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ANALYSIS OF PROBLEMS OF FOOD CROP CONSERVATION BY STORAGE

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ABSTRACT

Interrelationships between food losses and world hunger are explored, the several components of the complex post harvest sector are outlined and a technical analysis of food losses presented. Problems of food conservation in the CARICOM Caribbean, with particular reference to perishable commodities, are briefly described. It is concluded that food conservation is an important aspect of the interface between food availability and human nutrition.

INTRODUCTION

After harvest, crop commodities pass through a series of operational stages, in a variety of marketing systems before reaching the consumer. The time from harvest to consumption varies from a few hours to several months and the commodities from very perishable to relatively durable. In any event, holding of the commodities at the prevailing high temperatures and humidities in the tropics e.g. the Caribbean, require specific conditions of handling and storage, in the absence of which considerable post harvest food losses occur. The most serious problem resulting from such losses in developing countries is that their considerable effects on food availability and human nutrition have not been completely grasped. Thus, despite the resolution assigning priority to reduction of post-harvest food losses by 50% by 1985, passed at the Seventh Special Session of the UNITED Nations General Assembly in 1975, very little has been done in developing countries to reduce these losses, particularly of perishable commodities.

On the other hand, considerable efforts and resources have been assigned to increasing crop production. These efforts have resulted over the last 20-30 years in

a) increased grain productivity of 40%
b) increased grain production of 80%
c) rate of growth of grain production similar to that in more developed countries.

Indeed, despite global food production levels which seem adequate to satisfy minimum levels of nutrition, it is well known that there are

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serious nutrition problems in many parts of the world. It will be argued that many of these problems could be eradicated by reducing post harvest loss, which is, therefore, seen as the most important problem of food conservation in developing countries. The problem is explored in this paper under the following headings:

Food Losses and World Hunger
Technical Analysis of Food Loss
Problems of Food Conservation

FOOD LOSSES AND WORLD HUNGER

Data on percentage increases in world food production in relation to world population (Table 1) showed that per capita increases in food production ranged from 0.3% in developing countries to 1.7% in developed countries over the 10-year period 1962-1972. This production was sufficient to maintain minimal nutritional requirements even in developing countries. On the other hand, by conservative estimates malnourished and undernourished people in the world in 1974 numbered 500 million (Table 2). Moreover, some 434 million or 87% of these people were in developing countries. In Latin America, it was estimated that in 1974 some 36 million people had serious nutritional problems. If it is assumed that the percentage level of malnutrition in the CARICOM Caribbean is similar to that in Latin America (13%), then some 650,000 of a total population of 5 million have sub-optimal food intake levels. Since 60-80% of the population and workforce in developing countries is engaged in agriculture, then it would seem that problems of food distribution cannot account for all of the malnutrition problems. Data (Table 3) showed that food losses in developing countries in 1976, estimated at 103 million tons, were sufficient to feed more than 300 million people and worth some US$10.5 billion. It is projected that these losses would increase to 117 million tons in 1985. In Latin America, food losses in 1974 were estimated at 38 million tons i.e., sufficient to feed some 45 million people and worth US$5 billion. In the CARICOM Caribbean, similar losses are estimated at 460,000 tons which would provide for the nutritional needs of 540,000 people or 83% of the malnourished population.

Therefore, reduction in post harvest losses in developing countries would lead both to substantial increase in food availability, reduction of food imports and should contribute substantially to solution of problems of malnutrition.

TECHNICAL ANALYSIS OF FOOD LOSS

Food supply has been a major problem of mankind throughout recorded history. Apart from major famines caused by crop failure due to floods and drought as well as pests and disease attack, low yielding production systems have resulted in chronic food shortages, particularly in developing

Table 1.--Percentage increase in food production in relation to population increase

	Annual % Increase (1962-1972)		
	Population	Food Production	
		Total	Per Capita
World	1.9	2.7	0.8
Developed market economics	1.0	2.4	1.4
Developed planned economics	1.0	3.5	2.5
Developing market economics	2.5	2.7	0.2
Developing planned economics	1.9	2.6	0.7
Latin America	2.9	3.1	0.2

Source: FAO 1974, The Present State of World Agriculture and Nutrition.

