CORN QUALITY PATTERNS IN U.S. MARKETS

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ABSTRACT. *Data on U.S. corn quality were summarized by geographic region and market location. There were significant variations in composition (protein, oil, starch) within and across regions. Intraregional composition differences are economically significant at the first handler level, but one uncontrolled commingling will eliminate any usable differences. Physical quality, as measured by U.S. grade factors, did not show regional patterns.*

Corn breakage [Broken Corn Foreign Material (BCFM)] increases steadily through the market chain, beginning at about 1% at harvest. The data showed a 0.5% BCFM increase per transfer to be a reasonable estimate. Breakage susceptibility does not change after its initial value set by harvesting and drying practices. Changes in particle-size grade factors will not provide incentives to change practices that increase breakage susceptibility.

Keywords. *Corn, Grades and standards, End-use value, Breakage, Protein, Composition.*

Interest in improving the image of U.S. corn in world markets has led to calls for changing U.S. corn grades. The primary interest has been in the Broken Corn Foreign Material (BCFM) factor because corn consistently breaks as it moves through market channels. One industry group, the Grain Quality Workshop, proposed separating this factor into two factors, broken corn and foreign material (NAEGA, 1986). The Federal Grain Inspection Service (FGIS) established definitional standards for BC versus FM (FGIS, 1990), but has awaited economic evaluation to propose formal changes to the grades. More long-term interest has included intrinsic composition factors such as protein, oil, and starch contents.

Broken kernels are defined as material passing through a 4.8-mm (12/64-in.) round-hole sieve, but not through a 2.4-mm (6/64-in.) sieve. Foreign material is the material passing through the 2.4-mm (6/64-in.) sieve (fine foreign material, FFM) plus the coarse nongrain material handpicked from atop the 4.8-mm (12/64-in.) sieve. This latter material is also referred to as coarse foreign material (CFM). Thus, FM = FFM + CFM and BCFM = BC + FM. The BCFM is still the grade determining factor, although any of the others can be listed on official certificates by request of either trading party.

Historically, there have been several screen sizes proposed for BC [from 6.4 mm (16/64 in.) down to (10/64 in.)] (Hill and Bender, 1992). Likewise, at least two sizes [3.2 and 2.4 mm (8/64 and 6/64 in.)] have been proposed for FM (NAEGA, 1986). The choice of sieve size will obviously change the percentages of material classified as BC and FM, although the relative mix of sizes remains constant over BCFM percentages and market locations (Meinders and Hurburgh, 1992a).

Changes in grain standards have the potential to create regionally or locationally disproportionate consequences. For BCFM standards, some regions could experience greater discounts or be forced to remove more screenings. No regional profile of corn quality is presently available.

Should the burden of changes fall on certain handlers preferentially over others, then these handlers will be forced to absorb costs they cannot pass directly forward or backward. The consequences would be increases in fees or margins unrelated to the particle size factors, and no incentives to prevent the breakage problem.

Handlers certainly believe that BCFM changes will not affect all of them uniformly. In an industry survey, Hill et al. (1991a) reported that nearly 50% of country elevator managers favored change, whereas about 65% of other interior elevator managers (river, subterminal, terminal) opposed change. In a different survey, export elevator managers opposed to change slightly outnumbered proponents (38 to 33%) (Hill et al., 1991b). Farmers showed opposition (60 to 40%) to changing the BCFM factor (Hill et al., 1991c). These mixed and conflicting opinions reflect uncertainty about where the burden of change will fall.

In essence, the U.S. market has three options for reducing broken corn levels as received by users—domestic or foreign.

- More corn can be cleaned more often.
- Corn can be handled fewer times or less abusively.
- Corn handling and drying operations can be modified to resist breakage.

These options are not mutually exclusive, and none are dependent on grade changes, only on market willingness to provide more incentives for cleanliness. More cleaning, by definition, means new expenses to offset. Fewer handlings

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are cheaper but may work against transportation economics. Breakage resistance is primarily determined by harvesting and drying—operations controlled by farmers and first-handlers.

