Advances in Cereal Science and Technology

Edited by Y. Pomeranz,

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PREFACE

In 1974, the American Association of Cereal Chemists decided to undertake the development of a new publication, *Advances in Cereal Science and Technology*. The purpose of this new biennial publication is to bridge the gap between the two AACC periodicals, *Cereal Chemistry* and *Cereal Foods World*, and the in-depth studies which appear infrequently in the *Monograph Series*. The *Advances* will bring together new information on cereal research and technology and should be of value to scientists in all parts of the world.

Progress in the various aspects of cereal production, processing, and utilization can best be achieved by a multidisciplinary "whole package" approach. The editor and authors attempt to include in this single publication a favorable balance between theoretical and applied research and between the best current technology and new or novel technology.

Advances in Cereal Science and Technology, Volume I has been ably edited by Dr. Y. Pomeranz, who has successfully obtained the collaboration of outstanding world leaders who have contributed chapters covering their fields of expertise. As a result, we find brought together between the two covers of this first volume an excellent blend of theoretical and practical views of outstanding scientists and engineers representing different disciplines, institutions, geographic regions, and countries. Another interesting aspect of this book is that the authors attempt to indicate within their specialties the areas which need additional research to solve problems which now stifle progress.

Volume I deals with wheat, barley, and soybeans across the entire spectrum of research and technology, from breeding and production through marketing to processing.

I am convinced this volume will be a valuable reference for all who are involved in any aspect of cereal research or technology.

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February, 1976

INTRODUCTION

The power of population is indefinitely greater than the power in the earth to produce subsistence to man.
Thomas Robert Malthus, British Economist, 1798

Any time a publishing company announces a new series of "Advances in . . .," "Progress in . . .," or "Reviews of . . .," we can expect some to shrug their shoulders with: "Another one?", "Who has the time to read it all?", "At this price?" I would like to answer briefly some of those queries and tell the reader how this series came about and what it is supposed to do.

Attaining progress in the production, processing, and utilization of cereals is a multifaceted problem. It will come about painfully slowly unless we use a multidisciplinary approach. Such an approach requires the contribution of experts from many disciplines (geneticists, plant physiologists, agronomists, food chemists and technologists, nutritionists, and economists). The second prerequisite to true "Advances" is finding a balance between, and combining, novel and imaginative concepts with sound ways of implementing them. It is our hope that the *Advances* will do something that is important yet could not be done elsewhere, namely cover "under one roof" all important aspects of a major problem or review a specific aspect of many problems in the broad area of cereals and cereal foods. We will attempt to present balanced and multidisciplinary reviews from scientists from all over the world. We will discourage the notion that if a review came from a small and unknown place, it must be small in scope and significance, and if it was written by someone in a big and prestigious institution, it must be good and important.

We hope to convince the pragmatic, technologically-oriented reader that cereal grains do not grow in silos and that true understanding of biological systems requires a knowledge of their biochemistry; and at the same time we hope to persuade the theoretically-inclined scientist that little will come of all the breakthroughs in biochemical genetics of cereals unless they lead to applied bioengineering and are put to practical use in farming, marketing, and processing.

We also hope that in preparing future reviews, both the technologist and the scientist will keep in mind that the distinction between good and bad research is much more important than the distinction between theoretical and applied or pure and dirty research. Some of us are often terrified to make changes because the tradition "That's the way it was always done" becomes hallowed and sanctified with age. We hope the reviewer will outline needed changes, provided they will make things better and not merely different.

If this series can make some of those things come true, the *Advances* could truly advance the cause of producing more and better cereal foods. Then, perhaps, we can decrease in a small way the danger of the Damoclean sword of Malthus's dire prediction hanging over our heads.

Y. Pomeranz

March, 1976
Manhattan, Kansas

Advances in Cereal Science and Technology

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CHAPTER 1

GRAIN MARKETING

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I. INTRODUCTION

The purpose of agricultural marketing is to transform raw products into goods that meet consumer demands for food and fiber. This transformation involves changing the form of the product, moving the product through time, and distributing the products across geographical space. The motivation for these activities is provided by consumer preferences transmitted into market signals by price. Price differentials over time, form and space stimulate the marketing activities of storage, assembly, processing and distribution that result in an increase in value at each successive stage of the marketing chain from farmer to final consumer.

