Nutrient Composition of Selected Wheats and Wheat Products. I. Description of Samples[1]

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ABSTRACT

This initial paper describes the samples, the sampling plan, and procedures for procurement, preparation, and distribution of samples in a study on composition and nutrients of wheats and wheat food products in the United States. To study the wheat foods available to the consumer in different sections of the country, ten types of food products were obtained from each of two cities in each of five geographical regions of the United States (100 samples). Products were: all-purpose flour, biscuit mix, breakfast cereals (whole-grain, wheat flakes, and shredded wheat), enriched white breads (conventional and continuous-mix), whole-wheat bread, hamburger rolls, and doughnuts. Fifty-six other samples of wheat products were studied to determine changes in composition from grain to food product. These comprised 11 wheats, flour milled from those wheats, and products prepared from the flours. Hard wheat flours were made into conventional and continuous-mix breads, semolina into macaroni, and soft wheat flours into cakes (bleached flour) or crackers (unbleached flour). Samples were obtained by the American Institute of Baking and after preparation (freeze-drying, grinding, blending, etc.) subsamples were distributed to participating laboratories for nutrient analyses. Analytical determinations at three laboratories include total solids, protein, ash, 6 macro-minerals, 18 amino acids, thiamine, riboflavin, niacin, reducing and nonreducing sugars, starch, lactose, pentosans, fatty acids, the three forms of vitamin B-6, trace minerals, and the individual tocopherols of vitamin E. Results will be reported in accompanying and subsequent articles.

Wheat products comprise about 82% of the flour and cereal products consumed by the civilian population and they make important contributions toward the nutrients of the national food supply, including approximately 16% of the protein and calories, 30% of the carbohydrates, more than 20% of the iron, and 10% of the phosphorus. Smaller but important contributions are made to lipid, calcium, and B-vitamin supplies (1). Despite their importance, composition data based on multinutrient analyses of well-defined samples of wheat and wheat products are very sparse and have been limited to studies of wheat, flour (and other milling fractions), and bread (2 to 9). The results of a recent survey by the U.S. Department of Agriculture (10) have shown an increase in consumption of bakery products other than bread; however, the nutrient composition of these foods has received little prior attention.

Recent developments in processing procedures have not been fully evaluated on a nutritional basis. Separation of flour by air classification may alter the distribution of nutrients as compared to conventional milling procedures. Production of bread by continuous-mix procedures has meant a change in formula ingredients and would be expected to alter the nutrient composition as compared with that produced by conventional sponge-dough procedures.

This study was undertaken by the U.S. Department of Agriculture to determine the nutrient composition of wheat products available to the consumer in five geographical regions of the United States, and of wheat grains of known history,

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flours from these grains, and typical food products made from these flours: bread by continuous-mix and conventional sponge-dough procedures, macaroni, cake, or crackers. Through this study it is hoped that a number of factors may be assessed, including the degree of uniformity of nutrient composition of products over the country, the contribution of wheat products to the American diet, and changes in nutritive value which are produced by milling and baking processes.

The three laboratories participating in the study were the American Institute of Baking (AIB), Purdue Research Foundation of Purdue University, and the Food Composition Laboratory, Human Nutrition Research Division, USDA. The AIB procured, baked, prepared samples for analysis, and performed the following analyses: moisture, ash, protein; the minerals calcium, magnesium, iron, phosphorus, sodium, and potassium; the vitamins thiamine, riboflavin, and niacin (free and bound); and the 18 commonly occurring amino acids. Total lipids and fatty acid composition (involving determinations for 15 individual fatty acids) of the extracted lipids were determined at Purdue University. The Food Composition Laboratory determined: the carbohydrate fractions, reducing and nonreducing sugars, starch, lactose, and pentosans; the three forms of vitamin B-6: pyridoxine, pyridoxal, and pyridoxamine; the individual tocopherols comprised in vitamin E; and trace mineral elements which occur in sufficient amounts to be measured by atomic absorption spectra, including copper, manganese, zinc, nickel, magnesium, chromium, lead, tin, cadmium, and cobalt.

