Tropical Roots and Tubers
Tropical Roots and Tubers

Production, Processing and Technology

Edited by

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The Institute of Food Science and Technology (IFST) is the leading qualifying body for food professionals in Europe and the only professional organization in the UK concerned with all aspects of food science and technology. Its qualifications are internationally recognized as a sign of proficiency and integrity in the industry. Competence, integrity and serving the public benefit lie at the heart of the IFST philosophy. IFST values the many elements that contribute to the efficient and responsible supply, manufacture and distribution of safe, wholesome, nutritious and affordable foods, with due regard for the environment, animal welfare and the rights of consumers.

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Preface

Tropical roots and tubers occupy an important place in the global commerce and economy of a number of countries and contribute significantly to sustainable development, income generation and food security, especially in the tropical regions. Researchers have demonstrated the importance of tropical roots and tubers to human health, contributing an important source of carbohydrates and other nutrients. The perishability and post-harvest losses are the major constraints in their utilization and availability, therefore they demand appropriate storage conditions at different stages and value addition. The objectives of this book are therefore to provide a range of options from production and processing to technological interventions in the field, in a comprehensive form at one place.

This book focuses on all the major aspects related to tropical roots and tubers. With a total of 18 chapters, contributed by various authors with diverse expertise and background in the field across the world, this book reviews and discusses important developments in production, processing and technological aspects. Individually, taro, cassava, sweet potato, yam and elephant foot yam are mainly discussed and covered. The chapters in the book describe and discuss taxonomy, anatomy, physiology, nutritional aspects, biochemical and molecular characterization, storage and commercialization aspects of tropical roots and tubers. Good agricultural practices and good manufacturing practices are also given special emphasis. The HACCP approach in controlling various food safety hazards in processing of tropical roots and tubers is also discussed. Technological interventions, brought out in different tropical roots and tubers, constitute a major focus and it is expected that this book will find a unique place and serve as a resource book on production, processing and technology.

This book is designed for students, academicians, industry professionals, researchers and other interested professionals working in the field/allied fields. A few books are available in this field but this book is designed in such a way that it will be different and unique, covering production, processing and technology of lesser publicized tropical roots and tubers. The text in the book is standard work and therefore can be used as a source of reference. Although best efforts have been made, the readers are the final judge.

Many individuals are acknowledged for their support during the conception and development of this book. Sincere thanks and gratitude are due to all the authors for their valuable contribution and co-operation during the review process. The valuable input from Wiley and the assistance by publishing and copy-editing departments is
PREFACE

gratefully acknowledged. Sincere efforts have also been made to contact copyright holders. However, any suggestions or communications with respect to improving the quality of the book will be appreciated and the editors will be happy to make amendments in the future editions.

Harish K. Sharma
Nicolas Y. Njintang
Rekha S. Singhal
Pragati Kaushal
1 Introduction to Tropical Roots and Tubers

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Department of Food Engineering and Technology, Sant Longowal Institute of Engineering and Technology, Sangrur, India

1.1 Introduction

Roots and tubers are considered as the most important food crops after cereals. About 200 million farmers in developing countries use roots and tubers for food security and income (Castillo, 2011). The roots and tubers contribute significantly to sustainable development, income generation and food security, especially in the tropical regions. The origin of tropical roots and tubers along with their edible parts is presented in Table 1.1.

Individually, cassava, potato, sweet potato and yam are considered the most important roots and tubers world-wide in terms of annual production. Cassava, sweet potato and potato are among the top ten food crops, being produced in developing countries. Therefore, tropical roots and tubers play a critical role in the global food system, particularly in the developing world (Amankwaah, 2012). The leaders, policy-makers and technocrats have yet to completely recognize the importance of tropical tubers and other traditional crops. Therefore, there is a need to focus more on tropical roots and tubers to place them equally in the line of other cash crops.

