Tropical Fruit Processing

Jethro Jagtiani
Food Technologist
International Consultant
Bombay, India

Harvey T. Chan, Jr.
U.S. Department of Agriculture
Agricultural Research Service
Tropical Fruit and Vegetable Laboratory
Hilo, Hawaii

William S. Sakai
College of Agriculture
University of Hawaii-Hilo
Hilo, Hawaii

ACADEMIC PRESS, INC.
Harcourt Brace Jovanovich, Publishers
San Diego New York Berkeley Boston
London Sydney Tokyo Toronto

ACADEMIC PRESS, INC.
1250 Sixth Avenue, San Diego, California 92101

United Kingdom Edition published by
ACADEMIC PRESS INC. (LONDON) LTD.
24–28 Oval Road, London NW1 7DX

Library of Congress Cataloging in Publication Data

Jagtiani, Jethro.
Tropical fruit processing.

Bibliography: p.
Includes index.
1. Tropical fruit—Processing. I. Chan, Harvey T., Date II. Sakai, William Shigeru, Date
III. Title.
TP440.J34 1987 664'.8046 87-13339
ISBN 0–12–379990–2 (alk. paper)

PRINTED IN THE UNITED STATES OF AMERICA

88 89 90 91 9 8 7 6 5 4 3 2 1

Preface

The specter of hunger, famine, and malnutrition have been the legacy of mankind since recorded time. Overpopulation in the old world in the late nineteenth century resulting in depletion of available resources coupled with famine and pestilence led to a series of massive emigrations from the European and Asian continents to the Americas, to the African subcontinent, and to Australia. These emigrants brought with them newly developed technologies of the European industrialized nations and the time-honored agricultural methods of the Orient. The skills and knowledge of these emigrants helped develop the virgin resources of the newly discovered and undeveloped continents. As we enter the twenty-first century the regular cycles of overpopulation, famine, and political instability are again with us. However, this time there are no new continents left to be discovered and no new colonies left to be developed to feed their respective mother countries. Every available inhabitable room in our Spaceship Earth has been claimed and populated and is rapidly reaching its capacity. The only real option left to cope with this dilemma is to become better stewards of our renewable and nonrenewable resources.

Recent estimates of food losses due to spoilage and mishandling in the lesser and undeveloped countries have been stated to be between 25 and 40%. Most of these losses can be prevented using available technology. Some of the available technology such as dehydration is of ancient origin but has been developed from an art to a science. Throughout the world the art of food preservation has been practiced for centuries. Modern methods of food preservation in some cases have refined the ancient methods to ensure both uniformity and quality of the final product and most important of all to minimize failure of the preservation process. This book contains information useful to tropical fruit processors in both the lesser

developed and the developed countries. The authors felt that it was important to document food preservation methods used at the village level as well as those used industrially. Preservation methods that have been practiced successfully in one underdeveloped country would most likely find success in another such country.

It is our firm hope and belief that improved food-preservation practices must be continually used and developed in order that a better fed world will become a more peaceful world.

Acknowledgments

The authors dedicate this book to those individuals who have profoundly influenced the direction of their lives and careers.

Jethro Jagtiani expresses his sincerest gratitude to his parents, Khubchand and Navli, for giving him limitless faith and ambition to write and a Vedantic outlook on human life; to his wife, Duru, and children, Anjali and Arun, for their patience and understanding during the many years that this manuscript was in preparation; and to his professors—Emil Mrak, a friend, philosopher, and guide, T. J. Mirchandani, J. C. Ramchandani, William Cruess, Reese Vaughn, Hermann Phaff, George Marsh, and J. K. Makhijani.

William Sakai expresses his appreciation to his parents, Mary Shige and John Shozo Sakai, for their support and inspirational guidance into the field of plant science, and to his wife, Marcia, and his son, David, for their patience and support during the preparation of this book.

Harvey Chan extends his sincerest gratitude to his grandmother Mary F. Lum for her loving and spiritual guidance during his early childhood, to his earliest scientific mentor, Duncan K. Law, for his direction into the field of food technology, and his subsequent professors and mentors—Edward Ross, whose concept of brotherhood and humanity in the food sciences will never be forgotten, John Brekke, whose pragmatic skills and approaches are forever useful, and Harry Y. Yamamoto, whose philosophy of clear thinking and insistence on "the basics" have always proven to be right—and finally but not least to his wife, Doreen, for her continuous support.

