two months period.

Unfortunately, the research report does not provide further details on the data collection aspects. Nevertheless, the data analysis can give an indication of what major features were considered in the survey. The analysis consisted in the estimation of a regression model where the level of losses was considered to be a function of the volume of the product handled and the working experience of the individual retailers, measured in years. A set of dummy variables was included to allow for slope and intersection changes

and no attempt was made to include additional independent variables.

Since the loss causing variables considered were only the two mentioned above, we are led to assume that the survey could not obtain the elements for a more complete model specification. As previously discussed, the use of questioning for the purposes of loss estimation is likely to generate incomplete or irrelevant results. The findings of Brandt et al. are therefore limited by such shortcomings in the basic data.

Another example of the utilization of the questioning method for the generation of food loss estimates is the work of Ueno in the city of Sao Paulo, Brazil (65). The study attempted to evaluate the magnitude of the retail losses for a group of 35 fruit, vegetable and root crops, with the specific objective of calculating indexes for adjustments in the computation of marketing margins. Twenty of each neighborhood stores, street fair stalls, and supermarkets were visited in two marketing seasons and the respondents perceived level of losses was recorded. The responses were then used to calculate average losses by product and by type of retail operation, and no attempt was made to identify causes of losses or to carry out further analyses.

Again, we are led to consider these estimates with reservation for purposes other than the one indicated in the

study's objective, given the clear limitations in the data basis.

Apparently, the works of Brandt et al. and Ueno were based on the approach adopted in two studies carried out in the early seventies by the Brazilian development agency for the Northeast (SUDENE) (61,62). The data collection methods for these studies were therefore, similar to those utilized in the above mentioned reports.

It is nonetheless noteworthy of the attempt to include a set of structured questions to identify the major causes of losses as perceived by the respondents. At least theoretically, the use of a method as such may give satisfactory indications of the overall situation, provided the set of questions is properly devised. In the SUDENE studies however, the answer options presented to respondents were such that for almost all products surveyed, the major cause of losses reported was "the excessive time lag between purchasing and retail (or wholesale) sale," a variable which clearly encompasses many important factors under the same heading. Hence, the information derived from the identification of causes could not provide a strong basis for corrective action.

A group of more comprehensive surveys was carried out in the Dominican Republic in 1976 by the IICA and the Dominican Secretariat of State for Agriculture. The studies, developed separately for tomatoes, potato and cassava, attempted to quantify the level of losses for these commodities during the

entire marketing process, covering rural assembly, wholesale and retail operations as well as transportation among the different stages. The study for cassava also examined losses at the consumer level (40,41,63).

The research approaches adopted are basically the same. The few variations are mainly related to the choice of sampling units and of measurement methods. The first step in the surveys was the analysis of the existing marketing systems. As a general rule, the channel would be followed by the researchers and information was generated to identify the steps involved, the most adequate points in the process for sampling purposes, and to elicit the cooperation of sampling elements. Informal interviews and visual examinations were also performed to provide information on type and possible causes of losses.

The study for tomatoes utilized a pre-sampling step which was carried out concurrently with the analysis of the existing marketing system. The pre-sample was intended to allow a first estimation of variability for purposes of determination of sample sizes and to provide additional elements for the design of a sample plan.

The actual samples were determined on the basis of the information provided by the initial step. Samples were taken at the farm level, during storage in rural assembly centers, at the wholesale level, at various types of retail operation, and for cassava, at the consumer level. Samples were also

taken before and after products were moved from one stage to the next, for the evaluation of transportation losses.

Procedures for measurement were mainly the weighing of produce before and after the performance of a given marketing function. Counting was used only when weighing was too cumbersome. At the farm level, the study for cassava considered as losses the percentage of lost produce in relationship to the total produced, both in terms of units and weight.

In general, the criteria for determination of what constituted an actual loss were the standards adopted by the participants in the marketing chain in their trade practices. At retail level, for instance, participants were asked to save the products which they considered unfit for sale and at the end of a normal business day the researchers would collect these samples for the performance of appropriate measurements.

The identification of causes of losses was also based in the first step of the survey. The main causes identified at the initial analysis were properly checked on the sampling stage and a breakdown of the total level of losses by cause could in this way be established.

The research results provided useful information for action towards the improvement of the overall levels of performance of each individual marketing system. Once the extent of the problem was assessed and its main causes identified, programs for the reduction of losses were suggested, priority orders were determined and the professional and institutional requirements were pointed out.

The IICA's approach was proven to be the most satisfactorily acceptable by the experience of the institution. The methods utilized in these surveys are now the basis for a series of ongoing projects in the area of Central America and the Caribbean.

The relative superiority of the approach is clear. A survey like the ones just reviewed can be performed in about 4 months requiring limited amounts of personnel and at reasonable levels of cost. The average cost of the three studies appraised was about $8,000, from which 50% was allocated to technical assistance, 25% to the purchase of samples and 25% to operating costs. The IICA estimates that in countries where basic data is not available, the total cost of a similar study will be from 50% to 100% higher, which in absolute terms is still reasonable.