Table 2.--Estimates of percentage and number of malnourished persons - 1974

	Population (millions)	% Malnourished	No. malnourished (millions)
World	4000	12.5 - 25.0%	500 - 1000
Developed market economics	1070	3	28
Developing market economics	1750	25	434
Latin America	280	13	36
Caricom Caribbean	5	13 1/	0.650

Source: FAO 1974, Present State of World Agriculture and Nutrition.

1/ Assumed to be at the same level as that for Latin America.

Table 3.--Estimates of food losses and feedind capacity

	Loss	
	Loss/ann. (millions)	Feeding capacity (Million persons/ann.)
27 countries (1948)[1/]	65	100
Developing countries[2/]	107	300
World (1974)[3/]	400 - 675	1000
Latin America (1975)[4/]	38	45
CARICOM Caribbean	0.46	0.54

1/ Cotton 1948
2/ NAS 1978
3/ FAO 1974
4/ Pimentel et al. 1975
5/ Author's 1971 estimate

Table 4.--Estimated percentage losses of utilization/production operations in Latin America[1/]

Production losses	3 - 8%
Harvest losses	3 - 5%
On farm selection losses	1 - 2%
Packaging losses	3 - 6%
Transport losses	1 - 4%
Storage losses	4 - 8%
Processing losses	1 - 5%
Handling losses	1 - 5%
Distribution losses	2 - 8%

Handling losses	8 - 25%
Storage losses	4 - 8%
Processing losses	1 - 5%

1/ After Amezquita and La Gra (1979).

countries. There were high hopes for solution of these problems through introduction of new high performance varieties in the GREEN REVOLUTION of the sixties. However, the collapse of the revolution except in a few specialized cases e.g. N. Mexico and N. India has led to reassessment of food supply problems. Such reassessment has led to the notion that many of these problems can be better overcome by preventing the considerable losses that occur after harvest, rather than by seeking to effect dramatic increases in production, which will in any case overburden an already weak post harvest sector. Only when such an approach has been successfully implemented can be establishment of buffer stock as an insurance against natural disasters be seriously considered. However, technical analysis of the problems of food conservation show that they present no easier solution than the problems of production. These problems are briefly outlined under the following headings:

The post harvest sector
Analysis of food loss
Food loss in the Caribbean

The Post Harvest Sector

There are at least fourteen alternative component systems involving four categories each of producers and consumers of national, regional and international origin in a typical post harvest sector (Fig. 1). Each system has different requirements for handling, packaging, storage and often food quality standards are properly defined only in international markets. Therefore, there are different problems of food conservation associated with each system requiring different approaches to their solution. Further, the problems of the sector as a whole are different in developing countries where 60-80% of the population is involved in agricultural production compared with those in developed countries, where only 5-15% of the population is so involved. Moreover, a much higher percentage of the resources of the sector is applied to provision of sophisticated facilities for handling, packaging, transport and storage in the latter countries.

Transfer of food from producer to consumer also involves many marketing transfer operations, e.g.

- From farmer to middleman at Farmgate
- From middleman to retailer at wholesale market
- From retailer to consumer at retail market

Although food losses occur at transfers from farmer to middleman and from middleman to retailer, these losses are often less than those which occur in the retailer/consumer transfer. A particular feature of this latter transfer operation both in developed and in developing countries is the number of different arrangements for effecting it which prevail. Accordingly, at least eight different arrangements relevant to the CARICOM Caribbean may be identified as follows:

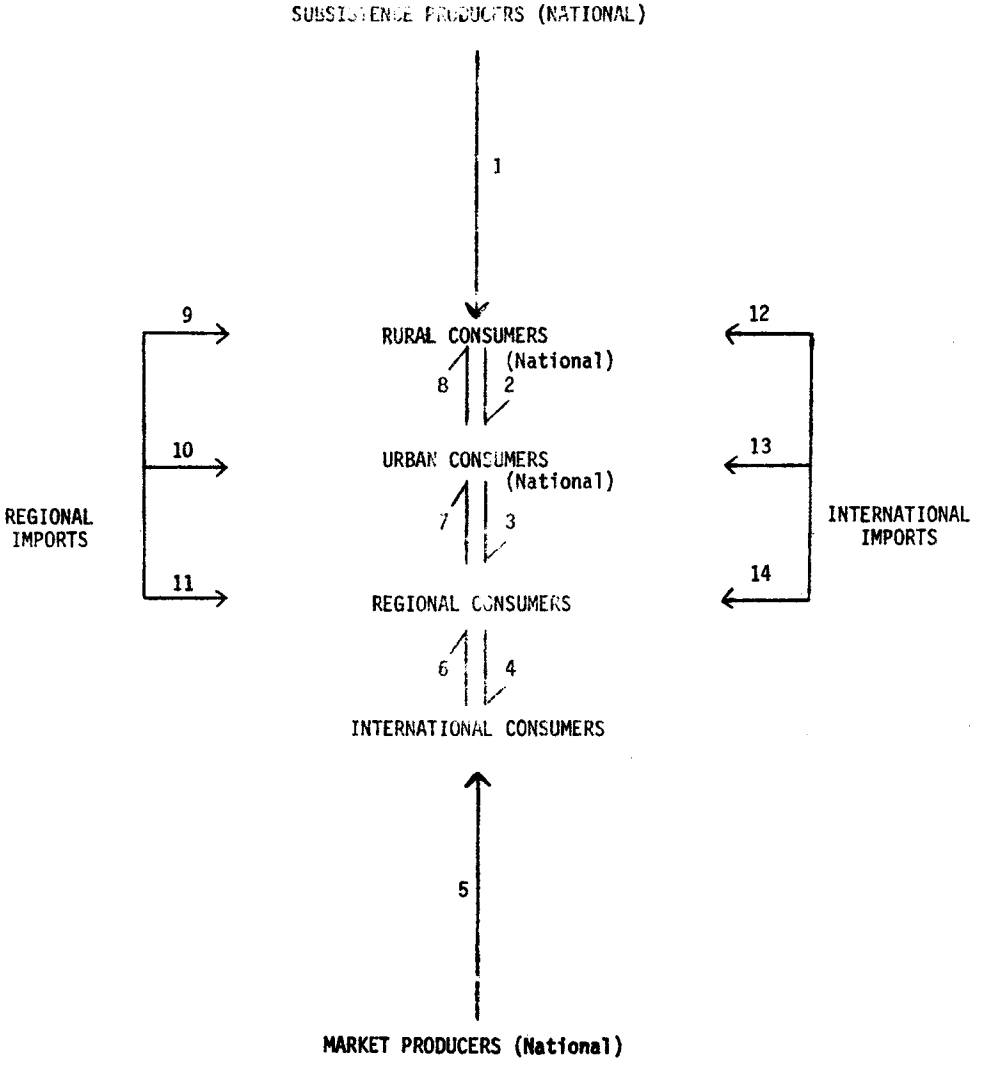
SUBSISTENCE PRODUCERS (NATIONAL)
1
9
10
11
REGIONAL IMPORTS
RURAL CONSUMERS
(National)
8
2
URBAN CONSUMERS
(National)
7
3
REGIONAL CONSUMERS
6
4
INTERNATIONAL CONSUMERS
12
13
14
INTERNATIONAL IMPORTS
5
MARKET PRODUCERS (National)

FIG. 1

- Government Marketing Corporation outlets
- Supermarkets
- Small food shops
- Urban markets
- County or village markets
- Roadside markets
- Farmers markets
- Pick your own operations

Again, there are considerably different requirements for effecting food conservation and preventing food loss in the different marketing arrangements of the retailer/consumer transfer.

