Preparation and Properties of Defatted Flours From Dry-Milled Yellow, White, and High-Lysine Corn Germ

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ABSTRACT

Dry-milled germ fractions originating from six different mills and derived from yellow, white, and high-lysine corns were evaluated as sources for the preparation of food-grade, high-protein flours. Germs from commercial streams were separated into three fractions: +6, −6+10, and −10. The two fractions larger than 10 mesh were aspirated separately, combined, flaked, extracted with hexane, dried, and ground. The finished flour consisted of material that passed through a 9XX bolting silk. Yield and compositional data on fat, ash, fiber, and protein were obtained on the crude germs, all intermediate fractions, and the finished flours. Protein content of the six finished flours ranged from 20.5% in a white corn germ to 25.2% in a yellow germ. Amino acid compositions of the protein in the flours were similar regardless of corn type or mill source. Lysine accounted for approximately 5% of the 17 amino acids recovered from the flours. However, lysine represented only 1.5% of the amino acids in three other dry-milled products that included yellow and white corn meals and hominy grits. Color measurements showed that the corn germ flours contained more yellow pigments than did a bleached all-purpose wheat flour.

Each year dry millers process approximately 150 million bushels of white and yellow corn into a variety of food, feed, and industrial products. Traditional ingredients made from corn include flour, meal, grits, and oil. Flour, meal, and grits, endosperm products containing 85–90% starch, are used largely for human foods. However, the germ, which accounts for 10–12% of the corn kernel, has had a long history of use as an ingredient in animal feeds (Wall et al 1971). Gardner et al (1971) have reviewed and summarized compositional data and earlier nutritonal studies on corn germ. Data from proximate analyses, amino acid patterns, and protein efficiency ratios show that the germ is the most nutritious part of the corn kernel (Earle et al 1946, Wall et al 1971). The nutritional quality of the protein in defatted corn germ can be influenced by drying temperatures and by the procedure used to extract the oil. Investigations on nutritive value of proteins in hominy feed fractions (Wall et al 1971) showed that corn germ can be a source of quality protein when drying temperatures are minimal and oil is removed by solvent extraction rather than by the more rigorous expeller process. Commercially processed dry-milled corn germ was examined as a source for preparing a flour for human consumption (Blessin et al 1972). That work resulted in a laboratory-scale preparation of a solvent-extracted, defatted flour containing approximately 25% protein. Preliminary taste-panel evaluations of cookies, muffins, and beef patties incorporating various levels of defatted corn germ flour were satisfactory (Blessin et al 1972). In addition, detailed information has been published on the effect the defatted germ flour had on the composition of these three food products (Blessin et al 1973). In other studies, Tsen (1976) reported that fortifying oatmeal cookies made from composite flours with up to 36% defatted corn germ flour improved taste, flavor, and texture. Defatted corn germ flour has also been investigated as a nutrient fortifier for bread (Tsen 1975, Tsen et al 1974). These foregoing studies indicate that corn germ flour has considerable potential for use as a supplement in a variety of foods and, as such, provides a new protein source for both domestic and foreign markets.

In this paper we further describe the preparation and properties of different defatted flours from dry-milled, full-fat yellow, white, and high-lysine corn germ originating from several commercial mills.

[1]Mention of firm names or trade products does not imply endorsement or recommendation by the USDA over other firms or similar products not mentioned.

MATERIALS AND METHODS

Full-Fat Crude Corn Germ

Dry-milled germ fractions from yellow and white corn were obtained from germ streams at commercial mills. Processed germ from yellow corn was supplied by three different mills, and germ from white corn came from two different mills. The germs were typical of those available on a production basis. The germ material from high-lysine corn was separated in a large-scale pilot plant located in a commercial dry-milling facility. Standard dry-milling techniques were followed during separation of the three types of germ in both the commercial mills and the pilot plant.

Other Food Products

All-purpose enriched wheat flour, yellow and white corn meal, and white corn grits were purchased as consumer food products at a local supermarket.