V. BASIC ELEMENTS FOR THE DESIGN OF LOSS ASSESSMENT SURVEYS IN DEVELOPING COUNTRIES

This section outlines the elements to be considered in the design of surveys to assess the nature and extent of losses of selected commodities in marketing systems. The approach adopted is basically the one recommended by the InterAmerican Institute for the Agricultural Sciences, reviewed through a working example in the preceding section.

The methodology recommended by IICA can be divided in a group of major activities, and although the elements of concern in each of these activities will vary depending on factors such as product, area, resources, etc., their general characteristics will invariably hold. For the purposes of this review, IICA's approach is presented in a concise format, with some additional suggestions introduced. Hopefully, the exposition will constitute a framework for the design of loss assessment surveys in developing countries.

Selection of products and market area

The choice of these two main variables will be ideally made within the framework of national goals and objectives expressed in plans or programs affecting the food system. Additionally, an examination of existing studies on marketing

aspects of food products will certainly provide information for the identification of major needs.

In many cases, information on the existing marketing processes for different food products will be few or inadequate, and the selection of variables has to be done on the basis of common knowledge or through proxies.

The concept of Gross National Waste of Foods (GNWF), introduced by Tainsh (13), can be a useful way to provide approximate figures on the magnitude of losses based in statistics readily available in most developing countries. The Gross National Waste is defined as '. . . the waste of all kinds between harvest and consumption' (13), and its computation can be summarized in the following formula:

$$GNWF = (P(1-s) + I-E-nC)k, \text{ where:}$$

GNWF = Gross National Waste of a given food product, expressed in weight/year.

P = Total production in weight/year

s = Percentage of production retained for seed

I = Total imports in weight/year

E = Total exports in weight/year

n = Total population

C = Most likely per capita consumption

k = correction factor, ranging from 1.0 for grains to 1.2-1.3 for perishable foods.

The GNWF concept has been successfully applied by Tainsh in India and Egypt, and it can easily provide an initial

idea of the performance of different post-harvest systems for purposes of definition of priorities. Thus, the selection of products for research can be done in basis of this concept , in the absence of more complete information.

There will be instances in which products possessing similar marketing characteristics will justify a joint appraisal in the loss assessment survey. Nevertheless, the experience of international agencies working in the problem area suggests that surveys should not be done for an extensive group of food products at a given time, at least until expertise on the matter can be developed. It is therefore advisable to start loss reduction programs with surveys aiming at a few priority products.

The selection of a market area will be primarily a function of the product(s) selected for investigation. The area should not be extensive, being necessarily representative of the system under analysis. In order to facilitate the data collection process, the area boundaries should be clearly defined, preferably in some recognized form of geographical division, such as a cluster of census regions, a metropolitan area or another similar territorial classification.

Representativeness is essential if the research results are to be extrapolated, given that for sampling purposes a market area can be regarded as the initial stage in a multistage sampling process.

Needless to say, both choices will also be influenced by the constraining resources. It becomes then necessary

to assess factors such as accessability, costs of samples, likelihood of cooperation from elements in the system and another aspect affecting research costs, before selection can be made.

Identification of steps and functions in the marketing chain

This second stage in the research process calls for a detailed investigation of the marketing processes for the product under analysis, and the purposes served by such an investigation are many.

Knowledge of food marketing processes in developing regions is generally inadequate. The particular characteristics of individual marketing systems for different products and areas imply that generalizations cannot be made without the risk of misconceptions. The need to provide a clear diagnostic of the existing system is therefore a major consideration before any program aiming at the improvement of performance levels can be properly designed.

The investigation at this stage can be done informally, without rigidity in the data collection process. The IICA studies conducted this type of investigation by following the product flow backwards, from the retailers to the early stages in the chain, and the approach used was one of informal interviews with the participants in the system.

In addition to the provision of information on the problems faced by the participants in the marketing chain, the interviews constituted a good way to elicit cooperation for the forthcoming stages of the study. A major product of the informal

interviews was a first account of the perceived level of losses as well as their probable causes.

Observation also plays an important role in this process. The analysis of product movements through the chain at this stage provides information on possible shortcomings of the system and generates input for decisions in regard to the points in the channel where sampling should take place at further stages in the research.

An alternative to the informal approach suggested by IICA is the conduction of a pilot survey among the participants in the marketing channel. Questionnaires can be designed to generate the information needed, and even though survey costs are likely to be increased with this alternative, the approach has the advantage of providing data in a standardized way, which certainly facilitates interpretation and reporting. Furthermore, surveys with standardized questionnaires require less skilled personnel than the former alternative.

Clearly, the trade-offs between the alternative approaches should be assessed before a decision is reached.

Sampling aspects

The normal sampling approach for the studies under appraisal is the utilization of a stratified, multi-stage sampling design. For that matter, a representative market area is selected as a primary sampling unit, stratification by participants in the channel is done, and subsequent sampling stages are introduced until actual product selections are undertaken.

