Amit Baran Sharangi · Suchand Datta *Editors*

Value Addition of Horticultural Crops: Recent Trends and Future Directions

Springer

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To
Our
Beloved Parents

Foreword

No production system and production process can be viable without value addition. Value addition is a process that elevates a production into a product. So everyone has to go inclusive and critical on value addition process for creating new market demands or indulging renewed demand from the set of conventional customers. The problem of Indian horticulture is that it goes far for biological production, can be called a super green horticulture and at the same time presents a bleak story for golden horticulture that is value added horticulture to bring more returns for the growers and more satisfaction to the customers. A value added agriculture and horticulture can ignore the inflicts of seasonality in food availability and market vagaries. We are having a huge horticultural diversity that sprawls from sea to mountain ranges and more so we are having a huge pool of indigenous skill and acumen that need to be dovetailed to this massive process of value addition. The other essential ingredient for this renewed revolution shall be the creation and functioning of supply chains.

We are, through different missions viz., NHM and FSM, well triggered up to make agri-horticultural production into mega agri-horticultural entrepreneurships to go for global competitions as our external policy and create economic buoyancy as a fiscal policy. This book, I believe, has been a milestone in presenting different concepts, in very lucid and readable forms, to ultimately offer a kaleidoscopic vision of value addition in horticulture. The approach will generate the much needed reforms in our market policy, industrial outfits and a new treats for the livelihood of millions of farmers reeling under social and economic stresses. The targeted readers, especially students and teachers, will be much educated on the current discussion on secondary horticulture. I congratulate Dr Amit Baran Sharangi at BCKVV, Mohanpur, West Bengal, for the excellent compilation, editing and final check of the tables and figures. I also congratulate the publisher Springer for accepting the book for publication.

KAU, World Noni Research Foundation
Chennai, India

(K.V. Peter)

Preface

We feel delighted to bring out this volume entitled *Value Addition of Horticultural Crops: Recent Trends and Future Directions*. Value addition is both the science and art of transforming a production into a product. The connotation 'value addition' receives a new dimension, whenever prefixed or suffixed with 'horticulture'. Horticultural crops being different in nature as compared to agricultural ones pose a considerable challenge to the stakeholders in various stages, right from production to processing. Knowingly or unknowingly, the process of value addition is on since time immemorial, and thanks to the technological grooming that it is receiving currently, the horizon of our imagination is getting wider and wider.

The book with comprehensive coverage on the subject is a state-of-the-art compilation of background information, principles, research works, and scientific discussion coupled with adequate references on basic and applied aspects on the subject. The main features of the book is an in-depth narration of the scope of quality horticultural crops as a product in influencing present-day global export market arising out of renewed interest in these crops throughout the world. The book will also take care of the rational scientific approaches to post-harvest management of quality horticultural crops. It covers the traditional as well as present-day techniques, along with judicious blending of environment, society, technology and market compulsions in related areas viz., biodiversity, microbiology, ecology, biotechnology and the past as well future knowledge base regarding the subject of interest.

We would like to convey our deep appreciation to all the contributors and well wishers, especially Prof. K.V. Peter, who has been kind enough to write the foreword for the book. Dr. Mamta Kapila and her team from Springer deserve all praise for their best efforts in publishing the book.

Kalyani, India
25 December, 2014

Amit Baran Sharangi
Suchand Datta

Contents

1 **Introduction** 1
S.K. Acharya, K. Pradhan, P. Choudhuri, and A.B. Sharangi

2 **Preparation of Value-Added Products Through Preservation** 13
M. Preema Devi, N. Bhowmick, M.R. Bhanusree and S.K. Ghosh

3 **Value Addition in Vegetable Crops** 43
S. Datta, R. Chatterjee, and J.C. Jana

4 **Value Addition in Spice Crops** 59
S. Datta, S. Guha, and A.B. Sharangi

5 **Value Addition in Flowers** 83
M.S. Mebakerlin and S. Chakravorty

6 **Flower Arrangement Toward Value Addition** 101
S. Das, T. Mandal, and S. Sultana

7 **Value Added Products from Medicinal Plants** 113
S. Maitra and P. Satya

8 **Postharvest, Product Diversification and Value Addition in Coconut** 125
D.K. Ghosh

9 **Product Diversification of Areca Nut, Cashew Nut and Oil Palm** 167
J.K. Hore and M. Anitha

10 **Value Addition of Fruits and Vegetables Through Drying and Dehydration** 179
S. Datta, A. Das, S. Basfore, and T. Seth

11 **Value Addition of Fruits and Vegetables Through Packaging** 191
G. Mandal

12 **Breeding Methods for Quality Improvement in Horticultural Crops** 201
S. Debnath and S. Guha

13 Value Addition of Non-timber Forest Products: Prospects, Constraints, and Mitigation 213
Sumit Chakravarty, Anju Puri, Mohit Subba, Tanusri Dey, Prakash Rai, Gopal Shukla, and Nazir A. Pala

14 Mitigate Climate Change and Use Processed or Value-Added Harvested Wood Products 245
Sumit Chakravarty, Anju Puri, Nazir A. Pala, and Gopal Shukla

15 Essential Oil: Its Economic Aspect, Extraction, Importance, Uses, Hazards and Quality 269
M. Preema Devi, S. Chakrabarty, S.K. Ghosh, and N. Bhowmick

16 Total Quality Management in Horticulture: Concepts and Modalities 279
K. Pradhan and S. Pradhan

17 Supply Chain Management of Horticultural Crops 293
T.N. Roy

18 Development of Women Entrepreneur Through Value Addition of Horticultural Crops 315
P.K. Pal and R. Chatterjee

19 *Phytophthora*: A Member of the Sixth Kingdom Revisited as a Threat to Food Security in the Twenty-First Century 325
S. Guha Roy

20 Future Directions 339
A.B. Sharangi and S.K. Acharya

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Suchand Dutta did Ph. D. from Uttar Banga Krishi Viswavidyalaya. He joined his service during 2001 as the post of Lecturer in Uttar Banga Krishi Viswavidyalaya. Presently, he is serving as Associate Professor in Vegetable and Spice Crops in the Uttar Banga Krishi Viswavidyalaya, Pundibari, Cooch Behar, West Bengal, India. During his academic career he guided a number of M.Sc. students as chairman and published 45 research papers in national and international journals, 5 popular articles in English and a large number of popular articles in local languages. He has participated and presented more than 25 research papers in different national- and international-level seminar/symposia/conference/World Congress in India and abroad. He was associated as Co-Principal Investigator in Central Scheme for the Development of

Medicinal Plant Sponsored by National Medicinal Plants Board Dept. of ISM & H, Ministry of Health and Family Welfare, Govt. of India and associated as Scientist Integrated Programme for Development of Spices and now it is renamed Mission for Integrated Development of Horticulture from 2002 to till date. He organized one national-level workshop and recently he has taken the responsibility of In-Charge, All India Co-ordinate Research Project on Spices, Uttar Banga Krishi Viswavidyalaya, Pundibari. He wrote four books and three book chapters. He has actively participated in different training programmes for the benefit of the farmers.