Tropical root and tubers are the most important source of carbohydrates and are considered staple foods in different parts of the tropical areas of the world. The carbohydrates are mainly starches, concentrated in the roots, tubers, corms and rhizomes. The main tropical roots and tubers consumed in different parts of the world are taro (Colocasia esculenta), yam (Dioscorea spp.), potato (Solanum tuberosum L.), sweet potato (Ipomoea batatas), cassava (Manihot esculenta) and elephant foot yam (Amorphophallus paeonifolius). Yams are of Asian or African origin, taro is from the Indo Malayan region, probably originating in eastern India and Bangladesh, while sweet potato and cassava are of American origin (Table 1.1). Naturally suited to tropical agro-climatic conditions, they grow in abundance with little or no artificial input. Indeed, these plants are so proficient in supplying essential calories that they

2  TROPICAL ROOTS AND TUBERS – PRODUCTION, PROCESSING AND TECHNOLOGY

### Table 1.1  Origin of tropical roots and tubers

<table>
<thead>
<tr>
<th>Tropical roots and tubers</th>
<th>Origin</th>
<th>Edible part</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sweet potato</td>
<td>Central/South America</td>
<td>Root, leaves</td>
</tr>
<tr>
<td>Cassava</td>
<td>Tropical America</td>
<td>Root, leaves</td>
</tr>
<tr>
<td>Taro</td>
<td>Indo-Malayan</td>
<td>Corm, cormels, leaves and petioles</td>
</tr>
<tr>
<td>Yam</td>
<td>West Africa/Asia</td>
<td>Tuber</td>
</tr>
<tr>
<td>Elephant foot yam</td>
<td>Southeast Asia</td>
<td>Tuber</td>
</tr>
</tbody>
</table>

**Figure 1.1**  Post-harvest handling stages in the storage of tropical roots and tubers.

are considered a “subsistence crop” (www.fao.org). Because of their flexibility in cultivation under a mixed farming system, tropical roots and tubers can contribute to diversification, creation of new openings in food-chain supply and to meet global food security needs.

The perishability and post-harvest losses of tropical roots and tubers are the major constraints in their utilization and availability. The various simple, low-cost traditional methods are followed by farmers in different parts of the world to store different tropical roots and tubers. The requirements of storage at different stages during the post-harvest handling of tropical roots and tubers are presented in Figure 1.1. The perishable nature of roots and tubers demands appropriate storage conditions at different stages, starting with the farmers to their final utilization (consumers). Therefore, an urgent requirement exists to modernize the traditional methods of storage at different levels, depending upon the requirements of keeping quality.

The various interactive steps involved in post-harvest management of any tropical root or tuber, if not controlled properly, may result in losses. To prevent these losses, several modern techniques such as cold storage, freezing, chemical treatments and irradiation may be widely adopted. Roots and tubers not only enrich the diet of the people but are also considered to possess medicinal properties to cure various ailments. So the role of roots and tubers in functional products can also
be investigated in the light of medicinal properties. An immense scope exists for commercial exploitation in food, feed and industrial sectors. Since tropical roots and tubers crops are vegetatively propagated and certification is not common, the occurrence of systemic diseases is another problematic area. Some of these root and tuber crops remain under-exploited and deserve considerably more research input for their commercialization.

### 1.2 Roots and Tubers

#### 1.2.1 Roots

The root is the part of a plant body that bears no leaves and therefore lacks nodes. It typically lies below the surface of the soil. Edible roots mainly include cassava, beet, carrot, turnip, radish and horseradish. Roots have low protein and dry matter compared to tubers. Moreover, the major portion of dry matter contains sugars. The major functions of roots include absorption of inorganic nutrients and water, anchoring the plant body to the ground and storage of food and nutrients.

#### 1.2.2 Tubers

Tubers are underground stems that are capable of generating new plants and thereby storing energy for their parent plant. If the parent plant dies, then new plants are created by the underground tubers. Examples of tubers include potatoes, water chestnuts, yam, elephant foot yam and taro. Tubers contain starch as their main storage reserve and contain higher dry matter and lower fiber content compared to roots. Various tropical roots and tubers are presented in Figure 1.2.

The production of roots and tubers can be grouped into annuals, biennials and perennials. The perennial plants under natural conditions live for several months to many growing seasons, as compared to annual or biennial. The main points of difference among annuals, perennials and biennials are presented in Table 1.2. The perennials generally contain a greater amount of starch as compared to biennials.

### 1.3 Requirements for the Higher Productivity of Tropical Roots and Tubers

The factors that need to be focused upon to meet the objectives of food security, sustainable farming and livelihood development are farming systems, pest and pathogen control systems, genetic systems and strategies for improvement, together with marketing strategies and the properties of the products and constituents.