Preparation of Flours

Defatted corn germ flour was prepared according to the scheme diagramed in Fig. 1. An arrow following a fraction means that the fraction was removed from the system and was no longer involved in the preparation of the flour.

Details of the flour preparation procedure have been reported in a previous publication (Blessin et al 1974). The procedure is described briefly in this paper to show the origin of the various fractions of the germ. A gyratory sifter was used to separate 100 lb of dry-milled germ into three fractions: +6, −6+10, and −10. The +6 and −6+10 fractions were then aspirated separately. The refined fractions were combined, mixed, tempered with water, and flaked at ambient temperature. The flaked germ was defatted with hexane at room temperature by a batch submersion method. The flakes were dried at room temperature and ground in a mill. The finished flour consisted of the material passing through a 9XX bolting silk.

Proximate Analyses

All samples were ground in a mill to pass a 40-mesh screen. Fat was determined by extracting the sample with hexane for 16 hr in a Soxhlet apparatus. Ash was determined by ignition in a platinum dish at 575°C for at least 16 hr. Fiber and protein analyses were conducted by standard AACC procedures (1961).

Amino Acid Analyses

Hydrolysates were prepared by refluxing approximately 200 mg of sample in 150 ml of 6*N* hydrochloric acid for 24 hr. After the acid was removed by evaporation, the sample was dissolved in pH 2.0 citrate buffer. Analyses were performed on a Technicon TSM amino acid analyzer, which was interfaced to a central computer. All integrations and calculations were done by computer.

Flour Color Studies

Color values of the finished corn germ flours were determined with a Hunterlab Model D25 Color Meter (Hunter Associates Laboratory, Inc., Fairfax, VA 22030).

RESULTS AND DISCUSSION

Yields of Processed Corn Germ Fractions

The typical full-fat germ fraction as received from the mill contains fragments of hull, tip cap, endosperm, and dark-pigmented material, usually from the hilar layer. Additional separations for germ purification are desirable to prepare a flour suitable for use as a food ingredient. The starting material consisted of 100 lb of crude germ as received from the mill (Table I). The larger pieces of germ were separated into +6 and −6+10 fractions to study the effect of size on chemical composition. Yields of the larger fraction (+6) ranged from 22 to 42 lb for the germ from yellow corn and averaged 49 lb for the germ from white corn. The yield of 73 lb of +6 germ from high-lysine corn was considerably higher than the same fraction from yellow or white corn. The higher yield may have indicated a better germ separation in the pilot plant or a poor separation, with the germ containing attached hull and endosperm.

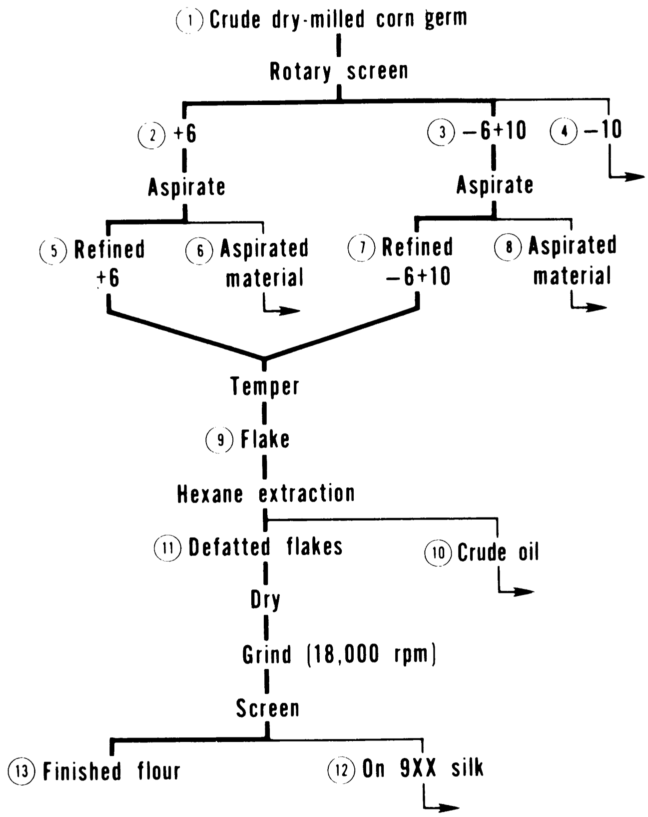

Fig. 1. Preparation of defatted corn germ flour. Arrows indicate fractions removed from system. Numbers in circles refer to fractions obtained during different processing operations.

