Food and Agriculture Organization of the United Nations

Food loss analysis: causes and solutions

Case study on the cassava value chain in the Republic of Guyana

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FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
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Abbreviations and acronyms

ADB	Agricultural Development Bank
ADP	Agricultural Export Diversification Project
CABA	Caribbean Agribusiness Association
CARICOM	Caribbean Community
CARIRI	Caribbean Industrial Research Institute
CARDI	Caribbean Agricultural Research and Development Institute
CAREC	Caribbean Epidemiology Centre
CLP	Critical Loss Point
CRU	Cocoa Research Unit
FAO	Food and Agricultural Organization of the United Nations
FSC	Food Supply Chain
GDP	Gross Domestic Product
GOG	Government of Guyana
GMPP	Guyana Micro-Projects Programme
GTIS	Guyana Trade and Investment Support
IDB	International Development Bank
IFAD	International Fund for Agricultural Development
IICA	Inter-American Institute for Cooperation on Agriculture
ILO	International Labour Organization
MFPLMA	Ministry of Food Production Land and Marine Affairs (Trinidad and Tobago)
NAMDEVCO	National Agricultural Marketing and Development Corporation (Trinidad and Tobago)
NAREI	National Agricultural Research and Extension Institute (Guyana)
NGMC	New Guyana Marketing Corporation
PRCSSP	Poor Rural Communities Support Services Project (Guyana)
READ	Rural Enterprise and Agricultural Development Project (Guyana)
RH	Relative humidity
THA	Tobago House of Assembly
USAID	United States Agency for International Development
UWI	University of the West Indies
VS	Vascular Streaking

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Executive Summary

Cassava (*Manihot esculenta Crantz*) is a woody perennial shrub of the Euphorbiaceae family. In view of its favourable agronomic traits, tolerance to abiotic stresses and adverse environments, the crop is produced by small farmers in marginal agricultural areas in the Caribbean as well as other parts of the world. In recent years in African, the Caribbean and Latin American countries, cassava production has grown and is projected to increase further because of its demand as food and its value as raw material for industrial use. In Guyana, cassava production has increased by a modest 11 percent from 2007 to 2012. Cassava cultivars are classified into two groups based on the amounts of hydrogen cyanide (HCN) present. Sweet types contain less than 50 mg kg-1 (fresh weight) and are generally sold as fresh roots, whereas bitter types have a larger amount of HCN, but have higher yields and starch content.

Fresh cassava roots are highly perishable under ambient conditions, becoming unmarketable in 3 days or less. With proper post-harvest handling and management practices fresh roots can be stored up to 30 days. In recognition of the importance of cassava as a source of carbohydrates and the potential for further development of a diverse range of value-added products, FAO in collaboration with CARICOM initiated a project entitled 'Reduction of post-harvest losses along the food chain in the CARICOM subregion 'Reduction of post-harvest losses along the food chain in the CARISOM sub-region' and identified cassava as one of the three commodities for post-harvest loss measurement.

The main objectives of the investigation included: an in-depth analysis of post-harvest handling practices of cassava producers, retailers (roadside and mobile market vendors, municipal markets, supermarkets), wholesalers, exporters, processors for development of value-added products and consumers, to obtain a more complete understanding of the system-wide nature of quality deterioration and subsequent losses in order to formulate appropriate solutions for quality management and loss reduction strategies; analysis of the cassava value chain as items for food consumption, with quality attributes, which must be protected and enhanced in various marketing channels; the examination of the significance of losses of both technological and socio-economic origins; examination of links between growers and provisions for transferring relevant research information on identified problems to producers, traders and processors; the design and evaluation of improved operations throughout the system and alternative post-harvest handling systems; and the description of key factors affecting the logistics performance in the CARICOM Region with particular emphasis on logistics that affect produce losses in the supply chain.

Post-harvest losses of cassava were measured at three critical loss points (CLPs) after screening the value chains in both countries. The critical loss points were at harvest (CLP#1), packinghouse operations (CLP#2) and at retail markets (CLP#3).

At CLP#1 total losses averaged 6.5 percent mainly because of physical damage and pathological and entomological damage being 3 and 3.5 percent respectively. No physiological losses were measured at CLP#1 and 2 and total losses at CLP#1 were at least three times more than CLP#2. Losses were cumulative and injuries to roots at CLP#1 created avenues for further quality degradation as the commodity was moved along the value chain to CLP#3. Nevertheless, while the nature of all types of damage was almost the same (3.5 percent) after 6 days of retail marketing, the limit to marketability based on qualitative ratings was only up to day 2.

Strategies to reduce post-harvest losses include the use of appropriate harvesting tools such as the hand lifter to minimize breakage; removal of roots within 2-4 hours after harvest and providing protection against sunlight to minimize the desiccation of roots; washing of roots to remove dirt and dipping in a fungicide such as immazalil to limit microbial contamination; storing treated roots in polyethylene bags at a safe low temperature and high relative humidity 85-90 percent; inducing curing treatment to heal superficial wounds by keeping roots at 28-30 °C and 85-90 percent relative humidity; and application of wax treatment at 55-65 °C for a few seconds after treatment with a fungicide.

Chapter 1
Introduction

Background information

A high incidence of post-harvest losses exacerbates the problems of low agricultural productivity and food security in countries of the Caribbean Community (CARICOM). Post-harvest losses cause food quality and quantity to be severely reduced, thereby affecting incomes and impacting on the rural poor in the region. The Food and Agriculture Organization of the United Nations (FAO, 2012) has indicated that post-harvest losses are highest in developing countries. Fonseca and Vergara (2014) reported that in the Latin America and Caribbean (LAC) region 50 percent of the fruits and vegetables and 37 percent of roots and tubers are lost before they reach consumers and suggested that improving logistics systems and management would be an efficient approach to reducing losses across the supply chain. They found that failure in logistics operations including product handling, precooling, packaging, storage, transportation, and inappropriate infrastructure, are among the most common reasons for the high quantities of food losses. These estimates do not include loss of quality, nutritional value and the health burden associated with consuming contaminated food products.

Several factors contribute to post-harvest losses along the supply chain such as preharvest factors, environmental hazards (inadequate temperature and relative humidity control) pests and diseases and senescence. Reducing the incidence of post-harvest losses along the food chain in the CARICOM subregion will contribute to improving food availability to address food insecurity, enhancing food quality (better packaging, handling and storage), increasing economic access to food through job creation and income-generation, development of efficient logistics systems to improve market access by delivering the right product at the right time.

In the past, efforts to combat this situation have not been very successful partly because countries have lacked the required and up-to-date information about the scale of the problem that could have helped them develop programmes to address the problem. This lack of reliable and up-to-date information has continuously prevented governments, the private sector and other key stakeholders from implementing workable solutions. While there is increasing acknowledgement among governments in the CARICOM Region and the international community that post-harvest loss (PHL) reduction is one of the key elements required to reduce food insecurity, the use of inappropriate and out-dated approaches is limiting current interventions. This rapidly changing context, because of urbanization and globalization, means that interventions that were once regarded as successful may no longer be so, and this is causing governments to improperly handle the challenges facing the post-harvest sector.

Given the need to better understand the strengths and weaknesses of the post-harvest handling systems in the CARICOM and to identify, plan and implement interventions policies and practices, two countries, Guyana and Trinidad and Tobago were identified by FAO to conduct detailed value chain analyses pertaining to cassava, tomato and mango.

Study objective

The main objective of this study was to conduct an in-depth analysis of post-harvest handling practices of cassava producers, marketers, processors and consumers, to obtain a more complete understanding of the system-wide nature of quality deterioration and subsequent losses so as to formulate appropriate solutions for quality management and loss reduction strategies. Furthermore, the assessment sought to identify the critical loss points and causes of losses at these points by using PHL assessment methodologies and tools. In addition, desk research was conducted to identify cost effective, environmentally friendly and gender appropriate solutions to reduce post-harvest losses, drawing on an inventory of past and current technologies and practices both within the region and outside.

Chapter 2
Methodological approach

Selection of countries and subsectors

CARICOM Member Countries Guyana and Trinidad and Tobago were selected for this study based on the importance of the targeted subsectors: cassava, mango and tomato. In addition, the assessment was conducted in Saint Lucia, which is not only a CARICOM Member Country but also a member of the Organization of Eastern Caribbean States (OECS). The study in Saint Lucia was undertaken to compare and verify the results obtained in Guyana and Trinidad and Tobago.

Selection of food supply chains

Three subsectors that are important in the CARICOM Region were identified during a preceding study. The identification of these priority crops followed an in-depth desk study to review the available information on production, post-harvest handling including processing, marketing and export, etc. for the major food crops in the CARICOM Region. Reports from previous studies conducted by the FAO, CARICOM, regional institutions and other national and international organizations were analysed. Several crops were identified that are important in the agricultural systems of the Region. However, cassava, tomato and mango emerged as important food value chains and were therefore recommended as the priority crops for the project on the reduction of food loss and waste in the CARICOM Region.

Selection of stakeholders

The cassava value chain includes a highly diverse and complex number of producers (farmers) and traders (market types: farmers' or public municipal, roadside, mobile, supermarkets, processors) characterized by widely scattered production areas and fragmented marketing facilities. This structural variety, coupled with widely differing post-harvest practices among participants, posed considerable challenges to this investigation, which attempted to understand the entire value chain and its operations. Field observations and interviews were of paramount importance in discovering the differences in post-harvest operations among the diverse range of producers and marketers, as well those linked to cultural methods in different areas of the study.

In Guyana, the wholesale markets selected for the study were Bourda and Stabroek municipal markets. Two of the largest supermarkets, Nigel's and Bounty, were visited as well as one of the smaller ones (Bunny's), and the Guyana Shop operated by the New Guyana Marketing Corporation. Roadside and mobile markets were selected at random throughout the villages. Supermarkets were selected that had been in operation for the last 3 years, possessed refrigerated displays and had a minimum output of 12 to 15 kg of cassava. At each market outlet, every stage that could potentially reduce marketable quality and eventually manifest post-harvest losses, from the field in the case of a producer, or from procurement in the case of a trader to the point of purchase by the consumer, was selected for in-depth analysis. This approach is referred to as the 'systems approach'.

Methodology and data collection

The methodology used for this study involved a literature review; collection and analysis of the documentation and technical information on cassava; selection of the specific supply chains for the study and justification for the choice. Identification of 3 to 4 stages of the food chain where the losses are higher or have the greatest impact and selection of 1 to 2 stages for detailed analysis so as to participate in and contribute to the development of a comprehensive approach, including the appropriate tools for data collection and analysis so as to identify the scope and limitations of the study as well as gaps, which was to ensure all marketing aspects, including handling and shipping, were included. The implementation strategy for this study embraced the FAO recommended Food Loss Assessments

methodology, which was, where necessary, adapted to the Caribbean situation.