The breakdown in further stages will vary depending on the characteristics of the marketing system. As a general rule, it will encompass each of the major marketing functions performed in the system, the different kinds of containers used in product movements, and finally, the individual product samples from the selected containers.

Despite the peculiarity of the problem analyzed, the sampling process does not differ significantly from the usual procedures. The initial step requires the obtention of a frame in which the population is meaningfully identified. Such lists should be obtained for each of the major functions performed in the marketing process and their purpose is to assure equal probability of selection for each sampling unit.

Area frames have also been suggested if population lists are not available (2). By this method, maps or aerial photographs are divided into a number of smaller areas and subsamples are selected at random. Within the sampled areas, either a complete enumeration is carried out or a further sampling stage is introduced.

Most of the studies reviewed in this paper relied on population lists for sampling purposes. Nonetheless, the randomness of the selection process has been consistently substituted by a subjective selection of elements willing to collaborate with the survey (12,14,40,41,63,65,67).

Indeed, cooperation is a critical aspect to be considered in any sampling design, and public relations programs before the realization of surveys have often been recommended

to elicit participation from the survey elements (35). A well designed campaign in this regard is likely to overcome the necessity to subjectively select sampling units, thereby ensuring randomness in the process.

Another question which arises in the survey design has to do with the sizes of samples - how many farmers, truckers, processors or retailers should be contacted and how much product should be sampled from each of them.

From conventional sampling theory, we know that the size of a sample will be determined by both the standard deviation of the variable analyzed in the population and the degree of precision desired for the sampling estimates. The latter is in general determined by the amount of resources available for the research, whereas the former can be obtained either from previous studies, from the estimates generated in the diagnostic stage, or even by a rule of thumb (the so-called 1/6 rule).

The standard deviation will be estimated for the whole population, if allocation of this total sample among strata is to be done in proportion to size, or it will also have to be estimated for each of the stratum, in the case of disproportionate allocation.

Following these guidelines, the determination of how many participants in the marketing channel should be examined in each stratum is straightforward. The remaining sampling unit - the product - has been sampled in a less statistically precise research procedure. In most studies, the amount

sampled varied depending on the stage in the channel in which the sample was taken. As a general rule, samples are selected from the populations in an amount equal to the common trading unit, be it a box, a sack, a crate, or the like. In some other examples, the amount sampled ranged from the whole loss of a given working day to a group of different product containers randomly positioned in sampled warehouses.

The lack of a standard procedure for product sampling suggests that researchers should make such a decision on the basis of knowledge acquired in the diagnostic stage of the study. The general rule adopted in most cases (one sample of the common trading unit) is apparently preferred as a way to keep costs to a minimum, since these samples have to repeatedly be bought over a given period of time. The alternative approaches were clearly devised to fit the particular situations which cannot be generalized. Therefore, flexibility, knowledge and common sense will play the key role, as far as a product sampling decisions is concerned, and as long as consistency is assured throughout the research process, the reliability of the estimates will not be negatively affected.

Samples for purposes of identification of causes of loss will be also determined without statistical rigidity in regard to size. The common approach has been the selection of a small amount of lost product (most times 1 kg.).

Once the problem of sample size is resolved, the remaining question is the time period over which samples will

be repeatedly taken. Again, no standard procedure was identified and the decision will also be based on the specific characteristics of the system under analysis. These time periods have ranged from as short as biweekly over a two week period, to as long as weekly during three years (3,14,40,41, 63,67).

In short, the sampling questions will require careful appraisal in basis of both the knowledge of the system analyzed and the degree of accuracy required for the survey results.

Loss assessment and cause identification

The procedures for assessment of food losses were reviewed in Section IV. Recalling that the concern is with evaluation of quantitative and qualitative losses, measurements should preferably be carried out in terms of percentages of lost weight in the former and in terms of value, in the latter case.

The underlying reason for selection of weight as the standard of measure for physical losses is straightforward. In fact, most of the research done in the area has adopted the weight criteria, due to its clear advantages over volume, units and other alternatives.

Although the methods for estimation of weight losses can vary in accordance to the sampling stage, the common procedure adopted is the "before-after" difference discussed earlier in this report. Such measurements are undertaken at each stage of the system for further aggregation.

Qualitative losses should be assessed on the basis of a product grading framework. Even though no clear research procedure could be identified for quality loss assessment, it seems that the most appropriate way to identify such losses is to recognize the extent of downgrading occurring throughout the marketing channel, then attributing a value differential which will represent its level. Percentage estimates can also be carried out by simply assessing the amount of product which is downgraded throughout the system. Clearly, these estimates have little meaning unless accompanied by a value.

The main problem with estimation of quality losses is the reliance upon a product grading framework, which in many developing countries is nonexistent. Nonetheless, commercial practices often create an informal set of "grading" standards which, if properly identified in the diagnostic study, can be used as a proxy in the absence of more precise standards. Considering that losses in quality constitute an important factor in the reduction of returns to the participants in the food system, their inclusion in the evaluation of the performance of the system should not be overlooked.

