

RICE: CHEMISTRY
AND TECHNOLOGY

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PREFACE TO THE SECOND EDITION

Rice is the principal food cereal in tropical Asia, where 90% of the world's rice crop is grown and consumed. Significant progress in the chemistry and technology of rice in the last decade has prompted the Publications Committee of the American Association of Cereal Chemistry to revise its Monograph No. 4, *Rice: Chemistry and Technology*, edited by Dave Houston and published in 1972.

The present monograph updates the 1972 monograph, with emphasis on developments in the 1970s and 1980s. Chapters on parboiling and milling emphasize the Asian situation, since the status in the United States and Europe is adequately discussed in published chapters. Extrusion-cooked rice foods and rice noodles are emphasized, as well as Japanese convenience foods. Rice straw is included because of the current interest in biomass utilization. All chapters on technology and processing were contributed by authorities on the subject. Contributors were encouraged to emphasize varietal differences and possible topics for future research. As editor, I elected to write most of the chemistry chapters and those on by-products and residue, to minimize overlap and maximize coverage of the interfaces between the chemistry and structure of the rice grain and its technological properties. This monograph was mainly planned, written, and edited in 1983—1984 during my sabbatical leave from the International Rice Research Institute (IRRI).

I wish to thank the contributors for their time and talent in writing the chapters; R. Don Sullins, then chairman of the AACC Publications Committee, for his assistance and support; M. S. Swaminathan, Director General of IRRI, for approving my leave; the Southeast Asian Research Center for Agriculture for providing me a Visiting Professorship and office space; the IRRI Department of Communications and Publications for graphics and photography; the IRRI library staff for rechecking literature citations; Daisy Herrero for typing the manuscripts; and my research colleagues in the Cereal Chemistry Department for reviewing my chapters. Finally, I wish to thank my wife, Linda, and my children for their patience and understanding during the preparation of the monograph.

B. O. J.

PREFACE TO THE FIRST EDITION

Rice, as one of the two major food cereals, provides—together with a comparable amount of wheat—a large proportion of the total nourishment of the world's population. However, reported research on rice chemistry and technology has lagged markedly behind that reported for wheat. Moreover, the available information on rice other than on its culture has remained largely scattered in contrast to that for wheat, which has been well collected and summarized.

The present monograph, the fourth in the Monograph Series sponsored by the American Association of Cereal Chemists, attempts to minimize this disparity. The book has two major aims: to collect and present for the first time in a single work an ordered, coherent, and informative series of reviews on rice chemistry and technology; and to provide an extensive bibliography that will permit direct access to the primary literature. This combination offers useful data to all connected with the handling, processing, or sale of rice and its by-products, as well as to any individual seeking information on rice composition or technology. A third, minor, aim is to use predominantly the metric system of measurement in accord with its extensive scientific acceptance and the worldwide trend towards its general adoption.

As a multiauthored work, the monograph has the advantage that each chapter is presented by an authority on the subject—and some disadvantages that inevitably accompany this type of publication. The dedicated efforts of the authors have provided the values to be found in this volume; errors and omissions must be attributed to the editor, who welcomes all corrections and suggestions for improving any possible later edition.

Credit for initiating this work belongs to the Monograph Committee of the Association and to Past President Byron Miller and Executive Vice-President Raymond J. Tarleton, who put the plan into effect. My particular thanks go to Director of Publications Merrill J. Busch, and to Assistant Editor Carolyn M. Light and her able proofreading and typesetting co-workers, who diligently, patiently, and cooperatively handled the multitude of details in preparing this work for publication. I thank also my wife, Twylla, not only for her aid, but especially for her sustained forbearance during preparation of the monograph.

D. F. H.

Rice:
Chemistry
and
Technology

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CHAPTER 1

PRODUCTION AND UTILIZATION OF RICE

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I. INTRODUCTION

Rice (*Oryza sativa* L.) is one of the leading food crops of the world, the staple food of over half the world's population. It is generally considered a semiaquatic, annual, grass plant. Cultivars of the two cultivated species, *O. sativa* L. and *O. glaberrima* Steud., can grow in a wide range of water-soil regimes, from deeply flooded land to dry, hilly slopes (Lu and Chang, 1980). Both *O. sativa* and *O. glaberrima* have 12 pairs of chromosomes. Because of its long history of cultivation and selection under diverse environments, remarkable diversity exists in rice. This grain is grown in over 100 countries on every continent except Antarctica, extending from 53° north to 40° south and from sea level to an altitude of 3,000 m. However, *O. glaberrima* is grown only in Africa and only on a limited scale. Production practices for rice range from very primitive to highly mechanized.