Study execution approach

The study had four main components:

Literature review and search of previous studies documented by regional institutions such as the FAO, the Caribbean Agricultural Research and Development Institute (CARDI), the Inter-American Institute for Cooperation on Agriculture (IICA), the University of the West Indies, the University of Guyana, the University of Trinidad and Tobago and other national institutions such as the respective Ministries of Agriculture, Central Marketing Agencies and stakeholders such as the Agricultural Society of Trinidad and Tobago, the National Food Crops Farmers Association and the Trinidad and Tobago Agribusiness Association was undertaken to identify ongoing work in the field of food losses and examine the completeness and gaps.

Selection of the specific supply chains and the geographical area (countries) of the study and justify the reasons for this choice – The main actors in the supply chain of each commodity included farmers, processors, retailers, wholesalers, supermarkets and associations. Selection was based on production and marketing volumes from data obtained from the national marketing institutions in both countries. Processing companies or cottage industries involved in development of major value-added products from each commodity in each country were also included.

Conducting and managing field interviews – Approximately 2.5 months were spent in the field to conduct interviews and collect data. In an effort to catalogue all the standard operating practices in the cassava value chain, a set of themes of inquiry was developed to guide the interview process and to compile a questionnaire. Preliminary interviews identified the themes to be included in the questionnaire. All interviewees cooperated, many enthusiastically, when the interview was conducted within their own work environment in a two-way fashion, that is, employing the 'mirror image technique' (Ref). The main elements of the mirror image technique involve dynamic, face to face interviews revealing an interpersonal process with key decision-makers associated with production, post-production, processing into value-added products, distribution and marketing functions; the consultants establish a rapport with interviewees while marshalling an extensive complex of variables in an intensive environment; the consultants have the flexibility to switch from a non-directive role, during the early stages of the interview, to a more directive one afterwards; examining post-harvest practices with respect to each theme of inquiry; perceptions among cassava farmers of the possible nature of post-harvest problems in terms of changes in quality and losses were examined; automatic checks were set up so as to avoid data collection errors arising from interviewees' bias, lack of knowledge of the correct answer or deliberate falsification of data by tracing and tracking the original causal factor.

Management of the interviews varied from farmer to trader to processor. While some were located with the assistance of the Agricultural Assistants in the county extension offices of the MFPLMA in Guyana, others were located using their addresses as they appeared in the list of registered farmers and processors. On several occasions, cassava farmers were met while attending Agricultural District Meetings. A combination of methods was used with supermarket retailers being informed by telephone to alert them of the existence of the survey, potential objectives and uses. Interviews with wholesalers, public markets, mobile market and roadside market vendors were conducted at the actual location, mostly without being previously arranged. Interviews almost always took place in the midst of the activity characteristic of post-harvest operations. As such the consultants were able to pose questions in the work environment and, in many cases, to actually witness the traders' decision-making where and when it occurred.

The great advantage of being able to observe and record manifest behaviour pertinent to systematic processes needed to be tempered by strict attention to methodology. It was imperative that the consultants, stayed in an observational role, and did not introduce themselves into the process to the extent that they became a variable thereby altering, even imperceptibility, the actual decision-making environment. The consultants and technicians recognized their presence could encourage a typical response. These effects were believed to have been minimized after thoroughly crosschecking responses with a wide variety of outlets.

Identification of 3-4 stages of the food chain(s) where the losses are higher or have the greatest impact and detailed analysis of 1-2 – The Critical Loss Points (CLPs) were identified by

observation, the literature review, interviewing of experts, marketing quality assurance officers and field officers. For each commodity supply chain one value-added product was followed at the particular processing facility either a village industry or larger-scale processing company. For each commodity a flow diagram was prepared to pinpoint the location of the CLPs and this was investigated in detail to identify causes and potential solutions. At least two stages were identified for detailed analysis during systematic evaluation of losses of the entire post-harvest handling system of each commodity and where there was potential for post-harvest losses to dominate.

Description of the key activities of the study

The flow of cassava from the point of harvest to consumption for producers and traders was documented by observing and recording the duration of each component of the system, the time taken for the cassava to move from one stage to the next, including delays as well as measurable characteristics of the environment, i.e. temperature, relative humidity and time of day. In addition, hands-on familiarization with the cassava handling operations provided the framework for examining typical patterns of decision-making and actions taken by participants within the cassava value chain. This also provided information on the dynamics of the cassava value chain and permitted the chain to be comprehensively mapped . By inserting the stages of the post-harvest handling system for cassava within the value chain also provided the template for tracking and tracing and, more importantly, identification of the Critical Loss Points (CLPs). The key activities carried out during the study are summarized below.

Screening was conducted to identify the additional information or new information, survey and analysis to be provided on food losses in the cassava subsector. Flow charts were used to show the various stages in moving cassava from the farmer or producer level to various market outlets, such as farmer's, mobile retail, wholesale, supermarkets, roadside and export, and processing plants for development of value-added products. The range of post-harvest losses at each stage along the commodity handling system was analysed based on available studies and reports. Frequent meetings, short questionnaires using electronic process and face-to-face or telephone interviews and or actual visits to sites to enable the action plan. Figure 1 provides a general view of the various activities screened by the consultants on preproduction, production, postproduction and sales characterizing the cassava value chain.

Survey involved mapping the current state of knowledge of the selected commodity and how it is handled in the wet and dry season in the particular market. Field data were collected from the point of harvest to the point of retail. Close attention was placed on the implications of indigenous handling practices on post-harvest losses and identification of best post-harvest practices to eliminate or reduce such losses. The methodology employed the proposed 4-S (Screening, Sampling and Survey, and Synthesis) approach for loss assessment based on the Food Loss Assessments methodology recommended by FAO as well as the diverse lessons learned by FAO's Rural Infrastructure and Agro-Industries Division.

Sampling was used in tracking and tracing the dynamic nature of the commodity handling system based on cultivar, season and market type, documentation of harvesting methods, harvesting techniques, maturity indices used, precooling practices, transport links to packinghouses, packinghouse design and process flow patterns. Thus all the steps indicated above covered environmental conditions, atmospheric composition, management practices to assist in determining the actual causes for quality deterioration at each step and the possible implication for cumulative losses. The questionnaire and site visits identified critical areas where there were post-harvest losses. By recording the above, then at harvest, the relationships between harvesting practices and post-harvest losses were assessed; identification of alternative methods for improving harvesting practices were determined as well as whether negative or positive effects could be determined from the resulting harvesting tools.

Cassava samples were purchased at each CLP and at the exact location where the activity of that particular stage was observed. Each sampling consisted of three replications of 12 to 15 kg of randomly selected cassava, which was representative of a market load. Simulated post-harvest storage trials of cassava samples were conducted in the laboratory at the UWI and evaluated after 2, 4, and 6 days similar to marketing conditions observed and recorded during field and market visits.

Each cassava sample was examined for marketable quality on a scale of 1 to 9 based on a method developed by Sherman *et al.* (1982) with 1 = unusable, 3 = unsalable, 5 = fair (limit to marketability), 7 = good and 9 = excellent. Each cassava sample was examined for damage and classified into two

FIGURE 1
Analysis of the cassava value chain

Pre-production

Crop attributes and inputs
- Favourable agronomic traits
- Tolerance to abiotic stress and adverse environment
- Drought resistance
- Early water stress and poor soil fertility limit production
- Breeding improvements targets nutritional content, disease resistance and yield

Production

Pre-harvest production
- Labour constraints
- Virus disease limitations
- Early planting spacing, monocropping, weeding and delayed harvesting can increase yield
- Varietal selection prolongs harvest with fewer physiological disorders
- Global production projected to increase by 2030

Postproduction

Post-harvest storage and transportation
- Fresh roots deteriorate after 2 to 3days
- Bulky and heavy to transport
- Low cost storage technology can increase shelf life to 2 weeks
- Value-added processing
- Processing reduces cyanide content, reduces weight and increase consumption
- Reduces post-harvest losses and increases marketing period
- Provide ingredients (starch, purees, flour) for tertiary products in baked products

Sales

Commercialization
- Limited international trading
- Limited industrial uses in the Caribbean
- There is potential for regional and internal trade in cassava flour, chips, starch, frozen logs and purees.

broad categories: marketable and unmarketable, based on the severity of the damage. The unmarketable cassava samples were designated as the post-harvest loss, weighed and the percentage loss calculated against the original weight. To determine the nature of the damage in the unmarketable category, cassava samples were further subdivided into three categories according to the nature of the apparent damage at that location, that is, physical, physiological and pathological and entomological.

Physical damage included cuts, bruises, punctures, scratches, splits, crushes, abrasions and cracks. Physiological damage included vascular streaking 1 and 11 (VS-1, VS-11), moisture loss (wilting, shrinkage), chilling injury. Pathological and entomological damage included that caused by fungi, bacteria, and insects. The weights in each category of damage were recorded and the percentage of post-harvest losses calculated for each category. Total post-harvest losses were obtained by summing the losses recorded at each CLP (Figure 1). Cassava samples were also taken to the University of West Indies and the National Agricultural Research and Extension Post-harvest laboratories to collect data on root dimensions, firmness and total soluble solids.

Synthesis involved visiting centres or institutions such as the respective Ministries of Agriculture, marketing and research agencies for production and marketing data and farms to observe cropping practices. In addition, the type of data and analytical procedures that are necessary to guide policy makers when engaging in strategic interventions to improve the post-harvest handling system for the selected commodity were determined. Policy options concerning key logistics to reduce post-harvest losses through application of simple inexpensive post-harvest innovative methods that would strengthen the post-harvest knowledge system were analysed and recorded. The marketing channels of each priority crop in each country were appropriately defined based on observations, analysis and feedback. Costs were calculated for the respective volumes of produce associated with each value chain as well as for post-harvest losses as determined by the surveys.

Chapter 3
Situation analysis

RELEVANT INSTITUTIONS

Two public agencies are largely responsible for carrying out activities related to post-harvest handling and are primarily concerned with post-harvest losses in root crops, fruits and vegetables. They both come under the purview of the Ministry of Agriculture and are the National Agricultural Research and Extension Institute and New Guyana Marketing Corporation (NGMC).

National Agricultural Research and Extension Institute (NAREI) is the principal Research and Extension Institute for field crops (excluding rice and sugarcane), fruits and vegetables, biofuels as well as for plant quarantine services. NAREI was established 28 years ago to develop and extend the necessary technology and support services to facilitate national agricultural development. During 2010, with the passing of a new NAREI Act in Parliament, its research and development programmes were re-oriented bearing in mind the Acts, national and global changes as well as aiming to promote greater efficiency in the crops and agricultural product industry, to provide enhanced services in agricultural research and extension and crop protection, regulation of trade, commerce and export of crops and agricultural products.

