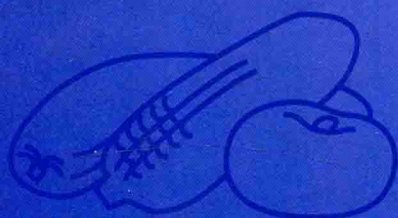


# HANDBOOK of VEGETABLE SCIENCE and TECHNOLOGY

PRODUCTION, COMPOSITION, STORAGE,  
AND PROCESSING



edited by  
D. K. SALUNKHE  
S. S. KADAM

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PRODUCTION, COMPOSITION, STORAGE,  
AND PROCESSING

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D. K. SALUNKHE

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HANDBOOK of  
VEGETABLE SCIENCE  
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*To Dr. L. H. Pollard,  
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Logan, Utah*

*and*

*Dr. S. H. Wittwer,  
Professor of Horticulture, Michigan State University,  
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# Preface

The world's most urgent need is to increase the production of nutritious food so that we may adequately feed the hungry people of the planet. A major and often neglected step toward offering a greater volume of nutritious foods is to prevent loss of food between the time of harvesting and consumption. According to a report published by the National Research Council of the National Academy of Sciences (Washington, D.C., 1978), postharvest losses may be as high as 30–40% in both developed and developing nations. With application of adequate technology to prevent their deterioration after harvest, supplies of fresh fruits and vegetables can be increased to the extent of their existing postharvest losses.

Fresh vegetables and fruits are vital sources of minerals, vitamins, and dietary fibers. Both contain nutritionally important compounds, such as vitamins, that cannot be synthesized. They supply certain constituents that other foods do not. Vegetables and fruits contribute over 90% of dietary vitamin C. Green vegetables are a rich source of vitamin A. Similarly, niacin and folic acid (which are required for normal body functions) are present in significant quantity. Because vegetables and fruits are perishable products with high metabolic activity during the postharvest period, proper postharvest handling plays an important role in increasing their availability.

Recent developments in agriculture have contributed significantly to the improvement of vegetable production throughout the world. Similarly, remarkable improvements have been made in the postharvest handling of various vegetables and control of their market diseases. Storage practices have been developed to protect the vegetables and add to consumer appeal. The development of sizing equipment, conveyors, and package fillers all contribute to the success of vegetable handling. New chemicals more effective in decay control have been developed by the chemical industry to serve the fruit and vegetable industry. Improvements in refrigerated rail wagons, trucks, and trailers have helped to reduce losses during transport. All of the information above is scattered in many recent research papers, reviews, bulletins, and books. There was a need to have information on production and postharvest technology of vegetable crops compiled in one volume. This book will be useful to students of horticulture, marketing, food processing and engineering, food science, and nutrition as well as growers, processors, and shippers of vegetables in both developed and developing countries.

*D. K. Salunkhe  
S. S. Kadam*

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**HANDBOOK of  
VEGETABLE SCIENCE  
and TECHNOLOGY**

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# Introduction

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Hunger is a widespread and growing phenomenon, and billions of people suffer from severe malnutrition in Asian, African, and Latin American countries (1). There is a nearly 20-year difference in the life expectancies of rich and poor nations. Apart from caloric needs, there is a severe shortage of food materials, such as fruits and vegetables, tubers, root crops, and fruit nuts, which are the most important plant foods to supply humans with many of their nutritional requirements, including minerals, vitamins, proteins, starches, fats, and sugars. They provide crude fiber and bulk as well as a variety of flavors and odors. Vegetables, with the increasing recognition of their value in the human diet, are gaining commercial importance (1).

Many vegetables are grown on different continents. These include roots, tubers, bulbs, leafy vegetables, beans, melons, squashes, corn, mushrooms and many other vegetables (Table 1). Yamaguchi (2) classified vegetables based on botany, end uses, or a combination of both (Tables 2 and 3) as well as growing requirements such as salt tolerance and tolerance to soil acidity. Weichmann (3) classified vegetables according to respiratory behavior (Table 4). Vegetables have also been classified according to metabolic characteristics (2,3) and sensitivity to chilling temperature during postharvest storage (3).