Detailed descriptions of aspects of rice production have been published by De Datta (1981) and Yoshida (1981), and Luh (1980) has described production and utilization of rice.

II. RICE PRODUCTION COMPARED WITH THAT OF OTHER CEREALS

Annual production of rough rice approaches that of wheat and corn (FAO, 1982) (Table I). Rice and wheat are the two most important food cereals, since corn is mainly a feed grain except in Latin America and parts of Asia.

Rice is the staple food of East, Southeast, and South Asia, where 90% of the world's rice crop is produced and consumed (Table I). Mean yields of rice are second only to those of corn (Table II). Cereal yields are generally higher in the temperate countries in Europe, Oceania, and America than in Asia and Africa.

When the actual extraction rates of the cereals (the fraction of each grain utilized as food) are considered (Lu and Chang, 1980), rice actually is calculated to produce more food energy per hectare than the other cereals (Eggum, 1969,

1977, 1979; FAO, 1982) (Table III). Total food protein production per hectare is also high for rice, second only to that for wheat. When the superior quality of rice protein is considered, the yield of utilizable protein is actually higher for rice than for wheat.

China contributes 38% of the world's rice production on 24% of the world's rice-growing area, and India contributes 17% of the production on 28% of the area (Herdt and Palacpac, 1983). The other countries of Asia, Latin American countries, and African countries south of the Sahara contribute 35, 4, and <2%, respectively, of the world's rice on 38, 6, and 3%, respectively, of the rice-producing area.

Of the 138.8 million hectares of 1978–1980 rice land in developing countries, 52% were irrigated (i.e., water is added to supplement that supplied by natural processes), 34% were rain-fed wetland (areas where standing water is expected

TABLE I
Annual Production of Cereal Crops by Region: Mean for 1979–1981^a

Area	Annual Production (million tonnes)								Total
	Wheat	Rough Rice	Corn	Sorghum	Millet	Barley	Rye	Oat	
Africa	8.7	8.4	28.0	10.5	10.1	3.8	0.01	0.2	71.3
North and Central America	89.3	9.1	212.8	24.7	0	20.4	1.1	10.4	370.0
South America	12.2	13.4	32.6	6.9	0.2	0.9	0.2	0.8	67.3
Asia	135.1	360.2	84.8	20.2	16.4	16.3	1.8	1.2	639.6
Europe	91.6	1.9	54.2	0.7	0.03	68.8	12.6	14.3	247.7
Oceania	14.8	0.7	0.3	1.1	0.02	3.5	0.01	1.4	21.9
USSR	92.1	2.5	8.6	0.1	1.6	44.8	8.9	15.2	175.0
World	443.9	396.3	421.4	64.3	28.5	158.5	24.7	43.5	1,592.8
Number of countries producing	102	112	146	84	66	81	42	55	165

^aData from FAO (1982).

TABLE II
Mean Grain Yield of Cereal Crops by Region: Mean for 1979–1981^a

Region	Mean Grain Yield (t/ha)								Total Cereals
	Wheat	Rough Rice	Corn	Sorghum	Millet	Barley	Rye	Oat	
Africa	1.1	1.8	1.3	0.7	0.6	0.8	0.2	0.5	1.0
North and Central America	2.2	4.4	5.4	3.3	0	2.5	1.7	1.9	3.5
South America	1.3	1.8	1.9	2.7	1.2	1.2	0.8	1.3	1.8
Asia	1.7	2.8	2.3	1.0	0.7	1.5	1.3	1.5	2.1
Europe	3.6	5.1	4.6	3.6	1.6	3.4	2.3	2.7	3.5
Oceania	1.3	5.8	4.1	2.0	0.8	1.3	0.5	1.1	1.3
USSR	1.5	4.0	2.9	1.1	0.6	1.3	1.9	1.3	1.4
World	1.9	2.8	3.3	1.4	0.7	2.0	1.6	1.7	2.2

^aData from FAO (1982).