Introduction

1

S.K. Acharya, K. Pradhan, P. Choudhuri, and A.B. Sharangi

Abstract

There are three basic phases of agricultural growth and revolution and these are: inductive, stimulative and simulative. The inductive phase of agriculture is characterized with intensive crop production with a support from several basic critical inputs viz., the magic seed, the fertilizer and agrochemicals and irrigation water leading to the agrarian magnum opus called Green Revolution. This inductive phase has a clear thrust on highest possible production within shortest possible time and all done just to tackle the threat of famines, the growth of industry or to keep supply line well-loaded with food and fruits attuned to war field. In the second phase, subsidies and allied incentives were integrated with the production process so that the target farmers can be benefitted, empowered and ascribed with a sense of social dignity. This phase has been characterized with huge corporate social responsibility and incubation of agro-based small and big ventures to invite the inevitable transformation of green agriculture into a silvery agriculture. Here the value addition process took a quantum jump to generate a belligerent market for agri-horti products. The simulative phase of agricultural growth and development has been characterized with future projections, digitized configuration and precision production factors. It started and went functionally geared up during 1980s, 1990s and 2000 onwards. This has been the value addition genera, keeping focuses on and with branding, market segments, and value chain management, and inclusive growth takes place through a denial to the geographic, temporal and spatial barrier.

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The history of agriculture transcends 10,000 years, and in the beginning, it has to support some few thousands of human beings across the globe. Now the same agriculture has to sustain the hunger and nutrition of 6.5 billion people across the world. The nomadic life starts not with agriculture but of course with horticulture, livestocks and fisheries. The Neanderthal's Diaspora kept on exploring roots, nuts, fruits and modified vegetative organs as their food; the source of animal proteins had been complemented by wild animals, ichthyofauna and even jungle birds. In experimenting or trying with the palatable fruits or capsules, some ancient people have to sacrifice their lives. This has been perhaps the oldest human experiments in screening out palatable food from poisonous food. After that and with the rapid improvisation in tools and techniques, a meagre transformation had been there, from Stone Age civilisation to Metal Age civilisation. The hunting economy has been transformed into a primitive production economy, and thus, the first agriculture started appearing for different clans and Diaspora some 10,000 years back.

With special reference to India and anywhere in the world, we can find three basic phases of agricultural growth and revolution, and these are (a) inductive, (b) stimulative and (c) simulative.

The inductive phase of agriculture is characterised with intensive crop production with a support from three basic critical inputs, (a) the magic seed, (b) the fertiliser and agrochemicals and (c) irrigation water, leading to agrarian *magnum opus* called *Green Revolution*. This has been done with a desperate attempt to rejuvenate and reconstruct the war-ravaged institutions and production system. The decades of 1940s, 1950s and 1960s across the world are the history of war, invention, industrialisation and agriculturisation. In India, a score of boost-up programmes were undertaken to ensure the intensive growth in agriculture and rural economy. These are community development programme (1952), intensive agricultural district programme (1960), intensive agricultural area programme (1964), high yielding variety programme (1965) and training and visit programme (1974):

So, this inductive phase has a clear thrust on highest possible production within shortest possible time and all done just to tackle the threat of famines, the growth of industry or to keep supply line well-loaded with food and fruits attuned to war field. Value addition, the concept and process, still has been a far lying proposition.

The second phase was the stimulative phase wherein subsidies and allied incentives were integrated with the production process or factor productions so that the target farmers or populace can be benefitted, empowered and ascribed with a sense of social dignity. The concept of welfare state and welfare economy were bound to operate so as to remove the stigma of famines and brunt of political economy is transforming social ecology which could be more resilient to absorb the conflict and resentment. This phase encompasses the decades of the 1970s and 1980s wherein the predominating programmes were IRDP, TRYSEM, DCWRA, ITDP, SFDA and so on. This phase has also been characterised with huge corporate social responsibility at one hand and on the other hand incubation of agro-based small and big ventures to invite the inevitable transformation of green agriculture into a silvery agriculture and that started creating the ground for agri-hort-preneurships:

Albeit, a basket of diverse agriculture started entering the global scenario in its gross production forms, the value addition process took a quantum jump to generate a belligerent market for agri-horti products and also a reinforced and renewed attempt to create and make functional product-based supply chain vis-a-vis value chains sprawling between site of production to site of consumption.

The simulative phase of agricultural growth and development has rightly been characterised with future projections, digitised configuration and precision production factors. It started and went functionally geared up during 1980s, 1990s and 2000 onwards. The beginning of globalisation

era in the form of LPG (i.e. liberalisation, privatisation and globalisation) regime and the opening up of fiscal markets to the global one added a new favour to the production system and value addition. Now, every kilogramme of vegetables has to go globally saleable; the apple of a country with a value sticker can travel all islands and territories beyond the aqua geography. So, an ICT (information and communications technology)-driven and satellite-supported agriculture enters a virtual space of data sharing and product manoeuvring across the geography and sociology of the global market. Future tradings and online marketing have become the go and eye of modern agri-horti-entrepreneurships:

This has been right across the value addition genera, keeping focuses on and with branding, market segments, value chain management and inclusive growth takes place through a denial to the geographic, temporal and spatial barrier.

1.1 Issues of Food Security: The Role of Creating Value-Based Entrepreneurship

Every farm economy should be based on the basic pledge for ensuring food security, especially for the weaker section of the society. Food security includes physical volume (sufficient amount), its proper absorption (easy metabolic processes) and affordability (at cheaper price). It is very difficult to get all these three things operating at a common point. A lot of endeavours are there to integrate these three aspects by increasing the productivity through genetic modification and hybridisation, incorporating minerals and vitamins through golden rice project and mobilising community to access cheap but nutritionally rich natural foods.

Food security is a condition related to the ongoing availability of food. The concerns over food security are from time immemorial. The term 'food security' was established at the 1974 World Food Conference. A new definition was given at the 1996 World Food Summit with the emphasis on individuals enjoying food security, rather than the nation. According to the Food and Agriculture Organization (FAO), food security 'exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life':

Entrepreneurship cannot simply shy away with the responsibility of food and nutritional security. What is needed is to have as change from volume of green production to volume of golden production.

1.2 Global Food Requirement and Present Status

Crop yields worldwide are not increasing quickly enough to support estimated global needs in 2050. It has been estimated in the past that global agricultural production may need to increase 60–110 % to meet increasing demands and provide food security. In the current study, researchers assessed agricultural statistics from across the world and found that yields of four key crops (viz. maize, rice, wheat and soybean) are increasing 0.9–1.6 % every year. At these rates, the production of these crops would likely to increase 38–67 % by 2050, rather than the estimated requirement of 60–110 %. The top three countries that produce rice and wheat were found to have very low rates of increase in crop yields (CGIAR 2014).

The overall demand for agricultural products (including food, feed, fibre and biofuels) is expected to increase 1.1 % per year from 2005/2007 to 2050, from 2.2 % per year in the past four decades.

Increases in food demand are due to population growth and changes in diets.

As the population grows and more countries and population groups attain per capita food consumption with little scope for major increases,

global food demand will grow at much lower rates. But for a long time to come, some countries might have difficulty increasing food consumption due to low income and significant poverty (Alexandratos and Bruinsma 2012).

A recently published WHO/FAO report recommends a minimum of 400 g of fruits and vegetables per day (excluding potatoes and other starchy tubers) for the prevention of chronic diseases such as heart disease, cancer, diabetes and obesity, as well as for the prevention and alleviation of several micronutrient deficiencies, especially in less developed countries (WHO 2014).

1.3 Inclusive Growth

Inclusive growth is a concept which advances equitable opportunities for economic participants during the process of economic growth with benefits incurred by every section of society.

The definition of inclusive growth is related to the macroeconomic and microeconomic determinants of the economy and economic growth. The microeconomic dimension captures the importance of structural transformation for economic diversification and competition, while the macroeconomic dimension refers to changes in economic aggregates such as the country's gross national product (GNP) or gross domestic product (GDP), total factor productivity and aggregate factor inputs (World Bank 2014).

Sustainable economic growth requires inclusive growth. The inclusive growth approach takes a longer-term perspective, as the focus is on productive employment as a means of increasing the income of poor and excluding groups and raising their standards of living (Ianchovichina and Lundstrom 2009).