Grain marketing provides an excellent illustration of these generalized market relationships. Demand for grain is largely a derived demand with intermediate products and processes separating the final consumer from the producer of the raw products. The price difference between the farm and the consumer, often called the marketing margin, represents the sum of value added at each stage in the marketing chain. The marketing margin provides the incentive for performing the marketing activities required to turn raw grain into products such as bakery goods, meat, margarine, and corn oil. Prices, conditioned by end-use value and the cost of performing the marketing activities, transmit information back to the primary producer thereby involving the producer in the marketing chain.

This review of grain marketing is divided into four distinct but closely related areas: 1) production as it affects the market, 2) functions performed by the market, 3) the structure and organization of marketing firms, and 4) the final consumer. A description of the marketing functions and the market channels for grain will provide the setting in which to discuss marketing problems and the progress of research in solving these problems. The grains to be included in the

review are the food grains—wheat and rice; the feed grains—corn, sorghum, barley, and oats; and the primary oilseed crop in the United States—soybeans. The relative importance of these grains is illustrated by their 1974 farm value of production shown in Table I.

Soybeans are included with the cereal grains because they are used in both food and livestock feed and because they generally use the same marketing facilities and follow the same market channel as the cereal grains.

II. GRAIN PRODUCTION

Production decisions at the farm are affected by the price information which the market conveys to the producer. Producers, in turn, rely on the market to transform their raw materials into consumer products. Changes in grain production are important determinants of market organization, consumer prices, and profitability of marketing firms.

A. Trends in Grain Production

Over the years, farms have become fewer in number, larger in size, and more specialized by region and by enterprise. These changes have been accompanied by a general increase in productivity per hour of labor as a result of increased substitution of capital for labor. This substitution has generally taken the form of improved technology, including genetic improvements. The increased productivity is illustrated by the increase in crop yields shown in Table II.

The effect of increased yields in many of the cereal crops was diminished during the 1960's and early 70's by acreage restrictions imposed as part of government price support programs (Table III). The removal of acreage controls in 1972 resulted in an increase in the harvested acreage of all the major grain crops. The decrease in average yield of each grain between 1972 and 1974 was in part the result of returning less productive land to crop production and spreading the available inputs, such as labor, over a greater number of acres. Less intensive cultivation tends to give lower production per acre.

Total crop acres have remained relatively stable over this period except for the crop land idled under government programs (Table IV). However, there have

TABLE I
Farm value of major U.S. crops, 1974[a]

Crop	Farm Value, $'000
Corn	13,716,772
Soybeans	8,245,590
Wheat	7,241,671
Sorghum	1,751,432
Rice	1,195,009
Barley	821,832
Oats	927,555

[a]Source: Field Crops, 1973-74, CrPr 1 (75), Statistical Reporting Service, USDA, Washington, D.C., May 12, 1975.

TABLE II

Yield per acre of major U.S. grain crops (for grain only) for selected years 1950-74[a]

Year	Wheat (bu/acre)	Rice (lb/acre)	Corn (bu/acre)	Oats (bu/acre)	Barley (bu/acre)	Sorghum (bu/acre)	Soybeans (bu/acre)
1950	16.6	2,371	37.6	34.9	26.9	23.4	21.7
1960	26.1	3,423	54.7	43.4	31.0	39.7	23.5
1965	26.5	4,255	74.1	50.2	42.9	51.6	24.5
1970	31	4,618	72.4	49.2	42.8	50.4	26.7
1971	33.9	4,718	88.1	55.9	45.7	53.7	27.5
1972	32.7	4,700	97.1	51.2	43.6	60.5	27.8
1973	31.7	4,274	91.2	47.4	40.3	58.7	27.7
1974	27.4	4,441	71.3	46.6	37.2	45.1	23.5

[a]Source: Agricultural Statistics, 1974, USDA, Washington, D.C. Source for 1973 and 1974 is Crop Production, 1974 Annual Summary, CrPr 2-1 (75), Statistical Reporting Service, USDA, p. B3.

TABLE III

U.S. cropland acreage withheld from production under specified government programs (million acres)[a]

Year	Corn	Sorghum Grain	Barley	Oats	Wheat	Total
1961	19.1	6.1	0	0	0	25.2
1965	24.0	7.0	3.7	0.1	7.2	42.0
1970	26.1	7.4	3.9	0	15.7	53.1
1971	14.1	4.1	0	0	13.5	31.7
1972	24.4	7.3	4.9	0	20.1	56.7
1973	6.0	2.0	1.4	0	7.4	16.8
1974	0	0	0	0	0	0

[a]Source: Agricultural Statistics, 1974, USDA, Washington, D.C.