The yield of the −6+10 germ fraction was 42–56 lb for the yellow germ and 31 and 37 lb for the white germ. As would be expected, the yield for this fraction from high-lysine germ was less (25 lb).

If the described procedures were applied in commercial practice, the −10 fraction would be recycled to a feed operation for solvent extraction of additional oil. The −10 fraction contained smaller particles of germ as well as pieces of hull and endosperm. The −10 fraction, the smallest of the three fractions, accounted for 12–28 lb of the yellow germs and 13 and 21 lb of the white germs. Only 2 lb of this fraction was separated from the crude high-lysine germ.

Separate aspiration of +6 and −6+10 fractions removed pieces of hull and particles of endosperm at a faster rate and produced cleaner germ than did combining the fractions before aspiration. Materials removed by aspiration from the +6 fraction showed considerable variation, with yields ranging from 1 to 3 lb from yellow germ, 5 lb from white germ, and 2 lb from high-lysine germ. Aspiration of the −6+10 fraction yielded 2–5 lb of material from yellow germ, 4 and 9 lb from white germ, and 1 lb from high-lysine germ. The higher yield of 9 lb from one sample of white corn germ indicated a considerable amount of hull associated with the −6+10 fraction.

Combining and flaking the refined +6 and −6+10 fractions produced yields of 65–83 lb of flaked material from yellow germ and 65 and 78 lb from white germ. However, the highest yield (95 lb) of flaked material was produced from high-lysine germ. Solvent extraction of the full-fat flakes with hexane removed the crude oil, leaving 48–65 lb of dried, defatted flakes from yellow germ, 50 and 62 lb from white germ, and 70 lb from high-lysine germ. Screening the defatted material after grinding yielded 38–60 lb of finished flour from yellow germ and 4–10 lb of material remaining on the 9XX silk. Comparable data for white germ were 40 and 48 lb of flour and 10 and 13 lb retained on the 9XX silk. The high-lysine germ gave the highest yield of flour (65 lb), with 5 lb of material retained on the 9XX silk. Larger quantities (10–13 lb) of material retained on the 9XX silk with one sample of yellow germ and both samples of white germ indicated that considerably more unground material existed in these samples. This was probably due either to

TABLE I
Yields of Processed Corn Germ Fractions[a]

		Germ Type and Mill Number					
		Yellow			White		High-Lysine
	Fraction	1	2	3	4	5	6
(1)[b]	Crude germ	100.0	100.0	100.0	100.0	100.0	100.0
(2)	+6	42.0	22.5	30.1	50.5	48.2	72.9
(3)	−6+10	45.5	56.0	41.8	36.8	31.0	25.0
(4)	−10	12.5	21.5	28.1	12.7	20.8	2.1
(5)	Refined +6	38.8	21.6	28.4	45.7	43.4	70.9
(6)	Aspirated from +6	3.2	0.9	1.7	4.8	4.8	2.0
(7)	Refined −6+10	43.9	52.6	36.5	32.6	21.7	24.0
(8)	Aspirated from −6+10	1.6	3.4	5.3	4.2	9.3	1.0
(9)	+6,−6+10 flaked	82.7	74.2	64.9	78.3	65.1	94.9
(10)	Crude oil	17.6	18.0	16.9	16.7	15.1	25.3
(11)	Defatted flakes	65.1	56.2	48.0	61.6	50.0	69.6
(12)	On 9XX silk	5.2	4.1	9.6	13.4	10.0	4.9
(13)	Finished flour	59.9	52.1	38.4	48.2	40.0	64.7

[a] Based on 100 lb of crude germ.
[b] Numbers in circles refer to fractions obtained during different processing operations shown in Fig. 1.

larger quantities of hull material or to a form of the germ that was more difficult to grind. All samples were ground with the same technique and speed of mill.