In addition to marketing transfer operations, each component system in the post harvest sector is characterized by a number of procedural steps (Fig. 2) collectively referred to as the food chain. At each step, considerable food loss could occur unless specific and well defined conditions to reduce or prevent it are applied. Moreover, the post harvest problems of different categories of commodities in the sector e.g. non-perishable cereals and grains versus perishable roots and tubers, fruits and vegetables are quite different because of their different capacities and requirements for storage.

Therefore, the post harvest sector might be visualized as a hierachy of operational arrangements of increasing complexity for a number of different commodities with different requirements and capacities for storage including:

- procedural steps
- marketing transfer operations
- food chains
- marketing systems

Reduction of post harvest food losses in the sector will only result when the problems of every component operation in the Sector are understood and solutions applied to them. Unsolved problems for a commodity in a single procedural step will lead to increased losses not only in that step, but also in all the subsequent steps in the component system.

ANALYSIS OF FOOD LOSS

Post harvest losses are associated with each utilization operation in the food chain. Thus Amezquita and La Gra (1979) estimated typical total losses ranging from 19-51% of which 13-38% were post harvest losses (Table 4). These losses can be broadly classified into handling, storage and processing losses which account for the following percentages of the total loss.

Handling losses	8-25%
Storage losses	4-8%
Processing losses	1-5%

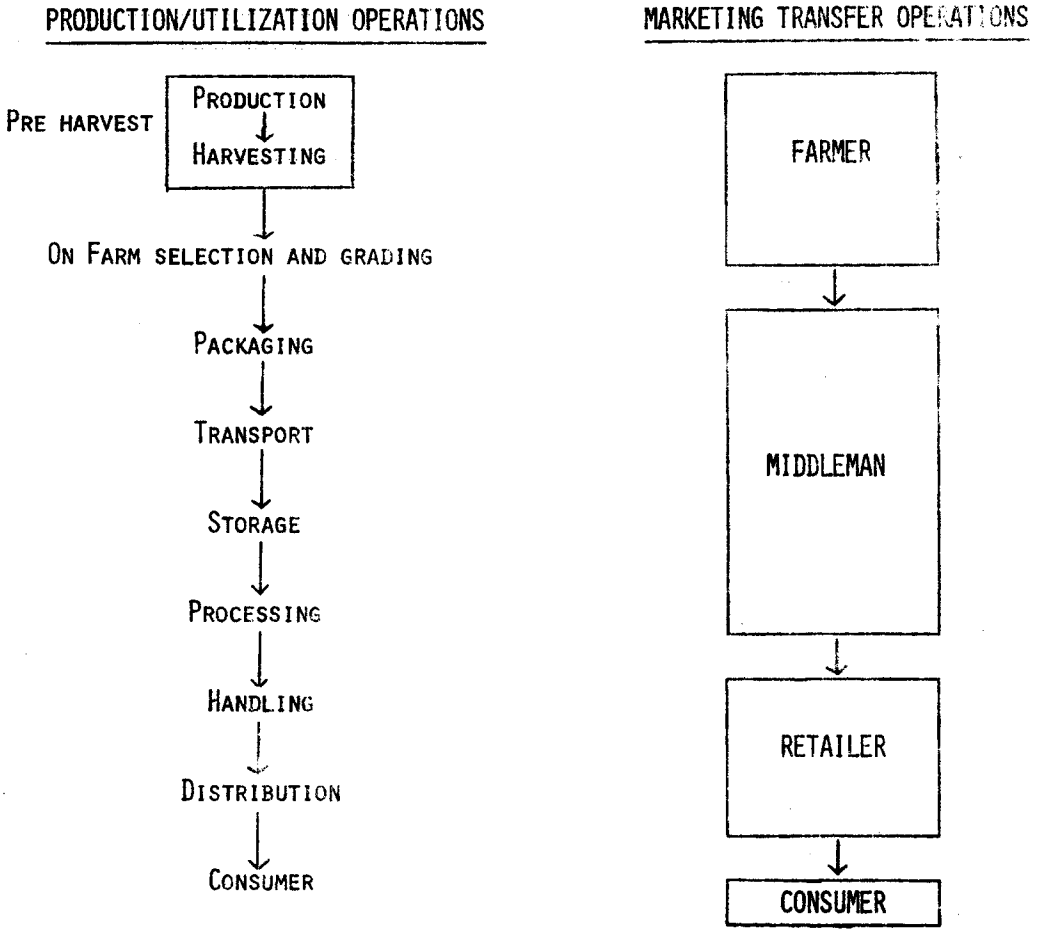

FIG. 2 PROCEDURAL STEPS IN THE FOOD CHAIN

Handling losses are for the most part caused by physical and mechanical damage; storage losses by pest and disease attack and undesirable physiological changes in the commodity e.g. premature ripening in fruit; and processing losses by quality selection of raw material as well as by processing operations e.g. pulping, peeling, milling, etc. There are operational interrelationships between the various components of the food chain in that undetected losses due to say physical or physiological mechanical damage could lead to increased storage or processing losses at a later stage in the chain. All of these losses can be considerably reduced in a properly managed system.