The intrinsic composition factors are of demonstrated economic significance to end users (Hurburgh, 1990). The composition factors can be measured efficiently with near-infrared technology (Norris and Williams, 1987; Hurburgh, 1988). Genetics and growing environment are the primary factors influencing composition, which has stimulated many recent genetic developments in "value-added grains" (Wheat and Wilson, 1991). Iowa State University routinely publishes composition data in its genetic performance trials (Zeigler, 1992), and in 1992 initiated a special performance test exclusively for corn hybrids designed for a particular end-use. As with physical factors (those in the Grades), regional variations in composition factors will affect market response to their use as pricing criteria.

Insight into market reactions can be gained by compiling 1) a regional profile of corn quality and 2) a market-locational profile of corn quality. Considerable data is available to develop these profiles, but the data have not been organized for application to economic impact studies.

OBJECTIVES

The objectives of this analyses were to:

- Identify regional patterns in physical and compositional grain quality factors.
- Summarize and interpret reports of corn physical quality by market location.
- Compose a profile of corn quality changes as corn moves through the U.S. marketing network.

MATERIALS AND METHODS

The FGIS, from 1987 through 1989, reported new-crop quality by state (FGIS, 1987, 1988, 1989). This compilation included all official grade factors. Hurburgh (1990) reported intrinsic corn quality by state, in the years 1987 through 1989. Other sources have reported quality changes, particularly in particle-size factors and breakage susceptibility. Data from all sources were compiled by state and region. Regions were defined as:

Western Corn Belt (WCB):	Iowa, Kans., Minn., Mo., N.D., Nebr., S.D.
Eastern Corn Belt (ECB):	Ill., Ind., Mich., Ohio, Wis.
Midsouth (MDS):	Ark., Ky., La., Miss., Okla., Tenn., Tex.
Southeast (SE):	Ala., Fla., Ga., N.C., S.C.
East Coast (EC):	Del., Md., N.J., Pa., Va.

Where possible, market location was identified. The composition data represented only two regions because these regions were the sources of the annual USDA production survey samples used for analysis.

In the data used for this analysis, the following methods, with associated references, were used:

U.S. Grade factors:	Official procedures (FGIS, 1990)
Composition:	Near-infrared spectroscopy (protein, oil, starch) (Norris and Williams, 1987)
Breakage susceptibility:	Wisconsin Breakage tester and Stein breakage tester (Watson and Herum, 1986)

RESULTS AND DISCUSSION

Tables 1 and 2 give the regional distribution of intrinsic and physical corn quality, respectively. All years were averaged. Weighting was done by sample numbers within a year and arithmetically across years. There was some variation in quality across years, as shown in table 3. The intrinsic qualities varied more on an annual basis than did the physical quality represented in the grades.

The regional variation in quality was, interestingly, not large. Northern states had 0.2 to 0.4% higher protein than the average. There was little difference in hardness or genetic breakage resistance properties by region. Eastern locations had higher BCFM and lower test weight in the FGIS data. This probably is attributable to greater harvest moisture and thus to more artificial drying. Nearly any quality level can be found in all regions. The current Standards measure soundness, which can be maintained by handlers everywhere. Until recently, the Standards were never intended to be more than a gauge to monitor physical quality in shipment and handling.

The range in the composition factors is economically significant. One percentage point (of any of the three factors) has a theoretical impact of 6 to 12¢/bu. The samples described in tables 1 and 2 were collected from individual fields, which caused the maximum possible variation. Although the composition of corn lots will not change after harvest, uncontrolled commingling will automatically reduce variations. The usual formulation for standard error of a mean can be used to estimate the reduction in variability from blending.

For example, assume 100,000-bushel storage bins filled with 225- to 450-bushel loads. The standard deviation among bin means (for protein) would be the standard deviation (0.75% points) divided by the square root of the estimated number of loads, 0.75/15 = 0.05 percentage points. If grain is not segregated by intrinsic factors when first delivered, variations will be reduced to overall regional differences, which usually are not large.

The breakage susceptibility data reported in table 1 are genetic breakage susceptibility. The samples for this data were hand-harvested, air-dried, then mechanically shelled. Harvesting and drying stress will magnify these values in market channels.