The worldwide production of roots and tubers and other vegetables, including carrots and melons (4), is presented in Table 5. China, India, the United States, Turkey, and Italy are the major vegetable-producing countries in the world (Table 6). Among the vegetables, including roots and tubers, potato ranks first in production, followed by cassava, sweet potato, cabbage, onion, and melons (Table 5). Even though potato is included as a vegetable, it is used as a staple food in many countries of Europe and Latin America. Similarly, cassava stands second in production, but its production is concentrated mainly in African, Asian, and South and Central American countries, where it is utilized as a staple food.

The nutritional value of vegetables as a vital source of essential minerals, vitamins, and

TABLE 1 Important Vegetables Grown Worldwide

Common name	Scientific name
Amaranth	<i>Amaranthus tricolor</i> L.
Artichoke	
Globe	<i>Cynara scolymus</i> L.
Jerusalem	<i>Helianthus tuberosus</i> L.
Asparagus	<i>Asparagus officinalis</i> L.
Basella	<i>Basella alba</i> L.
Bitter gourd	<i>Momordica charantia</i> L.
Bottle gourd	<i>Lagenaria siceraria</i> (Mol.) Standl
Breadfruit	<i>Artocarpus altilis</i> L.
Brinjal (Eggplant)	<i>Solanum melongena</i> L.
Broad Bean	<i>Vicia faba</i> L.
Brussels sprout	<i>Brassica oleracea</i> var. <i>gemmifera</i>
Cabbage	<i>Brassica oleracea</i> var. <i>capitata</i>
Capsicum	<i>Capsium annuum</i> L.
Cardoon	<i>Cynara cardunculus</i> L.
Carrot	<i>Daucus carota</i> var. <i>sativus</i> (Hoffm.) Arcong.
Cassava	<i>Manihot esculenta</i> Crantz
Cauliflower	<i>Brassica oleracea</i> var. <i>botrytis</i>
Celery	<i>Apium graveolens</i> L. var. <i>dulce</i> (Mill.) Pers.
Chicory	<i>Chichorium intybus</i> L.
Chinese cabbage	<i>Brassica chinensis</i> L.
Cluster bean	<i>Cyamopsis tetragonoloba</i> (L.) Taub.
Cowpea	<i>Vigna unguiculata</i> (L.) Walp.
Cucumber	<i>Cucumis sativus</i> L.
Drumstick	<i>Moringa oleifera</i> L.
Elephantfoot yam	<i>Amorphophallus campanulatus</i> L.
Endive	<i>Cichorium endivia</i> L.
Fenugreek	<i>Trigonella</i> sp.
French bean	<i>Phaseolus vulgaris</i> L.
Garden beet	<i>Beta vulgaris</i> var. <i>rubra</i>
Garlic	<i>Allium sativum</i> L.
Hyacinth bean	<i>Lablab purpureus</i> (L.) Sweet
Indian squash	<i>Praecitrullus fistulosus</i>
Ivy gourd	<i>Coccinia indica</i>
Jackfruit	<i>Artocarpus heterophyllus</i> L.
Kale	<i>Brassica oleracea</i> var. <i>doephala</i>
Kakrol	<i>Momordica dioica</i> L.
	<i>M. cochinchinensis</i> L.
Knoikhol (Kohlrabi)	<i>Brassica oleracea</i> var. <i>gongylodes</i>
Leek	<i>Allium ampeloprasum</i> L. var. <i>porrum</i>
Lettuce	<i>Lactuca sativa</i> L.
Lima bean	<i>Phaseolus lunatus</i> L.
Muskmelon	<i>Cucumis melo</i> L.
New Zealand spinach	<i>Tetragonia tetragonioides</i> L.
Okra	<i>Abelmoschus esculentus</i> (L.) Moench
Onion	<i>Allium cepa</i> L.
Parsley	<i>Potroselinum crispum</i> (Mill.) Nym.