Data (Table 5) from several sources suggested that losses could rise to alarming proportions, both for perishable and non-perishable crop commodities. However, these losses are for the most part estimates rather than precisely determined statistics. Indeed apart from cereals, standard methodology for determining food losses does not exist. Global averages for developing countries of 10% and 20% for losses in durable and perishable commodities were suggested by the U.S. National Academy of Sciences publication on "Food Losses in Developing Countries" (NAS 1978).

Although Amezquita and La Gra (1979) reported storage losses at only 21-31% of post harvest losses (Table 4), the storage function is considerably more important, than is suggested by this statistic, particularly for perishable commodities, because it severely limits the time period over which these commodities are available to consumers. Thus, storage of tropical fruits and roots and tubers from one harvest to another is virtually unknown in the Caribbean and the high percentage of wastage of vegetables in weekend markets, particularly in times of glut production is related to the unavailability of facilities for storage of vegetable commodities beyond a few days. However, under proper storage conditions, fruits and vegetables could be stored for periods ranging from 2-24 weeks (Table 6) depending on the inherent perishability of the commodity. Such storage conditions are related to the origin of the commodity, but maintenance of the commodity in a LIVING CONDITION after harvest by postponing the advent of senescence is the common requirement of successful storage operations.

Although initiation, growth, development and maturity are common features of the genesis of yield organs of different origins, the post harvest biological processes (Fig. 3) which lead to senescence and hence unacceptability of the commodity as an item of human food are greatly different. Thus for leafy vegetables senescence itself is the only post-harvest process leading to deterioration, whilst for roots and tubers, dormancy and germination and for fruit, ripening, are interpolated between maturity and senescence. Despite the very diverse biochemical and physiological components of these processes, three easily controlled parameters conditions i.e. mechanical damage, humidity and storage temperature, are found to postpone senescence in the three commodity types. Mechanical damage can be controlled in commercial practice by careful harvesting and handling methods and humidity by ventilated or plastic film wrapped storage. However, provision lowered temperatures for extended storage

Table 5.--Estimated percentage losses of different crop commodities in Latin America[1/]

Cereals & grains	5 - 50%
Roots & tubers	40 - 75%
Fruit staples (plantains and green bananas)	30 - 65%
Fruits	35 - 70%
Vegetables	35 - 70%

1/ After Amezquita and La Gra (1979)