These figures indicate that recovery of 2–3 lb of finished corn germ flour from every bushel of milled yellow or white corn should be possible.

Proximate Analyses and Characteristics of Processed Corn Germ Fractions

The composition of commercial dry-milled corn germ can vary

TABLE II
Proximate Analyses of Processed Corn Germ Fractions[a]

	Fraction	Yellow											
		Mill 1				Mill 2				Mill 3			
		Fat	Ash	Fiber	Protein	Fat	Ash	Fiber	Protein	Fat	Ash	Fiber	Protein
(1)[b]	Crude germ	19.8	7.4	3.3	18.6	22.5	7.1	2.7	16.2	21.8	5.6	4.2	17.4
(2)	+6	17.4	7.2	5.9	18.5	25.9	8.2	3.1	16.9	25.6	8.0	4.3	16.9
(3)	−6+10	22.3	8.0	3.7	19.4	23.6	7.7	3.0	16.5	24.1	5.8	4.0	15.9
(4)	−10	17.9	7.4	2.2	19.7	17.3	5.6	2.4	16.7	17.1	2.6	3.3	18.5
(5)	Refined +6	19.3	7.5	5.6	18.6	25.1	8.2	3.0	17.0	26.7	8.2	4.5	16.4
(6)	Aspirated from +6	8.6	3.0	11.5	11.6	10.6	3.6	7.3	11.6	9.8	2.7	9.8	18.3
(7)	Refined −6+10	21.6	8.4	2.9	19.9	24.3	7.6	2.6	16.3	26.1	6.7	4.3	16.6
(8)	Aspirated from −6+10	12.3	4.2	8.2	13.5	11.5	3.8	6.1	12.4	8.2	2.5	10.5	17.4
(9)	+6, −6+10 flaked	22.1	7.2	3.5	19.1	24.5	8.1	3.0	16.8	26.5	6.9	4.4	17.1
(11)	Defatted flakes	1.1	10.5	4.3	24.7	0.3	11.5	3.6	23.1	0.5	10.1	5.6	22.6
(12)	On 9XX silk	0.8	4.9	11.0	15.8	0.7	5.4	11.3	16.1	0.7	6.9	9.0	17.9
(13)	Finished flour	1.1	11.0	4.0	25.2	0.3	11.6	3.3	23.1	0.5	10.4	5.1	23.0

	Fraction	White								High-Lysine			
		Mill 4				Mill 5				Mill 6			
		Fat	Ash	Fiber	Protein	Fat	Ash	Fiber	Protein	Fat	Ash	Fiber	Protein
(1)[b]	Crude germ	19.0	5.5	4.7	17.4	20.9	5.6	4.3	17.3	26.4	7.1	4.9	17.0
(2)	+6	16.9	4.4	4.8	16.0	21.6	7.3	5.9	17.7	25.3	8.0	5.1	17.4
(3)	−6+10	22.6	6.6	3.9	16.9	19.9	5.8	4.8	17.5	27.9	6.5	5.0	16.2
(4)	−10	23.2	8.1	2.8	18.6	23.7	5.3	3.8	14.0	12.9	2.3	1.9	20.4
(5)	Refined +6	17.8	5.0	4.3	17.8	22.9	7.5	5.0	17.3	26.7	8.1	4.6	17.3
(6)	Aspirated from +6	15.2	4.3	12.9	11.0	10.0	7.5	8.2	13.8	10.3	3.3	9.2	20.1
(7)	Refined −6+10	23.3	6.9	3.8	16.5	22.8	6.4	3.8	18.5	28.6	6.7	3.4	16.7
(8)	Aspirated from −6+10	20.5	5.8	7.5	13.9	13.9	4.7	7.4	12.7	11.5	2.5	9.7	19.4
(9)	+6, −6+10 flaked	21.9	5.7	3.6	16.1	24.0	6.6	5.3	17.3	27.2	7.2	4.2	16.8
(11)	Defatted flakes	0.8	6.5	5.1	19.0	1.2	9.4	6.3	22.5	0.6	11.1	5.4	22.1
(12)	On 9XX silk	0.3	2.2	5.5	15.0	1.1	6.8	10.3	20.7	0.7	9.9	9.8	21.4
(13)	Finished flour	0.8	7.8	5.6	20.5	1.0	10.1	4.9	23.7	0.5	11.6	5.1	22.3