SAMPLE PROCUREMENT

Consumer Wheat Products

To study the wheat foods available to the consumer in different sections of the country, 10 types of wheat food products were obtained from each of two cities in each of five geographical regions (total, 100 samples) as shown in Table I. Collectors purchased at least three brands of flour in 5-lb. packages and as many brands as possible of other products. Exhaustive sampling of all available brands was not attempted, but selections were typical of the brands readily available to the consumer at food stores in each particular region.

The foods were shipped to the AIB for sampling. Perishable baked products (breads, rolls, doughnuts) were rushed by air express special delivery to ensure

TABLE I. REGIONS, CITIES, AND PRODUCTS FOR CONSUMER WHEAT PRODUCTS STUDY, WITH IDENTIFYING CODE SYMBOLS

GEOGRAPHICAL REGION	CITY	PRODUCTS PER CITY
NE—Northeast	A—New York	1—All-purpose flour
	B—Boston	2—Biscuit mix
SE—Southeast	A—Atlanta	3—Whole-wheat cereal to cook
	B—Charlotte	4—Shredded wheat cereal
C—Midwest	A—Chicago	5—Wheat flakes cereal
	B—Minneapolis	6—Enriched white bread,conventional
NW—Northwest	A—Seattle	7—Enriched white bread,continuous-mix
	B—San Francisco	8—Whole-wheat bread
SW—Southwest	A—Los Angeles	9—Hamburger rolls
	B—Dallas	10—Doughnuts

arrival during the time products would normally be purchased and consumed. Samples were immediately placed in freezer storage.

Approximately equal quantities of each brand collected in a metropolitan area were combined into a single, composite sample representative of the typical food product consumed in that area.

Grain-Flour-Product Samples

For a study of the changes in composition incurred by processing wheat to flour and flour to food product, a total of 56 samples were obtained. As outlined in Table II, these comprised 11 wheats, 20 flours milled from those wheats, and 25 products prepared from the flours. Both conventional and continuous-mix bread were prepared from the hard wheat flours, macaroni from durum semolina, and cake and crackers from the soft wheat flours.

Samples of wheat and their flours were obtained directly from commercial milling companies. All wheat samples were taken after cleaning. They represent typical commercial blends used in normal milling operations at the particular mill. Hard and soft wheats were from the 1965 crop year. Durum wheat samples were probably blends of the 1964 and 1965 crop years.

With the few exceptions noted in Table II, flours were of commercial production and were typical for the wheat blend and expected usage. All wheats were milled at a normal extraction rate of approximately 72% (72 lb. of straight flour per 100 lb. cleaned wheat). The refinement necessary to produce the various flour grades reduced the proportion of wheat represented by a given flour. To avoid confusion in terminology, values in Table II are given on the uniform basis of "percent of cleaned wheat." Details of air classification could not be provided, but it was stated that the process removed portions of high-protein fractions from the total flour.

All cake flours except that from the Michigan soft white wheat received normal, commercial treatment for mellowing gluten proteins and bleaching. Those from soft red and from Intermountain soft white wheat were treated with benzoyl peroxide and chlorine.

PROCEDURE

Preparation of Products from Flours

Bread was prepared in the AIB experimental bakery from each of the hard wheat flours; the conventional sponge-dough procedure and a continuous-mix process were used. The latter employed a Wallace & Tiernan Baker Dō-Maker, laboratory-model continuous mixer. The bread formulas (Table III) are those adopted for standard use in the experimental bakery and are believed to be typical of those employed in commercial practice for the two types of bread. Absorption and mixing requirements were predetermined by farinograph test. A single lot of each ingredient (except yeast) was used for all samples. Loaves were not subjected to scoring, but all samples were judged to be of satisfactory commercial quality.

Macaroni was prepared in the form of "elbows" by a milling company laboratory under commercial procedures. A dough absorption of 25% was used with both semolina samples. Drying time was 41 hr. at 38°C.(100°F.).

