POSTHARVEST BIOTECHNOLOGY OF OILSEEDS

Authors

D. K. Salunkhe, Ph.D.
Vice-Chancellor
Mahatma Phule Agricultural University, Rahuri
Maharashtra State, India

B. B. Desai, Ph.D.
Associate Professor, Postharvest Technology
Mahatma Phule Agricultural University, Rahuri
Maharashtra State, India

CRC Press, Inc.
Boca Raton, Florida

Library of Congress Cataloging in Publication Data

Salunkhe, D. K.
Postharvest biotechnology of oilseeds.

Bibliography: p.
Includes index.
1. Oilseeds—Postharvest technology. I. Desai,
B. B., 1941- . II. Title.
SB298.S32 1986 633.8'5 85-11659
ISBN 0-8493-6289-X

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Direct all inquiries to CRC Press, Inc., 2000 Corporate Blvd., N.W., Boca Raton, Florida, 33431.

International Standard Book Number 0-8493-6289-X

Library of Congress Card Number 85-11659
Printed in the United States

PREFACE

The need for a reserve food supply to alleviate hunger in the future must have been as much a concern in prehistoric times as it is today. Increasing world population and rising standards of living are two major pressures on the food supply, which include vegetable oils and oilseeds. Every man, woman, and child has the inalienable right to be free from hunger and malnutrition and to develop fully and maintain their physical and mental faculties. The eradication of hunger is a common objective for all countries in the international community. The nutritional diseases deserving the highest priority are protein-calorie malnutrition, xerophthalmia, nutritional anemia, and endemic goiter. After protein and energy, vitamin A, iron, and iodine deficiencies are of global importance and thiamin, niacin, and vitamin D deficiencies are of local importance.[1]

The minimum nutritional requirement of fat as specified by the Indian Council of Medical Research is about 20 kg per capita per annum, and the per capita availability of edible oil and vanaspati (hydrogenated oil) in most developing countries is less than about 5 kg per annum. If the national average is so low, the predicament of the poorer sections of the society is bound to be even worse.

Calorific value, O_2 and CO_2 equivalents, and respiratory quotient of the three major food constituents, viz., carbohydrate, fat, and protein, are given in Table 1. The average heat produced in calories per gram by burning (oxidizing) the food constituents (as measured by combustion calorimeter) are glucose, 3.96; starch, 4.2; animal fat, 9.5; and animal protein, 5.6. Taking into consideration the losses due to incomplete oxidation of food constituents in the human body, the average caloric value when carbohydrate, fat, and protein are metabolized is 4.1, 9.3, and 4.1 cal/g, respectively. Fats thus produce more energy twofold than either carbohydrate or protein.[2] In addition to the role as the most effective source of stored caloric energy, dietary lipids serve as carriers of vitamins and provitamins, like vitamin A (beta-carotene), D, E, and K, which because of their solubility in fats, occur in nature mainly in association with oils and fats. Dietary lipids have an important role in the absorption of calcium, carotene, and thiamin. They provide certain essential fatty acids, like linoleic and linolenic acids, which cannot be produced by the body, but are required. The oils and fats deposited in adipose tissue of the body protect the vital organs; it is also believed that they perform a specialized function of paramount importance in the metabolism of lipids.

Although lack of food is the ultimate factor in hunger and undernutrition, poor distribution of food is the main cause of malnutrition. Conditions of malnutrition range from widespread protein-calorie deficiencies in many parts of the underdeveloped world, to obesity in the better-off industrial countries (due to excessive consumption of fats and carbohydrates). Obesity is a widespread and lethal disease of nutritional imbalance, commonly observed in industrially developed countries. The human population in these affluent societies derives nearly 42% of dietary calories from protein and 48% from fats, whereas people in less developed countries obtain about 73% of food calories from carbohydrates and 7% from cheaper protein sources like beans. Hyperlipoproteinemia, a disease caused by excessive consumption of fats and proteins, leads to arteriosclerosis (hardening of the arteries) and heart attack caused by an increase in blood cholesterol levels.

Fat-fried convenience foods such as french fries, potato chips, doughnuts, fried chicken, and several Indian fried foods like *puris, bhajis,* and *pakodas* are continuously fried in the same oil or fat. Such overheating of oils often produces peroxides, hydroperoxides, and free oxide radicals, which can induce carcinogenicity in man.