Among its basic functions, NAREI is tasked with advising and developing appropriate systems to promote balanced, diversified and sustained agricultural production through adaptive and investigative research. In addition to broad research and development activities for Guyana's agricultural sector, NAREI is also responsible for transferring the technology it has developed to farmers, students and extension personnel.

New Guyana Marketing Corporation (NGMC) is a government corporation that was established in the 1960s under Section 46 of the Public Corporations Act, Cap 19:05 of the Laws of Guyana. It was reorganized in 1985 and its functions include provision of market facilitation services; dissemination of post-harvest technology; conducting market research and the provision of market intelligence services.

In addition to the above, the NGMC manages two fresh produce packaging facilities: the Central Packaging Facility at Sophia and the Parika Agro-Packaging Facility. NGMC also operates the Guyana Shop, which purchases locally made, value-added, appropriately packaged products and sells them thus promoting and raising awareness within the population. The products area is also promoted overseas at various fairs and special events.

University of West Indies is another key institute in the region. Post-harvest studies are currently being pursued in both faculties on innovative methods to reduce losses of tropical commodities and to enhance value-added products. The UWI has also conducted several workshops throughout the Caribbean. The Third International Conference on Post-harvest and Quality Management of Horticultural Products of Interest to the Tropical Region was held by UWI in July 2013 in Trinidad under the auspices of the International Society of Horticultural Science (ISHS). The theme was 'Post-harvest technological initiatives to improve food security and market access'. A follow-up workshop entitled 'Post-harvest management strategies to reduce losses of perishable crops' was held in Trinidad from 24 to 25 February 2014 by UWI/CTA/NAMDEVCO to train certified farmers, exporters and field officers.

FIGURE 2
Post-harvest handling activities at a packinghouse facility at Piarco, Trinidad and Tobago

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DESCRIPTION OF SUBSECTOR SUPPLY CHAIN WITH GENDER DISAGGREGATED DATA

While gender disaggregated data on the cassava supply chain was not available for this study, there were general country data that can guide the thought process.

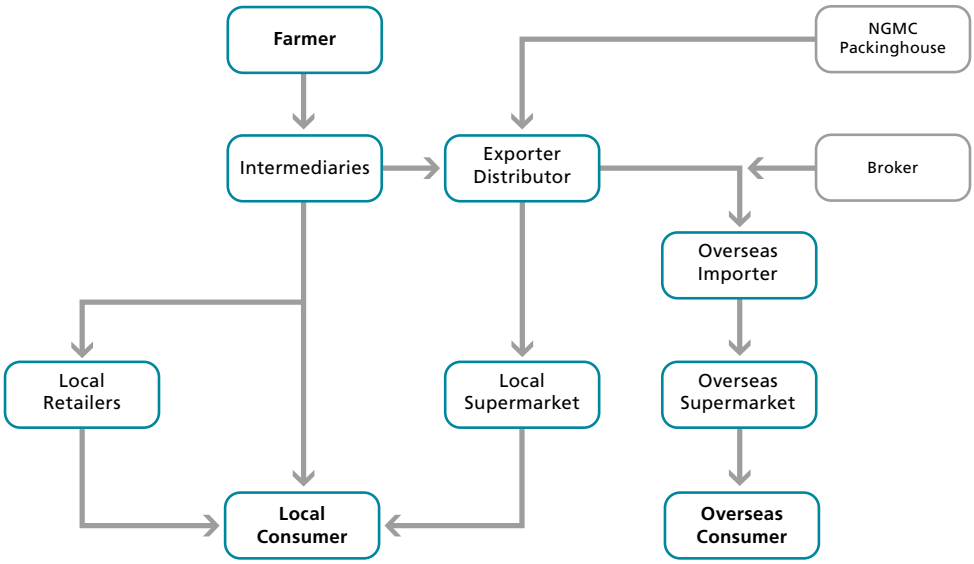
The main areas of population concentration in Guyana have not changed over the decades, although some of the sparsely populated regions have begun to show increased numbers. Region 4, where the capital city Georgetown is located as well as the East Bank Demerara FSC, had 41 percent of the population according to the 2002 population census. Similarly, Region 3, where the East Bank Essequibo FSC is located, had approximately 14 percent of the population. The four main hinterland Regions (1, 7, 8 and 9), shown in Figure 3, cover nearly three-quarters of the total land area are sparsely populated and comprise less than 10 percent of the population. Further to the above, the Guyana 2002 population census notes that the

FIGURE 3
Map of Guyana showing the ten administrative regions

Key: Names of the regions
1) Barima/Waini
2) Pomeroon/Supernam
3) Essequibo Islands/West Demerara
4) Demerara/Mahaica
5) Mahaica/Berbice
6) East Berbice/Corentyne
7) Cuyuni/Mazaruni
8) Potaro/Siparuni
9) Upper Takatu/Upper Essequibo
10) Upper Demerara/Berbice

Source: www.statisticsguyana.gov.gy/census.html

FIGURE 4
Current non-traditional agriculture value chain



Note: Some farmers also act as middle -men

percentage gender distribution of the population by region is similar to the national distribution. With the exception of Region 4, the proportion of males is higher than for females in the 2002 census. The largest gender differentials – where men outnumber women, are seen in Regions 8, 1, 7 and 9 in rank order.

It should be noted that the Guyana 2002 population census observed that the high proportion of women, in what would be called non-economic activity (unpaid) is generally misleading, as many women who report doing 'home duties' are usually involved in some small activity, e.g. making sugar-cakes, mitai, etc. or tend a garden to supplement family income or have a small income of their own. Further, some other non-economic activities performed by women such as cooking or caring for the family are usually chores that normally have to be paid for where women work and should be valued as a contribution to the household budget.

In Guyana, for the most part, non-traditional agricultural produce has a traditional marketing chain from farmer to wholesaler (intermediary/exporter) to retailer to consumer. There are four main actors involved in the value chain. Often one person or one family plays several roles and it may not be clear who is doing what. The wholesaler (intermediary) may supply the local retailer, supermarket, exporter or consumer directly as shown in Figure 4. There is no specialized wholesale market even though wholesaling is very common at several key trading or marketing points throughout the country. At the same time farmgate buying by intermediaries is common in most regions. In addition, Regions 2, 3 and 4 farmers in particular have greater options to also sell directly to retailers, supermarkets, exporters and processors.

IDENTIFICATION OF ONGOING WORK ON REDUCTION OF POST-HARVEST LOSSES

There is no evidence of ongoing work on post-harvest losses for any commodities in Guyana. The major gaps are: systematic measurement of post-harvest losses at each step of the system was not determined and the nature of losses based on type of damage, market type, season, cultivars were not determined.

DESCRIPTION OF THE EXISTING MARKETING SYSTEMS

Cassava is produced in all ten regions of Guyana across varying soil types. The Parika/Salem/Ruby area of Region 3 and the Craig/Friendship area of Region 4 are the main producing areas in the coastal regions. Cassava tubers move from the

FIGURE 5
Different cassava products being marketed in Guyana

(a) Cassava for sale at roadside vendor

(b) Farine at GMC's Guyana Shop

(c) Mini cassava bread

(d) Cassava bread squares

(e) Cassareep for sale at Guyana Shop

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farming areas to the consumption centres by way of intermediaries, wholesalers and retailers. Discussions with farmers and agricultural professionals and empirical evidence suggest that the demand for fresh cassava tubers on the coast may be considered modest, if not weak, and does not appear to be growing. While the demand for fresh cassava tubers has not been quantified the general information indicates they are used by people living on the coast for meals such as *metegee* (cassava boiled in coconut milk with other root crops, plantain and breadfruit with or without meat or fish); dry food (cassava boiled in water with other root crops, plantain and breadfruit and traditionally served with salted fish fried down with lots of onions); boil and fry (as the name suggests cassava, sweet potato, eddo and plantains boiled and fried); cassava bread, cassava chips, or cassava pone; and egg ball (where cassava is an integral component).

This rather stable coastal demand for cassava, compares to a strong market demand for farine and cassava bread in the interior regions. Amerindians traditionally use farine and cassava bread as staples and for a range of fermented drinks. The expansion of the gold and diamond mining enterprises particularly with the influx of Brazilians in recent years has put pressure on the relatively small quantities of cassava, which is the raw material for farine. Casareep is perhaps the other major value-added product used by coastal dwellers and Amerindians alike, even though there are differences in the final product used. The challenge is that the specific size of the market for any one product is unknown.

The domestic market for cassava is therefore primarily a non-segmented, low value market, almost exclusively for fresh cassava root. In addition to the value-added products already mentioned, one other – cassava starch – was very popular some decades ago as every home used it to 'starch' clothes when ironing. Natural cassava starch has long lost its niche value, and while there are several industrial uses, cassava tubers have not been used in recent years as an input for any major industry in Guyana.

Other observations of the cassava supply chain were as follows:

FIGURE 6
Different cassava products being marketed in Tobago

Cassava farine

Cassava bread

Cassava fruitcake

Cassava khurma

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- There was no organized marketing, no large-scale buyers of cassava tubers for commercial production of any cassava product; no storage or major collection point. The distribution system was in the hands of intermediaries.
- As at January 2014, farmers reported low farmgate prices of GYD 15/lb (USD 0.17/kg) and as a result they were not encouraged to expand production or to increase productivity (varieties, fertilizers, etc.). Farmers were limiting investments and some have recently reduced their acreage. Farmers have stuck to the traditional farm to market packaging: in polyethylene bags, which have long replaced jute bags in the rice industry; and from which the non-traditional sector takes its cue.
- Farmers were mostly disorganized when it came to marketing. They were engaged in, individual production, made individual sales to intermediaries and therefore had no group bargaining power.

Several cassava varieties are being cultivated in Guyana including Four Month, Brancha, Butterstick, Uncle Mack, M Mex 59, Mex 52, Red Stem and Bad Woman.

FIGURE 7
Tobago – Cassava beverages sold at Tobago Cassava Shop

Cassava punch (small size portion)

Cassava cola

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FIGURE 8
Tobago – Other value-added cassava products sold at The Tobago Cassava Shop

Cassava value-added products

Cooking cassava farine in Tobago

Tobago Cassava Shop

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Chapter 4
Study findings

SECONDARY DATA AND KEY-INFORMANT (EXPERT) INTERVIEWS

Literature review

The literature review of cassava production in Guyana did not reveal much data or information. A FAO document (Blair, 2010a), *The actual and potential market for cassava in Guyana* and a NAREI report (Homenauth, 2009) *Cassava production, processing and marketing opportunities in Guyana* were the most recent substantial documents seen. In addition, there is a Farmers' Manual, a chapter reports on *Cassava cultivation and post-harvest handling* and a NGMC/NAREI Information Sheet on post-harvest handling and market preparation, which are listed in the Bibliography along with others.