Contents

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INTRODUCTION

This book covers four tropical fruits, guava, mango, papaya, and passion fruit, which heretofore were consumed only by inhabitants of the tropics but recently are becoming more familiar to the temperate zone consumer. Tourism has increased the exposure of these fruits to new consumers, and advances in transportation methods have also made it possible to ship these exotic fruits to more distant markets. In addition, advances in and proliferation of both printed and electronic media have also increased consumer awareness of both the exotic and mystical attractiveness of tropical fruits. Changes in immigration regulations in both the United States and Western European nations have permitted an influx of former residents of tropical regions. These new immigrants have brought with them into their newly adopted countries a desire for their ethnic foods and, of course, a taste and desire for tropical fruits, with which they are very familiar.

Most recently a new trend in consumer patterns has transpired that has lasted long enough to be not merely discounted as a food fad. That trend is best described as the "healthy-natural food" preference that has become part of the consumerist "anti-food additive" and "anti-technology" movement in the industrialized nations. The "health-natural food" consumer has created a significant demand for fresh fruits and vegetables or processed foods devoid of food additives. Significantly an increased demand for dried fruits has occurred mainly because of their use in "trail mixes" and their addition to "fruit and fiber" cereals. Tropical fruit juices are also in demand due to the overall increase in "natural fruit" juice consumption as an alternative to the traditional caffeine-containing beverages such as coffee, tea, or carbonated soft drinks. By incorporating tropi-

cal fruits into fruit juice blends, food technologists have been able to exploit their exotic flavors without adding artificial flavors. This is especially true with highly aromatic fruits such as mango and passion fruit. The four fruits guava, mango, papaya, and passion fruit were selected as the main topics for this book because the authors consider them to have the greatest potential for growth. This potential is based on the knowledge and technology acquired in their cultivation, processing, and preservation.

Guava

The major producers of guava products are South Africa, India, United States (Hawaii), Colombia, Puerto Rico, Jamaica, Brazil, Israel, the Philippines, and Taiwan. A great portion of these guava products are consumed locally by the producing country. In many tropical countries the varieties of guavas available for consumption are gathered in the wild and are therefore of the acid type; when they are processed, sweeteners must usually be added to make them palatable. In some countries such as India and Taiwan many of the cultivated varieties are of the sweet dessert types which are low in acid and hence consumed as fresh fruit.

Some of the finest dessert types (i.e., Apple colour, Safeda Allahbad, Red-fleshed, Karela, Chittidar, Mirzapur, Lucknow-49, and Seedles) are grown in India on more than 125,000 acres (Teotia, personal communication, 1959). Certain varieties have been described as having small cores of seeds which can be eaten like a freestone peach with the fleshy portion bitten off, leaving the seedy core.

The canning of guava was initiated at Lyallpur, India (now in Pakistan) in the early 1940s, and also at Ambala, India, by Jagtiani in 1949. Currently over 6,000 tons of guava nectar is exported to the Soviet Union, the Middle East, and other countries while most of the canned guava halves are consumed by the Indian Defense Forces.

In Hawaii 90% of the fruit processed is harvested from cultivated Beaumont seedlings, which are of the acid type. Most of the guava is prepared as puree and stored frozen, or aseptically processed and packed in either cans or aseptic bag-in-boxes. Some of the frozen whole fruits are processed into jelly stock. Most of the guava is consumed locally as guava nectars or drinks or is blended with other juices such as orange and/or passion fruit. A large volume of these guava drinks and drink blends are sold and distributed either in aluminum soft drink cans or in half-gallon fiberboard dairy cartons. Approximately 8.8 million pounds of guavas are processed annually in Hawaii. It is estimated that by year 1991 the total production of guava puree in Hawaii will exceed 21 million pounds. The State of Hawaii

has expended a considerable amount of its resources to develop its guava industry, and the results of its many feasibility studies have been summarized by Scott and Shoraka (1974) and by Shigeura and Bullock (1983).

In South Africa guavas are eaten fresh, processed into jellies, nectars, fruit paste, or "cheese," or canned as halves in syrup. The Fan Retief and Frank Metherbe varieties have been found to be especially suitable for canning.

In the Philippines, besides the jams, jellies, and juice blends that utilize guavas, a wine using guavas is produced that is popular.

The major importers of guava products are the United Kingdom, Puerto Rico, Federal Republic of Germany, and Switzerland. The Latin American population in the United States also consumes several guava products.

Colombia supplies small quantities of guava jelly to the Federal Republic of Germany and Switzerland. South Africa is the principal supplier of canned guavas in syrup to the European market, with 60% of it being sold to the United Kingdom (Anonymous, 1971). The United Kingdom also imports guava paste (cheese), which is consumed mostly by its immigrants; the small quantities consumed are supplied by Jamaica and India.

