COMPOSITION OF THE COMPONENT PARTS OF TWO HYBRID HIGH-AMYLOSE CORNS[1]

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ABSTRACT

A chemical analysis of the component parts — endosperm, germ, and bran — of two potentially industrial high-amylose corn hybrids and ordinary dent corn revealed several significant differences. Samples of 57- and 67%-amylose corns had more protein and oil and less starch than ordinary corn. The quantity of endosperm from the high-amylose corns was less than from the ordinary corn, and their protein and fat contents were greater, while their starch contents were less. No outstanding differences were noted in the composition of the germ fractions. More bran was obtained from the two high-amylose corns, and their protein and fat contents were somewhat greater than noted in ordinary corn bran.

As the high-amylose corn breeding program progresses, it is believed that by breeding, the quantity and composition of the component parts of high-amylose corn will become more like those of ordinary dent corn.

High-amylose corn, once an oddity of the plant breeder, is now an item of commerce. For the past ten years or more, corn breeders have been studying the effect of different genetic combinations on the carbohydrate contents of corn, to find a combination of genes that give corn with starch of high amylose content. A number of publications report attainment of apparent amylose contents (measured by iodine affinity) as high as 80% in the starch of samples from genetic studies, but more generally in the 50 to 65% range for hybrids (5,9,11). In 1958 semicommercial plantings of a double-cross hybrid corn with starch containing 57% apparent amylose were processed by the corn refining industry, and several hundred thousand pounds of starch was either sold or evaluated commercially for its potential applications (4). The next year an experimental planting of a single-cross hybrid corn with starch of 67% apparent amylose resulted in a corn with improved milling characteristics (3).

Pilot-plant wet-milling evaluations of these two hybrid corns have been previously reported (2,3). An analysis has been made of the component parts of the two corns to aid in their economic evaluation. Such analytical work had previously been done on ordinary corn and grain sorghum (6,7). More recently, Zuber *et al.* investigated the relationship

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between amylose content and other components of the inbred high-amylose corn kernel (10).

The two high-amylose corns analyzed were selected primarily because of their semicommercial quality and the industrial interest shown in them. These analytical results should assist plant breeders, industrial processors, and researchers concerned with high-amylose corn and starch.

Materials and Methods

The corn was hand-separated into its component parts – endosperm, bran, and germ – by procedures previously described (6,7). Bran and germ samples were ground in a laboratory Wiley mill with a 20-mesh screen, and endosperm and whole corn samples were ground through a 60-mesh screen. Protein, ash, crude fat, starch, crude fiber, and moisture determinations were carried out essentially as given in *Cereal Laboratory Methods* (1). Pentosans were determined by the TAPPI method, Standard T450 M-44 (8).

Discussion

The chemical composition of the corn samples is shown in Table I. These high-amylose corns contained more protein and fat, but less

TABLE I
COMPOSITION OF THE WHOLE GRAIN
(Moisture-free basis)

Chemical Component	Corn Type		
	Ordinary[a]	57% Amylose Content	67% Amylose Content
	%	%	%
Ash	1.44	1.61	1.60
Protein	10.3	13.9	11.3
Crude fat	4.8	7.1	5.2
Starch	71.5	62.7	66.4
Crude fiber	...	2.54	1.93
Pentosans	...	7.53	6.97

[a] Average of eleven different corn varieties (6).

starch, than did ordinary varieties. This relationship has been noted in most high-amylose corn samples examined. Both from a processing and an economic standpoint, it would be desirable for high-amylose corn to have a starch content as high as that of ordinary dent corn. Plant breeders believe that this relationship can be achieved by further breeding studies as soon as the desired amylose content is attained. On this basis, then, when the starch content of high-amylose corn is in-

creased, the amount of protein and fat should correspondingly decrease, probably to a figure in the range of protein and fat present in ordinary corn.

Physical distribution and chemical compositions of fractions of the three corn samples are given in Table II. The proportion of endosperm

TABLE II
COMPOSITION OF CORN FRACTIONS
(Moisture-free basis)

	Endosperm			Germ			Bran		
	Ord. Corn [a]	57% Amylose	67% Amylose	Ord. Corn [a]	57% Amylose	67% Amylose	Ord. Corn [a]	57% Amylose [b]	67% Amylose [b]
	%	%	%	%	%	%	%	%	%
Proportion of whole grain	81.9	76.5	78.9	11.9	14.2	13.1	5.3	9.2	8.0
Ash	0.31	0.42	0.40	10.1	8.98	9.08	0.84	1.11	1.31
Protein	9.4	12.2	10.4	18.8	17.2	19.0	3.7	6.2	7.3
Crude fat	0.8	1.70	0.93	34.5	36.1	28.9	1.0	3.92	4.36
Starch	86.4	80.0	82.3	8.2	9.52	12.5	7.3	4.02	4.03
Crude fiber	...	0.98	0.95	...	3.61	3.72	...	18.7	17.3
Pentosans	...	3.16	...	...	11.3	...	...	32.5	...

[a] Average of eleven different corn varieties (6).
[b] Tip cap included in bran fraction. (In ordinary corn the tip cap amounts to about 0.8% of the whole grain; see ref. 6.)

in the two high-amylose corn samples was somewhat less than in the ordinary corn, whereas the proportion of germ and bran was greater. These differences would be expected from an examination of the analysis of the whole grain (Table I). The endosperm fraction represented 76.5% of the 57%-amylose corn, 78.9% of the 67% material, and 81.9% of ordinary corn. The major differences in the chemical compositions of the three endosperm fractions were an increase in the protein and crude fat content of the high-amylose corns, and a lesser quantity of starch in them. The smaller quantity of starch, of course, is primarily responsible for lower recoveries from high-amylose corns by the wet-milling procedure. The higher protein and fat contents of the high-amylose corn endosperm may possibly be a factor in the difficulties experienced in starch-gluten separation (2). The 67%-amylose corn had better processing characteristics than did the 57% material (3). This improvement in milling might be expected, for there was more endosperm present in the 67%. Also this endosperm contained less protein and fat than did the 57%. The data also indicate that the percentages of endosperm and of starch are not necessarily correlated with the amylose content of the endosperm.

The amount of germ separated from the two high-amylose corns ranged from 10 to 20% higher than that from the ordinary corn (1 to 2 percentage points). There were no outstanding differences noted in chemical composition of any germ fraction, except that the crude fat content of the germ from the 67%-amylose corn was somewhat less than that from either 57%-amylose corn or ordinary corn.

Bran fractions of the high-amylose corns were considerably greater in quantity than those from the ordinary corn. Compared to ordinary corn, almost twice as much bran was separated from the 57% material; the 67%-amylose corn had about 1½ times as much bran as ordinary corn. The ash, protein, and crude fat content of the brans from the two high-amylose corns were greater, and the starch content less, than that in bran from ordinary corn. Possibly breeding might reduce the quantity of bran in high-amylose corn and thereby improve yields of the more valuable fractions.

Inasmuch as analytical data were not available for the crude fiber and pentosans in all eleven ordinary corn samples used and their fractions, comparisons with similar analyses of the two high-amylose corns could not be made. The tables show that in the values of these constituents there are no great differences between the two high-amylose corn samples or their fractions.

Although the particular high-amylose corn hybrids studied are not the end product of plant breeders' efforts, analyses of these and of their component fractions provide information that aids engineering and economic evaluation of this new raw material in the mill. A basis is thus established on which to estimate the cost of further treatment and/or modification of any products of milling. Such information also guides plant geneticists in determining quality factors which should be modified to improve industrial applicability of this new corn.

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