The identification of causes of losses is more in the domain of the biological scientists than of the economist, and an extensive discussion on the matter would be beyond the scope of this report. However, drawing on the experience of previous research in the area, some general suggestions in regard to the basic elements to be considered in this task, can be identified.

A first concern in the organization of this step in the research process is to provide a general classification of causes by major categories. Following the suggestions of Amezquita et al. (4), three major headings can be used, namely mechanical damage, physiological damage and damage by infection.

Mechanical damages will encompass the losses caused by improper handling at different stages in the system, and by the utilization of inadequate containers, transportation and the like. Physiological damages are caused by inadequate storage practices, by early or tardy harvest or by excessive delays throughout the channel. Damages by infection will include insect, bird or rodent infestation, in addition to diseases caused by microorganisms or other pathogenic agents (4).

Obviously, further breakdowns can be introduced if basis for them is identified. The degree of specificity in this stage is also to be determined by the experts in loss cause identification, and the above framework should not be regarded as an all-inclusive classification scheme.

The relationships between the causes of losses and the conditions under which they occur should also be identified, with particular reference to the institutional and coordinational mechanisms affecting the food system. These are known in some cases to bring about conditions favoring the occurrence of food losses, and there is reason enough to suspect that much of the problem is rooted in the imperfection

or inadequacy of such mechanisms.

A clear example of such inadequacies is the failure of most governments to recognize the role of middlemen in the food system. Too rigid controls on these elements are not uncommon and such interventions on the system often contribute to the reduction of returns to the participants. Disincentive to improve operations follows, with the associated effects on performance variables.

It is therefore of relevance to analyze such relationships in the context of examining the extent and causes of food losses, as a basis for prescriptive action.

Data Analysis

The analysis of the data generated in the survey is relatively simple. Basically, what has to be done is the consolidation of partial estimates, the cross tabulation of the data by the relevant dimensions considered, and the estimation of a model depicting the relationship between the level of losses and a series of selected explanatory variables.

Aggregation of partial estimates to generate figures for the whole system, though an apparently simple task, can easily mislead researchers when losses are being reported as percentages. As pointed out by Bourne (10), the summation of percentages at each difference level in the marketing system does not yield the percentage of loss for the total system. To illustrate, we can think of a post-harvest system for which a 25% level of losses is assumed for each of its five levels.

If these figures are added up, an absurd 125 percent level of losses would be reported for the system, when in fact the correct aggregated figure is 76.26 percent. Thus, the appropriate way to consolidate is through the expression $Lt = 1-\prod_{i=1}^{n}(1-a_i)$, where Lt is the total level of losses in terms of percentage and a_i is the percentage of losses at each level.

The percentage level of losses calculated as above should also be reported in terms of value, which is easily computed by multiplying an average market price by the total volume of product marketed. Additional statistics, like the number of people which could be fed with the amount of food lost or the amount of foreign exchange needed to offset losses through imports, should also be computed since such figures depict the magnitude of the problem in a clearer way than a simple percentage.

Cross tabulations should be done by the dimensions which present more relative importance for purposes of analysis. Examples of commonly used cross tabulations were the extent of losses by level in the marketing system and the extent and value of losses by level and by cause, among others. Another aspect of concern in the data reporting aspects is the measurement system to be adopted. Although local units have in some cases been used in the sampling stages, all research findings should be reported in a more widely understandable framework, preferably the metric system, following the suggestion of Amezquita et al. (4).

A further task in this data analysis stage is the estimation of a model relating losses with selected independent variables, which will constitute an important instrument for decision-making.

A model as such can be estimated with cross sectional data generated in the early stages of the survey, and its structural form should be determined by the best judgment of the research team, including both those variables for which quantification is straightforward and those of a qualitative nature. Conventional regression techniques can be used for its estimation, but suggestions have also been made for the development of more complex systems simulation models (4,60).

Despite widespread recognition of the importance of a model estimation in the relevant literature, most of the works reviewed in this report did not present any form of analysis including mathematical models. The exceptions were the Zambian study carried out by Adams and the work of Brandt et al. in Brazil (3,12). Both works used fairly standard estimation techniques. In the Zambian case, a series of simple regression models were estimated to study the relationships between losses in storage with variables such as period of storage, moisture content and others. Brandt's work, already described in Section IV, has suggested that qualitative aspects can also be introduced in the structural equations by means of common dummy variables. Hence, the estimation of similar models should not pose any methodological problem for

the research team.

The estimation of the model and the interpretation of the findings complete this stage of the research process. Its outcome will be the basis for the recommendation of alternative strategies for the minimization of losses in the system.