Other countries which produce guava products are Malaysia, Australia, Thailand, Taiwan, and Fiji. Jamaica produces a guava spread with ginger.

Mango

The mango *(Mangifera indica)* is one of the most important and oldest of the cultivated tropical fruits. The natural spread of the genus is limited to the Indo-Malaysian region, stretching from India to the Philippines and New Guinea; the species is concentrated in the Indochina and Malay peninsula, where it occurs wild. There are 41 species of *Mangifera* with 17 of them bearing edible fruit.

The Portuguese have been credited with the introduction and distribution of mango into Goa, Africa, and Brazil. Mangoes are now cultivated in southern China, Taiwan, Burma, Thailand, Malaysia, Sri Lanka, and northern Australia. In Africa, mangoes are grown in Egypt, Sudan, Kenya, Mali, Senegal, the Congo, Upper Volta, Tanzania, and Madagascar. In Central America, mangoes are grown in Mexico, Honduras, Panama, Nicaragua, Costa Rica, and Guatemala. In the West Indies, mangoes are grown in Jamaica, Cuba, Haiti, Trinidad, and the Dominican Republic. In South America, mangoes are grown in Brazil, Colombia, Venezuela, and other countries. In the United States, mangoes are grown only in Florida, Puerto Rico, and Hawaii.

The worldwide production of mangoes is estimated to be 9 million

tonnes (metric tons), of which 7 million tonnes are produced in India. Hence, it is not surprising that the mango is an important Indian crop, not only economically and nutritionally, but also culturally. The mango has been cultivated for more than three thousand years in India, where the earliest Sanskrit texts describe its beauty and exotic flavor. The earliest of India's rulers, the Mughal Emperors, encouraged and fostered the improvement of mango cultivars. The center of mango culture during the Mughal dynasty was Amroha (which means mango and fish), where many new exotic varieties were created and where presently 200 varieties still exist. The major mango-producing areas of India are Uttar Pradesh (267,000 hectares), Andhra Pradesh (100,000 hectares), Bihar (84,000 hectares), and Orissa (48,000 hectares).

Mangoes destined for export as fresh fruit should be free of fibrous tissue and terpene off-flavors. Mangoes of between 225 and 450 grams are preferred since mangoes are usually sold on the European market by the piece.

The major exporters of mangoes in the East are the Philippines and Thailand. The principal market for the Philippines is Hong Kong; for Thailand the markets are Singapore and Malaysia.

India exports to European countries such as the United Kingdom, Italy, the Netherlands, Poland, Sweden, and Switzerland, as well as to the Middle Eastern countries of Behrain, Dubai, Kuwait, Muscat, Quatar, Iran, and Lebanon. South Africa, Kenya, Mexico, and Egypt are also exporters of mangoes to the European market.

France, the largest European importer of mangoes, is supplied by New Guinea, Mali, Upper Volta, the Congo, and India. Mangoes are available year-round in France, because of the diverse geographical locations of the suppliers.

The United States, in addition to the mangoes furnished by Florida, imports mangoes from Mexico (65%), Haiti (32%), and the Dominican Republic (2.5%). The mangoes produced in Hawaii are not permitted to be shipped to the continental United States due to quarantine restrictions which prohibit the shipment of fruits infested with fruit flies and mango weevils.

The principal consumers of mango juice and nectars are the Soviet Union, Middle Eastern countries, and East European countries; suppliers are India, Egypt, Taiwan, and Korea.

Canned mango slices are exported by Thailand, the Philippines, Mexico, East Africa, India, and the People's Republic of China. Alphonso, Dusehri, and Bauganapalli are the major varieties exported from India as canned slices to consumers in Great Britain and the Federal Republic of Germany.

Mango pickles, chutneys, and brined mango slices, which are processed into chutneys by the importers, are the traditional export items of India,

Pakistan, and Bangladesh. Export of mango pickles and chutneys are mainly directed to Great Britain, the United States, the Federal Republic of Germany, Kuwait, Hong Kong, Singapore, Canada, and Denmark, while brined mango slices are exported to Great Britain and the Federal Republic of Germany.

Papaya

Papaya *(Carica papaya)* is a popular tropical fruit. It is also the source of papain, a protease used in the food, leather, cosmetic, and pharmaceutical industries. The immature, green papaya is consumed as a cooked squash, while the ripe papaya is consumed as a fresh fruit.

Papaya is indigenous to southern Mexico and Costa Rica. It was taken by the Spaniards to Manila in the mid-sixteenth century and reached Malacca shortly afterward. From there it was introduced to India; it was reported in Zanzibar in the eighteenth century and in Uganda in 1874 (Purseglove, 1968). The introduction of papaya to Hawaii is usually credited to Don Marin, an early Spanish settler and horticulturist, who brought the seeds from the Marquesas Islands sometime between 1800 and 1823.