The creation, refinement and addition of new skills into the depletive domain of classical skills, suffering from redundancy, will help eliminate the gender and community disparity and disparages. The value addition process centring around locally available resources and skills needs to be upgraded, and a market-linked enterprise cafeteria shall help the marginalised and weaker farmers to come up stronger and compete with the belligerent market and thus help them go stronger with inclusive growth.

1.4 Market for Field Crops Are Gradually Turning Inelastic

Food being the primary consumers goods and basic requirement, it is vulnerable to face the market inelasticity for a given market demand. The farmers, across the world, are stressed to divert from food crops to commercial crops in order to respond to a belligerent market for biofuels, ethanols, etc. This has set a new dimension for value addition to the agri-horticultural production system both at micro and mega levels and has been good enough to have redesignated agri-horticultural policy:

- The seasonal nature of agriculture leads to a lagged supply response. As demand has outpaced supply, prices have increased significantly, particularly for maize (corn), rice and wheat. Fertiliser prices have also increased dramatically over the last 2 years as increased supply to match rising demand has been held back by the limited production capacity.
- Biofuel policies. Surging demand for food crops has increased faster than supply due primarily to biofuel policies in industrialised countries and to a lesser extent changing diets in rapidly growing developing countries. Biofuel policies have diverted food crops from traditional export markets to the production of ethanol and biodiesel. The growing demand for livestock products, particularly in Asia, has increased the consumption of grain for feed. Erratic weather, trade policies and seasonal lags have slowed producers' response to the higher prices.

1.5 Brunt of Climate Change

The brunt of climate change has already been reflected through the decline of productivity, shifting of critical growth zones, mutagenesis of physiological expression of different genomics and intrusion of exotic genes to tantalise the

classical functioning of sui generis characters, and these all are posing newer threats to food security. 1 °C change in night temperature will invite a 20 % downfall of wheat productivity and 12 % for rice. That is again rendering a stage for juxtaposition between population growth and productivity fallout.

Horticultural crops are gone unmanaged in the brunt of climate change. Even a protected condition may provide higher deterrent climate change effects.

Climate change presents a major concern, often interacting with existing problems. It makes new demands for adaptation and coping strategies and presents new challenges for the management of the environment and agroecosystems. The Intergovernmental Panel on Climate Change (IPCC) report (Adger et al. 2007) ignores the role of diversity in production systems and the central role that agrobiodiversity will have to play in both adaptation and mitigation at the country, landscape, community and farmer levels:

- Nearly 20 % of all US food is imported, so climate extremes elsewhere will also have an effect. In 2011, 14.9 % of US households did not have secure food supplies, and 5.7 % had very low food security.
- Latest EU projections suggest that the most severe consequences of climate change will not be felt until 2050. But significant adverse impacts are expected earlier from more frequent and prolonged heatwaves, droughts and floods. Many crops now grown in southern Europe, such as olives, may not survive high temperature increases. Southern Europe will have to change the way it irrigates crops.
- In 2011, Russia banned wheat and grain exports after a heatwave. Warming will increase forest fires by 30–40 %. This will affect soil erosion and increase the probability of floods.
- In the Middle East and North Africa, declining yields of up to 30 % are expected for rice, about 47 % for maize and 20 % for wheat.
- Egypt expects to lose 15 % of its wheat crops if the temperatures rise by 2 °C and 36 % if the increase is 4 °C. Morocco expects crops to remain stable up to about 2030, but then to drop quickly later. Most North African countries traditionally import wheat and are therefore highly vulnerable to price shocks and droughts elsewhere.

1.6 Gender Empowerment

Gender empowerment has got two basic components, gender enabling and gender mainstreaming. While gender enabling is basically an economic process, gender mainstreaming is exclusively a social process. These two processes are subject to policy implications and operational role on the part of government and institutions. In economic enabling process, the postharvest processing and quality management initiatives can go in compliance with unique gender requirements and natural skills. Both horticulture and livestock, across the length and breadth of society, have got intrinsic and systemic property to go attuned with gender skills and behaviour:

- As identified by UNICEF, women are the potentially vulnerable group in this process. In some of the poorest areas of South Asia, cultural restrictions on women's ability to participate fully in food production activities have left them particularly vulnerable in times of economic crisis.
- Despite considerable cross-cultural variations in the gender division of labour, there does appear to be a general predominance of women in the household-based processing stage of crop production as well as in the transformation of raw food into edible form.
- There appears to be a fairly widespread gender differences in the involvement in livestock rearing. Larger stocks (cattle, buffalo, horse, etc.) have to be grazed over larger distances and often require male labour at least for some stages of livestock care. Smaller stock and poultry can be cared for with female labour alone. This often leads to greater male rights over cattle and female rights over smaller stock. In Bangladesh and India, 'share rearing' of goats and poultry is a common means by which poor women transform their only resource – labour power – into a productive

asset. Other common examples of primarily female activities are cultivation of homestead plots and 'backyard' gardening. If household food security is an objective of project intervention, then clearly targeting these spheres of activity will help to enhance women's control over household food resources.

1.7 Value Addition of Horticultural Crops World Scenario vis-a-vis Indian Scenario

After independence, India recorded faster growth in food-processing sector specifically during the early 1980s. After the Green Revolution, the country had increased agricultural production needed for its postharvest management. The importance of the sector was realised by the business community leading to diversification from grain trading to processing (Kachru 2006). In some areas like the solvent extraction industry, the growth in installed processing capacity has been far higher than the supply of the raw materials. However, in areas like horticultural crops especially fruit and vegetable processing, the growth has not been satisfactory due to poor demand for processed products by the consumers. In such cases, the industry has also not been able to develop the demand adequately. This is due to the food habits of the population. Indians mainly prefer fresh fruits and vegetables, spices, etc., over processed fruits and vegetables. India has experienced a considerable degree of crop diversification in terms of changes in the area under various crops since the Green Revolution, which mainly targeted the increased food grain production to resolve the country's food security problem. In the past one decade, the change in cropping pattern is more towards the horticulture sector and commercial crops (Mittal 2007). Horticultural crops comprising of fruits, vegetables, flowers, medicinal and aromatic plants, spices and plantation crops play a leading role in the food and livelihood security of India. Though these crops occupy only 8.5 % of arable land, they contribute 29.5 % of the GDP in agriculture (Economic Survey 2007–2008). This calls for technology-led development. Cultivation of these crops is labour intensive, and as such, they generate a lot of employment opportunities for the rural population. India produced 261.98 million tonnes of horticultural crops from an area of 23.4 million hectare (NHB 2013). The performance in the production is lucrative, but in value addition part, India's share is not as expected. India only contributes 2 % in the world horticulture trade. The concept of agri-export zones and mega food parks has been promoted by the Indian government to promote food-processing industry and also its subsector like fruit and vegetable processing industry in India. Indian government has sanctioned US $ 22.97 million in establishing around 10 M food parks and offered the tax benefits to the concerned subsector of the food-processing industry. The share of food-processing industry in GDP has gone up to Rs.44, 93,743 crore in 2009–2010 with compound annual growth rate (CAGR) of 8.40 %. The current horticultural crop processing scenario in India, compared to the developed countries, is not satisfactory. The factors responsible for this are so many.