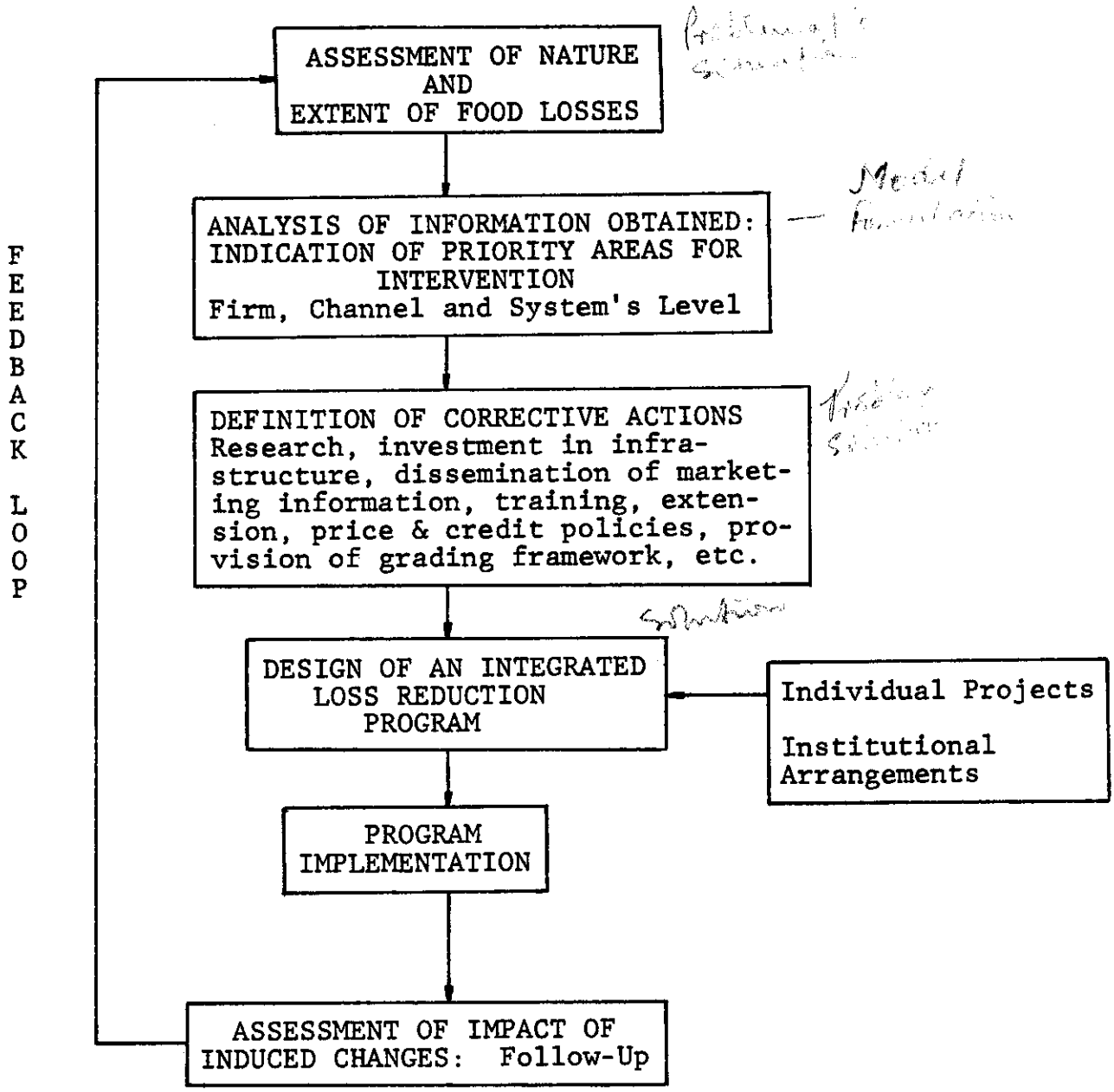
Designing food loss reduction programs

The approach to obtaining knowledge on the nature and extent of marketing losses of foods discussed above will provide the foundation for the prescription of corrective actions towards the improvement of performance levels.

The process whereby such an information base is used as a first step in the design of loss reduction programs, is represented in Figure 3.

From the data base, a detailed analysis of the loss causing variables and the related conditions for their presence in the system will permit the identification of critical areas for intervention. Following the framework proposed by Harrison et al. (27), the needs of the system will be identified at the firm or farm level, at the distribution channel level and at the overall system's level. Such a framework will enable the analyst to better define the particular kind of changes to be induced in the system. IICA's approach recommends the utilization of summary tables to facilitate the task of analysis, and an example of them is reproduced in the appendix to this report.

FIGURE 3. An Approach to the Reduction of Marketing Losses of foods.



Reducing food wastage in the marketing system will require managerial, technological, and institutional changes which will have to be induced through an integrated and coordinated governmental effort. Corrective action must be defined with close cooperation with the appropriate levels of decision-making, in order to ensure the workability of the proposed changes. The reforms will likely encompass investments in basic infrastructure, training programs to improve the managerial capabilities of producers and middlemen, introduction of innovative channel arrangements, pricing and credit policies, and many other forms of intervention. Those will be fostered through individual projects and institutional arrangements put together as an integrated loss reduction program.

The integrated program will be designed after adequate evaluation of cost/benefit aspects is made for the proposed projects. Although not mutually exclusive, they will most likely be competing for the available resources. The evaluation will therefore, provide a basis for the definition of priorities for implementation.