Contrary to these enemies of health caused by excessive consumption of oils and fats, a majority of people in the developing countries like India do not receive even 8 to 10% of oil in their diets. The acute protein-calorie deficiency in the diets of these people may seriously hamper their physical and mental development, especially in children. Under-

Table 1
CALORIFIC VALUE, O_2 AND CO_2 EQUIVALENTS, AND RESPIRATORY QUOTIENT OF CARBOHYDRATE, FAT, AND PROTEIN

Particulars	Carbohydrate	Fat	Protein
Calories per gram	3.7—4.3	9.5	4.3
Liters CO_2 per gram	0.75—0.83	1.43	0.78
Liters O_2 per gram	0.75—0.83	2.03	0.97
Respiratory quotient	1.0	0.707	0.801
Caloric value per liter O_2 (cal)	5.0	4.7	4.5

From Cantarow, A. and Schepartz, B., *Biochemistry*, Saunders International Student Edition, 4th ed., W. B. Saunders, Philadelphia, 1967, 326. With permission.

nourished children, for example, have been found to lack as much as 20% the normal amount of brain cells for their age, and their IQs have ranged as much as 25% below average. Every cell in the human body needs oil or lipid material, which gives a smooth and shining luster to the skin. The health of people in both developed and underdeveloped countries can be improved if fat intake in affluent societies is reduced from about 48% to 20 to 22% and fat intake in poorer societies is increased from 8% to 15 to 20%.

Fats, unlike carbohydrates such as glucose, can only be consumed orally and cannot be injected intravenously. Lipids modify the taste and flavor of other compounds in foods, and are capable of influencing the physical state of the food which affects the movement of compounds to the taste and odor receptor sites. When oil is taken in through the mouth, mixing the oil with saliva distributes any present flavor compounds between the oil and the aqueous saliva. Coating the tongue with oil may decrease or prevent the perception of water-soluble taste compounds and might thereby magnify the effects of oil soluble flavors as well as its own flavor. The flavor contribution may arise from both volatile and nonvolatile lipids. Lipids of low volatility (above C_{10}) are tasteless in terms of sourness, sweetness, bitterness, and saltiness. The metallic taste in fatty foods is attributed primarily to 1-octen-3-1. A candle-like flavor has been attributed to these low-volatile fatty acids. Any release of glycerol from saturated fats imparts a sweet taste. The role of lipids in oral sensation is perhaps how they contribute to texture. Oils and fats thus influence food consumption through their effects on food taste and flavor.

Oilseeds are rich in both proteins (about 15 to 30%) and fats (about 25 to 50%). Oilseed meals have been recognized as a potential new source of protein for human consumption in developing countries. The major world oilseed crops such as soya, cottonseed, peanut, and sunflower contain high amounts of oil and protein. Subsequent to oil extraction, a cheap protein-rich meal can be recovered. Oilseeds can furnish as much protein as animal sources provide for human consumption on an annual basis. However, oilseeds presently serve as a major source of protein in animal feed in the industrially developed world. They could provide direct protein to man without animals being used as processing media. The wider use of oilseeds as human food in underdeveloped countries is conditioned by the level of their economic development. Out of about 100 million tonnes of oilseeds produced in the world, approximately 9 million tons of soybean and 3.5 million tonnes of peanut, coconut, and other oilseeds are utilized for various edible products. Apart from the oil extracted from these seeds, which is used mainly in cooking and for similar purposes, about seven eighths of the oilseed produced is not used for human consumption but is utilized for manufacturing various industrial products.

The world production of edible oils and fats increased from about 36 to 48 million tonnes (MT) from 1970 to 1980. Vegetable oils and fats represent about two thirds of edible fats. Despite the largest area in the world (about 20 million ha) under oilseed cultivation, India, which was a net exporter of edible oils two decades ago, is now the biggest importer of edible oils in the world. During 1983, India had to import edible oils worth 1000 crores[3] (approximately 10 billion U.S. dollars).

Oilseeds are the second major agricultural crop next to food grains. Oils and fats, apart from forming an essential part of the human diet, serve as important raw material for the manufacture of soaps, paints and varnishes, cosmetics, pharmaceuticals, and other products. Oil cake and deoiled meal are valuable livestock and poultry feed, and serve as manure and soil conditioners.