Cake was prepared at AIB from the appropriate flours, with a standard formula for white layer cake (Table IV). A single lot of each ingredient was used for all cakes. Cakes appeared to be uniformly excellent in physical characteristics except

TABLE III. BREAD FORMULAS FOR PROCESSING STUDY SAMPLES

Sponge-Dough Conventional Process		Continuous-Mix Process	
Ingredients	Parts per 100 parts flour	Ingredients	Parts per 100 parts flour
Flour	100	Brew:	
Water	variable	Water	variable
Yeast	2.5	Sugar	8.0
Yeast food	0.5	NFDM	2.0
Salt	2.0	Yeast	2.5
Sugar	6.0	Salt	2.3
NFDM	4.0	Nonphosphate yeast food	0.5
Shortening	3.0	Calcium acid phosphate	0.2
Calcium propionate	0.2	Calcium propionate	0.2
Baking: temperature	232°C.(450°F.)	Fermentation:temp.	30°C.(86°F.)
Baking: time	23 min.	Fermentation:time	2.5 hr.
		Dough:	
		Flour	100
		Brew	as above
		Shortening (including flakes and emulsifier)	3.25
		Oxidation solution:	
		Potassium bromate	50 p.p.m.
		Potassium iodate	12.5 p.p.m.
		Baking temp.	210°C. (410°F.)
		Baking time	18 min.

those made from cake flour derived from Michigan soft white wheat, which had a noticeably coarser crumb. The over-all quality of this sample of cake was quite acceptable otherwise and was considered remarkably good for a flour not generally used for cake production and which had not been bleached.

Crackers were prepared from the appropriate flours in the experimental baking laboratories of a commercial firm; the formula and conditions used are shown in Table V. Bread and cake were placed in a freezer within 2 hr. after baking and were held there until sampled.

Preparation of Samples

While still in the frozen state, samples of bread, rolls, doughnuts,and cake were crushed in a Hobart model M800 vertical mixer and then freeze-dried. So as to avoid separation of fat, doughnuts were given no further treatment. Cake presented great difficulties in handling because of its high sugar and fat contents. The freeze-dried cake was treated in a Waring Blendor to produce smaller-sized particles. The remaining freeze-dried baked products and samples of dry products (except flour and biscuit mix) were hammer-milled to pass the 0.024-in. screen. All samples

TABLE IV. WHITE LAYER CAKE FORMULA FOR PROCESSING STUDY[a]

Ingredients	Amount g.	Ingredients	Amount g.
Flour	800	NFDM	90
Salt	24	Egg white (dried)	63
Baking powder	50	Shortening (emulsified)	400
Sugar	960	Water	1,000

[a]Scaling: 14 oz. batter per 8-in. layer pan

Baking: temp. 191°C. (375°F.)
Baking time: 23 to 25 min.