1.7.1 Extent of Postharvest Losses

India is the second largest producer of fruits and vegetables in the world. The country has emerged as the world's largest producer of spices, coconut and tea and the second largest producer and exporter of tea, coffee and cashew. Nanda et al. (2012) reported that in the post-Green Revolution era, even though food grains have been taken care of, horticultural crops, mainly fruits and vegetables, because of the need for simple processing, preservation and transport technologies, have suffered postharvest losses, estimated to be more than 25 %, amounting to a revenue loss of Rs. 500 billion (Tables 1.1 and 1.2). About 10–15 % fresh fruits and vegetables shrivel and decay, lowering their market value and consumer acceptability. Minimising these losses can increase their

Table 1.1 Postharvest losses in horticultural crops during different channels of handling/farm operations in India

Postharvest handling channel	Fruits, %	Vegetables, %	Plantation crops and spices
Harvesting	0.92–4.56	0.84–3.61	0.16–3.66
Collection	0.23–1.20	0.23–1.77	0.16–0.86
Sorting/grading	0.93–4.79	1.54–3.30	0.31–1.36
Packaging	0.08–0.94	0.10–1.64	0.06–0.24
Transportation	1.06–2.77	0.44–3.14	0.01–0.31
Total loss in farm operations	4.18–13.92	4.61–11.03	0.89–7.89
Total loss in storage	1.20–4.13	1.51–3.04	0.23–1.66
Overall total loss	5.77–18.05	6.88–12.98	1.12–8.64

Table 1.2 Postharvest losses in horticultural crops during different levels of storage in India

Level of storage	Fruits, %	Vegetables, %	Plantation crops and spices, %
Farm level storage	0.84–5.54	1.18–4.62	0.13–1.94
Godown/cold storage	0.00–3.34	0.30–2.18	0.21–0.61
Wholesaler level storage	0.99–5.91	1.32–3.87	0.22–1.24
Retailer level storage	1.10–3.79	1.70–2.62	0.14–2.09
Processing unit level storage	0.03–5.71	0.09–2.34	0.03–1.37
Total loss in storage	1.20–4.13	1.51–3.04	0.23–1.66
Overall total loss	5.77–18.05	6.88–12.98	1.12–8.64

supply and improve general nutrition of the common Indian without bringing additional land under cultivation. Improper and faulty handling, storage and marketing cause physical damage due to tissue breakdown. Mechanical losses include bruising, cracking, cuts and microbial spoilage by fungi and bacteria, whereas physiological losses include changes in respiration, transpiration, pigments, organic acids and flavour. On account of poor postharvest management, the losses in farm produce in India have been assessed to be of a very high order. It has been studied that the extent of losses could be curtailed to less than 50 % through the adoption of proper agro-processing technology. For reducing the rest of the losses, new initiatives need to be called for. Hence, long-term attention should be focussed on such as proper grain storage structures, cold stores and processing systems to avoid the losses. India is very ambitious to increase the processing level to 20 % by 2015 (MOFPI 2011).

1.8 Commodity-Wise Value Addition

1.8.1 Fruits and Vegetables

Joint efforts by the R&D institutions, farmers, government agencies and the trade has resulted in India being the second largest producer of fruits and vegetables after China. In the year 2012–2013, the country produced about 77.7 million tonnes of fruits and 159.5 million tonnes of vegetables contributing 25 % of the total world production (NHB 2013). However, the growth in postharvest sector has not kept pace with the production. Only about 2.2 % of the total fruits and vegetables produced are processed as compared to countries like the USA (65 %), Malaysia (83 %), the Philippines (78 %), France and Brazil (70 % each), etc. The fruit and vegetable processing in India is highly decentralised, small-scale industries accounting for 33 %, organised 25 %,

unorganised 42 % and large number of units in cottage/household and small-scale sector having capacities of up to 250 tonnes/year. In organised sector of India, there are about 5,000 units, and several thousands in unorganised sector of fruit and vegetable processing are in the job. Significant developments in technology include better understanding of the process of ripening of fruits, optimum harvesting time, pre-cooling of freshly harvested produce, cold storing of the raw fruits and vegetables and sorting, cleaning, waxing and packaging technology for fruits. At CFTRI, DFRL and IIHR, Bangalore; IARI, New Delhi; GBPUA&T, Pantnagar; IIVR, Varanasi; and HPKV, Palampur, a number of technologies have been developed. Over the last few years, there has been a positive growth in ready-to-serve beverages, fruit juices and pulps, dehydrated and frozen fruit and vegetable products, tomato products, pickles, convenience veg-spice pastes, processed mushrooms and curried vegetables. The most significant work has been recorded in the technology for ripening of the fruits under controlled conditions. The production of juices and value-added products including jams, jellies, pickles, canned products, etc., has become a commercial success. The industry using indigenous technology includes units engaged in juice extraction, concentration of juices, canning and production of several of the products like jams, jellies, canned fruits, dried vegetables, etc. Technology is still being imported for the establishment of large-scale exported oriented units for the production of items like banana paste, concentrates of various fruit juices and sorting, cleaning, washing, waxing and packaging of raw fruits and vegetables. Presently, India is processing so many fruit and vegetable processed products (Table 1.3).

1.8.1.1 Export Scenario of Indian Processed Fruits and Vegetables

Fresh fruits and vegetables comprise almost 35 % of the world trade in horticulture. The major product category in processed fruits and vegetables which are exported are mangoes (fresh and pulp), grapes, other fresh fruits, dried and preserved vegetables, pickles and chutneys and fruit beverages. But almost two-thirds is accounted for

Table 1.3 List of existing and new value-added products of fruits and vegetables in India

Fruit/vegetable	Existing products	New products
Apple	Juice, AJC, jam, jelly, cider, wine, pulp	Osmotically dried rings, canned apple, vinegar, carbonated juice, apple seed for nurseries, pectin, fibre from pomace
Apricot	Pulp, squash, RTS, jam, appetiser, dried apricot	Osmotically dried apricot, oil, apricot oil-based cream, etc.
Plum	Pulp, squash/appetiser, RTS, chutney, jam, wine/brandy	Plum sauce, seed oil
Peach	Canned peach, pulp, jam/chutney	Wine, kernel oil
Pear	Canned pear, pulp, jam	Apple pear blend, sand pear candy, vermouth
Mango	Pulp, RTS, squash, powder (amchur), slices in brine, pickle	Pulp/juice from in situ mangoes, pectin from just-ripe fruits
Apple	Juice, AJC, jam, jelly, cider, wine, pulp	Osmotically dried rings, canned apple, vinegar, carbonated juice, apple seed for nurseries, pectin, fibre from pomace
Apricot	Pulp, squash, RTS, jam, appetiser, dried apricot	Osmotically dried apricot, oil, apricot oil-based cream, etc.
Grapes	Raisin, juice	Carbonated juice/RTS
Litchi	Juice, squash, nectar/RTS	Carbonated drink
Cauliflower	Pickle, slices in brine	Frozen cauliflower heads, left over for drying powder
Carrot	Pickle, slices in brine, preserve, candy	Freezing and drying
Chillies	Green chilli puree, powder	Green chilli paste, oleoresin
Tomato	Juice, sauce, ketchup, paste	Drying, powder

by four items, namely, citrus, banana, apple and grape. India exported 724,178.09 million tonnes of processed fruits and vegetables valuing 383,616.21 lakh rupees (APEDA 2014). The major destinations for processed fruits and vegetables like dried and preserved vegetables are exported to Sri Lanka, the USA, the UAE, Germany, France and the Netherlands; mango pulp goes to the UAE, Saudi Arabia, Kuwait, the Netherlands and Hong Kong; pickle and chutney are taken up by the UK, the USA, the UAE, Germany, Canada, the Netherlands and Saudi Arabia; other processed fruits and vegetables (tomato paste, jams, juices, etc.) are imported by the USA, the Netherlands, the UK, the UAE, Indonesia, the Philippines and Russia. Russia is a major importer of processed fruits and vegetables from India, and the country imported 13,477 million tonnes of dehydrated vegetables and fruits worth Rs 5,963 lakh in 2010–2011. The second major importer is the USA with 11,164 million tonnes of dehydrated fruits and vegetables in 2010–2011. The consumption of processed fruits and vegetables is low in India compared to the primary foods because they are available fresh in the market to the consumer. The demand for processed foods is mostly lied in the urban market due to the lifestyle and purchasing power of the urban population. Thus, there is a large demand for processed food in the export market, and India can capture this market by restructuring and strengthening its infrastructure.