Review of the production and value of the produced cassava

Table 4.1 shows the volume of fresh cassava tubers produced in Guyana between 2007 and 2012. Production increased from 2 848 tonnes in 2007 to 11 724 in 2008 but by 2011/2012 production had fallen to 3 000–4 000 tonne. While these are the official figures, farmers from the two selected areas – East Bank Demerara and East Bank Essequibo (Parika-Salem) reported having to plant decreasing acreage because of limited markets.

No data are available on the area of cassava planted and the volume of processed cassava products (such as cassava casareep, cassava chips, cassava bread and egg ball which is a boiled egg fried in a thick batter of previously boiled cassava) produced. These are all outputs of small, primarily home-based cottage industries that fall outside the normal monitoring system and that present challenges to monitor in every respect.

The consultants are not aware that there is any gender disaggregated data related to the cassava value chain, however, it is common knowledge that cassava production is also exclusively a male dominated activity. Men and women farmers are directly involved in wholesaling and retailing; and this is the same for wholesaling and retailing by intermediaries. However, the intermediary function of purchasing cassava at the farmgate seemed to be mostly by men, while retailing at the various municipal and other markets was almost exclusively by women. Further to the above, in the coastal regions, the manufacture of products such as cassava pone, cassava chips, cassava bread and egg ball were almost exclusively by women.

Table 4.2 shows the volume and value of cassava and cassava products exported from Guyana during the 2008–2012 period. Exports of cassava tubers in 2011 and 2012 were encouraging signs but at 3.8 tonnes valued at approximately USD 2 000, this could only be considered investigatory quantities. Of importance, however, is the second item in the table, cassava casareep. The volume of this product grew from almost 8 tonnes in 2009 to 19 tonnes valued at USD 93 000 in 2011. These types of value-added products will contribute to the sustainability of the cassava industry.

TABLE 4.1
Volume of fresh cassava tubers produced in 2007–2012

Year	2007	2008	2009	2010	2011	2012
Tonnes	2 848	11 724	NA	9 612	3 355	3 994

Source: New Guyana Marketing Corporation

TABLE 4.2
Volume and value of cassava and cassava products exported 2008 to 2012

Exported Items	2008		2009		2010		2011		2012	
	Tonnes	USD	Tonnes	USD	Tonnes	USD	Tonnes	USD	Tonnes	USD
Cassava tubers	0.3	144	1.0	449	2.3	673	3.8	2 228	1.3	1 144
Cassava cassareep	17.6	86 749	7.8	38 227	3.2	15 813	19.0	93 137	2.3	11 275
Cassava flour	0.05	163	0.5	1 463	0.1	325	1.0	3 074	NA	NA

Source: New Guyana Marketing Corporation); USD 1 ≈ GYD 200

TABLE 4.3
Average annual wholesale prices for cassava tubers (GYD/kg)

Markets	2007	2008	2009	2010	2011	2012
Anna Regina municipal	78.92	90.20	74.11	52.17	101.68	157.38
Bourda municipal	69.07	106.36	91.83	58.12	121.58	182.80
Charity	75.90	96.70	92.40	43.94	103.61	183.33
Parika farmgate	42.56	68.33	64.51	30.69	93.56	131.79
Parika open gate	52.58	80.6	92.4	47.71	112.01	160.58
Stabroek municipal	72.46	109.92	96.05	61.71	120.84	184.87
New Amsterdam Municipal	104.45	113.4	119.31	121.00	161.76	173.59

Source: New Guyana Marketing Corporation); USD 1 ≈ GYD 200

TABLE 4.4
Average annual retail prices (GYD/kg)

Markets	2007	2008	2009	2010	2011	2012
Bourda municipal	111.05	155.76	142.90	98.72	170.73	254.88
Stabroek municipal	104.53	134.88	131.81	97.87	164.06	248.66
Difference	6.52	20.88	11.09	0.85	6.67	6.22

Source: New Guyana Marketing Corporation); USD 1 ≈ GYD 200

With respect to prices, the three markets to observe are the Bourda and Stabroek wholesale and retail prices and the Parika farmgate prices. Traditionally, most produce entering Georgetown goes through these markets and this has not yet changed. Because the Craig/Friendship districts are relatively close to Georgetown, and because the volume produced is smaller than that originating in the East Bank Essequibo, price is not 'formed' there, as it is for produce coming from the Parika/Salem/Ruby areas of East Bank Essequibo.

Table 4.3 shows that in Guyana, during the 2007–2012 period there was a GYD 2-4 difference between Bourda and Stabroek markets' wholesale prices with the latter being the more expensive. While there are no recent studies on volumes and price movements of produce traded at these or other municipal markets, it is generally accepted that most fresh produce traded in Guyana pass through these two markets. This takes place on a daily basis. Observations at these markets suggest, as previously noted, that men and women are engaged in wholesaling but that most retailing is by women.

On the other hand, Table 4.4 shows that during same 2007–2012 period retail prices were always higher at Bourda than at Stabroek. There was no noticeable trend but in 2011 and 2012, a GYD 6-7 difference was observed between Bourda and Stabroek average retail prices.

The ultimate comparison is the spread between the Parika farmgate prices and Bourda municipal market retail prices. During the 2007–2012 period,

TABLE 4.5
Price comparison

Item	2007	2008	2009	2010	2011	2012
Bourda municipal – Retail	111.05	155.76	142.9	98.72	170.73	254.88
Bourda municipal – Wholesale	69.07	106.36	91.83	58.12	121.58	182.8
Parika farmgate	42.56	68.33	64.51	30.69	93.56	131.79
Difference between farmgate price and wholesale price	26.51	38.03	27.32	27.43	28.02	51.01
Percentage difference (farmgate and wholesale)	62	56	42	89	30	39
Difference between wholesale and retail prices	41.98	49.40	51.07	40.60	49.15	72.08
Percent difference (wholesale and retail)	61	46	56	70	40	39
Difference between farmgate and retail prices	68.49	87.43	78.39	68.03	77.17	123.09
Farmgate price as a percentage of retail price	38	44	45	31	55	52

Source: New Guyana Marketing Corporation); USD 1 ≈ GYD 200

Parika farmgate prices for cassava ranged from 31 to 55 percent of the Bourda municipal market retail prices. So in 2011 and 2012 for example, cassava farmers got about 50 percent of the retail price (Table 4.5).

Principle cassava supply chains

Cassava production in Guyana is widespread and five main supply chains were identified: Region 1 (several areas); Region 2 (Pomeroon River); Region 3 (East Bank Essequibo); Region 4 (East Bank Demerara) and Region 9 (several areas). Of the five, the two main cassava supply chains are considered to be the Parika/Salem area of East Bank Essequibo, Region 3 and the Craig/Friendship area of East Bank Demerara, Region 4. These are the two main areas that supply cassava tubers to Georgetown and the environs. It is largely cassava from these districts that provide the ingredients for the various dishes prepared on a daily basis at numerous eateries and cottage industries, which for example make cassava pone or egg ball for a roadside stall or cassava chips to sell to school children.

Table 4.6 shows six stages of the FSC against a number of parameters, associated with the FSC, inclusive of the following: location, months available, product(s), nature of project support, facilities/equipment, duration/distance and inputs and services. The cost of production and the value of products at each stage are also shown where the information is available.

The study found that the FSC contributes significantly in terms of economic importance, job creation, and income-generation. However, the contribution of the FSC towards the generation of foreign exchange is insignificant. The FSC is also considered to be of significant economic importance and contributes to employment generation and poverty reduction. Nevertheless the FSC is rated as low in food security because there are other consumption options available for people living in these areas when compared to residents of Regions 1, 7, 8 and 9.

The main final products in the FSC are fresh boiled cassava root, egg ball and cassava pone (primary products) and cassava bread and cassareep (secondary products). Cassava tubers are mostly bought by households to be consumed as fresh boiled cassava root as part of a dish as explained. Increasing quantities are used by smaller eating establishments in the preparation of egg balls and cassava pone. In addition, groups of people from the East Coast Demerara area (villages such as Ann's Grove) manufacture cassava bread and casareep for direct sale (cottage industries) or for wholesale to supermarkets.

Farine is the staple food of the Wapishana and Makushi tribes of Region 9 and part of Region 8. They also consume a small amount of cassava

TABLE 4.6
Detailed description of the cassava supply chain in Guyana, East Bank Demerara

Stage in food supply chain	Location	Months of the year	Number of actors	Products	Volume (Tonnes)	Facilities/ Equipment	Duration/ Distance	Inputs and Services	Cost of production (GYD)	Value of products GYD
Primary production	Craig/ Friendship	January-December	50	Cassava tubers	500	Tractors and ploughs for land preparation; cutlass for cutting planting material; shovels for drains	Year-round	Planting material, labour for cleaning, weed control and drain maintenance, herbicide, insecticide	325 000/ha	
Harvest	Craig/Friendship	January-December	50	Cassava tubers	500	Forks, bags, cutlass	Year-round	Labour to harvest, bag and load roots into boats, carts or pickups	80 000/ha	44/kg
Post-harvest handling	From Craig/ Friendship to wholesale market point	January-December	50	Cassava tubers	450	Polypropylene bags, twine	8 km from farm to collection point plus 11 km from collection point to Stabroek Municipal Market, about 2 hours	Labour, Packaging materials	10 227/tonne	44 000/ tonne
	From farm to retail market	January-December	50	Cassava tubers	400	Polypropylene bags, twine	19 km farm to Stabroek municipal market, about 2 hours; 10 km from Stabroek market to Plaisance municipal market about 30 minutes; 145 km from Stabroek market to Linden municipal market, about 2 hours;	Labour, Packaging materials	9 090/tonne	44 000/ tonne

TABLE 4.6
(Continued)

Stage in food supply chain	Location	Months of the year	Number of actors	Products	Volume (Tonnes)	Facilities/ Equipment	Duration/ Distance	Inputs and Services	Cost of production (GYD)	Value of products GYD
Transportation	From farm to Stabroek market; from Stabroek Market to Plaisance municipal market; from Stabroek market to Linden municipal market	January-December	20	Cassava tubers	400	Pickups, trucks, vans, bags		Driver, labour to load and unload	10 000/tonne	
Retail market sales	Several municipal markets including Plaisance, Mon Repos, Bourda, Stabroek	January-December	100	Cassava tubers. - Cassava root is mostly bought to be consumed as fresh boiled cassava; - Groups from the East Coast area manufacture cassava bread and cassareep for direct sale or for wholesale to supermarkets.	320	Covered and open air markets; trays of pickups; open spaces at markets; covered display stands; weighing scales, plastic bags	19 km from the farm to Stabroek municipal market, about 2 hours; 10 km from Stabroek market to Plaisance Municipal market, about 30 minutes; 145 km from Stabroek market to Linden municipal market, about 2 hours	Driver, labour to load and unload, sell		255.00/kg
Cooking/ Processing	Small eating places – Georgetown and environs	January-December	25	Cassava roots used by smaller eating places in the preparation of egg balls (boiled eggs deep fried in cassava batter)	5	Water, peeling tools, washing basins, cooking utensils, stove, cassava roots, eggs, seasonings		Labour to wash, peel, cut cassava and cook egg balls		357/kg

Note: USD 1 ≈ GYD 200
Note: USD 1 ≈ GYD 200

bread. Other Amerindians eat cassava mostly as cassava bread, with occasionally some farine. The Rural Enterprise and Agricultural Development Project (READ) has been supporting cassava farmers in the coastal regions and the Ministry of Amerindian Affairs has, over the years, supported the Amerindian communities in these regions to increase cassava production, processing and marketing.

