3572

COMPOSITION AND FUNCTIONAL PROPERTIES OF MILLED FRACTIONS OF TRITICALE

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Triticale, a wheatlike cereal grain, created by man by selectively crossing wheat and rye, is becoming increasingly known throughout the hard wheat-growing areas of the United States and Canada. While primarily raised as a feed grain, triticale possesses properties that also make it potentially useful in both food and industrial applications. Certain food aspects of triticale are being studied; e.g., baking characteristics (1-5), noodle manufacture (3,6), and brewing (4). Little has appeared in the literature on possible industrial uses for triticale grain or any of its components. Some preliminary work has been done at the NRRL on millability of triticale (7,8). The present report relates to continued studies on both dry- and wet-milling characteristics of three triticale grains.

Materials. The three triticale samples we have studied to date were supplied by Farm Management Services, Inc., Wichita, Kansas. They include FasGro 204, a spring hexaploid grown in Texas, and FasGro 131 and FasGro 385, both winter hexaploids, grown in Kansas. Analyses of these grains and selected wheat and rye samples are given in Table 1. Triticales 131 and 385 appeared to be harder than 204, and differed slightly in appearance from 204, being less wrinkled.

Table 1. Composition of triticales and other (9) cereal grains (moisture-free basis)

Component	Triticale 204	Triticale 131	Triticale 385	Typical Wheat				Typical Rye
				Durum	Hard Red Spring	Hard Red Winter	Soft Red Winter	
Crude protein (N X 5.7),%	17.1	13.9	13.9	15.0	16.4	14.6	12.3	13.4
Crude fat, %	1.7	1.9	1.5	2.2	2.1	1.8	1.8	1.8
Crude fiber, %	3.1	2.4	2.4	2.5	2.7	3.0	2.5	2.6
Ash, %	2.1	2.0	2.0	2.0	2.0	2.0	2.0	2.1
Nitrogen-free extract, %	76.0	79.8	80.2	78.3	76.8	78.6	81.4	80.1

Analytical Methods. Chemical analyses were made according to procedures described in Approved Methods of the American Association of Cereal Chemists (10).

Dry Milling and Air Classification. The triticales were milled in a Buhler pneumatic laboratory mill, type MLV-202, to determine their milling characteristics and to obtain flour for wet milling and air classification. Typical milling results are given in Table 2.

Table 2. Milling triticale grain in a Buhler mill (14% moisture basis)

Fraction	Yield, %			Protein, %			Ash, %		
	204	131	385	204	131	385	204	131	385
Straight flour	63.8	61.9	65.0	12.1	10.2	10.4	0.54	0.58	0.58
Shorts	9.9	12.4	13.5	16.5	---	---	2.78	---	---
Bran	26.3	25.7	21.5	---	---	---	---	---	---

Milling presented no problems; there was a clean separation of bran and shorts from the flour. The yield of flour from triticale was lower than usually obtained from hard wheats. Ash contents of the straight flour from the triticales were about the same magnitude as those generally found from hard wheats milled on the Buhler.

To facilitate air classification, flour particles first must be ground finely, a step which is accomplished by passing the flours three times through a pin mill. The basic principle of air classification is diagrammed in Figure 1. The flour particles are impinged on a rotating plate. A stream of