To implement the program, developing countries may benefit from financial and technical assistance provided by most of the agencies identified in Section III of this report. Even though many interventions can be carried out with local resources, assistance will be of particular relevance for

those actions requiring capital, technology and expertise not available in most of the developing world.

what do you mean? reevaluate?

An effective program to minimize food losses will demand close monitoring and constant reevaluation. Periodical assessments of the impact of induced changes will be necessary, so that adjustments in the original program can be made. The interactive process will then ensure the performance of the system at the desired level, and the net result should be a substantial increase in the availability of foods through a more optimal post-harvest system.

VI. SUMMARY AND CONCLUSIONS

The problem of food losses in marketing systems is recognized as a major factor contributing to the reduction in the supply of food for human consumption. Food losses are socially and, in most instances, economically undesirable, and their minimization can play an important role in the development process.

Despite the relatively incipient stage of research in the area, sufficient basis for the development of a workable approach for the design of corrective programs was found to exist. This approach is based on the execution of loss assessment surveys, through which the nature and extent of the problem can be determined.

Such surveys should be regarded as a first and foremost consideration in the design of policies to minimize food losses in marketing systems. Their objectives are not limited to the provision of a set of figures on the magnitude of losses. On the contrary, the methodology for arriving at loss estimates is such that knowledge on the performance of the existing marketing system is greatly increased in the process of gathering the relevant information. Hence, even though the major performance variable is still the level of losses, it is likely that the information obtained on the behavior of the

existing system will prove useful in forming policies for other variables as well.

The research results will constitute the main basis for the establishment of corrective policies. It is through a detailed analysis of causes of losses and the factors leading to them that the adequate intervention measures can be defined.

Strategies for the reduction of food losses will be oriented to each of the three main levels of the marketing system, namely the firm or farm level, the distribution channel level and the overall system's level.

The diffusion of the proposed changes will raise many issues to be considered on an economic basis. Success of any loss reduction program will depend to a large extent on the willingness of individual decision units to adopt innovations. The choice, based on perceived costs and returns, may not be proven feasible unless acceptance is widespread.

Situations like the above will clearly call for sound coordination at a more aggregated level. Policy makers should not overlook these considerations in their recommendations for marketing improvement reforms.

A program for reduction of food losses will require at the national level, a recognition that the problem exists and that a commitment to its solution is necessary. It is just through coordinated and determined action of every interested level of government that the goal of self reliance in food provision through an optimized post-harvest system can be achieved.

BIBLIOGRAPHY

1. Adams, J.M. "A bibliography on post-harvest losses in cereals and pulses with particular reference to tropical and subtropical countries", Report of the Tropical Products Institute, G110, London, July 1977.

2. _____. "The estimation of post-harvest losses in durable commodities, basic principles". Documento VI-G, Seminario sobre reduccion de perdidas post cosecha de productos agricolas en el area del Caribe y America Central, IICA, 1977.

3. Adams, J.M. and Harman, G.W. "The evaluation of losses in maize stored on a selection of small farms in Zambia with particular reference to the development of methodology", Report of the Tropical Products Institute, 6109, London, April 1977.

4. Amezquita, Rafael G. "La problematica de Post-Cosecha: Situacion actual y enfoque metodologico para realizar diagnosticos y elaborar programs y proyectos de Reduccion de Perdidas de Post Cosecha", Documento IV-A, Seminario sobre reduccion de perdidas post cosecha de produtos agricolas en el area del Caribe y America Central, IICA 1977.

5. Anon. "War declared on cereal losses", Ceres No.55 January/February 1977.

6. Asian Productivity Organization. "Post harvest prevention of waste and loss of food grains. A training manual". Tokyo 1974.

7. Atwa, A.A. et al. "Physical Changes in Egyptian onions during transportation (A) weight loss %", Agricultural Research Review, March 1974.

8. Axel, Caro A. "Experiencias de la FAO en la conservacion de Alimentos", Documento II-A, Seminario sobre reduccion de perdidas post cosecha de productos agricolas en el area del Caribe, America Central, IICA 1977.

9. Baker, Robert C. and Robinson, Willard B. "Food Science research needs for improving the utilization, processing and nutritive value of food products", A Report to the Science and Technology Policy Office, National Science Foundation", Mimeo 1975.

10. Bourne, Malcolm C. "Post harvest food losses - The neglected dimension in increasing the world food supply"; Cornell International Agriculture Mimeograph 53; Cornell University, Ithaca, New York, April 1977.

11. _____. "The role of post harvest food loss reduction in improving the economic and nutritional status of tropical populations", Document I-B, Seminario sobre reduccion de perdidas post cosecha de productos agricolas en el area del Caribe y America Central, IICA 1977.

12. Brandt, Sergio Alberto et al. "Estimativas de perdas na comercializacao de hortalicas no mercado de Manaus", Seiva, Ano 34, No. 82, Abril a Junho de 1974, Universidade Federal de Vicosa, Vicosa MG, Brasil.

13. Brett-Crowther, M.R. "The waste and spoilage of food", International Relations, Vol. V, No. 6, November 1977.

14. Ceponis, M.J. and Butterfield, J.E. "The nature and extent of retail and consumer losses in apples, oranges, lettuce, peaches, strawberries and potatoes marketed in greater New York", Marketing Research Report No. 996, USDA, 1973.