1.8.2 Value Addition in Spices

India is traditionally known as the spice bowl of the world. According to the Bureau of Indian Standards, about 63 spices are widely grown in our country. India is the largest producer, consumer and exporter of spices in the world with a 46 % share by volume and 23 % share by value, in the world market. India produced 57.44 lakh tonnes of spices from an area of 3.08 million hectare (NHB 2013). These spice sectors also play a significant role in the development of Indian economy. The Indian story of value-added spice products began in the early 1970s. Over the years, with investments in quality and supply chain management, it has emerged to be the largest in the world. It is not only a local sourcing and processing point but has also changed itself as a value addition hub for the spice crops from the Asia-Pacific region and elsewhere across the globe. Different value-added products of spices available in India are spice oils and oleoresin, dehydrated pepper, freeze-dried green pepper, ginger candy, ginger beer/in brine/squash, ginger flakes, garlic pickle and paste, chilli powder, paste, puree, oleoresin, etc. (Table 1.4). The contribution of R&D to PHT of spices includes equipment and processes for cleaning, grading and packaging of whole spices and production of value-added products such as oleoresins and spice oils. Institutions like CFTRI, DFRL, Indian Institute of Spices Research and some of the SAUs including TNAU, Coimbatore, have contributed significantly to this development.

1.8.2.1 Global Market of Value-Added Spice Products

India is the largest exporter of spices in the world. The share of spices in total agricultural export is 6 %. Indian spices flavour foods in over 130 countries, and their intrinsic values make them distinctly superior in terms of taste, colour and fragrance. More than 150 spice-based value-added products from India are available across the globe. The USA, Canada, Germany, Japan, Saudi Arabia, Kuwait, Bahrain and Israel are the main markets for Indian spices and spice products. We have near monopoly in spice oils and oleoresins. India supplies more than 70 % of the total world supply of spice oils and oleoresins. Indian spices have obtained geographical indicators such as Malabar pepper, Alleppey green cardamom, Coorg green cardamom and Naga chilli. The demand for organic products is steadily increasing in the western markets at 20–25 % every year and that of organic spices is about 2 %. Spice exports have registered substantial growth during the last 5 years, registering a compound annual average growth rate of 23 % in value and 11 % in volume, and India commands a formidable position in the World Spice Trade during 2012–2013; a total of 8,62,542 tonnes of spices and spice products

Table 1.4 List of existing value-added products of spices in India

Spices	Existing products
Black pepper	Oleoresin, green pepper in brine, dehydrated green peppers, canned green pepper, frozen green pepper, cured green pepper, pepper oil, freeze-dried green pepper, white pepper powder, etc.
Ginger	Powder, wines, dry ginger, starch from spent ginger, preserves, gingiberin oil, oleoresin
Turmeric	Natural pigments, curcuminoids, oleoresins
Chillies	Powder, pickles, paste, oleoresin, oil, brined chilli, sauces
Paprika	Colour, paprika flavour
Coriander	Powder, oleoresins
Cumin	Powder, oleoresin
Fennel	Sugar-coated fennel, oleoresin, whole, etc.
Fenugreek	Powder, dried fenugreek leaves, etc.
Tree spices (cinnamon, cassia nutmeg, cloves)	Obesity regulators, stimulators, nutraceuticals
Paprika	Colour, paprika flavour
Cardamom	Encapsulated cardamom, cardamom tea, cardamom soft drink mix, cardamom oil and oleoresin
Garlic	Garlic powder, garlic paste, garlic oleoresin
Turmeric	Natural pigments, curcuminoids, oleoresins
Chillies	Powder, pickles, paste, oleoresin, oil, brined chilli, sauces
Paprika	Colour, paprika flavour
Coriander	Powder, oleoresins
Cumin	Powder, oleoresin
Fennel	Sugar-coated fennel, oleoresin, whole, etc.
Fenugreek	Powder, dried fenugreek leaves, etc.
Tree spices (cinnamon, cassia nutmeg, cloves)	Obesity regulators, stimulators, nutraceuticals

valued Rs.12,112.76 crore (US $ 2,212.13 million) has been exported from the country as against 5,75,270 tonnes valued Rs.9,783.42 crore (US $ 2,037.76 million) in 2011–2012, registering an increase of 26 % in volume and 24 % in rupee terms and 8.5 % in dollar terms of value (Table 1.4). During this period, the achievement in export earning is high, and it is mainly due to the rigorous focus and initiatives taken by the board for value addition and higher end processing of spices (Spices Board of India 2014). Value-added products like curry powder/paste, mint products and spice oils and oleoresins registered a growth of 46 % in volume and 37 % in value. During this period 8,665 t of spice oils and oleoresins valued at Rs 1,242 crore have been exported. Curry powder/paste followed suit with a 44 % increase in volume and 53 % increase in value. Turmeric marked an increase of 17 % and 45 % in volume and value of exports, respectively.

1.8.3 Processing of Plantation Crops

Plantation crops contribute substantially to the national economy with an export earning of Rs. 12.4 billion. Coconut alone contributed Rs. 1.72 billion by way of exports during 1996–1997. However, the coconut-based industry in India has been in the infancy stage. There is a considerable scope of product diversification, viz. production of coconut milk and milk powder, coconut cream, shell powder, shell charcoal, etc. Coconut wood utilisation needs more attention. In case of other crops, financially viable technologies for product diversification need to be developed. Such products are areca nut fat, tannin, arecoline, other chemicals from areca nut, honey-/chocolate-coated or salted kernels from cashew nuts and value-added products from by-products. The postharvest operations in these crops need to be

mechanised. Though the technology has been developed for desiccated coconut, coconut cream and other products, it needs refinement. At CPCRI, Kasargod, a coconut dehusker has been developed for manually opening the nuts. Another motorised unit is under development. Copra drier using LDPE cover and batch-type hot air copra drier using agricultural waste as source of fuel have also been developed at CPCRI, Kasargod; KAU, Thrissur; and TNAU, Coimbatore. In case of the plantation crops like oil palm, necessary efforts are required for processing and value addition, especially with regard to the quality of products, energy inputs, packaging, etc., to meet the international quality standards and to reduce the cost of production. Processing of cocoa beans at small scale also needs attention.

1.9 Constraints and Opportunities in Value Addition of Horticultural Crops in India

1.9.1 Constraints

1. Processing units of horticultural crops are established far away from production catchments resulting high cost of transportation and quality loss perishable horticultural crops.
2. Lack of contract farming system to ensure a uniform supply of raw material.
3. Concept of storage and cold chains and cargo facilities at airports and ports are very much inadequate.
4. Lack of availability of appropriate machinery and equipments based on the quality and quantity of indigenous Indian raw material.
5. High capital investment for the establishment of processing units and high operational costs.
6. Taxes on processed products in India are among the highest in the world. No other country imposes excise duty on processed food.
7. Majority of the processing units are operated by the unskilled and semi-skilled workers.
8. The need for modernisation of existing units as outdated machinery used in small- and medium-scale enterprises leads to poor quality and low yield of the finished product.
9. Lack of quality control facilities for small- and medium-scale enterprises leading to non-uniform quality of finished products resulting in poor market acceptability.
10. Poor linkage between R&D institutions and food industries/entrepreneurs.
11. Cooperatives and other semi-government organisations are weak, and people's participation, either through Panchayat Raj institutions, NGOs, farmer organisations or industries' associations in food sector, remains extremely inadequate.