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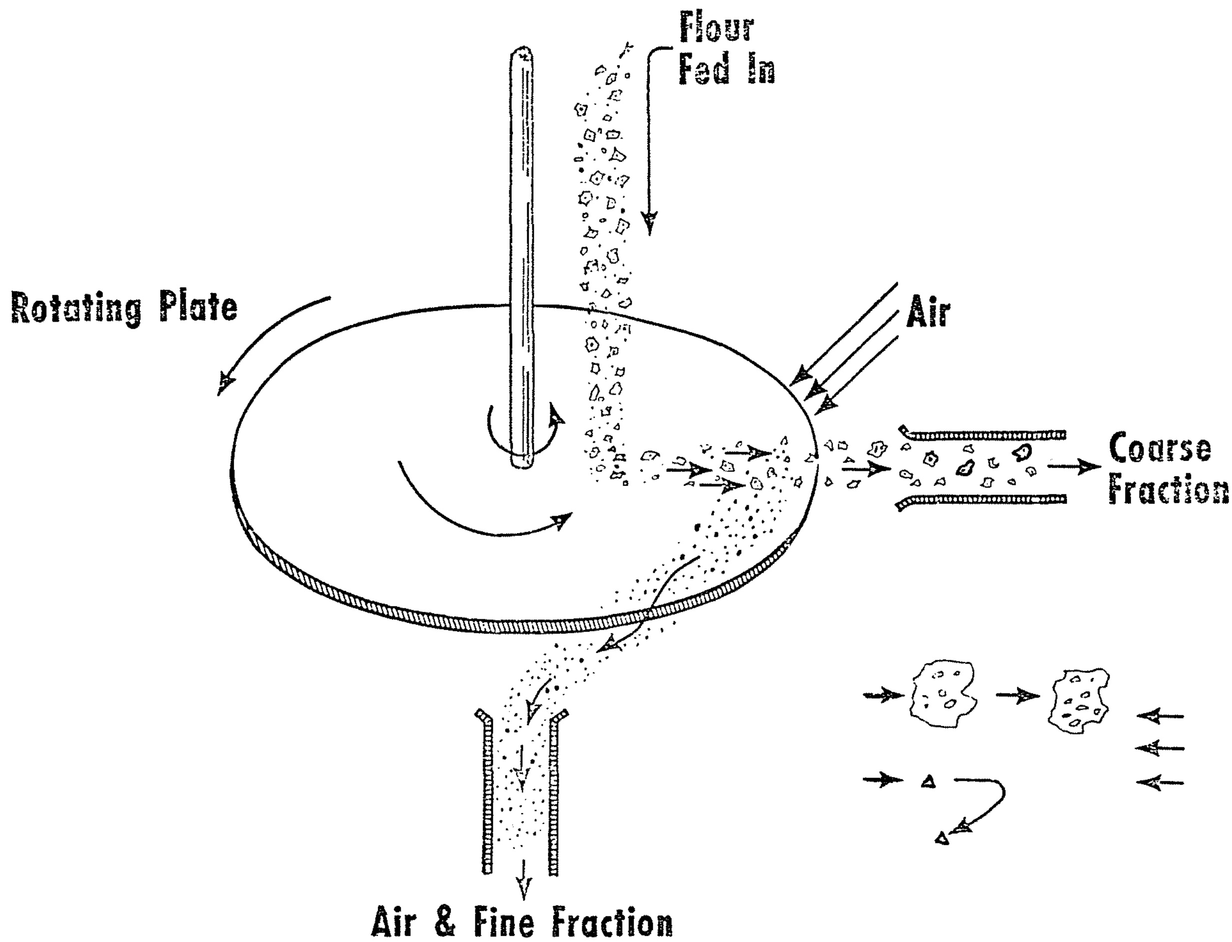

Figure 1. Principle of air classification of flour.

air deflects the particles into two fractions differing in size and density. In these experiments a Pillsbury laboratory model air classifier was used to separate the flour into a coarse and a fine fraction. The flours were separated into eight fractions by collecting a fine fraction, readjusting the classifier for a coarser cut, reclassifying the coarse fraction, and repeating the procedure until seven fine fractions and one coarse fraction remained. Classifier cut points were set to yield fractions with particle sizes (reported in terms of mass median diameter, that is, the diameter at which 50% of weight of sample is undersize) of about 11, 12, 15, 18, 21, 23, and 25 microns. Because of the large number of fractions taken and the intensive flour regrinding imposed, separations are near the maximum possible when using such a flour and this technique.

Yields and chemical analyses are given in Table 3 for air-classified fractions from triticale flours 131, 385 and 204. The triticale flours followed a pattern shown by all classes of wheat flour when air classified; namely, fractions with particle sizes below 15 microns had increased values of protein. Fractions 1-3 showed significant increases in protein content over that of the original flour. The highest protein content (34.3%) was found in fraction 1 from triticale flour 204. The finer fractions also contained higher fat and ash, and this feature appeared to parallel the higher protein contents.

The individual starchy or low-protein fractions 4 through 7 varied in quantity from 12% to 23% and in protein content from 4.4% to 6.8%. The coarse residues had essentially the same composition as the parent flours.