TABLE IV

Acres of major U.S. grain crops harvested (for grain only) for selected years, 1950-74[a]

	Acres Harvested (1000 acres)						
Year	Wheat	Rice	Corn	Oats	Barley	Sorghum	Soybeans
1950	61,741	1,637	73,202	42,027	11,191	10,346	13,807
1960	51,879	1,595	71,422	26,588	13,856	15,601	23,655
1965	49,560	1,793	55,392	18,522	9,166	13,029	34,449
1970	43,564	1,815	57,358	18,638	9,725	13,568	42,249
1971	47,674	1,818	64,047	15,772	10,151	16,301	42,701
1972	47,284	1,818	57,421	13,525	9,707	13,368	45,698
1973	53,869	2,170	61,894	14,065	10,452	15,853	55,796
1974	65,459	2,569	65,194	13,325	8,281	13,917	52,460

[a]Source: Agricultural Statistics, 1974, USDA, Washington, D.C. Source for 1973 and 1974 is Crop Production, 1974 Annual Summary, CrPr 2-1 (75), Statistical Reporting Service, USDA, p. B1.

been shifts among crops. Acreage devoted to production of oats has declined from 42 million in 1950 to 13 million in 1974 while corn, grain sorghum, and soybean acreage increased from 13 million to 52 million.

A review of production trends for individual crops and projection of these trends provides an important base for many studies of market adjustments. The trend toward regional specialization and increased production requiring larger marketing facilities has been projected to continue in corn and soybean production in the Midwest (Mikes *et al.*, 1973; Nebraska, 1970; Baumel *et al.*, 1974), in rice and soybean production in the South (Free, 1971; Godwin and Jones, 1967), and in the major wheat producing areas such as Oklahoma, Kansas, and Nebraska (Anderson and Breuer, 1971a).

The rapid expansion of grain production between 1950 and 1974 resulted in pressure on existing marketing facilities. Many of the market-oriented problems of the past decade have been directly related to the increased volume of grain marketed. Expansion of facilities, shifts in destination, inadequate transportation, adjustments in marketing channels, and loss of capital investments in marketing firms have been closely associated with changes in volume and location of production.

B. Location of Production

The expansion of grain production has not been uniform in all areas. Increased regional specialization and changes in markets, prices, and costs have stimulated shifts in production among regions. The extent of these shifts varies with the grain, but the degree of concentration, illustrated by the Lorenz curves of Figure 1, is an important determinant of the marketing channels and organization. Grain production—especially wheat, rice and grain sorghum—is concentrated in relatively few states. This encourages market concentration and developments of integrated marketing firms competing for control of supply into the major markets.

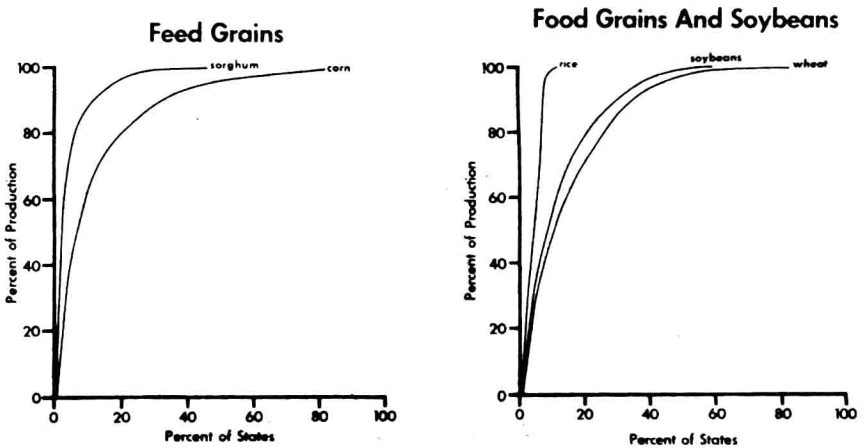

Figure 1. Concentration of production for selected grains, 1974.