[a] Percent, moisture-free basis.
[b] Numbers in circles refer to fractions obtained during different processing operations shown in Fig. 1.

TABLE III
Amino Acid Composition of Protein in Germs and Flours from Yellow, White, and High-Lysine Corn[a]

Amino Acid	Yellow						White				High-Lysine	
	Mill 1		Mill 2		Mill 3		Mill 4		Mill 5		Mill 6	
	Crude Germ	Finished Flour	Crude Germ	Finished Flour	Crude Germ	Finished Flour	Crude Germ	Finished Flour	Crude Germ	Finished Flour	Crude Germ	Finished Flour
Aspartic acid	9.1	9.1	8.9	8.9	8.5	8.7	8.4	9.1	8.5	8.9	9.7	9.9
Threonine	4.2	4.1	4.1	4.0	4.1	4.0	4.0	4.1	4.1	4.1	4.0	4.0
Serine	5.6	5.5	5.8	5.5	5.4	5.6	5.5	5.6	5.5	5.8	5.5	5.9
Glutamic acid	14.8	13.9	16.0	14.8	14.9	14.6	15.7	15.7	16.4	15.2	13.9	14.7
Proline	7.0	6.4	6.6	6.0	6.9	6.2	7.2	7.6	7.9	6.3	5.5	5.2
Glycine	6.0	6.4	6.1	6.3	5.6	6.3	5.3	5.7	5.2	5.9	6.4	6.4
Alanine	7.0	6.9	6.9	6.6	7.1	7.1	7.1	7.1	6.9	6.8	6.9	6.7
Cystine	1.0	1.8	0.9	2.1	1.8	1.8	1.5	1.7	1.5	1.7	1.9	1.4
Valine	5.4	5.0	5.2	6.3	5.8	6.4	5.3	4.9	5.6	6.1	6.8	6.5
Methionine	1.9	2.4	1.8	2.3	2.2	2.1	2.1	1.9	1.6	2.0	1.8	2.0
Isoleucine	3.6	3.6	3.5	3.4	3.5	3.5	3.6	3.5	3.6	3.7	3.4	3.5
Leucine	8.0	7.6	8.6	7.7	8.8	8.1	9.5	8.7	9.5	8.5	7.1	7.4
Tyrosine	3.5	3.8	3.8	3.5	3.9	3.8	4.1	3.9	4.1	3.9	3.6	3.6
Phenylalanine	4.7	4.9	5.0	4.6	4.9	4.8	5.1	4.7	5.0	5.0	4.9	4.8
Histidine	3.0	3.0	3.0	3.2	3.0	2.8	2.9	2.8	2.8	2.5	3.0	2.9
Lysine	5.6	5.9	5.0	5.4	5.0	5.4	4.9	4.8	4.6	5.0	5.6	4.7
Arginine	9.6	9.6	8.7	•9.3	8.4	8.8	7.8	8.2	7.2	8.6	10.1	10.5

[a] Percent of recovered amino acid.