The United States (Hawaii and Florida), Brazil, South Africa, the West Indies, Malaysia, and Taiwan are the main producers of processed papaya products. Smaller quantities of papaya products are exported by Cuba, Sri Lanka, Colombia, Puerto Rico, Mexico, and Australia. In Hawaii, the major papaya products are frozen papaya puree, aseptically packaged papaya puree, papaya jam, and papaya nectars. Most of Hawaii's papaya products are shipped to the continental United States and Japan. The importation of papaya products to the European market consists mainly of papaya slices or cubes in syrup and a tropical fruit cocktail containing papaya cubes. The production of papaya products in Cuba, Puerto Rico, and India is mostly for their own domestic consumption. The commercial production of papain is mainly in Sri Lanka, East Africa, and India.

Passion Fruit

Australia is the largest single market for passion fruit juice in the world. In addition to its own production, it imports limited quantities of passion fruit juice from Fiji, Formosa, Papua New Guinea, Tonga, and other countries from Southeast Asia (Morton, 1971). Australia also exports limited quantities of passion fruit products. The bulk of its passion fruit products are processed into juice, often blended with other juices, and

consumed locally as carbonated beverages. Carbonated passion fruit drinks are the largest market for passion fruit pulp; almost every Australian soft drink manufacturer produces a passion fruit drink. Passion fruit is also used as a flavorant in ice cream, confectionaries, and tropical fruit salads.

The majority of the passion fruit produced in Hawaii is consumed locally as drinks blended with other fruit juices such as orange and/or guava. Other minor uses are as a flavorant in syrups or as pie fillings. Because of its high labor costs, Hawaii has become an importer of passion fruit pulp from other developing countries such as Brazil, Taiwan, and Fiji.

In Hawaii, the largest volume of passion fruit juice is marketed in soft drink cans, while the remaining juice is marketed in the form of frozen juice bases. Developed at the University of Hawaii, the base is made by adding 60 parts of sugar to 100 parts of passion fruit pulp. It is served in a dilution ratio of 3 : 1 or 4 : 1 (Seale and Sherman, 1960).

Brazil has a well-established passion fruit juice industry with large-scale juice extraction factories. It is now perhaps the leading exporter of passion fruit juice. The purple passion fruit is preferred for fresh consumption and the yellow for juice processing and the making of preserves. Strains being grown for these purposes include Ouropretano, Muice, Peroba, and Pintado (Santos, 1962).

Since the introduction of the yellow passion fruit from Brazil to Venezuela in 1954, it has achieved industrial status and national popularity. Much effort is being devoted to improving its yield. The strains grown are known as Brasilera amarilla, Brasilera rosada, and Hawaiiana (Panella and Araque, 1965). Some of the popular passion fruit products include passion fruit juice, passion fruit ice cream, and a bottled passion fruit and rum cocktail.

Until recently in Sri Lanka, passion fruit was cultivated in home gardens. Plantation-scale cultivation has now commenced as a result of the development of a fruit-processing industry (Food and Agriculture Organization, 1972). At present, both the yellow and purple varieties of passion fruit are grown in Sri Lanka. Passion fruit products made by both government and private firms include jams and both sweetened and unsweetened juices.

Both wild and cultivated passion fruit is found to some extent in Fiji, Papua New Guinea, the Philippines, Tonga, and India. All these countries export considerable quantities of yellow passion fruit juice and pulp to Australia.

In Fiji and Papua New Guinea, passion fruit is produced largely for export to Australia and New Zealand as frozen unsweetened pulp or juice. In Fiji, the yellow variety is cultivated. Apart from exports, a significant portion of the production is consumed in Fijian homes and restaurants as

mixed drinks (Bula Tala), fruit syrup, ice cream toppings, and cake mixes. Passion fruit grows well in the Philippines, and its potential is being nutured through distribution of seedlings by Araneta University (J. T. Sulit, personal communication, 1972). A new factory for the processing of frozen passion fruit juice has been installed in Tonga. India cultivates small plots of passion fruit, which is processed into passion fruit squash.