HISTORY OF GOVERNMENT AND PRIVATE SECTOR INVOLVEMENT IN THE SUBSECTOR

In Guyana agriculture supports about 33 percent of the population and generates approximately 25 percent of GDP. In addition, almost 50 percent of Guyana's export earnings come from agriculture. Agriculture in Guyana is the pivotal sector for ensuring food and nutritional security, sustainable development and for income-generation. Sugarcane and rice are the pillars of Guyana's agriculture industry. Together, they are referred to as the traditional agricultural sector and coupled with the non-traditional agricultural sector; they are the key sectors for employment opportunities for most of the rural and urban population.

The Guyana economy is still heavily dependent on the primary agricultural sector; support for the sector is a testimony its importance to the Government of Guyana. The domestic economy continues to expand at approximately 4 percent per year, with a resultant increase in disposable income that will positively affect the demand for all agricultural products. However, from its inception, the agricultural sector has recognized diversity and crop improvement as the nucleus of its sustainability. In Guyana, traditionally, rice literally means food. It is both the material and psychological basis of food security and, along with sugar, has consistently been the highest earning agricultural export.

In an effort to meet the challenges of competition, to exploit niche opportunities and to decrease dependency on single commodities, the Government's attempts to promote and improve non-traditional agricultural enterprises are commendable. The non-traditional crop sector comprises about 70 economically important food plant species. Over several decades, and with the assistance of various donor agencies, the Government has implemented several projects benefitting farmers of non-traditional crops, inclusive of the three commodities that are the focus of this analysis: cassava, tomatoes and mangoes. These projects included the project funded by the International Development Bank '*Agricultural export diversification project* (ADP)', the International Fund for Agricultural Development (IFAD)-funded *Poor rural communities support services project* (PRCSSP) and the 'Rural enterprises and agricultural development project (READ)'; the European Union-funded Guyana micro-projects programme (GMPP); and the USAID-funded project '*Guyana trade and investment support*' (GTIS).

As it relates to value-addition and processing, a 2003 IICA/CIDA/CPEC study on marketing organic produce in Guyana observed that:

"*Inadequate power and potable water supplies are major constraints to the development of more appropriate processing, handling and storage facilities for the domestic market. They are obviously at the same time major limitations to accessing the export market. In addition, Guyana has a shortage of trained post-harvest technology technicians (Craig, 2003).*"

Further, a paper commissioned by the International Labour Organization (ILO) (Forde, 2005) observed the constraints to agroprocessing such as infrastructural deficiencies, including expensive and unreliable electricity; sporadic supply of low quality water; lack of access to affordable financing; high shipping costs; deficient market information; inappropriate technologies; inadequately prepared human resources; and high shipping costs/inadequacy of port facilities.

According to Craig (2007), the IDB-funded study whereby nineteen agroprocessors and cottage industry processors from the six coastal regions of Guyana volunteered information on their relationships with farmers. The areas of need were identified as financing; technical help – factory design, process flow; equipment; help to find new customers/support for exhibitions, study tours etc.; links to potential importers; negotiation skills; website development; GAP/HACCP standards; links with investors; product development to meet markets; sourcing packaging materials (bottles, caps etc.) at cheaper prices; and applied research at the field level. Many of these issues are currently being addressed through projects such as the READ, GEF Small Grants Programme and the Credit Guarantee Facility of the Small Business Bureau.

INVENTORY OF ACTIVITIES AND LESSONS LEARNED FROM PAST AND ONGOING INTERVENTIONS

The Guyana Trade and Investment Support (GTIS) Project, a joint project of the Government of Guyana and the Government of the United States, was formulated to provide support to enterprises, private sector organizations, and government institutions to identify new markets for Guyanese products and increase exports to regional and international markets (GTIS, 2009). The project, which was funded by the United States Agency for International Development (USAID), followed a market-led strategy, identifying global demands and then seeking to fulfil them according to the resources available in Guyana.

The project emphasized support for private sector driven initiatives and activities, based on the premise that ultimately it is private enterprise that will provide the impetus required to achieve sustainable export expansion, employment, income-generation and economic growth in Guyana. There were two phases of the project between 2004 and 2012.

During the life of the project, GTIS conducted several workshops on the techniques of pre and post-harvest handling for non-traditional agricultural products. These workshops further emphasized the need and provided recommendations for addressing problems related to cold storage and packaging. As an example, collaboration between New GMC, NAREI, Laparkan and the Guyana Agribusiness Association led to a pilot project to produce and market a special 'bull nose' hot pepper for an identified export market in the United States.

GTIS ran a series of trials to test the entire value chain, growing and exporting the hot pepper and butternut squash to prospective buyers as well as exporting several containers of mixed produce. These pilot tests highlighted the need for improvements in cultivation techniques, packing facilities, cold storage, post-harvest handling, packaging and transport and logistics and it became clear that Guyana needed not only buyers for its produce, but needed to address several gaps, one of which was the issue of post-harvest losses.

One of the lessons learned from the GTIS Phase 1 Project in the area of post-harvest handling was, *"Improved post-harvest handling throughout the supply chain is critical to achieving export quality standards. This process should begin in the field, where farmers should use the necessary equipment to protect harvested produce during transport, such as plastic crates and packing material, along with training in their proper application. Sector stakeholders should also expand the cold chain by including cold storage facilities at packing houses, an important factor in reducing spoilage in the hot climate of Guyana"* (GTIS, 2009).

CURRENT POLICY FRAMEWORK ON SUBSECTOR FOOD LOSSES

The Guyana Vision for Agriculture 2020, entitled, 'Agriculture as our vehicle for sustained economic and social prosperity' is, perhaps, the most recent (2012) MOA policy document. The document lists the opportunities, challenges and the strategic thrust for the sector until 2020. Twenty priorities are identified, which are obviously interrelated, but priorities 7 and 8 (see boxes) are those that speak most directly to the area of focus of this document – post-harvest losses.

At the regional level, Jagdeo Initiative 3, which was spearheaded by President Bharrat Jagdeo of

Priority 7 recognizes the importance of Transportation, Packaging, Storage and Cargo Space Facilities as crucial elements to support a modern and more effective agricultural sector.

This important priority was identified in the Jagdeo Initiative as a Key Binding Constraint for the development of agriculture in CARICOM. In Guyana, we will more comprehensively address the issue of transportation, packaging and storage facilities, including refrigerated storage facilities and refrigerated trucks, port cargo spaces and improved river and sea transportation. Food production includes the production of some seasonal products, but consumption is usually continuous. Food security (priority #11), therefore, depends upon robust systems of packaging and storage, including frozen, chilled and dry. Insufficient cargo space and irregular shipping schedules are major impediments and these must be addressed. As we extend agriculture and move beyond the present cultivated land, and expand export capacity, this priority will become a critical factor.

Priority 8 identifies Marketing as an important area for realizing the vision of an agricultural sector being the vehicle for economic and social prosperity in Guyana. Without marketing we will not be able to make agriculture profitable. Particular focus of our agriculture enterprise has to be on linking farmers, especially small-scale farmers, with markets. Successfully facilitating and supporting efforts to link small farmers to dynamic markets have become important issues on the agricultural and rural development agendas. The Jagdeo Initiative for the development of agriculture in CARICOM recognized the need for effective marketing as a Key Binding Constraint. We must have a robust export-marketing programme. In this regards, development of a Market Information System is critical. We will work with our partners to complete and operationalize a Market and Data Information System as soon as possible. Guyana must pursue production geared towards establishing a Brand Guyana and develop Brand Guyana as a reliable high quality product. Guyana's Demerara Gold Sugar, Eldorado Rum, etc. are examples of Brand Guyana. We must ensure similar success stories for other agricultural products out of Guyana. We will work with our farmers to guide production to satisfy changing consumer preferences, establish grades and standards, manage risks (farmers and exporters) and ensure greater fidelity of contracts. We will work with stakeholders, other than farmers and exporters, to create a more export-friendly environment. In particular, we will promote better understanding and greater cooperation of stakeholders such as shippers and the Custom and Excise Department. We will be proactive in removing hiccups such as the two weeks time period for processing custom documents and the regular unavailability of Custom Officers to process and approve shipment at Ports of Exit.

Guyana, encompasses the entire CARICOM agri-food/product system. The aim is for "*the creation of an enabling economic and business environment for competitive and sustainable agricultural and rural development*". The main critical constraints affecting agriculture in the region were identified, and strategies developed to overcome these constraints within the context of improved international competitiveness. The strategies identified: creating an enabling environment for business and private sector enterprise, including farmers; improving supply capacity and competitiveness; establishing and strengthening of private sector organizations; and refining the resource management capabilities for business and trade efficiency.

PRELIMINARY ANALYSIS OF POST-HARVEST LOSSES (SCREENING)

Cassava post-harvest handling system

Figure 2 highlights the cassava post-harvest handling system and value-added products based on information obtained from previous studies, and from discussions with several experts working in root crops postproduction technology. The main actors involved in the cassava value chain included farmers who sell to wholesalers and processors, farmers who retail at farmer's markets, roadside markets and mobile markets. There are also wholesalers who source from several producers and processors and process the product into frozen cassava logs, frozen grated cassava and cassava pone mix.