TABLE V

Production of winter wheat in 13 major states, for selected years 1950 through 1974 ('000 bu)[a]

	1950	1960	1965	1970	1971	1972	1973	1974
Kansas	178,060	290,640	200,070	299,013	312,605	314,900	384,800	319,000
Oklahoma	43,614	121,278	98,700	98,202	72,000	89,700	157,800	134,400
Nebraska	84,128	85,472	103,075	97,204	102,228	92,833	93,800	98,600
Texas	22,712	84,675	72,652	54,408	31,416	44,000	98,600	52,800
Subtotal	328,514	582,035	474,497	548,827	518,249	541,433	735,000	604,800
Washington	56,512	61,608	86,386	94,500	108,250	119,520	74,200	109,060
Montana	25,212	44,924	64,980	41,796	54,810	48,330	55,120	78,175
Colorado	38,199	65,313	42,441	65,550	59,080	51,600	58,800	67,065
Ohio	46,596	52,500	40,256	35,927	41,536	46,305	23,040	64,680
Illinois	27,440	46,226	58,384	35,748	46,000	54,000	37,800	53,700
Indiana	31,798	41,844	42,152	29,799	31,924	39,648	24,605	50,040
Oregon	18,450	23,752	24,650	26,404	32,016	35,190	32,900	47,520
Idaho	19,992	17,437	29,378	33,258	37,842	34,740	32,760	39,770
Missouri	24,516	37,648	41,140	31,222	31,000	36,075	25,500	37,990
Subtotal	288,715	391,252	429,770	394,204	442,458	465,408	364,725	548,000
Total U.S.	750,666	1,117,131	1,056,821	1,110,290	1,144,164	1,185,225	1,269,653	1,391,303

[a]Source: Agricultural Statistics, 1974, USDA, Washington, D.C. Source for 1973 and 1974 is Crop Production, 1974 Annual Summary, CrPr 2-1 (75), Statistical Reporting Service, USDA, p. B3.

Winter Wheat. Nearly 85% of the U.S. winter wheat production came from 13 states in 1974 as shown in Table V. Although total U.S. production also increased by 85% between 1950 and 1974, the increase was not uniform among all states. The four states Kansas, Oklahoma, Texas, and Nebraska maintained their 45% share of U.S. production between 1950 and 1974, with some variation between these years. Other states within the top 13 have decreased their relative share of production over this period, resulting in shifts among regions in relative importance.

TABLE VI
Production of spring wheat (including durum) in four major states, for selected years 1950 through 1974 ('000 bu)[a]

	1950	1960	1965	1970	1971	1972	1973	1974
North Dakota	120,724	127,500	177,235	151,578	289,774	214,640	250,140	201,640
(durum)	(31,306)	(33,969)	(69,866)	(50,522)	(82,063)	(72,912)	(84,860)	(68,800)
Minnesota	14,190	26,043	21,908	22,288	58,728	48,512	76,968	79,782
Montana	68,746	34,593	37,968	43,371	57,201	50,501	41,594	41,933
S. Dakota	30,686	28,903	29,058	25,188	45,558	29,050	36,958	33,470
Subtotal	234,346	217,039	266,169	242,425	451,261	342,703	405,660	356,825
Total U.S.	276,089	246,312	297,548	259,935	473,825	359,711	441,747	402,019

[a]Source: Agricultural Statistics, 1974, USDA, Washington, D.C. Source for 1973 and 1974 is Crop Production, 1974 Annual Summary, CrPr 2-1 (75), Statistical Reporting Service, USDA, p. B3.

TABLE VII
Production of rice in four major states, for selected years 1950 through 1974 ('000 cwt)[a]

	1950	1960	1965	1970	1971	1972	1973	1974
Arkansas	7,975	13,440	18,662	21,024	22,271	21,939	25,424	34,352
Texas	11,544	12,718	21,252	21,015	23,868	22,122	20,530	25,258
Louisiana	10,491	13,282	18,282	20,397	19,836	19,967	21,394	24,720
California	7,772	13,536	16,023	18,867	17,212	18,868	22,579	24,709
Subtotal	37,782	52,976	74,219	81,303	83,187	82,896	89,927	109,039
Total U.S.	37,971	54,403	76,281	83,754	85,768	85,439	92,823	114,096

[a]Source: Agricultural Statistics, 1974, USDA, Washington, D.C. Source for 1973 and 1974 is Crop Production, 1974 Annual Summary, CrPr 2-1 (75), Statistical Reporting Service, USDA, p. B3.