World interest in oilseeds generally focuses on increasing production. It is assumed that success will follow merely by increasing oilseed production. While some success has been achieved in enhancing the world oilseed production, agricultural scientists and technologists have not yet succeeded in protecting what has already been produced. No one knows for certain how much food (cereals, legumes, fruits, vegetables, roots, and oilseeds) is lost due to improper postharvest handling and storage, although some estimates run as high as 30%.[4] Cramer[5] estimated world losses of oils and fats at about 42 million tonnes annually, which was valued at approximately 50 billion U.S. dollars. This loss constitutes about 10 to 15% of oilseed production. Beyond the physical losses in quantity there are losses of food quality (nutritional value) as well as marketing losses. For want of adequate storage facilities, producers are required to sell their produce for whatever price the market will pay. Storage thus not only conserves the crop, but also serves as a marketing tool.

There is growing recognition that production of food alone does not solve the food problem. Food must be preserved in an edible, nutritionally adequate condition until it can be distributed and consumed by those who need it. Even the relatively durable (compared to perishable fruits, vegetables, etc.) food grains like oilseeds suffer heavy postharvest losses, which may be as high as 30% in some instances. These losses are mainly due to inadequate storage and marketing facilities. The problems of oilseed conservation are especially critical in the hot and humid parts of the world in which many poorer peoples live.

Certain preharvest events or factors cause drastic postharvest food losses. Oilseed crops damaged by pests (especially insects and disease), for example, will have lower yields of oil and protein than healthy oilseed crops not infested by pests. Increased losses have been experienced during oil refining from field- and frost-damaged soybean. The oil produced have off-colors and inferior flavors. The high moisture of field-damaged beans facilitates degradation of the oils by enzymes such as lipase which produce free fatty acids, and lipoxygenase, which in turn oxidizes polyunsaturated compounds and produces off-flavors in both oils and meals. Mycotoxin formation results in losses of poultry and cattle to the farmer and may create potential hazards to man. Animal and poultry products like milk, meat, and eggs may be contaminated with aflatoxins. Aflatoxin levels higher than 5 ppb in foods are considered hazardous to human beings. Aflatoxins produced by *Aspergillus flavus* and *A. parasiticus* contaminate peanuts, cottonseed, and many other foods and feeds.

Improper handling of oilseeds from farm to consumer can contribute to major losses that occur. Inadequate storage, multiple transfers during shipment from farm to ultimate consumer, and overheating of oilseeds due to high temperature and respiration are the main causes of oilseed losses. The time a crop is harvested, including oilseeds, affects both the scope of preservation as well as quality. In general, the longer the growing period, the larger the crop. Early harvesting may imply loss of revenue but overripe produce is not a good subject for preservation (e.g., oil palm fruit). Temperature alone influences all phases of the crop cycle — germination, growth, development, maturation, ripening, senescence, and the final deterioration. Within limits, an increase in temperature leads to a speed-up of each phase in the cycle; a decrease in temperature brings about the reverse. The temperature factor is also important in relation to viability and germination capacity of oilseeds. Enzymes are mediators of buildup and breakdown changes in crop growth and storage. Enzyme activity, over a fairly narrow range of mechanisms, is moisture dependent. Above a certain moisture content (depending on the particular crop) the mechanism is temperature dependent.[4]

The purpose of this book is to describe the detailed loss reduction biotechnology of oilseeds, covering the major and minor oilseed crops of the world. Postharvest deterioration of oilseeds is closely related to botany, physiology, and biochemistry of the individual crop, which ultimately influence the growth, development, maturation, ripening, and senescent phases of the crop. Significant differences in storage and postharvest behavior are noted in the different species and cultivars of oilseeds. The principal causes of postharvest deterioration include attack by storage insects and diseases caused by microorganisms, especially fungi.

A detailed technology available to conserve oilseeds and minimize their postharvest losses has been reviewed and updated. This book is in series with our earlier volumes on *Postharvest Biotechnology of Fruits (Volumes I and II), Postharvest Biotechnology of Vegetables (Volumes I and II), Postharvest Biotechnology of Cereals,* and *Postharvest Biotechnology of Food Legumes.*

The opportunity and potential impact of newly developing biotechnologies for increasing food supplies in developing countries are enormous. Oilseed supplies, at least to the extent of about 10 to 15%, can be enhanced by the application of biotechnologies described in this volume. This task can be achieved without bringing any additional land under cultivation and without using any additional energy in the forms of fertilizers, pesticides, and irrigation. In certain tropical regions like Africa, India, and Latin America, the savings of oils and oilseeds would be much higher. Protection of high-energy proteinaceous foods like oilseeds is as vital to advanced countries like the U.S. as it is to the hungry underdeveloped world.