Table 6.--Approximate storage life of fresh fruit and vegetables

Perishability rating	Storage life at 0 - 12° C
Extremely perishable	
Mangoes, pawpaws, melons, cauliflower, green peas and beans, lettuce, spinach	2 - 4 weeks
Perishable	
Avocados, pineapples, cabbage, tomatoes	4 - 8 weeks
Slightly perishable	
Limes, oranges, onions, celery	6 - 12 weeks
Very slightly perishable	
Lemons, grapefruit, carrots, pumpkins, sweet potatoes	12 - 24 weeks

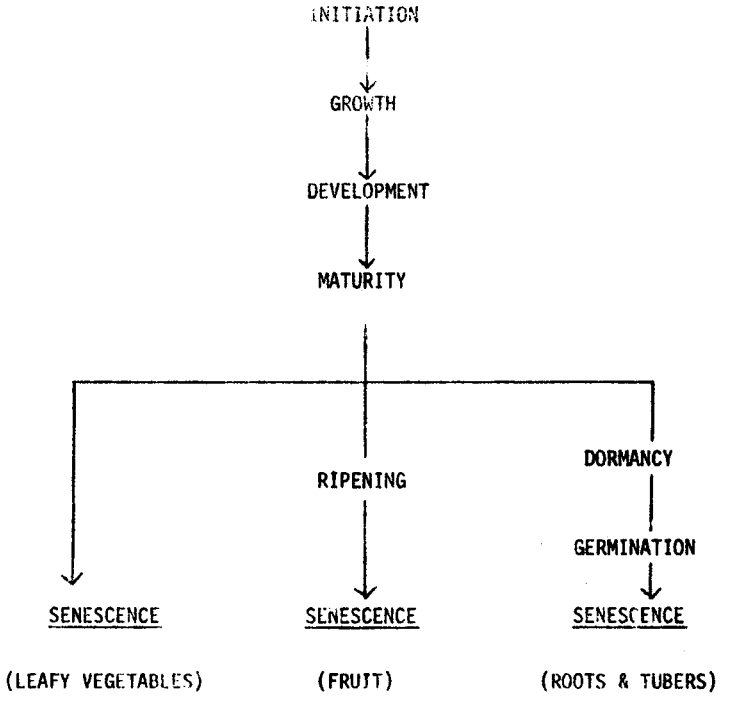

FIG. 3. POST HARVEST BIOLOGICAL PROCESSES INVOLVED IN CROP COMMODITY STORAGE

must be carried out with precision to avoid low temperature injury of tissues leading to poor quality. Further research offers great promise for more specific methods for control of storage life through application of controlled atmosphere storage and use of hormones e.g. for bananas and yams.

Thus it can be concluded that commercially applicable methods can be developed or are already available for extending the storage life of perishable commodities. However, a major problem of the application of such technology to preventing food losses in the Caribbean is that the detailed studies of the component parts of the food sector necessary to identify specific problems have not yet been carried out, nor has there been precise commercially oriented studies on the technology and economics of low temperature storage of individual perishable commodities.

FOOD LOSSES IN THE CARICOM CARIBBEAN

In the absence of reliable data, food losses in the CARICOM Caribbean are estimated from actual (1971) and projected (1985) food demand data assuming conservative losses of 10% and 20% for cereals and grains and other perishable food commodities, respectively (NAC 1978). (Table 7). Food losses of 456, 408 and 647, 611 tons in 1971 and 1985, respectively, are estimated i.e. sufficient food to take care of most of the malnutrition problems in the region.

PROBLEMS OF FOOD CONSERVATION IN THE CARICOM CARIBBEAN

It has been so far established that reduction of food loss could lead to substantial improvement in the nutritional problems of developing countries, but that the postharvest sector is perhaps more difficult to manage than the production sector because of the operational complexity and the number of marketing transfers involved in the passage of food from the farmer to the consumer. It is also evident that the problems of the sector will

a) vary with different participatory interest groups, e.g. consumers, farmers, middlemen, governments and

b) involve technological, cultural and socio-economic components.