15. Comptroller General of the United States. "Hungry Nations need to reduce food losses caused by storage, spillage and spoilage", Report to the Congress, Nov. 1, 1976.

16. Crepeulandt, H. Personal communication, Agricultural Services Division, FAO 1978.

17. Food and Agricultural Organization of the United Nations: "An analysis of an FAO survey of post harvest food losses in developing countries", AGPP-MISC 27, Rome, Italy, March 1977.

18. _____. "Bibliography on food and agricultural marketing 1977", Rome, Italy 1977.

19. _____. "FAO Action Programme for the Prevention of Food Losses: Guidelines and Procedures"; Mimeo, January 1978.

20. _____. "Prevention of food losses", Report C77/1g, August 1977.

21. _____. "Reducing post harvest food losses", Report COAG/77/66, Rome, Italy 1977.

22. _____. "The State of Food and Agriculture-1976", Rome, Italy 1977.

23. Greely, Martin. "Economic implications of food losses and food loss reduction", Unpublished paper, University of Sussex, England, October 1977.

24. Haard, Norman F. and Salunkhe, D.K. "Post harvest biology and handling of fruits and vegetables - a symposium", AVI Publishing Company, Inc., 1975.

25. Halloran, John; Allen, John and Pierson, Thomas. "Dairy losses in the U.S. food distribution system", Mimeo, Michigan State University, 1977.

26. Harris, Kenton W. "Post harvest grain losses study", Cereal Foods World, Vol. 22, No.3, March 1977.

27. Harrison, Kelly et al. "Improving food marketing systems in developing countries: Experiences from Latin America", Research Report No. 6, Latin American Studies Center, MSU 1974.

28. Hulse, Joseph H. "One should try to improve the existing post harvest systems, rather than offering radical new ones", Ceres, Vol. 10, No. 6, November/December 1977.

29. International Group for Agriculture Development; "Report on the participation of the IGAD/LAC office of coordination in IICA's seminar on reduction of post-harvest food losses in the Caribbean and Central America", Mimeo 1977.

30. "Post harvest systems in Central America, IGAD/LAC Program Identification, Mimeo, July 1977.

31. Janicki, Lawrence J. and Green, Jr.,Victor E. "Rice losses during harvest, drying and storage", Il Riso, Ressegna trimestrale di studi, No. 4, Dec.1976.

32. Johnson, D. Gale. "World food problems and prospects", Foreign Affairs Studies 20, American Enterprise Institute for Public Policy Research, Washington, D.C., 1975.

33. Karony, Susan; Allen, John and Pierson, Thomas. "Produce losses and waste in the U.S. food distribution system", Mimeo, Michigan State University, 1977.

34. Kasmire, R.F. "Poor temperature control still causes many losses", Western Grower and Shipper, Vol. 45, No. 77, July 1974.

35. Kearl, Bryant, Editor. "Field Data Collection in the Social Sciences - Experiences in Africa and the Middle East", Agricultural Development Council Inc., 1976.

36. Krishnamurty, K. "Post harvest losses in food grains", Bulletin of Grain Technology, Vol. 13, No. 1, 1975.

37. League for International Food Education. "AACC/COIN Project Proposal - Post Harvest Grain Losses: Development of an Assessment Methodology", Mimeo, February 1977.

38. Le Gra, Jerry. "Elements of regional program to reduce post-harvest food losses", Document IV-C. Seminario sobre reduccion de perdidas post cosecha de produtos agricolas en el area del Caribe y America Central, IICA, 1977.

39. Lowry, J.H. "World population and food supply", Edward Arnold (Publishers) Ltd., London 1970.

40. Mansfield, Jorge. "Post harvest losses of potatoes quantified during the marketing process: from rural assembly to wholesale and retail assembly in Santo Domingo during 1976." Document VI-J, Seminario sobre reduccion de perdidas post cosecha de productos agricolas en el area del Caribe y America Central, IICA, 1977.

41. Mendoza, Gilberto. "Study of post harvest losses of salad tomatoes in the Dominican Republic", Document VI-K, Seminario sobre reduccion de perdidas post cosecha de produtos agricolas en el area del Caribe y America Central, IICA 1977.

42. Ministry of Agriculture of the Republic of Guyana. "Introducing food loss assessment studies into country loss reduction programs", Unpublished paper, Georgetown, Guyana, March 1978.

43. Mittendorf, H.J. "Development of Marketing Systems for Agricultural Products and Food in Developing Countries: FAO's Program of Work", Agricultural Economics Seminar, Michigan State University, June 1978.

44. Moser, C.A. and Kalton, G. "Survey Methods in Social Investigation", Basic Books, Inc., New York 1972.

45. Musa, Sulafa, K. and Thompson, A.K. "Estimation of vegetable retailer losses and suggested size grades", Sudan Journal of Food Science and Technology, No. 8, 1976.