A review of published BCFM and breakage susceptibility data is given by market location in table 4. Varying breakage susceptibility methodologies make direct comparison difficult. An increase in BCFM entry was made if the data source gave information about successive handlings.

The progressive increase in BCFM is evident. The reason that few country elevators measure BCFM (Hill et al., 1991c) is that there is rarely enough BCFM to create discounts in excess of testing cost, with a 3.0% allowance. There would be even less FM if FM was determined separately. The Meinders-Hurburgh (1992a) equation would predict about 0.2% FM (20% of BCFM) in country elevator receipts if the 2.4-mm (6/64-in.) screen is used to define FM. If the 8/64 screen is used, there would be about 0.3 to 0.4% FM (35% of BCFM) in country

Table 1. Intrinsic quality* of U.S. corn in two regions, 1987-1989 crops (Hurburgh, 1990)

		n						Test Weight	Breakage Susceptibility
Region	State	1987	1988	1989	Protein (%)	Oil (%)	Starch (%)	(lb/bu)	(%)
WCB†	Iowa	185	211	195	8.0	3.4	60.3	55.6	4.0
	Minn.	151	152	163	8.1	3.5	60.1	55.5	4.1
	Mo.	104	101	111	8.1	3.5	60.3	56.1	3.8
	Nebr.	181	196	175	7.8	3.4	60.0	56.2	3.8
	S.D.	106	83	83	8.3	3.4	59.9	55.2	4.0
	Avg. WCB		2197		8.02	3.44	60.13	55.74	3.94
	Range				(5.5-10.9)	(2.3-5.2)	(56.4-62.8)	(48.0-61.6)	(0.1-19.8)
	Std. dev.				0.72	0.30	0.82	2.36	1.39
ECB†	Ill.	224	191	198	7.9	3.4	59.9	56.8	4.2
	Ind/	171	160	145	7.7	3.4	59.9	57.0	4.3
	Mich.	71	79	71	7.9	3.4	59.6	55.3	4.1
	Ohio	150	136	132	7.7	3.4	59.9	56.2	4.3
	Wis.	115	65	107	8.2	3.4	59.7	55.9	4.0
	Avg. ECB		2015		7.84	3.41	59.84	56.44	4.24
	Range				(4.8-10.5)	(2.2-5.5)	(55.8-64.2)	(48.1-61.7)	(0.5-9.9)
	Std. dev.				0.85	0.31	0.88	2.26	1.40
USA			4213		7.94	3.42	60.00	56.08	4.09
	Std. dev.				0.79	0.31	0.86	2.34	1.40
Average standard deviation within a state in a year					0.66	0.27	0.78	2.26	1.21
LSD‡ between states					0.1	0.1	0.2	0.5	0.2

* Basis 15.5% moisture, determined by analysis of samples provided by USDA from U.S. production surveys.
† WCB = Western Corn Belt; ECB = Eastern Corn Belt.
‡ Least significant difference (P = 0.05).

elevator receipts. At zero value (deductible) this would be about 0.5 to 1.0¢/ bu discount, with either a test required on every load or an implicit penalty of 0.5 to 1.0¢ included in the basis. It is not likely that these discounts would induce farmer action, although they certainly would create controversy. A reduction of 0.5% BCFM at the farm level would be unnoticeable at export destination.

The reported BCFM increases are consistent with trade estimates of a 0.5% BCFM increase per handling. In controlled tests at elevators, Converse and Eckhoff (1989) and Martin and Stephens (1977) reported a consistent BCFM increase of 0.6% per transfer. Herum and Hamdy (1981) reported a 0.4% increase per transfer at a small feed-mill elevator. There are two points to make:

1. The 0.5% per transfer estimate is an acceptable number to use for analysis.
2. BCFM increase per transfer is constant over repeated transfers in a given facility.

Several sources referenced in table 4 reported higher rates of increase in BCFM from the transfer after the export inspection (shiploading) and from destination handlings by pneumatic systems. Shiploading is acknowledged to be the roughest handling received by corn, partly because of high flow rates/long free falls and partly because the stevedoring crew has no incentive to protect the corn after the final inspection has occurred.