Total protein shift is the sum of the protein shifted into the high-protein fractions and out of the low-protein fractions, expressed as percentage of total protein present in the flour, as described by Gracza (14). In Table 4, fractionation results from classifying the three triticale flours are compared to those of a rye and three different types of wheat. The greater ease of fractionation of triticale 204 compared to triticales 131 and 385 is reflected in: 1) larger protein shift, 2) broader

Table 3. Fine grinding and air classification of triticale flours (14% moisture basis)

	Straight Grade Flour	Air Classification Fraction 1	2	3	4	5	6	7	8 (Coarse residue)
Triticale 204									
Yield, %	100.00	10.7	8.0	6.4	22.8	14.0	16.8	11.7	9.6
Protein, %	12.70	34.3	28.4	20.7	6.7	4.8	4.4	5.6	13.3
Ash, %	0.57	1.2	0.9	0.7	0.5	0.5	0.4	0.5	0.5
Fat, %	0.69	1.6	1.1	0.9	0.4	0.3	0.3	0.3	0.4
Triticale 131									
Yield, %	100.00	7.9	7.2	6.6	22.9	13.6	16.3	11.8	13.7
Protein, %	10.20	27.6	22.2	15.5	5.9	5.0	4.7	6.8	12.8
Ash, %	0.58	1.3	1.0	0.7	0.5	0.4	0.4	0.4	0.4
Fat, %	0.60	1.8	1.2	1.0	0.5	0.4	0.3	0.4	0.5
Triticale 385									
Yield, %	100.00	7.1	6.0	5.4	21.2	13.6	16.8	12.6	17.3
Protein, %	10.40	30.2	24.3	17.4	6.5	5.2	5.1	6.8	12.4
Ash, %	0.58	1.7	1.2	0.8	0.4	0.3	0.3	0.3	0.4
Fat, %	0.50	1.6	1.2	1.0	0.5	0.4	0.4	0.4	0.5

range of protein contents among the eight classified fractions, 3) higher yield of combined protein fractions 1 through 3 with higher protein content, 4) higher yield of combined starchy fractions 4 through 7 with lower protein content, and 5) lower yield of coarse residue. Analysis of Table 4 suggests triticale 204 behaved most like the soft wheat while triticales 131 and 385 were apparently somewhat more vitreous and behaved in a manner intermediate between soft and hard wheats.

Table 4. Comparison of fractionation responses of reground flours from triticale, rye (1), and wheat (2,3,4) (expressed as percent on 14% moisture basis)

Sample	Triticale 204	Triticale 131	Triticale 385	Rye, Commercial Mix	Wheat: Hard Red Spring Selkirk	Wheat: Hard Red Winter Wichita	Wheat: Soft Red Winter Vermillion
Straight flour, protein	12.7	10.2	10.4	10.9	12.8	10.9	9.4
Maximum range of protein contents among eight classified fractions	34.3-4.4	27.6-4.7	30.2-5.1	21.5-6.2	23.7-7.6	29.4-5.5	26.7-2.3
Combined high-protein fractions 1-3							
Yield	25.1	21.7	18.5	25.8	18.8	21.0	29.4
Protein	29.0	22.1	24.5	19.8	19.4	24.4	21.4
Combined starchy fractions 4-7							
Yield	65.3	64.6	64.2	56.8	49.5	52.9	64.5
Protein	5.5	5.6	5.9	7.4	8.7	6.5	3.3
Coarse residue fraction 8							
Yield	9.6	13.7	17.3	17.4	31.7	26.1	6.1
Protein	13.3	12.8	12.4	9.6	14.2	9.8	6.2
Protein shifted, total	73.0	58.0	56.0	41.0	29.0	50.0	82.0

Classes and Composition of Proteins in Flour and Air-Classified Fractions. Both quantity and type of proteins affect grain structure and functional properties of flours. Table 5 compares the amounts of the different classes of proteins in flours from several grains. The data are a composite of results obtained at the Northern Laboratory by different isolation methods. Grains listed in Table 5 are arranged so that those that produce the strongest doughs and yield the toughest glutens appear at the top. The strong wheats yield the least quantities of albumins and globulins and the greater amounts of glutenins and acetic acid-insoluble proteins. In contrast, triticale and rye, which form weak glutens, have protein containing a high level of salt solubles, small amounts of gliadin component, and little acetic acid insoluble protein. The high levels of water soluble proteins (albumins and globulins) in rye and triticale contribute strongly to lysine content and result in overall nutritional protein qualities superior to wheat (15).