#### 1.3.1 Farming Systems

Tropical roots and tubers are generally grown in humid and sub-humid tropics, which are not suited for cereal production. Significant differences exist in the farming system perspectives of tropical root and tuber crops, varying from complex systems of
Figure 1.2 Various tropical roots and tubers.
Table 1.2  Annual, biennial and perennial roots/tubers

<table>
<thead>
<tr>
<th>Life cycle</th>
<th>Limiting aspects</th>
<th>Benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual</td>
<td>Takes 1 year to complete its life cycle.</td>
<td>Growth can be a limiting factor in excess/scarcity of water for annual plants. Insect and disease problems are of minor concern.</td>
</tr>
<tr>
<td>Biennial</td>
<td>Takes 2 years to complete its life cycle.</td>
<td>Early growth and quality is affected by late-season moisture stress.</td>
</tr>
<tr>
<td>Perennial</td>
<td>Takes more than 2 years to complete its life cycle.</td>
<td>No specific period for growth. But by providing early and modified irrigation practices, production can be improved.</td>
</tr>
</tbody>
</table>

production to intercropping farming systems. These systems are important to consider when studying the variation of different crop farming systems. The increasing production in the Pacific region has depended largely on farming more land rather than increasing crop yields. This is contrary to the projections of FAO that the 70% growth in global agricultural production required to feed an additional 2.3 billion people by 2050 must be achieved by increasing the yields and cropping intensity on existing farmlands, rather than by increasing the amount of land brought under agricultural production (Hertel, 2010).

Farming systems need to be carefully looked after, by protecting and raising the production of tropical roots and tubers. For this purpose, various changes in attitudes and agricultural practices are desirable. Additional investments are required to reduce the impact of climate change and to overcome the disastrous effects of soil erosion. Diversity in the production of tropical roots and tubers and increasing production surface area may be adopted for higher productivity and better quality of tropical roots and tubers. Proper organization among small farmers, effective investment in mechanization, and improved storage and processing facilities can improve the productivity of tropical roots and tubers.

1.3.2  Pest and Pathogen Systems

The pest and pathogens of different tropical roots and tuber crops are varied. Roots and tubers are generally produced by small-scale farmers, debarring a few exceptions using traditional tools and without the adequate input of fertilizers or chemicals for pest and weed control. Therefore, the correct use of less expensive and effective dosages of pesticides and fertilizers is important to increase the productivity of
these crops. Moreover, the activities need to be designed to reduce environmental degradation. Biochemical approaches need to be followed to reduce the damage due to pests and pathogens. The assessment of loss caused by pests and pathogens cannot be overlooked, which otherwise affects the production of tropical roots and tubers. In addition, pest and pathogens are of particular concern because of their direct effect on human and animal health. The effect of climatic conditions on the damaging action of pests and pathogens needs to be highlighted. Therefore, proper crop protection, involving different management practices, needs to be followed to reduce the damage due to pests and pathogens and to enhance the productivity of tropical roots and tubers.

1.3.3 Genetic Systems and Strategies for Genetic Improvement

The genetic system of roots and tubers widely differs, so the strategies for genetic improvements also differ. The breeding of root and tuber crops is primarily done sexually. The fact is that the different genetic systems suffer from many breeding complications along with limited opportunities for genetic development and further modifications (Mackenzie, 1995).

Some of the tubers, such as sweet potato and potato, may benefit from breeding cultivars, which are adapted to shorter growing seasons, while other crops (e.g. cassava) may need to fit into some other system, as they have contrasting growing cycles (Mackenzie, 1995). Hundreds of genetically distinct varieties of the roots and tubers are known to exist. Therefore, a focus is needed to genetically improve and develop the variety of roots and tubers, depending upon the requirement to achieve the required target. The dissemination of knowledge to the field is also a great concern in the area. Other considerations (e.g. crop management practices and crop diversification) specify that the decision-making should be carried out in individual breeding programs so as to benefit from these advancements. The needs for improvement in the programs are actually unique for a specific crop, rather than to the group of these crops classified as tropical roots and tubers.

Higher production can be achieved by exploring the genetic yield potential and by gaining knowledge about the genetic background of tropical roots and tubers (Okoth et al., 2013). Proper plant breeding approaches and genetic modification need to be followed for creating new genetic varieties. Overall, modern breeding technologies open up new possibilities to create genetic variation and to improve selection, but conventional breeding techniques remain important to improve the production of these crops.

1.3.4 Marketing Strategy

Tropical roots and tubers produced for off-farm markets can vary considerably in their transportation, storage facilities, processing techniques, consumption patterns, economics, etc. These differences need to be taken into account when various opportunities are assessed for improving trade. In fact, some individual root and tuber crops are presently experiencing a segmentation of markets that will undoubtedly require substantially different types of cultivars to meet divergent market needs (www.fao.org).