46. Paniago, Euter et al. "Estudos sobre uma regiaoo agricola: zona de mata de Minas Gerais (II)", Instituto de Planejamento Economico e Social, Monografia No. 11, Rio de Janeiro 1973.

47. Pantastico, Er. B., Editor. "Post harvest physiology, handling and utilization of tropical and subtropical fruits and vegetables," The A.V.I. Publishing Company, Inc., 1975.

48. Parpia, H.A.B. "More than food would be saved", Ceres Vol. 10, No. 6, November/December 1977.

49. Pierson, Thomas and Allen, John. "Food wastes and losses in the U.S. food distribution system", paper presented at the Food Distribution Research Society Annual Meeting, October 5, 1977.

50. Raj, Des. "The design of sample surveys", McGraw-Hill 1972.

51. Reagan, Cynthia; Allen, John and Pierson, Thomas. "Dry grocery food losses in the U.S. Food Distribution System", Mimeo, Michigan State University 1977.

52. Ryall, A. Lloyd and Lipton, Werner J. "Handling, Transportation, and Storage of Fruits and Vegetables," Vol. I, The A.V.I. Publishing Company, Inc., 1972.

53. Ryall, A. Lloyd and Pentzer, W.T. "Handling, Transportation, and Storage of Fruits and Vegetables", Vol. 2, The A.V.I. Publishing Company, Inc., 1974.

54. Schermerhorn, Richard W. "Economic issues associated with food loss", A.E. Extension Series 203, University of Idaho, Moscow, Idaho 1976.

55. Seik, Cynthia; Allen, John and Pierson, Thomas. "Delicatessen Food Losses in the U.S. Food Distribution System", Mimeo, Michigan State University 1977.

56. _____; _____ and _____. "Frozen food losses in the U.S. food distribution system", Mimeo, Michigan State University 1977.

57. Sherr, Harris. "A basis for the reconsideration of wastes and losses in food marketing", Ag. Economics Research, Vol. XII, No. 2, USDA, 1960.

58. Snyder, Harry E. "Food losses - situation and opportunities for improvement" in: Dimensions of world food problems; Duncan, E.R., ed., Iowa State University Press, Ames, Iowa 1977.

59. Spensley, Philip C. "An eye on the granary", Ceres, Vol. 10, No. 6, November/December 1977.

60. Spurgeon, David. "Hidden Harvest - A systems approach to post harvest technology", International Development Research Center, Ottawa, Canada 1976.

61. Superintendencia do Desenvolvimento do Nordeste, Dept. de Agricultura e Abastecimento, Divisao de Abastecimento e Financiamento da Producao; "Perdas na comercializacao de produtos Horti-Fruiti-granjeiros na Cidade de Fortaleza", SUDENE/SUDEC/UFC 1972.

62. _____. "Perdas na comercializacao de produtos horti-fruti-granjeiros nos mercados de Teresina", SUDENE/SEAPI 1972.

63. Tejada, Romero. "Summary of study of post harvest losses of cassava in the Dominican Republic", Document VI-K, Seminario sobre reduccion de peridadas post cosecha de produtos agricolas en el area del Caribe Y America Central, IICA 1977.

64. Tomek, William G. and Robinson, Kenneth L. "Agricultural Product Prices," Cornell University Press, 1972.

65. Ueno, Lidia H. "Perdas na comercializacao de produtos hortifruticolas na cidade de Sao Paulo", Agricultura em Sao Paulo, Ano VI, No. 3, Marco de 1976.

66. United States Agency for International Development, "Summary of AID assistance on agricultural marketing and reduction of post harvest food losses in Central America", Mimeo 1977.

67. Wright, W.R. and Billeter, B.A. "Marketing losses of selected fruits and vegetables in the Chicago Area", Marketing Research Report No. 1017, USDA 1974.

APPENDIX

APPENDIX

PROGRAM FOR REDUCTION OF POST-HARVEST LOSSES -- PRODUCT :

PROBLEMS AND CAUSES		Corrective Actions*													Professional Requirements**							
		Applied Investigation /Transfer of Technology		Training -Courses - in service		Extension			Publications		Institutional Aspects***											
GENERAL	SPECIFIC	General	Specific	Technicians	Producers	Producers	Intermediaries	Consumer	Direct	Indirect	Public	Private	Infrastructure	Agroindustry	Agronomist	Economist	Food Technologist	Anthropologist	Entomologist	Food Pathologist	Extensionist	Ag. Technician
1.Mechanical Damage																						
a) Rough handling Harvest																						
Packing																						
Transportation																						
Storage																						
Wholesale																						
Retail																						
b) Container Poor design																						
Poor finish																						
Other																						
2.Physiological Damage																						
a) Storage																						
b) Early harvest																						
c) Delays																						
3.Infection																						
a) Micro-organisms																						
b) Insects																						
4.Excess Supply																						
5.Loss Nutritive Value																						
6.Seed Quality																						
7.Lack of Information																						

* 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 recommended the use of footnotes to complete the information concerning institutions and possible actions.

SOURCE: InterAmerican Institute For The Agricultural Sciences.