The importance of breakage susceptibility has been long recognized. Whereas Eckhoff (1989) reported that no breakage tester produced the same particle-size mix as actual handling breakage, breakage tester results have generally correlated well (r > 0.8) with handling breakage (Stephens and Foster, 1976; Herum and Hamdy, 1981; Eckhoff et al., 1987). The Stein test produced a more linear relationship between breakage susceptibility and breakage.

The causes of breakage susceptibility are operations at the farm or first-handler level, genetic selection, drying rate (as represented by kernel temperature in drying), and harvest stress. These operations produce internal-stress cracks. Corn progressively breaks along the crack lines with each handling. Thus, the amount of actual breakage is proportional to both the breakage susceptibility and the roughness of the handling. Either one alone will not predict BCFM generation. Instances of low correlation between BCFM level and breakage susceptibility have been reported (Hill et al., 1991b; Paulsen and Hill, 1977), but this is explained by the diversity of handling procedures that the various samples had received. When the handling procedure was constant and controlled, the correlations were greater than 0.9. (Eckhoff, 1989).

Breakage susceptibility is not a generic estimator of future BCFM levels, but, for an individual handler running corn through a specific flow path, a breakage susceptibility estimate can be very useful in predicting future quality. Because breakage susceptibility measurement is inherently variable (CV = 10 to 15%; Watson and Herum, 1986), a classification only (e.g., high, medium, low; 1, 2, 3, 4) probably is acceptable. The classification approach would alleviate the need for precise moisture content corrections and would prevent "overtrading" of data to a precision greater than the test is capable of giving.

Eckhoff(1989) and Hurburgh (1991) analyzed the sources of breakage susceptibility and technical reports about them. Figure 1 shows a simplified synopsis of the combinatorial effect of operations contributing to breakage

Table 2. U.S. grade factors for corn, by region (1987-1989) (FGIS, 1987, 1988, 1989)

Region	State	Samples (87-88-89) (No.)	U.S. Production (%)	Test Wt (lb/bu)	BCFM (%)	DKT* (%)	Grade Distribution (% by 1-2-3-4-5-S)
WCB	Iowa	838-597-387	18.7	57.5	1.8	4.1	44-28-12-7-5-3
	Kans.	124-98-31	2.3	57.6	2.4	2.4	41-25-13-8-5-5
	Minn.	15-31-5	8.5	54.9	3.0	8.9	11-16-22-14-16-22
	Mo.	41-45-11	3.1	57.2	2.0	7.7	31-37-8-~3-16
	Nebr.	264-234-362	12.7	58.1	1.7	4.3	58-21-8-~4-5
	N.D.	0-9-5	0.5	-	-	-	56-11-0-0-0-33
	S.D.	0-0-1	2.7	-	-	-	-
Averages		1282-1014-802	48.5	57.2	2.0	5.3	41-24-13-7-7-8
ECB	Ill.	447-122-665	16.5	57.2	2.4	2.8	41-38-10-5-6-0
	Ind.	0-0-0	9.0	-	-	-	-
	Mich.	0-0-0	2.7	-	-	-	-
	Ohio	393-190-121	3.8	56.0	2.2	5.9	53-31-9-2-2-3
	Wis.	143-44-0	3.1	57.1	1.6	3.2	62-26-8-3-1-1
Averages		983-356-786	35.1	57.0	2.3	3.4	48-35-10-3-3-1
MDS	Ark.	0-0-0	0.1	-	-	-	-
	Ky.	27-14-24	1.7	57.3	3.7	8.8	66-18-5-3-3-5
	La.	0-0-15	0.2	55.7	2.2	2.9	6-44-33-6-11-0
	Miss.	0-0-1	0.2	-	-	-	-
	Okla.	4-6-28	0.1	58.3	2.0	3.3	39-32-16-11-0-3
	Tenn.	35-23-34	0.8	57.8	1.8	1.2	45-47-4-1-1-1
	Tex.	261-180-150	2.1	57.1	3.2	4.3	23-33-18-10-9-6
Averages		327-223-252	5.2	57.3	3.1	5.3	41-31-12-6-6-4
SE	Ala.	220-23-212	0.2	54.4	2.9	8.0	18-27-22-15-6-5
	Fla.	0-0-0	0.1	-	-	-	-
	Ga.	0-1-7	0.7	57.2	1.9	2.5	38-50-12-0-0-0
	N.C.	0-34-13	1.2	56.8	3.0	2.7	17-37-26-15~0
	S.C.	0-0-0	0.4	-	-	-	-
Averages		220-58-232	2.6	56.7	2.6	3.2	24-40-21-10-3-2
EC	Del.	0-0-0	0.2	-	-	-	-
	Md.	0-7-0	0.5	-	-	-	0-14-0-14-43-29
	N.J.	0-0-0	0.0	-	-	-	-
	Pa.	0-0-0	1.3	-	-	-	-
	Va.	31-15-22	0.4	57.1	2.4	3.2	36-36-12-7-5-4
Averages		31-22-22	2.4	57.1	2.4	3.2	18-25-6-11-24-16
Others		490-688-588	6.2	57.1	1.6	2.2	62-24-8-3-2-2
USA		3336-2361-2676	100.0	57.1	2.1	4.8	43-28-12-6-6-5