TABLE II. WHEATS, FLOURS, AND PRODUCTS IN PROCESSING STUDY

WHEAT			FLOUR				PRODUCT	
Code	Type	Growing area	Code	Type	Yield[a]	Treatment	Code	Type
H-1-W	HRW	Kans.	H-1-F	Baker's patent	55	Normal bleaching, malting; no oxidant, no enrichment	H-1-B 1	Bread[b]
							H-1-B 2	Bread
H-2-W	HRW	Mont.	H-2-F	Baker's patent	66	No information[c]	H-2-B 1	Bread
							H-2-B 2	Bread
H-3-W	HRS	N.D.	H-3-F	Baker's patent	63.5	No information	H-3-B 1	Bread
							H-3-B 2	Bread
H-4-W	HRS, HRW	N.D., Kans.	H-4-F	Baker's patent	55	Normal bleaching, malting; no oxidant, no enrichment	H-4-B 1	Bread
							H-4-B 2	Bread
H-5-W	HRW	Tex., Okla.	H-5-F	Baker's patent	55	Normal bleaching, malting, oxidant; no enrichment	H-5-B 1	Bread
							H-5-B 2	Bread
D-1-W	Durum	N.D., Mont.,Minn.	D-1-F	Semolina	42	None	D-1-Mac	Macaroni
D-2-W	Durum	N.D., S.D., Mont.,Minn.	D-2-F	Semolina	42	None	D-2-Mac	Macaroni
S-1-W	SRW	Ill.,Ind.	S-1-F 1	Short patent	54	Benzoyl peroxide, chlorine	S-1-Ca 1	Cake
			S-1-F 2	Straight grade[f]	72	None	S-1-Cr 2	Cracker
			S-1-F 3	Cut off	18	None	S-1-Cr 3	Cracker
			S-1-F 4	Cake, air-classif.	-	Benzoyl peroxide, chlorine	S-1-Ca 4	Cake
			S-1-F 5	Cracker, air-classif.	-	None	S-1-Cr 5	Cracker

S-2-W	SWW	Mich.	S-2-F 1	Short patent[d]	-	No information[e]	S-2-Ca 1	Cake
			S-2-F 2	Cut off	-	No information	S-2-Cr 2	Cracker
S-3-W	SWW	Wash.	S-3-F 1	Short patent	54	Cake flour treat.	S-3-Ca 1	Cake
			S-3-F 2	Straight grade	72	None	S-3-Cr 2	Cracker
S-4-W	SWW	Idaho	S-4-F 1	Short patent	32	Benzoyl peroxide, chlorine	S-4-Ca 1	Cake
			S-4-F 2	Straight grade	72	None	S-4-Cr 2	Cracker
			S-4-F 3	Cake type, air-classif.[f]	-	Benzoyl peroxide, chlorine	S-4-Ca 3	Cake
			S-4-F 4	Cracker type, air-classif.[f]	-	None	S-4-Cr 4	Cracker

[a]Parts of flour per 100 parts cleaned wheat.

[b]Bread prepared by conventional sponge-dough procedure designated by final numeral 1; that prepared by continuous-mix designated by final numeral 2.

[c]Commercial bread flour; vitamin and iron analyses indicate enrichment.

[d]Not a normal commercial flour for this wheat blend.

[e]Tocopherol analyses suggest no special treatment.

[f]Air-classified on experimental equipment.

TABLE V., CRACKER FORMULA FOR PROCESSING STUDY

	Sponge			Dough		
	lb.	oz.	g.		lb.	oz.
Lard	2	12		N.D. malt		2
Yeast		1.5		Salt		3.5
Water	6			Soda		2.0
Enzyme[a]			1.071	Flour	8	12
Flour	16	4				

Sponge set at 22°C. (72°F.), fermented 20 hr.
Dough set at 29°C. (84°F.), fermented 4 hr.
Baking: time, 2.5 min.
Baking temp., 260° to 371°C. (500° to 700°F.)

[a]Proteolytic enzyme HT 200 Takamine, Miles.

were blended to uniformity in a PK Twin Shell dry blender and then were transferred to No. 2 size commercial tin cans which were hermetically sealed. At least two cans of each sample were sealed under nitrogen to serve as subsamples for fatty acid and tocopherol analyses. All cans of subsamples were stored at −23°C. until distributed.

Distribution of Subsamples

The nitrogen-filled subsample cans were shipped packed in dry ice. One of each sample was shipped to Purdue University for determination of fatty acids, and another to the Food Composition Laboratory at Beltsville for tocopherols analysis. The latter samples were shipped by air express to ensure arrival while they were still in frozen condition. Additional subsample tins (not nitrogen-filled) were also sent to the Food Composition Laboratory for measurement of carbohydrates, trace minerals, and vitamin B-6. One subsample tin was retained in freezer storage for analysis at AIB, and at least one tin of each sample was held in reserve supply in the event of loss and need of replacement. Subsequent papers in this series will report results of analyses for nutrient composition of these samples.

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