Table 5. Distribution of protein classes in wheats and other grains based on gel filtration separation

Type	Variety	Flour Protein (N X 5.7), %	Acetic Acid Soluble: Albumins and Globulins	Acetic Acid Soluble: Gliadin	Acetic Acid Soluble: Glutenins	Acetic Acid Insoluble
			Percent of Flour Protein			
Hard red spring semidwarf	Red River 68	12.7	12	25	25	33
Hard red winter	Ponca	10.7	15	29	27	22
Soft white winter	Brevor	9.5	17	26	24	25
Durum	Lakota	15.4	15	33	20	23
Triticale	FasGro 204	12.7	25	22	25	19
Rye	---	10.9	35	15	20	20

Amino acid patterns were determined for triticale 204 flour, and for the eight fractions after fine grinding and air classification (Table 6). The data show that lysine and leucine contents decrease from the finest fraction to coarse residue while methionine and phenylalanine increase. Contents of the other essential amino acids vary somewhat from fraction to fraction but show no particular trends. The higher values for lysine in finer fractions are probably due to a concentration of albumins and globulins.

Table 6. Amino acids in air-classified triticale 204 flour fractions (g. amino acid per 16 g. nitrogen)

Amino Acid	Parent Flour	Fraction 1	2	3	4	5	6	7	8
Lysine	2.5	2.6	2.3	2.5	2.3	2.4	2.3	2.2	1.9
Histidine	2.2	2.2	2.1	2.1	2.1	1.9	2.0	2.0	2.0
Ammonia	3.6	3.8	4.0	4.1	4.0	4.2	4.3	4.1	4.2
Arginine	3.9	3.9	4.1	4.1	3.8	3.5	3.7	4.2	3.4
Aspartic	4.9	4.4	4.1	5.6	5.3	5.8	5.6	5.2	4.1
Threonine	2.8	2.8	2.9	2.6	2.8	2.7	2.8	2.8	2.7
Serine	4.7	4.8	4.8	4.5	4.6	4.6	4.6	4.7	4.7
Glutamic	33.3	33.9	32.5	32.3	31.9	33.7	31.8	33.6	34.8
Proline	11.5	12.2	11.2	11.4	12.6	12.0	10.8	11.4	11.1
Glycine	3.6	3.6	3.4	3.5	3.4	3.7	3.5	3.5	3.3
Alanine	3.2	3.1	3.0	3.1	3.2	3.3	3.2	3.1	2.9
Valine	4.4	4.2	4.5	4.0	4.3	4.1	4.3	4.3	4.2
Methionine	1.4	1.3	1.1	1.2	1.6	1.2	1.5	1.7	1.6
Isoleucine	3.5	3.5	3.5	3.2	3.9	3.3	3.6	3.6	3.6
Leucine	6.9	7.0	6.4	6.5	6.3	6.7	6.3	6.4	6.4
Tyrosine	3.0	3.0	3.6	2.8	3.1	2.8	3.1	3.1	4.0
Phenylalanine	4.9	4.7	5.7	4.5	4.9	4.6	4.8	4.9	5.8

Wet Milling of Triticale 204 Flour. The proteins of cereals influence not only baking properties of flour but also milling characteristics and the nature of milled products. With growing interest both domestically and abroad in protein concentrates for food uses and with increasing use of starch for food and industrial applications, considerable attention has been directed to wheat and related grains as possible raw material sources. Triticale with its higher protein content is a potential source of gluten, and we investigated the isolation of triticale gluten by wet milling of flour.

A Martin-type process on a laboratory scale was used. The flour was kneaded to yield a dough ball which was washed to remove the starch. Since triticale yielded a soft, weak gluten ball, the dough could be worked only with care. Results of wet processing of triticale 204 are given in Table 7 and are compared with earlier reported (16) yields and characteristics of products from wheat flours. Yields of gluten and starch were comparable to those from wheat. Solids present in the process waters were 10% of the flour. These soluble solids contained 26% protein (MFB) and, if dried, have potential in foods, feeds, fermentation media or as a source of water-soluble proteins (albumins and globulins).

Table 7. Yields and analyses of wet-milled fractions from various flours (expressed as percent on moisture-free basis). Martin-type process.