Brief description of the cassava value chain

The cassava value chain includes a highly diverse and complex number of producers (farmers) and traders (market types: farmer' or public municipal, roadside, mobile, supermarkets, processors) characterized by widely scattered production areas and fragmented marketing facilities. The flow of cassava from the point of harvest to consumption, for producers and traders, was documented after observing and recording the duration of each component in the system, the time taken for the cassava to move from one stage to the next, including delays as well as measurable characteristics of the environment, i.e. temperature, relative humidity and time of day. In addition, hands-on familiarization with the cassava handling operations provided the framework for examining typical patterns of decision-making and action taken by participants within the cassava value chain. This also provided information on the dynamics of the cassava value chain and allowed for a comprehensive mapping of the cassava value chain (Figure 9). By inserting the stages of the post-harvest handling system for cassava within the value chain provided the template for tracking and tracing and, more importantly, identification of the critical loss points (CLPs). As shown in Figure 4, the following components were identified as the CLPs for cassava (CLP#1 harvesting, CLP#2 packinghouse operations, CLP #3 retail display), where qualitative and quantitative losses were measured.

FIGURE 9
Cassava post-harvest handling system and value-added products

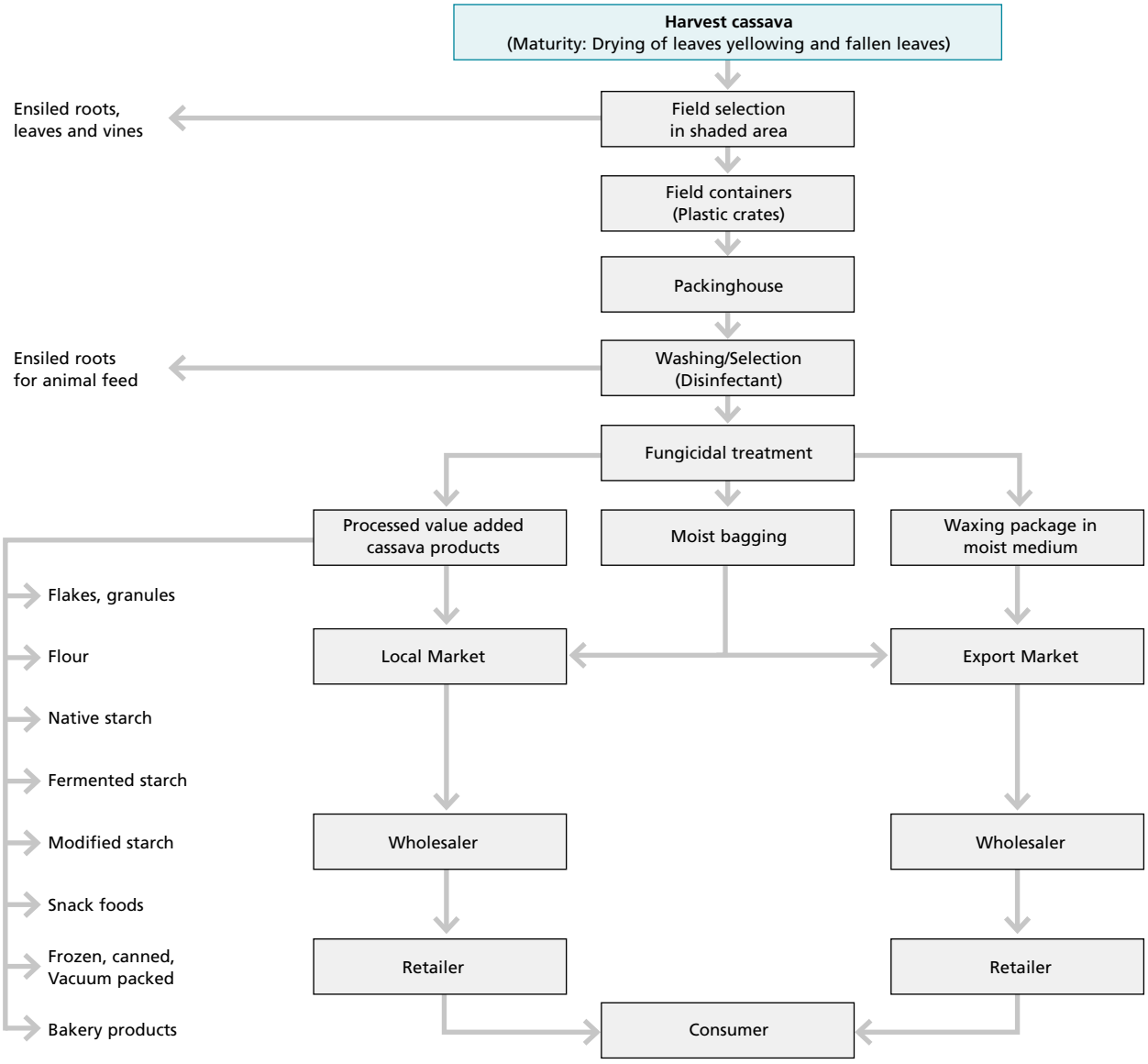
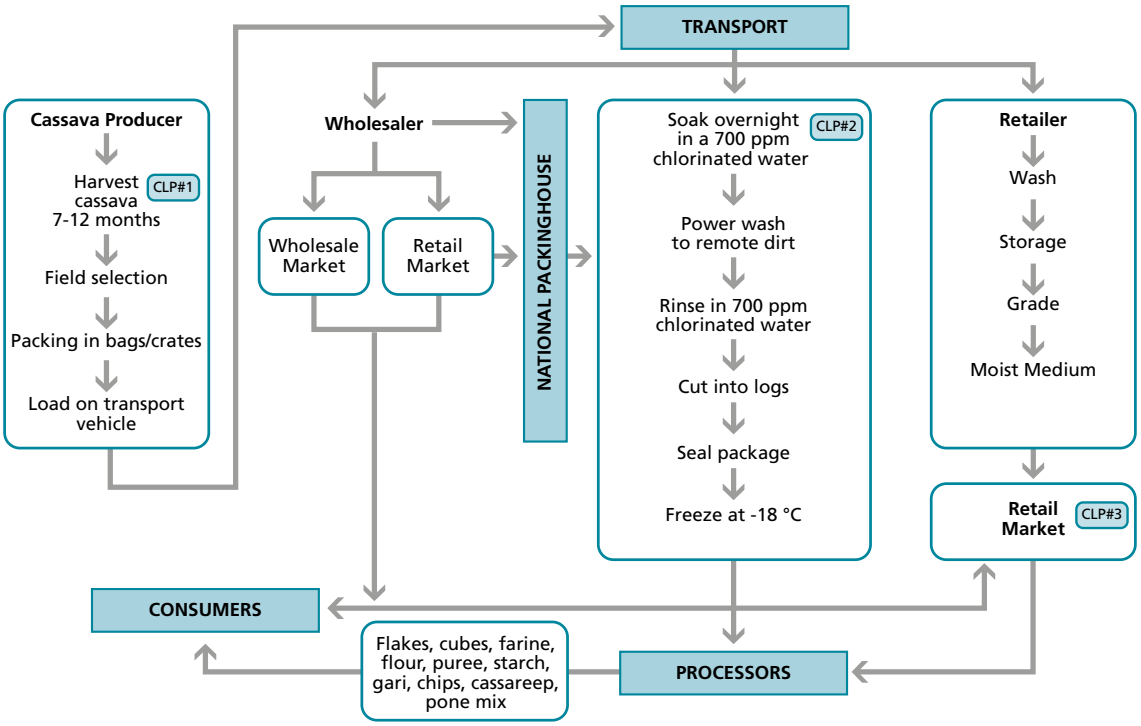


FIGURE 10
Cassava value chain in Guyana



Chapter 5
Food losses

CRITICAL LOSS POINTS – TYPE AND LEVEL OF FOOD LOSSES

The types of losses associated with cassava in Guyana were both quantitative and qualitative with critical loss points occurring at field harvest (CLP#1), packinghouse (CLP#2) and retail marketing (CLP#3). The qualitative and quantitative are presented in Table 5.1 and 5.2.

SAMPLE ANALYSIS

In Guyana the average of three replicates with each replicate comprising five cassava root samples were analysed for fresh weight, length, width and total soluble solids as shown in Table 5.3. Data were also taken on prevailing environmental conditions at the critical loss points in the cassava value chain (Table 5.3).

CAUSES OF LOSSES

Quality losses

Quality losses of cassava roots initiated in the field and were primarily associated with the manual method of uprooting plants using a fork to loosen the soil from the roots and a cutlass to separate roots from the mother plant. The resultant physical damage were punctures and abrasions when incisions were made by the fork on the peel and flesh as well as breakage at the primordial and distal ends caused by the manual force exerted when the root was extracted from the soil and with the subsequent separation of the soil from the roots. Quality losses varied in Guyana between 30 and 40 percent, and were not only related to the equipment and method of harvesting but to the soil type as well. Clay soils, which are more

TABLE 5.1
Guyana – Qualitative losses occurring in the cassava value chain

Stage in food supply chain	Quality reduction (%)
Harvesting method	5
Bagging and loading	3
Transportation and unloading	5
Storage (ambient)	7
Packinghouse	1
Retail	4 (after 3 days)

TABLE 5.2
Guyana – Quantitative losses occurring in the cassava value chain

Critical Loss Points	Weighted quantitative loss (%)
Harvesting	6.5
Packinghouse	0.8
Retailing	3.25 (after 3 days)
Supermarkets	0.3
Wholesale markets	0.05
Total	**12**

TABLE 5.3
Quality attributes of cassava and environmental conditions at the three critical loss points

Parameter	Quality attributes		
Fresh weight (kg)	0.30 - 0.55		
Length (mm)	205.3 - 266.9		
Width (mm)	44.6 - 55.0		
Total soluble solids	3.2 -3.4		
	Environmental conditions		
	Skin temperature °C	Pulp temperature °C	Relative humidity (%)
CLP# 1	30 - 32	34 – 36	60 – 65
CLP# 2	27 - 29	29 – 30	55 – 65
CLP# 3	31 - 33	35 – 37	55 – 65

dominant in Guyana, accounted for higher levels of quality losses.

In Guyana, labourers performed both harvesting and bagging at the same time, but the cassava-filled bags remained in the field exposed to environmental conditions and, at times, there was a delay before transportation to the packinghouses, which resulted in loss of quality.

Polypropylene feed bags, which were often used, had poor ventilation and slippery surfaces. These bags contained 42 to 44 kg of tightly packed cassava roots, sometimes with root protrusions puncturing the bags. Such handling practices, coupled with loading from the field onto the hard surfaces of carts, vans and tractor-driven trailers, accentuated quality losses. In many instances cassava filled bags were loaded at a height that further caused loss of quality averaging 20 percent in Guyana (Tables 5.1 and 5.2). Transport of overfilled, improperly stacked, slippery bags that were transported over rough roads and hilly terrain accounted for higher quality losses in Guyana because of the distances between production sites and packinghouses. In Guyana, cassava roots were stored under ambient conditions for longer periods before being sold at market outlets thus incurring a 30 percent loss in quality (Table 5.2).