Thus the problem of farmers, middlemen and retailers are likely to be economic and technological and related to enterprise profitability whilst those of governments and society will include wider considerations such as food availability, nutrition, social stability, employment, income distribution and balance of payments. Some of the technological problems will be considered from the points of view of different participants in the sector as follows:

Table 7.--Estimated food losses in the Caricom Caribbean (1971, 1985)[1/]

Commodities	Estimated Losses (Tons)	
	1971	1985
Cereals & Grains	71,686	91,199
Roots & Tubers	132,357	190,270
Fruits & Vegetables	106,343	152,597
Sugar	40,245	54,952
Oils & Fats	14,855	21,629
Meat, Fish & Animal Products	90,922	136,964
Total	456,408	647,611

1/ Estimated from food demand data (Bruce and Rankine (1979) with loss for cereals and grains at 10% and other losses at 20%.

- Farmers, middlemen, retailers, consumers/Governments.

However, it is emphasized that the sector includes at least 14 component systems each handling several commodities as shown in Fig. 1. Particular attention will be given to some of the problems of the local and regional components of the CARICOM Caribbean postharvest sectors as they apply to perishable commodities.

FARMERS' PROBLEMS

Since the farmer is invariably the first step in the food chain, many of the changes associated with loss reduction must start on the farm. Also since the majority of the food producers in the Caribbean are small, subsistence/market farmers, with limited land area and little capital, the major problem of food conservation is the limited availability of resources, e.g. capital, time, labour for improved food conservation measures. Such limited resources leads to

a) Preferential cultivation of high yielding varieties rather than those with good storage qualities e.g. sweet potato in St. Vincent, onions in Barbados.

b) Application of cultivation and harvest techniques which reduce the quality and storage life of the crop commodity e.g. inadequate control of preharvest nematode infection and infestation leading to high post harvest losses in yams.

c) Production of seasonal commodity gluts resulting in low prices and tremendous wastage because of inadequate storage facilities both on-farm and off-farm.

d) Hasty sale of produce to middlemen or in the market place to secure ready cash or to save time, because of the absence of adequate storage facilities.

Farmers have sometimes wittingly or unwittingly overcome these difficulties with approaches satisfactory to the farming sector, but not necessarily to consumers or to society at large, e.g.

(i) by production shorfalls at times of peak demand, e.g. at Christmas, resulting in exorbitant prices, e.g. TT$24/kg for tomatoes and TT$12.00/cabbage in Trinidad.

(ii) by producing high yielding/short storage life sweet potatoes for the low priced CARICOM market and low yielding/long storage life crops for the internation (UK) market.

(iii) by dumpling glut production on Government marketing corporations.

PROBLEMS OF THE MIDDLEMEN

The traditional marketing system in the Caribbean is characterized by the operation of several middlemen/retailers involved in the transfer of commodities from farmer to both retailers and consumer, variously known as hucksters in Guyana and the LDC's, hawkers in Barbados and higglers in Jamaica. The problems of this component of the sector include

(i) operation of large numbers of individuals with little resources, handling small amounts of produce with small marketing margins

(ii) inadequate packaging and transport facilities both for road and sea transport in local and regional markets, respectively, e.g. bagging of tubers and vegetables and sea transport on vessels with inadequate cool storage facilities and irregular sailing schedules.

(iii) inadequate grading and storage facilities at retail outlets.