D. K. Salunkhe
B. B. Desai

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THE AUTHORS

Professor D. K. Salunkhe, Vice-Chancellor, Mahatma Phule Agricultural University, Rahuri, Maharashtra, India, was a former Professor of Nutrition and Food Science at Utah State University, Logan, Utah (U.S.). Under his guidance 85 postgraduate students received their M.Sc. and Ph.D. degrees. He has authored over 300 scientific papers, book chapters, and reports. Some of his articles received recognition and awards as outstanding articles in biological journals.

He was an Alexander Humboldt Senior Fellow and a Guest Professor at the Technical University in Karlsruhe, West Germany. He was a Guest Lecturer at the Technological Institute, Moscow, U.S.S.R., and an exchange scientist to Czechoslovakia, Rumania, and Bulgaria on behalf of the National Academy of Sciences, National Research Council, Washington, D.C., as well as advisor to the U.S. Army Food Research Laboratories and many food storage, processing, and consumer organizations.

Professor Salunkhe was Sigma Xi President, Utah State University chapter; Fellow of Utah Academy of Sciences, Arts, and Letters; Fellow of the Institute of Food Technologists; and Danforth Foundation Faculty Associate. He delivered the Utah State University 50th Faculty Honor Lecture, "Food, Nutrition, and Health: Problems and Prospects", on the basis of his creative activities in research and graduate teaching.

Professor Salunkhe is presently a member of the editorial boards of the *Journal of Food Biochemistry, International Journal Qualitas Plantarum/Plant Food for Human Nutrition, Journal of Food Science, International Journal of Utilization and Research, and Journal of Food Quality.*

He authored two textbooks: *Storage, Processing and Nutritional Quality of Fruits and Vegetables* (CRC Press, 1974) *and Postharvest Biology and Handling of Fruits and Vegetables*, with Professor Haard, (AVI Publishing, 1975).

In addition, Professor Salunkhe has recently coauthored the following books: *Guidelines for the Preparation of Theses and Dissertations*, with J. K. Chavan and Urmilla D. Salunkhe (MPAU, Rahuri, 1982), *Preparation and Presentation of Scientific Publications*, with D. R. Bapat (MPAU, Rahuri, 1982), *Preparation of Research Proposals for Financial Support*, with S. S. Kadam (MPAU, Rahuri, 1983), *Postharvest Biotechnology of Fruits (Volumes I and II), Postharvest Biotechnology of Vegetables (Volumes I and II)* with B. B. Desai (CRC Press, 1984), *Postharvest Biotechnology of Cereals*, and *Postharvest Biotechnology of Food Legumes* with J.K. Chavan and S. S. Kadam (CRC Press, 1985).

Professor Salunkhe married Urmilla P. Shinde in 1955. They have two children: Kirti and Vishwas.

Dr. B. B. Desai is Associate Professor of Postharvest Technology, Mahatma Phule Agricultural University, Rahuri, India. He was born in India in 1941. He graduated with a B.Sc. (Agriculture) degree with honors from Poona University in 1963; in the same year he was appointed as a demonstrator in Agricultural Chemistry and promoted to a lecturer's position in 1965. He has been an Associate Professor since 1973. He received his M.Sc. (Agriculture) in 1969 and his Ph.D. in 1974 from Mahatma Phule Agricultural University, Rahuri, and the University of Agricultural Sciences, Bangalore, respectively. During his wide teaching and research experience, Dr. Desai has taught courses in organic chemistry, biochemistry, analytical chemistry, agricultural chemistry, food chemistry, biochemical techniques, postharvest technology of fruits and vegetables, and utilization of agricultural and industrial wastes to both undergraduate and graduate students.

Dr. Desai has authored over 50 scientific papers, book chapters, and reports in national and international journals. He has authored with Professor D. K. Salunkhe *Postharvest Biotechnology of Fruits (Volumes I and II)* and *Postharvest Biotechnology of Vegetables (Volumes I and II)* published by CRC Press in 1984. He has guided 15 students to Master's degrees and is a major advisor for two Ph.D. students.

The distinguished achievements of Dr. Desai have been recognized and recorded in the *International Who's Who of Intellectuals*, Volume VI, published by the International Biographical Center, Cambridge, England.

Dr. Desai married Vilasini A. Patil in 1966. They have three children: Varsha, Vikas, and Savita.

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