* Total damage.

susceptibility. The moisture level, for any combination of operations, will also change breakage susceptibility. The following exponential relationship was developed by Dutta (1986) and has been supported by other work (Eckhoff, 1989).

$$\frac{B_f}{B_o} = (1.40)^{M_o - M_f} \qquad (1)$$

where

B_o, B_f = initial, final breakage susceptibility (% by Stein or WBT)

M_o, M_f = initial, final moisture content (% wet basis)

This equation predicts the relative change (increase or decrease) in breakage susceptibility caused by small changes in moisture content. It is assumed that the drying procedure itself is not increasing stress cracks (e.g., using routine stored grain aeration). Thus, this correction is applicable after whatever drying procedure is used or to natural-air drying. The primary value of equation 1 is to correct breakage susceptibility data to a common basis of comparison (or pricing).

Figure 2 shows the consequences of progressive breakage per handling at a linear rate. If the rate is the usual 0.5% BCFM increase per handling, then several cleanings are required to achieve no more than 4% BCFM at export. Assuming that breakage rate is directly proportional to breakage susceptibility, the 0.25% line shows the advantage to be gained if breakage susceptibility

Table 3. Quality of U.S. corn at interior inspection locations, by year

Property	1987	1988	1989
Protein (%)*†	8.3	8.0	7.6
Oil(%)*†	3.3	3.6	3.5
Starch(%)*†	59.8	60.2	60.1
Breakage susceptibility(%)*†	3.9	4.3	4.2
Test weight (lb/bu)			
From ISU data*†	56.1	56.1	56.0
From FGIS data‡	57.5	57.3	56.7
BCFM (%)‡	1.8	2.1	2.0
Total Damage (%)‡	4.3	3.5	3.2

* Basis 15.5% moisture.
† Intrinsic property (Hurburgh, 1990).
‡ U.S. grade factors (FGIS, 1987, 1988, 1989).