It was observed that supermarkets in Guyana had no fresh cassava displayed for sale.

Quantitative losses

Although post-harvest losses of cassava roots in Guyana were only 4.5 percent were lower than those found in Trinidad and Tobago, the data in Table 5.4 show major differences in the nature of these losses at the CLPs. At CLP#1 total losses averaged 6.5 percent mainly as a result of physical damage and pathological and entomological damage being 3 and 3.5 percent respectively. No physiological losses were measured at CLP#1 and 2, and total losses at CLP#1 were at least three times greater than CLP#2. Losses were cumulative and the injuries to roots at CLP#1 created avenues for further quality degradation as the commodity moved along the value chain to CLP#3. Nevertheless, while the nature of all types of damage was almost the same (3.5 percent) after 6 days of retail marketing, the limit to marketability based on qualitative ratings was only up to day 2.

Physical damage included splits, lateral cracks and skin abrasions, wounding from harvesting equipment (forks and cutlasses mainly used), skin abrasions, skin and flesh bruises, punctures and stem and distal end breakage (Plates 5.1a and 5.1b). Damage was caused by inappropriate harvesting tools, over-packing in polypropylene bags, and abusive drop heights during loading and unloading in the field onto transport vehicles. Transportation from field to packinghouses over rough, narrow rough roads with cassava bags stacked 3-4 layers high without any buffer to cushion overhead weights resulted in the multiple physical injuries described above.

In Guyana limited access roads plus dominance of wet clay soils, unstable bridges and long travelling distances and duration, made transport of cassava from the field to the packinghouses more challenging, which contributed to the two-fold increase in physical damage at CLP#1 in Guyana (Tables 5.4 and 5.5). Harvesting and bagging were usually followed by multiple loading and unloading of the cassava into boats or trucks for distribution to wholesale and retail markets; thereby accounting for high levels of physical damage in Guyana.

TABLE 5.4
Types of post-harvest losses of cassava at critical loss points

Critical loss points (CLPs)	Types of post-harvest losses (%) unweighted				
	Physical	Physiological		Pathological and Entomological	Losses (%)
		VS-1	VS-11		
Field harvest CLP#1	3.0fg	0.0a	0.0a	3.5gh	6.5i
Packinghouse CLP#2	1.0bc	0.0a	0.0a	1.0bc	2.0de
Retail marketing CLP#2					
Day 2	1.5cd	1.0bc	0.0a	0.5ab	3.0fg
Day 4	1.0bc	1.0bc	1.0bc	1.0bc	4.0h
Day 6	1.5cd	1.5cd	2.5ef	2.0de	7.5jk
Losses	8.0j	3.5gh	3.5gh	8.0k	23.0l

Farmer who retails at municipal, roadside or mobile markets
Data taken on three replications of (12-15 kg) cassava x 10 times at different locations
Ambient conditions: 28-32 °C and 65-75 percent RH, VS: Vascular Streaking.

FIGURE 11
Manual harvesting of cassava late (left), showing physical damage to cassava (right)

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Physiological disorders were not detected at CLP#1 but cassava roots had visible evidence of moisture stress. Entomological damage was associated with insect damage causing cassava brown streak to develop, also related to waterlogged soils (Figure 11). Waterlogged soils, poor drainage and patterns of high rainfall posed similar challenges of a more consistent nature in Guyana thereby increasing pathological and entomological losses by an additional 1.5 percent, (Table 5.4).

Post-harvest losses of cassava at CLP#2 amounted to only 2 percent, while losses caused by physical damage were 1 percent. Likewise, physiological disorders such as vascular streaking (VS-11), identified as dark bluish or brownish radial veins or streaks near xylem vessels of the root pith (1 percent) and pathological and entomological was 1.5 percent (Table 5.4). The incidence of VS-11 was directly related to environmental field conditions, where temperatures were over 30-32 °C for more than 6 hours, impacted negatively on damaged root skin and flesh, which were eventually invaded by soil-borne pathogens (Figure 14).

In Guyana, at CLP#3 cassava roots had the highest levels of losses as duration of retailing increased from 2 to 4 to 6 days. Cassava is usually retailed under ambient conditions (Figure 12).

FIGURE 12
Pith breakdown resulting from waterlogging

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FIGURE 13
Cassava brown streak caused by *Botryodiplodia theobromae*

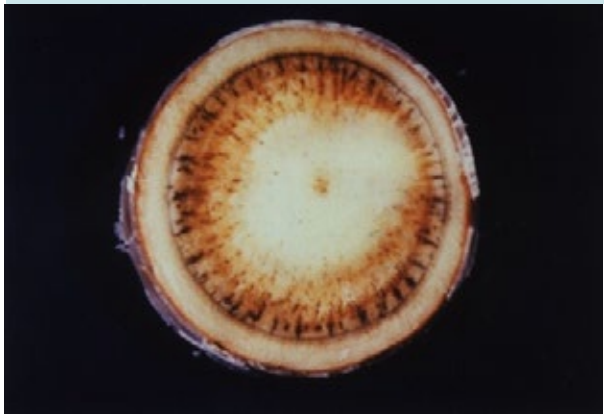
Cassava brown streak
Botryodiplodia theobromae
Root rot disease emergence is often favoured by waterlogged, poorly-draining soils

Rotting tubers cut open to reveal discoloration

Discoloration on tubers surface caused by root rot

SOURCE: J. ARACENA, 1993

FIGURE 14
Vascular streaking of cassava roots due to severe physical damage followed by secondary microbial development



SOURCE: J. ARACENA, 1993

Thus initiation of physical damage, resulting from wounding at harvest, was aggravated by multiple handling during loading, reloading, handling by consumers on the display as well as breakage from over-packing in polystyrene bags and emptying from variable drop heights onto relatively hard surfaces, was a significant factor in the severity of the damage thereby conferring higher incidences of VS-1 and VS-11 as retailing time increased (Tables 5.4 and 5.5). The higher incidence of VS-11, which was indicative of moderate to severe physical damage leading to a blue-black pigmentation of vessels, which commonly appeared on or adjacent to microbial infected areas of the root (Figure 14).

Please note 2 cultivars are usually grown in Guyana cv. Uncle Mac and cv. Bad Woman, which are harvested after 7 months maturity after which it becomes bitter.

TRACING AND TRACKING

When the various steps were traced, from the supplier to the finished product, post-harvest losses were 34 percent and 37.5 percent if cassava roots were obtained from sandy and clay soil types respectively (Table 5.5). These losses were determined from initial reception loads of 680 to 700 kg of fresh cassava roots. Cassava roots originating from fields dominated by clay soils sustained as much as 16.5 percent losses because of dirt and peel from the power wash operation but secured only 3 percent losses from vascular streaking as opposed to 11.5 percent from fields dominated by sandy soils.

FIGURE 15
Packinghouse operations for frozen cassava logs at NAMDEVCO facility

Soaked overnight | Power washed | Sanitized roots

Cutting and peeling | Peeled logs | Frozen logs

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FIGURE 16
Ungraded and graded cassava roots with larger diameter roots with core splits

Ungraded desiccated roots | Grading scheme

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Water stress was more severe in sandy soils than the clay soils and could be a factor responsible for the differences encountered. It was also noted that due to a lack of sorting and grading prior to cassava root soaking at the packinghouse, those tubers without a definite core split as shown in Figure 14 did not incur broken chips when chopped into logs compared to roots with a larger diameter where core splits were observed. Losses from broken chips and breakage at the distal and proximal ends were 12 percent and 13.5 percent for sandy and clay soils (Table 5.6).

Traceability studies were conducted in Guyana, where the main value-added products manufactured were cassava bread, farine and casareep. The production of cassava farine was investigated. At the village or community level an average of 60 kg of fresh cassava was used, and after sorting 10 to 12 percent could not be used because of peel and dirt, roots were too fibrous or woody, pathological decay, insect damage and vascular streaking. Roots were washed to remove dirt, peeled, rinsed in water, grated, pressed to remove liquid, which was used to make another by-product called casareep. The semi-dried pulp was then parched to produce farine. The 60 kg fresh cassava yielded 20 kg farine and 5 litres cassareep (Figure 5, pag. 10).

FOOD LOSS REDUCTION STRATEGIES – CONCLUSIONS AND RECOMMENDATIONS

Field harvest (CLP#1)

The following food loss reduction strategies are recommended for producers and marketers. The use of a manual hand lifter shown in Figure 17 should be recommended and made available to farmers to reduce physical damage during harvesting. Consideration should be given to engineering inputs for the design of this harvesting aid, which must be at an affordable price, or subsidized by the government, national marketing boards or agricultural associations for cassava producers. Also harvesting containers should be sturdy plastic crates, ventilated and light coloured to reflect heat and be stackable so that overfilling would be discouraged. Plastic crates with handles would also reduce abusive handling during loading and unloading as well as reduce potential damage caused by dropping from a height.

The strategy used by Guyana to uproot plants, isolate roots and pack at the same time significantly reduces unwarranted exposure of the roots to high field temperatures, which minimizes water stress and postpones or delays the incidence of vascular streaking. Farmers must place roots in a shaded area such as under a tree or preferably in a field shed, and then sprinkle water to keep roots moist, and even cover containers with broad leaves or polyethylene bags. Other activities could take place in the field shed such as removal of dirt from the roots, field sorting to eliminate defective roots, that is, roots that are undersize, with external and internal insect damage (Figure 18), oversized and woody roots with deep lateral skin and flesh wounds (Figure 19) and roots showing flesh breakdown and discolouration resulting from pathological agents (Figure 20) and other associated field-borne diseases.

FIGURE 17
Hand lifter as harvesting aid to reduce damage of cassava roots

Harvesting aid to reduce injury

Roots with no physical damage

FIGURE 18
External and internal insect damages

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FIGURE 19
Skin and flesh wounds including lateral cracks

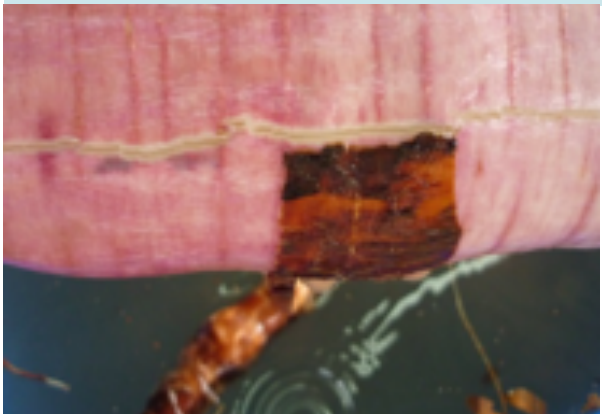

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FIGURE 20
Flesh breakdown and discolouration

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It is essential that farmers transport harvested cassava in plastic crates to the packinghouse within 1 to 2 hours following harvest. The current practice of leaving harvested roots for more than 4 hours in the field, where they are exposed to high temperatures, and then placing roots into containers afterwards must be discouraged. The use of polypropylene bags should be discouraged and replaced with plastic crates. Logistical arrangements to rent, or encourage farmers' groups and associations to pool resources to purchase large amounts of plastic crates at affordable prices, would be beneficial based on their durability, sanitizing efficiency, multi-purpose uses and potential for reducing physical damage during loading, unloading as well as to optimize field to packinghouse to market transportation linkages. This suggestion will need to be guided by awareness and economic considerations. Construction of feeder roads, and the use of trucks equipped with conveyor belts, would significantly reduce the incidence of physical damages arising during loading and unloading.