1.9.2 Opportunities

1. Contract farming system to ensure uniform supply of raw material.
2. Precision postharvest technologies using automation of postharvest handling, packaging, transportation and storage operations.
3. Introduction of low-cost bulk storage structures for the horticultural produce at production and despatch areas.
4. Development of complete cool chain on road and air for maintaining the optimum quality of the perishable produce from farm to fork.
5. Adoption of non-thermal/non-chemical processing and preservation of food products.
6. Production of safe food products with a maximum nutrient retention.
7. Faster detection of adulterants and chemical residues in processed horticultural products using bio-sensors/nano-bio-sensors.
8. Application of robotics, artificial neural networking, nutrigenomics, non-destructive and/or online testing techniques, supercritical fluid extraction for production of high-value products.
9. Recycling of horticultural wastes specially fruit, vegetable and plantation crops wastes into newer products.

10. Nanotechnological interventions in the development of bio-polymers for packaging and bio-composite for structures.

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Preparation of Value-Added Products Through Preservation

2

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Abstract

Fruits and vegetables provide an abundant and inexpensive source of energy, body-building nutrients, vitamins, and minerals. However, most fruits and vegetables are only edible for a very short time unless they are promptly and properly preserved. To make foods available throughout the year, humans have developed methods to prolong the storage life of products, that is, to preserve them. The rotting process can be postponed by adding preservatives, optimizing storage conditions, or applying modern techniques. Preservation in one form or another has been practised in all parts of the world since time immemorial, although scientific methods of preservation were developed only about a hundred years ago. Preservation also assures a stable market to farmers and horticulturists and enables them to expand their production without fear of a fall in demand. Fruits and vegetable preservation industry are still in its infancy in this country. Until about 50 to 60 years ago, other well-known methods of preservation such as jam, jellies, marmalades, etc. were confined to only a fewer larger industries. One of the main difficulties in the path of the growth of the fruit and vegetable industry has been the inadequacy of knowledge of the modern methods and techniques of preservation. So, to overcome these difficulties, an attempt is made in this chapter to highlight various aspects of the importance of various preservation methods and limitations to be considered during preservation of fruits and vegetables.

2.1 Introduction

Preservation is a process of keeping food materials in an altered condition for a long time without impairing their quality to the utmost extent, with the objectives to preserve fruits and vegetables at the stage of maximum palatability, taste, colour, flavour, quality, and nutritive value; to check

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wastage of local or seasonal surplus; to make the product available for a longer period even in places where it is not produced; to preserve food materials during transit from producer to consumer; and to facilitate handling of food materials, which is done primarily through various methods of packaging (Lal et al. 1959).

2.2 Importance of Fruit and Vegetable Preservation

Horticulture is concerned with perishable crops such as fruits and vegetables. Unless the preservation industry develops with the development of horticulture, it will be uneconomical. Preservation takes care of surplus produce and thereby checks wastage from rotting: that is, the more we preserve, the more we are able to consume in the future. Preservation helps the farmers to obtain a better return by checking wastage during a market glut. It keeps the products in proper condition, which is not possible under ordinary or cold storage conditions. Hence, preservation is a suitable substitute for storage. It allows fruits and vegetables to be available during off seasons and in locations where these are not grown. Also, preservation has the additional benefit of foods being more palatable. Several ancillary industries such as the productions of cans, bottles, caps, cardboard, etc. may be established, which will generate employment opportunities.

2.3 Scope of Fruit and Vegetable Preservation in India

Fruits and vegetables are important supplements to the human diet, as they provide minerals and vitamins essential for maintaining health and protecting us from different diseases and disorders. According to human dieticians, an adult person working moderately requires 85 g of fruits and 300 g of vegetables every day, in addition to cereals, fish, meat, milk, etc. Fortunately, India, with its wide range of soil and climatic conditions, is ideal for growing varieties of fruits and vegetables and is the second largest producer of fruits and vegetables, producing about 81.2 million tonnes of fruits and 162.2 million tonnes of vegetables, of which about 25 % to 30 % of the total produce is wasted because of spoilage (Anonymous 2013). Most fruits and vegetables are seasonal and perishable in nature. During the peak harvesting time there may be a market glut, but because of insufficient transport facilities and poor availability of packaging materials, the surplus cannot be taken quickly to the markets in urban areas. Moreover, the surplus often cannot be stored for sale in the off season because of inadequate local cold storage facilities; thus, the cultivators do not get a good price for their produce because of the glut, and some of it is spoiled, resulting in complete loss. Preservation of fruits and vegetables can help to solve these problems. Small, poorly shaped, overripe, and infected fruits and vegetables that are unacceptable in the market and fetch a lower price can be utilized successfully in the preservation industry. With increased urbanization, rise in middle-class purchasing power, changes in food habits, and decrease in the practice of making preserved products in individual homes, there is increasing demand for industry-made products in the domestic market. Moreover, some of these preserved products such as canned mangoes, fruit juices, salted cashews, dehydrated foods, and frozen fruits are gaining popularity in the foreign market and are good foreign exchange earners. In spite of all these reasons, only 2.2 % of the total produce is processed in India as compared to 40 to 83 % in developed countries.

Thus, there is considerable scope for expansion of the fruit and vegetable preservation industry in India, which in turn will help in the development of horticulture and in earning more foreign exchange.

2.4 Limitations of the Fruit and Vegetable Preservation Industry in India

Lack of coordination between growers and processing units. It is necessary to supply fruits and vegetables continuously for the processing

industries to run effectively. A contract between growers and the processing units would ensure continued availability of good-quality raw materials to the industry.

Lack of skilled manpower. Although India is an advantageous position in having a large reservoir of manpower, skilled manpower is in short supply. Workers should be properly trained.

Lack of awareness. Because most of the available knowledge regarding preservation is scattered in scientific papers, departmental reports, and other highly technical publications, people in general are not aware of the modern methods and techniques of preservation. To overcome this problem, this information has to be disseminated on a country-wide scale so that full advantage of it can be taken by all those interested in the industry.

Lack of marketing facilities. Although there is a demand for preserved products, there are not readily available in small towns because shopkeepers are unwilling to stock such items. The establishment of a growers' cooperative society would help in the marketing of such products.

Difficulty in the availability of containers. Bottles and cans are the two major types of containers required by the food processing industry. The initiative has already been taken up by a number of factories for manufacturing bottles of required specification, but there is great difficulty in the availability of cans because there are few factories for their manufacture. There is a need to set up more factories to meet the demand for cans.

2.5 Principles of Preservation

If prepared products of fruits and vegetables are kept for some time, the taste, aroma, and appearance of the products deteriorate rapidly (Amerine et al. 1965) for several reasons: (1) fermentation caused by microorganisms such as molds, yeasts, and bacteria; (2) enzymes present in the product may affect the colour and flavour adversely; (3) chemicals present in the pulp/juice may react with one another and spoil the taste and aroma; (4) air coming in contact with the product may react with glucosidal materials present in it and render the product bitter; and (5) traces of metal from the processing equipment may get into the product and spoil its taste and aroma.

All that inactivates the enzymes as well as microorganisms to control spoilage forms the basis of preservation techniques. In the preservation of foods by various methods, the following general principles are involved (Khurdiya and Roy 1986).