In the early 1960's Governments of Barbados, Jamaica, Cuyana and Trinidad and Tobago attempted to improve the traditional marketing system by forming marketing corporations e.g. Barbados Marketing Corporation in 1961, Jamaican Agricultural Marketing Corporation in 1963, Guyana Marketing Corporation in 1964 and the Central marketing Agency of Trinidad and Tobago in 1964. Later, marketing agencies were also formed in some of the LDC's. These marketing corporations which were usually well supplied with personnel and facilities e.g. cold storage, refrigerated trucks, assembly and grading centres, were intended both to provide guaranteed outlets for farmers and a regular flow of commodities to retailers and consumers at fair prices to all three groups. It was expected that these functions would have been facilitated by the improved assembly grading storage and packaging facilities in the corporations. After 15-20 years of operation in the Caribbean it is clear that corporations have not been completely successful because of the following problems:

(1) Poor management of infrastructure and personnel

(ii) Intractable civil service bureaucracy

(iii) Excessive post harvest losses due to inadequate attention to storage requirements of different commodities, e.g. application of suitable storage conditions will not improve the shelf life of poorly cured onions and infested, infected and damaged sweet potatoes and yams

(iv) Inadequate technical training and frequent turnover of professional and managerial staff

As a result, the traditional middlemen have used the corporations as buyers of last resort or as dump outlets in times of glut production. In turn, receipt of poor quality produce and the inability of the storage

system to cope with glut supplies have frustrated the operational efficiency of the corporations. In other words, the corporations have not succeeded in the function that they were set up to perform i.e. to extend the storage life of local and regional commodities in order to achieve more effective regulation of commodity flow. There is now an urgent need for reassessment of the structure, functions and operations of these marketing corporations.

PROBLEMS OF THE RETAILERS

The major problem of the retailers (supermarkets excepted) is the inadequate provision of proper storage facilities in the market place. Also, even some storage facilities do exist, effective storage is often sacrificed for attractive display to result in short shelf life, excessive post harvest losses, high prices and often reduced profitability. A particularly important result of poor storage facilities is the concentration of marketing to weekends, thus transferring the storage function to the consumer.

Alternatively, provision of adequate storage and display facilities in supermarkets is often frustrated by a poor pre-retailing history of the commodity in the hands of the farmer and middlemen. In these circumstances, even ideal storage conditions will not result in extension of commodity shelf life. However, the supermarkets do tend to spread availability of perishable commodities between weekends.

PROBLEMS OF CONSUMERS AND GOBERNMENTS

The major interests of consumers are regular supplies of high quality commodities at reasonable prices. When these interests are taken collectively they reflect food demand and nutritional requirements of the community. It is the suggestion of this paper that food demand and nutritional requirements will be satisfied only when post harvest food losses are considerably reduced by attention to all components of the post harvest sector.

Because of seemingly conflicting interests of producers and consumers, there needs to be firm control in the post harvest sector at national level. Such control must include attention to well defined standards of cultivation and harvesting as well as grading, packaging, transport and storage and the provision of adequate facilities for display and storage in the market place. Coordination of such an effort requires creation of national policy and planning groups for food conservation at the same level of already existing groups for production and in some cases, human nutrition. It is recommended that such groups should be created as a first step towards developing a strategy for controlling food losses in the CARICOM Caribbean. Such standards will lead to reduction of post harvest losses, increase in food availability and food quality and hence to improved nutrition of the community.

CONCLUSION

It is therefore that because of the direct effect that reduction of food losses could have on increasing food availability and thereby ameliorating existing malnutrition problems, food conservation might be considered as an important aspect of the interface between food availability and human nutrition. It is argued that food conservation supercedes food production in importance because increased production would lead to greater percentage food loss unless conservation measures and facilities are made available in advance to prevent them. Despite its importance, little progress has been made in food conservation in developing countries and specifically in the Caribbean, partly because the importance and complexity of the post harvest sector has not been fully grasped but also because sufficient resources and appropriate technology and management skills have not been systematically applied to improving the sector. Therefore it is recommended that food conservation policy groups should be included together with production and nutrition groups in the national planning apparatus of CARICOM Caribbean countries as a first step towards improving this situation. Existence of such national groups could then lead to a more meaningful forum for regional food and nutrition policy and programme planning.

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