Proper drainage and use of cambered beds would reduce losses caused by microbes and pests. Field sanitation, weed and pest management practices would also assist in reducing losses. Curing roots after harvest by exposure to temperatures of 32–35 °C for 2 to 3 days at 85–90 percent relative humidity would induce wound healing and decrease secondary infections (Figure 21).

Field days to demonstrate proper harvesting techniques, the use of the hand lifter equipment and curing procedures, sorting to remove defective and unmarketable roots, benefits of reducing moisture stress should be available to farmers, farmer groups and associations. Training should be accompanied by demonstrations of successful

FIGURE 21
Cured and uncured cassava roots

Cured roots

Uncured roots

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root treatments as well as manuals, factsheets and techpaks.

Packinghouse (CLP#2)

Cassava roots that are transported to packinghouses should be subjected to the following post-harvest treatments to maintain quality. A second sorting and grading procedure should be implemented at the packinghouse to remove damaged or unmarketable roots arising from transportation from the field to the packinghouse. Cured roots should be washed and dipped in an approved sanitizer, such as sodium hypochlorite at 500 to 700 ppm, followed by a fungicidal dip consisting of immazalil (Mertec). Treated cassava roots could then be packed in polyethylene bags, which would create a modified atmosphere (Figure 22) and high relative humidity within the sealed bags to reduce transpiration and respiration. This would extend the shelf-life up to 4 weeks and also prevent vascular streaking. To achieve this, however, roots must have minimal, or preferably no physical damage, be protected from sunlight, treated with a fungicide and packed within 2-3 hours of harvesting. Another method to limit vascular streaking is to cover the roots with paraffin wax by dipping the root in wax at a temperature of 55 to 65 °C for a few seconds after treatment with a fungicide to achieve a shelf-life up to 2 months (Figure 23).

Post-harvest training is therefor recommended so as to increase the capacity of all stakeholders involved in cassava production and handling including treatment to prolong shelf-life. Such training must be reinforced with a cost–benefit analysis of the proposed investment.

Retail marketing (CLP#3)

Cassava roots must be subjected to a rigorous sorting to eliminate all types of damage. Roots should not be marketed at CPL#3 beyond 2-3 days unless they are cured, treated with a fungicide, protected from sunlight waxed and placed in refrigerated storage. Cassava can be stored under refrigerated conditions at 3-4 °C for up to 4 weeks. However, if roots are stored at above 4 °C, roots develop vascular streaking more rapidly and have to be discarded after 2 weeks of storage. Supermarket produce managers should pack cassava roots in sealed polyethylene bags and store at 3-4 °C to acquire the benefits of modified atmosphere packaging, outlined above, since this technique is currently applied to other commodities at these outlets where equipment already exists for sealing packages and there are facilities for refrigerated display. Demonstrations, short workshop sessions and exposure to information are highly recommended so as to educate suppliers as well as produce managers about these post-harvest procedures.

Tracing of value-added products

A grading system to standardize dimensions of root length and width should be encouraged. Random samples should be selected and examined

FIGURE 22
Modified atmosphere packaging

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FIGURE 23
Cassava treated with fungicide and waxed

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for core splitting, as well as vascular streaking, and internal insect damage during growth and development. Processors should be classified as certified producers, who adhere to these quality control procedures, and even be given incentives to manage effective quality assurance initiatives.

Regular short courses for processors on post-harvest in quality management for production of value-added products should be incorporated into the certification programme. Video presentations should be created to show how to manage quality. Processors and packinghouse operators must follow a checklist of relevant postproduction activities. Processors should be encouraged to diversify their product base into other value-added products, and processors should be encouraged to be innovative and seek markets having export potential to facilitate the growth and development of a viable cassava industry.

These recommendations should be made to the New Guyana Marketing Corporation and to the various communities involved in cassava farine production. Selection of appropriate cultivars, sorting and grading protocols and processing steps should be monitored to prevent batch-to-batch variations in the quality of products. Appropriate equipment and tools can be introduced to beneficiaries through public-private sector collaboration. Training and outreach programmes, including food safety and sanitation practices, should be incorporated into the processor certification system.

Investment programme to reduce food losses

Although post-harvest losses of cassava roots in Guyana were 4 percent lower than those found in Trinidad, there were significant differences in the nature of these losses at the CLPs. At CLP#1 total losses averaged 6.5 percent mainly as a result of physical damage and pathological and entomological damage being 3 percent and 3.5 percent respectively. No physiological losses were measured at CLP#1 and 2 and total losses at CLP#1 were at least three times higher than CLP#2. Losses were cumulative and the injuries to roots at CLP#1 created avenues for further quality degradation as the commodity moved along the value chain to CLP#3. Nevertheless, while the nature of all types of damage was almost the same (3.5 percent) after 6 days of retail marketing, the limit to marketability based on qualitative ratings was only up to day 2.

Based on the 2012 annual production of 3 994 tonnes of cassava/year at USD 914/tonne, annu-

TABLE 5.5
Economic loss associated with respective critical loss points for cassava

Critical loss point	Percentage of losses	Value of annual production (USD)	Economic loss (USD)
Field harvest CLP#1	6.5		237 284
Packinghouse CLP#2	2.0	3 650 516	73 010
Retail marketing CLP#3	14.5		529 325
Total	**23.0**		**839 619**

USD 1.00 = GYD 200
Note: Based on 3 994 tonnes/year (2012) at GYD 182.80/kg or GYD 182 800/tonne (USD 914/tonne)

TABLE 5.6
Summary table of food losses, causes and interventions

Critical loss point	Percentage of losses	Economic loss (USD)	Cause of loss	Intervention to reduce losses	Loss reduction	Cost of intervention	Risks
Field harvest CLP#1	6.5	237 284	Wounds, heat, desiccation	Harvesting aids, crates, logistics management, credit facility	Comerer private	Cost of equipment = USD 500; supplies = USD 450 and training = USD 6 000	No perceivable risks
Packinghouse CLP#2	2	73 010	Same	Workshops	Same	Cost of supplies (wax) = USD 300 and training = USD 4 000	
Retail marketing zCLP#3	14.5	529 325	Same	Logistics management	Same		
Total	**23**	**839 619**					

al cassava production in Guyana is valued at USD 3 650 516 (Table 5.5). The percentage loss at each CLP level was then used to estimate economic loss. Table 5.5 also shows that at CLP 1, CLP#2 and CLP#3 the losses were estimated at about USD 237 300, USD 73 000 and USD 529 300 respectively; hence the total economic loss was estimated at about USD 839 600. As mentioned earlier, the estimate of economic loss was derived from data obtained from regions covered by the study and must only be considered estimates and should not be taken as official national statistics.

Cost benefit analysis of the proposed solutions

The cassava hand lifter is recommended for use in Guyana, more so on sandy clays or clayey sands. In Guyana, a 10-acre cultivation is not uncommon. The yield is assumed to be 5 000 lbs/acre and the selling price is USD 0.15/lb (Table 5.7). In this scenario profitability for the first year is approximately USD 193.

In Guyana, a 10-acre cultivation is not uncommon. The yield is assumed to be 5 000 lbs/acre and the selling price is USD 0.15/lb (Table 5.7). In this scenario profitability for the first year is approximately USD 193.

The information available in Guyana suggests that yields could easily double with better management and that would take place if famers can obtain better prices. Increased demand for fresh cassava from the production of value-added products could dramatically change this picture thereby achieving a win-win situation.

Use of field crates in cassava production is also recommended for Guyana. The main difference in the assumptions between those made for the hand lifter and those for the field crates are that the anticipated loss reduction is 60 percent; the cost of a crate is USD 200 with 5 years of depreciation. In Guyana, cultivation on a 5-acre plot shows a profitability of USD 233 (Table 5.8).

TABLE 5.7
Profitability of using the cassava hand lifter in Guyana on 10 acres of cassava

No.	Item	Unit	Calculation formula	Value
a	Product quantity	lbs/year		50 000
b	Product value	USD/lb		0.15
c	Loss rate	%		0.065
d	Anticipated loss reduction	%		0.5
e	Cost of intervention (Hand lifter)	USD		300
f	Depreciation	years		10
g	Yearly costs of investment	USD /year	e / f	30
h	Yearly costs of operation	USD /year		20
i	Total yearly costs of solution	USD/year	g + h	50
j	Client costs per lb product	USD/lb	i / a	0.001
k	Food loss	lbs/year	c x a	3 250
l	Economic loss	USD/year	k x b	487.5
m	Loss reduction	lbs/year	k x d	1 625
n	Loss reduction savings	USD /year	m x b	243.75
o	Total client costs	USD/year	i = a x j	50
p	Profitability of solution	USD/year	n - o	193.75

FIGURE 24
Cassava hand lifter in operation

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FIGURE 25
Example of plastic crates, to replace fertilizer bags, which are suitable for harvesting and handling of fresh cassava

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TABLE 5.8
Profitability of using field crates in cassava production (based on 5 acres of cassava)

No.	Item	Unit	Calculation formula	Value
a	Product quantity	lbs/year		50 000
b	Product value	USD/lb		0.15
c	Loss rate	%		0.065
d	Anticipated loss reduction	%		0.6
e	Cost of intervention (field crates)	USD		300
f	Depreciation	years		5
g	Yearly costs of investment	USD/year	e / f	40
h	Yearly costs of operation	USD/year		20
i	Total yearly costs of solution	USD/year	g + h	60
j	Client costs per lb product	USD/lb	i / a	0.0012
k	Food loss	tonne/year	c x a	3 250
l	Economic loss	USD/year	k x b	488
m	Loss reduction	tonne/year	k x d	1 950
n	Loss reduction savings	USD/year	m x b	293
o	Total Client costs	USD /year	i = a x j	60
p	Profitability of solution	USD/year	n - o	233

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