1. *Prevention or delay of microbial decomposition:*
   (a) By keeping out microorganisms (asepsis)
   (b) By removal of microorganisms, such as by filtration
   (c) By hindering the growth and activity of microorganisms, for example, by low temperature, drying, anaerobic conditions, chemicals, or antibiotics
   (d) By killing the microorganisms, for example, by heat or radiation
2. *Prevention or delay of self-decomposition of the food:*
   (a) By destruction or inactivation of enzymes, as by blanching
   (b) By prevention or delay of chemical reactions, for example, prevention of oxidation by means of an antioxidant
3. *Prevention of damage by insects, animals, mechanical causes, etc:*
   If all these principles are followed properly, the preserved products will remain in good condition by retaining the natural taste and aroma for a longer period.

2.6 Different Processes or Forms or Methods of Fruit and Vegetable Preservation

2.6.1 Liquid Form

2.6.1.1 Beverage

All drinks, unfermented or fermented, sweetened or unsweetened, are designated as beverages. Among these, fruit juices have an eminent place

as they are rich in essential minerals and vitamins and other nutritive factors. At present, synthetic beverages are becoming available and are produced in large quantities by aerated water bottlers in this country.

2.6.1.1.1 Unfermented Beverages

Fruit juices that do not undergo alcoholic fermentation are termed unfermented beverages.

1. *Pure fruit juice:* The natural juice pressed out of a fruit, then strained, that remains particularly unaltered in its composition during its preparation and preservation. Edible acid may be added before use for improving taste (citric acid), and the juice may be diluted also: for example, mango, pineapple, citrus, grape, apple, pomegranate, mulberry, jamun, phalsa, passion fruit.
2. *Fruit juice beverage:* A natural, coarsely strained fruit juice, pressed from a fruit, with a moderate quantity of fruit pulp, that is considerably altered in composition by adding water and a small amount of sugar during processing and preservation. Acid and chemical preservatives are also added according to requirements. It may be further altered in composition and diluted before consumption, as pineapple and papaya.
3. *Squash:* Squash is a type of fruit beverage containing 25–33 % fruit juice or pulp, 40–50 % total soluble solids (TSS), 1.0 % acid, and 350 ppm sulfur dioxide. This beverage is diluted with chilled water before serving (Jood and Ketarpaul 2002); for example, orange squash, lemon squash, mango squash, pineapple squash.
4. *Cordial:* A sparkling clear fruit juice derived either from fruit juice or from squash, from which all the pulp and suspended materials are removed completely by the siphon method. It may be sweetened by adding sugar. It contains at least 25 % fruit juice, 30 % TSS, 1.5 % acid, and 350 ppm SO_2: examples are lime, orange, almond.
5. *Crush:* A fruit squash or fruit beverage that contains at least 25 % fruit juice or pulp and 55 % TSS. It also contains 1.0 % acid, and is diluted before use, such as pineapple crush.
6. *Fruit juice concentrate:* Fruit juice that has been concentrated by removal of water by either heat or freezing. Carbonated beverages and other products are made from the concentrate, which contains at least 32 % TSS.
7. *Ready-to-serve (RTS):* This fruit beverage contains at least 10 % fruit juice and 10 % TSS plus about 0.3 % acid. It is not diluted before use: ber, jamun, custard apple.
8. *Nectar:* Also a coarsely strained fruit beverage that contains at least 20 % fruit juice/pulp, 15 % TSS, and about 0.3 % acid. It is not diluted before use: jamun, bale, custard apple.
9. *Syrup:* A fruit beverage containing at least 25 % fruit juice or pulp and 65 % TSS. It also contains 1.3–1.5 % acid and is diluted before serving (Sharma et al. 1988): grape, pomegranate, jamun, pineapple, orange, strawberry, raspberry, mulberry, etc.
10. *Synthetic syrup or sarbat:* A heavy sugar syrup of 70–75 % strength when flavoured and coloured with artificial essence of fruits, herbs, and colours is known as synthetic syrup or sarbat.
11. *Barley water:* A fruit beverage that contains at least 25 % fruit juice, 30 % TSS, and 0.25 % barley starch.

    Barley water is prepared from citrus fruits such as lime, lemon, grapefruit, and orange: lime and lemon are mostly used.
12. *Carbonated beverage:* When fruit juice or syrup is preserved in CO_2 gas, it is then called a carbonated beverage. Orange juice preserved in this method is known as orangeade, and, similarly, lemon juice as lemonade.

2.6.1.1.2 Fermented

Fruit juices that have undergone alcoholic fermentation by yeasts include wine, champagne, port, sherry, tokay, muscat, perry, orange wine, berry wine, nira, and cider.

(a) *Alcohol:* When any fruit juice having 10 %–12 % fermentable sugar is allowed to ferment with yeast (*Saccharomyces ellipsoideus*, *S. malei*, *S. cerevisiae*) in anaerobic

conditions and at 25–27 °C, after its sterilization ethyl alcohol is produced, which is then filtered and stored in an airtight container to check further infection and thereby fermentation with vinegar bacteria. It is also a sparkling clear liquid. The product contains varying quantities of alcohol. The alcohol content of wine varies from 7 to 20 %. Wines with 7–9 % alcohol are called light liquor or light wine, those with 9–16 % are termed medium wines, and those with 16–20 % are strong wines. Liquors contain 40–60 % alcohol, although in fruit brandy only 4–6 % alcohol is present: grape wine, apple cider, cashew apple feni, palm tree nira, aonla wine, etc.

(b) *Vinegar:* Vinegar is perhaps the oldest known fermentation product. It contains about 5 % acetic acid in water, a varying amount of fixed fruit acids, colouring matter, salts, and a few other fermentation products that impart a characteristic flavour and aroma to it.

Vinegar is a liquid derived from various substances containing sugar and starch by alcoholic, and subsequently acetic acid, fermentation. In the trade, vinegar is labelled according to the material used in its manufacture: vinegar made from malt is called malt vinegar, that from apple juice is called apple cider vinegar, and that from grape is called grape vinegar.

2.6.1.2 Other than Beverages

1. *Puree:* Puree is a concentrated fruit/vegetable pulp without seed and skin; 3–10 % sugar and 1 % salt are added with the chemical preservative, so that the concentration of total solid should be 12 %, of which 8.37 % is the salt-free fruit/vegetable solid.
2. *Sauce:* Sauce is the concentrated fruit/vegetable pulp without seed and skin. Sugar, salt, and various spices are added to the content so that one should not be dominant over another. The finished products should have not less than 18 % total solids. Vinegar may or may not be added along with a requisite amount of chemical preservatives: tomato, aonla.
3. *Ketchup:* Ketchup is made by concentrating fruit/vegetable juice or pulp without seeds and skins. Spices, salt, sugar, vinegar, onion, garlic, etc. are added to the extent that it contains not less that 12 % fruit/vegetable solid and 28 % total solid. Chemical preservatives may be added (30 mg/l of product)

2.6.2 Semisolid Form

(a) *Pulp:* Pulp of low pectin content fruit when concentrated with acid and a sufficient amount of sugar without addition of water is known as pulp. A chemical preservative is added.

(b) *Jam:* Jam is a mixture of fruit and sugar cooked to the consistency of a jelly, firm enough to hold the fruit tissues. It contains all the fruit pulp in its composition and is therefore not clear. A good jam must have a bright colour and true fruit flavor; it should be neither syrupy nor stiff, but of a proper jelly consistency, with evenly distributed fruit particles. It should be free from crystallization of sugar and must keep well. Examples: mango, pineapple, aonla, apple, pear, peach, plum.