TABLE IV
Amino Acid Composition of Protein in Corn Germ Flours, Corn Meals, and Hominy Grits[a]

Amino Acid	Yellow[b] Corn Germ Flour	White[c] Corn Germ Flour	High-Lysine Corn Germ Flour	Yellow Corn Meal	White Corn Meal	White Hominy Grits
Aspartic acid	8.9	9.0	9.9	5.9	5.7	5.8
Threonine	4.0	4.1	4.0	3.5	3.6	3.4
Serine	5.5	5.7	5.9	5.1	4.8	4.8
Glutamic acid	14.4	15.6	14.7	19.4	19.3	19.2
Proline	6.2	6.9	5.2	9.7	10.5	10.6
Glycine	6.3	5.8	6.4	3.3	3.2	3.2
Alanine	6.9	7.0	6.7	8.1	7.6	7.9
Cystine	1.9	1.7	1.4	1.5	1.8	1.9
Valine	6.0	5.5	6.5	4.9	5.1	5.1
Methionine	2.3	2.0	2.0	2.5	2.9	2.9
Isoleucine	3.5	3.6	3.5	3.7	3.4	3.4
Leucine	7.8	8.6	7.4	14.3	13.8	14.0
Tyrosine	3.7	3.9	3.6	4.9	4.8	4.9
Phenylalanine	4.8	4.9	4.8	5.5	5.2	5.2
Histidine	3.0	2.7	2.9	2.6	3.0	2.8
Lysine	5.6	4.9	4.7	1.5	1.6	1.4
Arginine	9.2	8.4	10.5	3.6	3.5	3.5

[a] Percent of recovered amino acid.
[b] Average of three flours.
[c] Average of two flours.

TABLE V
Hunter Lightness and Color Values for Wheat Flour and Corn Germ Flours

Mill Number	Flour	Lightness (L)[a]	Color Values +a[b]	−a[b]	+b[c]
	Wheat	91.4	0.1		5.9
	Corn Germ				
1	Yellow	84.5	0.3		12.1
2	Yellow	86.4	0.1		11.9
3	Yellow	85.6		0.6	12.4
4	White	80.7	0.8		13.1
5	White	85.6		0.3	9.9
6	High-lysine	81.9	0.9		14.8

[a] L measures lightness and varies from 100 for perfect white to 0 for black.
[b] Measures redness when plus, gray when 0, and greenness when minus.
[c] Measures yellowness when plus, gray when 0, and blueness when minus.

from mill to mill due to differences in equipment, milling techniques, oil extraction procedures, and manufacture of specific types of prime products. The commercial yellow corn germs used as starting material in our study showed some differences, as reflected by proximate analyses. However, the white corn germs, which originated from two milling companies, were similar in this respect (Table II). One of the objectives of our study was to determine if a relationship exists between size of the germ particle and composition based on proximate analysis. A germ that contains little attached hull or endosperm will show higher concentrations of fat, ash, and protein. Attached hull and endosperm not only can increase particle size but also can dilute the germ, causing changes in composition that are less desirable for the production of corn germ flour. Therefore, particles of commerical germ of the same screen size may differ considerably in composition.

Fat and ash contents can be suitable criteria for discussing separation of the various full-fat fractions because fat is the largest single component of the germ (Earle et al 1946). The three germ fractions from yellow corn from mills 2 and 3 showed decreasing fat content with decreasing germ particle size. However, the amount of fat of the three fractions from mill 1 was highest in the −6+10 fraction. The smallest fraction (−10) from the white corn germ from mill 4 had the highest fat content. Fat content of the three white germ fractions from mill 5 was about the same, regardless of particle size. The crude high-lysine germ and the +6 and −6+10 fractions were similar in composition. Lower fiber content of the −10 fraction compared with that of the +6 and −6+10 fractions was probably due to concentration of fragments of endosperm in the −10 fraction. Overall, the +6 and −6+10 fractions appeared to provide the best physical characteristics and compositions for the pilot-plant preparation of the corn germ flour. Use of the −10 fraction has several disadvantages. This fraction produces smaller flakes and more fines and, in addition, contains varying amounts of tip cap, hilar layer, and hull fragments.