Item	Triticale 204	Soft Winter Wheat	Hard Red Spring Wheat
Flour protein	14.7	14.2	16.4
Gluten yield from flour	17.0	14.0	17.8
Protein in gluten	70.0	80.0	78.0
Flour protein recovered in gluten	81.0	80.0	84.0
Lysine in gluten protein	2.3	1.9	1.6
Starch yield	69.0	71.0	70.0
Protein in starch	0.4	0.4	0.3

Amino acid analyses of triticale gluten, its parent flour, and grain are compared in Table 8. The leaching of water-soluble proteins from gluten during wet processing of the flour decreased lysine, valine and leucine but increased cystine, methionine, tyrosine and phenylalanine. Even though lysine content was lower in the gluten than in the parent flour or grain, it still is superior to the amount of lysine in wheat gluten. Triticale gluten also has a higher methionine content than wheat gluten, is softer in character, and possesses a bland flavor. These properties of triticale gluten offer interesting opportunities for its use in food. Growing requirements for fat emulsifiers, water-absorbing, and component-binding agents in prepared foods, and for nutritive supplements offer potential markets for use of glutens from triticale.

Further encouragement for industrial wet milling of triticale flours is based on the rather high yield, 69%, of low-protein starch (Table 7). The higher yields of grain claimed for triticale crops compared to those of wheat could result in a lower cost for triticale starch.

Table 8. Amino acid analysis of triticale 204 grain, flour, and gluten extracted from flour (g. amino acid per 16 g. nitrogen)

Amino Acid	Whole Grain	Flour	Gluten	Amino Acid	Whole Grain	Flour	Gluten
Lysine	3.3	2.5	2.3	Glycine	4.3	3.6	3.2
Histidine	2.3	2.2	2.4	Alanine	3.9	3.2	3.3
Ammonia	3.8	3.6	4.6	1/2 Cystine	1.1	1.4	1.6
Arginine	5.6	3.9	4.0	Valine	4.8	4.4	4.0
Aspartic	6.5	4.9	4.3	Methionine	1.2	1.4	1.5
Threonine	2.9	2.8	2.7	Isoleucine	3.6	3.5	3.4
Serine	4.7	4.7	4.6	Leucine	7.3	6.9	6.1
Glutamic	32.0	33.3	34.0	Tyrosine	2.8	3.0	3.9
Proline	9.5	11.5	11.8	Phenylalanine	4.6	4.9	6.4

Viscosity properties of triticale starch are compared to those of wheat and corn in Table 9.

Table 9. Amylograph viscosity patterns for triticale 204 starch and other starches

Starch	Pasting Temperature °C.	Brabender Units			
		Peak Viscosity	Viscosity at 95°C.	Viscosity After Hold at 95°C.	Cold Paste Viscosity, 50°C.
Triticale 204	63	790	780	650	1230
Wheat	64	740	670	570	1000
Corn	68	1090	960	750	1470

Triticale starch had a slightly lower pasting temperature than either wheat or corn. The other viscosity characteristics of triticale starch fell between those of wheat and corn. From the standpoint of viscosity, it would appear that triticale starch could be used in similar manner to that of corn starch. Other workers have shown that triticale starch posses chemical and physical properties somewhat like those of its parents (17, 18) and should therefore be suitable for many current starch applications that the parents are.

Wet Milling of Whole Kernel Triticale. Triticale grain (204) was wet milled (19) in the laboratory. Grain was steeped in 0.3% sulfurous acid for 24 hr. at 100°F. then processed by milling, screening, and tabling. No particular problems were encountered; steeped grain was soft and ground quite readily. Coarse and fine fiber fractions, which also included the germ, were washed essentially free of starch with little difficulty. They contained less than 12% of starch after routine washing. Starch-gluten separation was typical of that encountered in wet milling wheat (Table 10).

Table 10. Comparison of starch recovery and analysis from conventional wet milling of triticale, wheat (19) and corn (20) (expressed as percent on moisture-free basis)

Starch	Triticale 204	Hard Red Spring Wheat	Soft White Winter Wheat	Corn
In whole grain	58.2	60.3	67.4	73.8
Processing data:				
Yield	41.2	38.9	50.5	65.4
Recovery[1/]	70.6	64.5	73.2	87.9
Protein content	0.27	0.27	0.24	0.5

[1/] Based on starch present in grain.

Yield of starch from triticale was 41.2%, similar to that from hard wheats. Soft wheat will generally yield more starch. Starch recovery (which is a measure of the ease of starch-gluten separation) was 70.6% in the triticale similar to that from wheat milling, but considerably less than that from corn milling. Purity of starch with respect to protein was excellent.

Conclusions. Triticale grain can be readily dry milled into flour, which can be further milled and air classified into fractions with desirable physical and chemical properties. Starch and gluten can also be recovered from triticale grain or flour by conventional wet processing. Triticale is a good potential source of protein-rich supplements for food products, as well as a source of flour and starch fractions for food, feed, and industrial applications.

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