Table 4. Corn breakage and breakage susceptibility reports

Market Location	Reference	BCFM (%)	Breakage Susceptibility (%) Method	Breakage Susceptibility (%) Average	BCFM Increase /Handling (% pts)
At harvest	Feldmann, 1992	1.0	-	-	-
	Hill et al., 1982	1.2	-	-	-
	Pierce and Hanna, 1985 (19%M)	0.3	Stein*	15	-
	Pierce and Hanna, 1985 (24%M)	0.6	Stein*	20	-
	Hurburgh and Moechnig, 1984	1.0	Stein†	8	-
	Hurburgh et al., 1983	0.5	-	-	-
	Pierce et al., 1991	1.9	Stein*	12	-
	Hurburgh, 1987	0.7	WBT‡	13	-
	Hurburgh, 1984	0.7	WBT‡	14	-
		0.9			
Into storage (on farm or at country elevator)	Pierce and Hanna, 1985 (19%M)	1.1	Stein*	25	0.8
	Pierce and Hanna, 1985 (24%M)	1.2	Stein*	40	0.6
	Hurburgh and Moechnig, 1984	1.7	Stein†	32	0.7
	Hurburgh et al., 1983	0.7	-	-	0.2
	Pierce et al., 1991	-	Stein*	33	-
	Iowa Devel. Commission, 1977	1.4	-	-	-
		1.2			0.6
Shipments from country elevators	Hill et al., 1982	1.8	-	-	-
	Paulsen and Hill, 1977	1.2	Stein§	25	0.6
	Hurburgh and Bern, 1983	2.6	-	-	-
	Meinders and Hurburgh, 1992	3.1	-	-	-
	Iowa Devel. Commission, 1977	2.0	-	-	-
	Hurburgh, 1986	2.1	-	-	-
		2.0			0.6
Shipments from country elevators	Hill et al., 1982	2.6	-	-	-
	Paulsen and Hill, 1977	1.8	Stein§	26	0.6
	Hill et al., 1990	3.1	WBT‖	17	-
	Iowa Devel. Commission, 1977	2.1	-	-	0.7
		2.4			0.7
Shipments from export elevators	Paulsen and Hill, 1977	2.7	Stein§	27	0.9
	Hill et al., 1990	3.8	WBT‖	17	0.7
	FGIS, 1991	3.8	-	-	-
	Iowa Devel. Commission, 1977	3.2	-	-	0.3
		3.4			0.5

* Conditioned to 11.5 to 12.0% moisture, 4.8-mm (12/64-in.) screen.
† Conditioned to 12.8% moisture, 4.8-mm (12/64-in.) screen.
‡ Conditioned to 12.8% moisture, 4.8-mm (12/64-in.) screen.
§ As-is moisture, 4.8-mm (12/64-in.) screen.
‖ As-is moisture, 6.4-mm (16/64-in.) screen.

were cut in half. Corn with 1% BCFM at the farm (the average of table 4) could be exported without cleaning after up to eight handlings.

Modifications to the particle-size standards (as opposed to a test for breakage susceptibility) would also have a direct impact on handler-producer operations if market practice follows changes in standards. Table 5 gives an analysis of BCFM separation in terms of weight that would need to be removed to make grade (or of weight that would be subject to discount).

Because cleaners are progressively less efficient at removing larger particles (Hurburgh et al., 1989; Meinders and Hurburgh, 1992b), actual screenings are more concentrated in FM. They also contain some "corn", 15-20% in the survey done by Meinders and Hurburgh (1992b). In practice, the grain weights removed are larger and the FM percentages are higher than the theoretical calculations show. An economic analysis showed that interior throughput elevators (no long-term storage) do not have an incentive to add new cleaners until the actual BCFM exceeds the discount level by about two percentage points (Hurburgh and Meinders, 1992). These elevators probably operate existing cleaners when the difference exceeds one percentage point. Export elevators must clean because they face absolute loading limits, not discount schedules. By the previous analysis (table 5), there would not likely be even a one-percentage-point increase in discountable material if the standards were changed to separate BC and FM. Thus, there would be no more cleaning done unless, concurrently, the limits for BC and FM were lowered. If the latter were done, the importance of the definitional separation would be minimal compared with the impact of the total factor reduction.

SUMMARY

- There are regional patterns in some intrinsic corn quality factors, but there are no consistent regional differences of economic significance in U.S. grade factors.
- There was wide enough variation at the farm level in composition (protein, oil, starch) to be of economic significance to users. Normal blending will quickly