The +6 and −6+10 fractions were aspirated separately to provide cleaner particles of germ and to remove fine material that could interfere with the fat extraction process. The aspirated material removed from either the +6 or the −6+10 fraction was lower in fat, ash, and protein but considerably higher in fiber content than the crude yellow germ from mills 1 and 2 and the crude white germ from mill 4. Similar data were obtained on the white germ from mill 5, except that the ash content of the aspirated material and of the refined +6 germ fraction was the same. Protein content of the material aspirated from the +6 and −6+10 fractions from both the yellow germ from mill 3 and the high-lysine germ was greater than that of the original fraction. Apparently, a protein-rich material was removed during aspiration. In general, the compositional data indicated that the material removed by aspiration from most of the fractions consisted mainly of particles of hull and endosperm.

Selective screening followed by aspiration provided clean +6 and −6+10 fractions of germ for flaking. One effect of these refining steps was a higher fat content of the flaked material than of the material received from the mill. This occurred regardless of the type of corn germ or mill source.

Extraction of the flaked germ with hexane at room temperature by batch submersion reduced fat levels to approximately 1% or less. Removing the fat resulted in enriched ash, fiber, and protein content of the flakes by a proportional amount. Sieving the ground, defatted material through a 9XX silk produced flours with minor differences in composition. The range of values for the finished flours from yellow corn germ were fat, 0.3–1.1%; ash, 10.4–11.6%; fiber, 3.3–5.1%; and protein, 23–25.2%. Values for white corn germ flour were fat, 0.8 and 1%; ash, 7.8 and 10.1%; fiber, 4.9 and 5.6%; and protein, 20.5 and 23.7%. Data on composition of high-lysine corn germ flour were within the range for yellow and white corn germ flours.

Ground material retained on the 9XX silk contained less ash and protein and more fiber than the finished flour. Fat content was very low and showed no discernible trend. The high fiber content of the fraction removed on the 9XX silk indicated that particles of the hull were a significant component.

Protein Quality

Amino acid composition was determined on the crude corn germ and the finished flour from six mills (Table III). The amino acid composition of the crude germ and the flour was similar in all cases, showing that the protein mixture in the finished flour did not change as a result of the processing steps. Little variation was detected in amino acid composition of corn germ flour coming from various mills and different types of corn. Similar results have been reported on lysine content of germ originating from various types of corn (Bjarnason and Pollmer 1972). These results indicate that a flour product can be produced with a stable amino acid composition regardless of the source of germ material. This would allow producers and users to intermix germ products with a predictable amino acid composition in the final flour mixture.

Table IV compares the amino acid composition of corn germ flours, different corn meals, and hominy grits. The amino acid composition of the corn meals and hominy grits differs from that of the corn germ flours. The percentage of lysine and aspartic acid is lower and the percentage of leucine, proline, and glutamic acid is higher in the meals and grits. The essential amino acid pattern found in the corn germ flours compares favorably with that of hen's egg (Blessin et al 1973), whereas the pattern in meals and grits does not. This improvement in essential amino acid pattern in the germ flours is due to the increase in lysine and decrease in leucine.

Lightness and Color Values for Flours

The bleached all-purpose wheat flour gave a higher lightness value (91.4) than any of the corn germ flours (Table V). Values for the corn germ flours ranged from 80.7 for a white germ flour from mill 4 to 86.4 for a yellow germ flour from mill 2. The color values for the wheat flour as well as those for several of the corn germ flours gave low readings on the +a scale measuring redness. One yellow and one white corn germ flour produced low −a readings. However, the most significant readings for both wheat and corn germ flours were observed on the +b scale measuring yellowness. Readings for all the corn germ flours were higher than the readings for the wheat flour. The +b values for yellow corn germ flours were not significantly higher than those for white corn germ flours. High-lysine corn germ flour gave the highest +b value (14.8). No readings on the −b scale were obtained for any of the flours. The data indicate that corn germ flours contain more yellow pigments than the bleached all-purpose wheat flour. The slightly yellow color of corn germ flour should not be a deterrent to using this new ingredient in many food products.

Our study shows that defatted flours with acceptable properties can be prepared from dry-milled yellow, white, and high-lysine corn germ originating from several mills.

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