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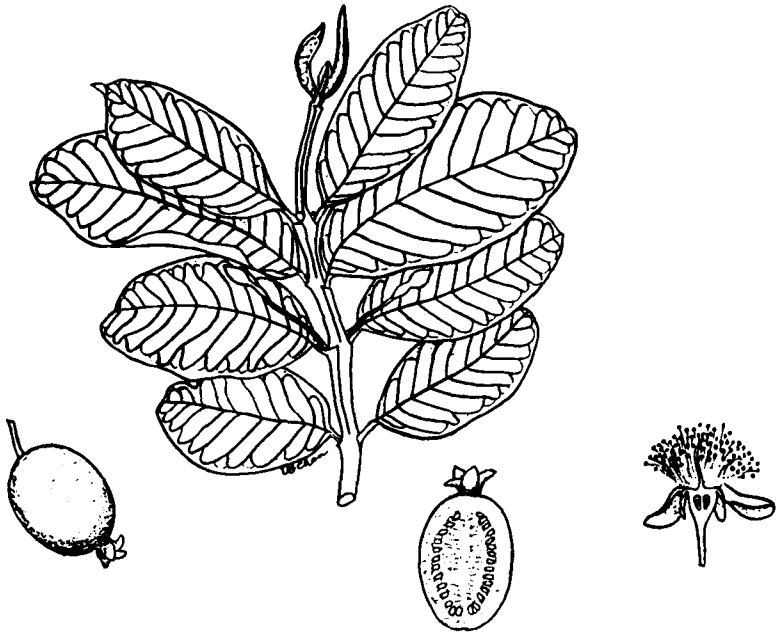
GUAVA



Introduction

Guava (*Psidium guajava* L.), a member of the dicotyledon family Myrtaceae, is a native of tropical America (Chopra and Singh, 1971). It is the most important fruit in a family, which includes jaboticaba (Myrciaria), guavasteen *(Feijoa),* Surinam cherry *(Eugenia),* rose apple *(Syzygium),* and the spices cinnamon, clove, allspice, and nutmeg. Guava was reported to be growing in Mexico and Peru when European explorers first visited (Hedrick, 1919). It has subsequently been introduced throughout the tropics and subtropics. Guava can withstand temperatures as high as 32°C and as low as 3°C (Nel, 1984).

Guavas are cultivated or grow wild throughout the tropical and subtropical regions of the world, and the fruit is primarily consumed fresh locally.

India leads the world in guava production with an estimated 165,000 tonnes (metric tons) of fresh fruit. Other major producers of fresh or processed fruit are Mexico, 127,000 tonnes; Pakistan, 105,000 tonnes; Colombia, 29,000 tonnes; Egypt, 28,000 tonnes; Brazil, 27,000 tonnes; South Africa, 11,000 tonnes; Venezuela, 4000 tonnes; the Dominican Republic, 3000 tonnes; Puerto Rico, 3000 tonnes; Jamaica, 3000 tonnes; Kenya, 3000 tonnes; Australia, 3000 tonnes; and Hawaii, 2000 tonnes (State of Hawaii, 1981). Total world production is estimated to exceed 500,000 tonnes.

World trade in the processed guava products—canned slices in syrup, purees, juices, paste or pulp, and jelly—is limited. Recorded shipments in 1972 were 3000 tonnes. Much of this production was from South Africa, with 1000 tonnes of the white-fleshed dessert fruit processed into canned slices; most of this was then shipped to the United Kingdom and New Zealand (State of Hawaii, 1981).

Botany

The guava is a low tree or shrub, 2 to 8 m high, commonly multiple trunked with wide-spreading branches. The trunk is often mottled in appearance with a reddish-brown outer scale bark and a lighter colored inner bark. Younger branches are square with leaves that are oval or oblong, prominently veined, 7 to 15 cm long, and commonly hairy underneath. The flowers are perfect, 2 to 3 cm across, with an irregularly split bell-shaped green calyx, four to six white petals, and numerous white stamens with yellow anthers. The ovary is inferior. The fruit is a berry with a fleshy pericarp, a seed cavity with fleshy pulp, and numerous small, hard, kidney-shaped seeds. The calyx is persistent on mature fruit. Fruits may be round, ovate, or pear-shaped, 3 to 10 cm in diameter and weighing from 50 to 500 gm. The skin color of ripe fruit is commonly yellow. Flesh color may vary from white, which is found in the sweet dessert fruit that are commonly processed into canned slices, to pink, salmon, or carmine. Numerous sclereids (stone cells) occur in the fleshy part of the fruit.

Besides the common guava, only one other species has been suggested as having commercial potential; *P. cattleianum* Sabine, which is red fruited, and *P. cattleianum* f. *lucidum* Degener, which is yellow fruited. Although these fruit are only 2 to 4 cm in diameter, they can be processed into flavorful jelly or juice. The short fruiting period is also an advantage for mechanical harvesting (Shigeura and Bullock, 1983). In addition, these guava lack sclereids in the fruit.