(c) *Jelly:* Jelly is prepared by cooking essentially a clear fruit extract, strained, free from insoluble matter and sugar, as in case of a jam. A perfect jelly should be sparkling, transparent, and attractive in colour and should have a strong flavour of the original fruit. It should not be gummy, sticky, or syrupy or have sugar crystallized on it. It may be thick or soft set, but should be firm enough to retain a sharp edge when cut with a knife. Examples: guava, karonda, sour apple, jamun, wood apple, plum, loquat, papaya.

(d) *Marmalade:* A jelly in which pieces of fruits are suspended. The term marmalade in this country is usually associated with a product made from citrus fruit (orange, lemon, grapefruit, etc.); in this case, the suspension in the jelly is the shredded peels of the fruit. A good marmalade must have the shreds (10–15 %) evenly distributed in the whole mass, in addition to all the characteristics of a good jelly.

(e) *Chutney:* When fully matured green fruits or matured but tender vegetables are peeled, boiled, crushed, and mixed with acid, sugar, salt, coarsely powdered spices, and herbs and cooked to a reasonably thick consistency, this is known as chutney. Vinegar may or may not be added. Here the high percentage of sugar, acid, and spices with vinegar collectively act as preservatives. Hence, addition of chemical preservatives is not necessary. Finished product should contain 40 % fruit juice and 50 %TSS: mango, ber, aonla, jack fruit.

2.6.3 Solid Form

(a) *Canning:* Whole fruits or pieces of fruits are placed in a 33–50 % sugar solution, which is known as syrup; vegetables are placed in a 3–5 % salt solution after blanching, known as brine solution; or the vegetables may be suspended in juice of that vegetable containing 0.5 % salt and 1 % acid. When packed in cans, this is known as canning: mango, orange, papaya, pineapple, apple, pear, peach, etc.

(b) *Drying:* When 85–88 % moisture is evaporated artificially from fruits or vegetable slices, either by keeping them in the sun or under controlled temperature and humidity conditions inside an oven, this is known as drying. Drying done by sun exposure is sun drying; when done under controlled temperature and humidity in a closed chamber (dehydrator), this is known as dehydration: dehydrated ber, banana, plum, apricot.
   1. *Leather:* Drying of strained fruits or vegetable pulp after adding a small amount of sugar then spreading on an aluminum plate until dried produces leathers. Fruit leather can be dried in a thin layer in a solar or cabinet drier. Spreading of the pulp can be repeated again on previously dried pulp and drying continued until the thickness reaches 2–3 cm. Finally, the leather is fumigated in a sulfur chamber and stored by wrapping tightly in butter paper: mango leather, tomato leather, papaya leather, custard leather, jackfruit leather, palm leather, jamun leather, etc.
   2. *Flake:* Drying of a single layer of pulp until fully dried and taken from an aluminum plate as dry thin pieces is known as flake: tomato flake, papaya flake, corn flake, etc.

(c) *Preserves:* A preserve is made from properly matured fruit pieces or mature, tender vegetable pieces by cooking in heavy syrup until tender and transparent. In its preparation not less than 40 lb of fruits is used for every 55 lb of sugar; cooking is continued until a concentration of at least 60 % of soluble solid is obtained: Bael preserves, Karonda preserve.

(d) *Candy:* Fruit or vegetable pieces when impregnated with heavy sugar and subsequently drained and dried are called candied fruits. The total sugar content of the impregnated fruits or vegetables is kept at 75 % sugar to prevent fermentation. Candied fruits covered with a thin, transparent coating of sugar that imparts a glossy appearance are called glaced fruits. Candied fruit is coated with crystals of sugar by rolling on a mild steel plate having 0.64-cm-diameter holes to allow air to enter the box for evaporation of moisture. Examples: karonda, cherry, amla, ber, jackfruit

(e) *Pickles:* Fruit or vegetable pieces are mixed with 8–10 % salt and 3 % acid, then kept for 6–8 days in the sun at about 29.4–30 °C for fermentation with the help of lactic acid bacteria, and finally mixed with coarsely powdered spices with or without vinegar and sealed by covering fully with moisture-free edible oil to produce pickle. Pickles should be kept another 3 weeks in the sun: lime, mango, cauliflower, ber.

2.7 Preparation and Preservation of Unfermented Beverages

Fruit juices that do not undergo alcoholic fermentation, termed unfermented beverages, include natural and sweetened juices, RTS, nectar, cordial,

squash, crush, syrup, fruit juice concentrate, and fruit juice powder. Barley waters and carbonated beverages are also included in this group (Girdhari et al. 2010).

1. *Selection and preparation of fruit:* Not all fruit juices are suitable for making fruit juice, either because of difficulties in the extraction of juice or because the juice obtained is poor in quality. Even some of the juicy fruits are not quite suitable as they do not yield juice of good beverage quality. The best juice is extracted from freshly picked, sound and suitable varieties at the optimal stage of maturity. Fully ripe, mid-season fruits, particularly citrus fruits, generally yield juice superior to that of fruits picked early or late in the season.
2. *Sorting and washing:* Decayed or damaged fruits do not yield juice. Small cull fruits, such as undersized, oversized, malformed, or blemished fruits, which do not fetch a good price in the fresh fruit market, are rejected. The fruits should be washed thoroughly with water, and in some cases scrubbed also while washing to remove any adhering dust and other extraneous matter. Residues of sprays of arsenic and lead should be removed: dilute HCl (23 l HCl in 455 l water) is adequate for this purpose.
3. *Juice extraction:* Juice from fresh fruits is extracted by crushing and pressing them. During extraction, the juice should not be unduly exposed to air, as oxygen in the air will adversely affect the colour, taste, and aroma and also reduce the vitamin content of the juice. Citrus juices, tomato juice, and even the more stable juices such as those of apples and grapes, deteriorate rapidly in quality when they are extracted by methods that expose them to air for unduly long periods. For products such as tomato juice, special extraction equipment has been designed recently to reduce incorporation of air to a minimum.
4. *Deaeration:* Fruit juice contains some air. Most of the air is present on the surface of the fruit particles and some is dissolved in the juice. In the case of citrus juices, particularly orange juice, which is highly susceptible to the adverse action of residual air, immediately after extraction the juice is subjected to a high vacuum whereby most of the air as well as other gases are removed. This process is known as deaeration. The equipment employed is fairly expensive. It is, however, necessary for large-scale production of orange and other pure fruit juices.
5. *Straining, filtration:* Fruit juices after extraction always contain varying amounts of suspended matter, which consists of broken fruit tissue, seed, and skin, and also various gums, pectic substances, and proteins in colloidal suspension. Usually coarse particles of pulp, seeds, and pieces of skin are removed by means of screens from almost all juices as their presence generally causes deterioration in the quality of the product. In the early years of the fruit juice industry, it was a common practice to completely remove all the suspended matter, including colloidal suspensions, before packing the juice in containers. Although this method no doubt improved the appearance of the product, it quite often resulted in lack of fruit character and flavour. The present trend is to let fruit juices and fruit beverages remain reasonably cloudy or pulpy in appearance. The recent comminuted fruit beverages, employing the whole fruit for extraction, are based on this concept and are claimed to be more nutritive than the clear juices.
6. *Clarification:* Complete removal of all suspended material from juice, as in lime juice cordial, is known as clarification, which is closely related to the quality of appearance and flavour of the juice.
7. *Addition of sugar:* All juices except those of grape and apple are sweetened by adding sugar. Sugar also acts as a preservative for flavour and colour and prolongs the keeping quality. Sugar-based products can be divided into three groups on the basis of sugar content: low (30 %), medium (30–50 %), and high (>50 %).

   Sugar can be added directly to the juice or as syrup made by dissolving it in water, then clarifying by addition of a small quantity of citric acid or a few drops of lime juice and filtering.