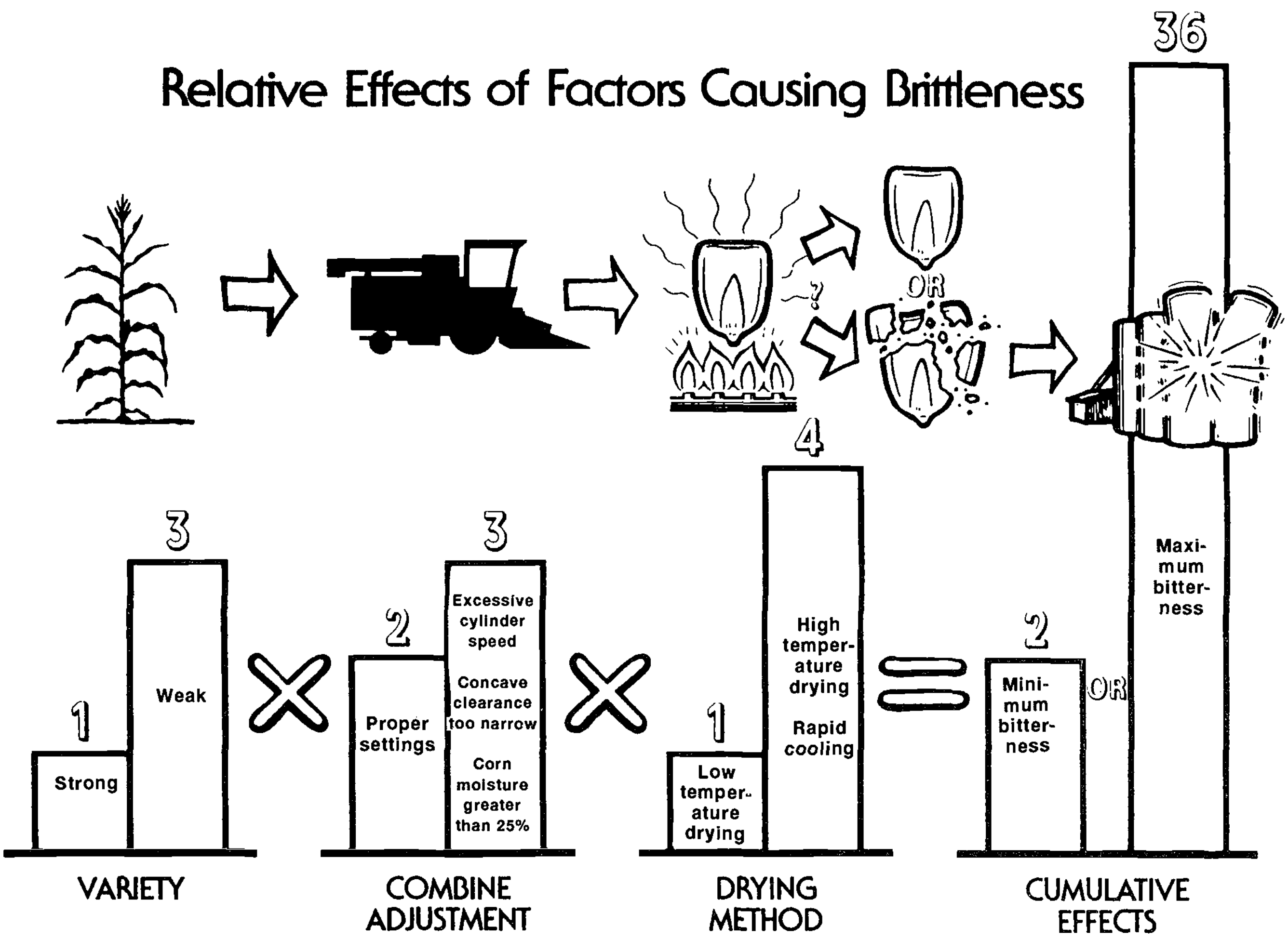

Figure 1–Relative magnitude of factors causing breakage susceptibility (Hurburgh, 1991).

even out these variations unless corn is segregated by composition at the first point of sale.

- In the FGIS new-crop surveys, corn BCFM averaged 2.1% and FM [2.4 mm (6/64-in.) definition] made up 26% of the BCFM. The FM was a higher than expected proportion of BCFM because previous studies did not include the handpicked material, which is a relatively larger fraction of BCFM in freshly harvested corn.
- By all reports, BCFM increased steadily from about 1% at harvest to 3 to 4% at export. An increase of 0.5% BCFM per transfer is a reasonable estimate of handling breakage in current practice.
- The BCFM increase is a constant over repeated handling though the same system, and breakage

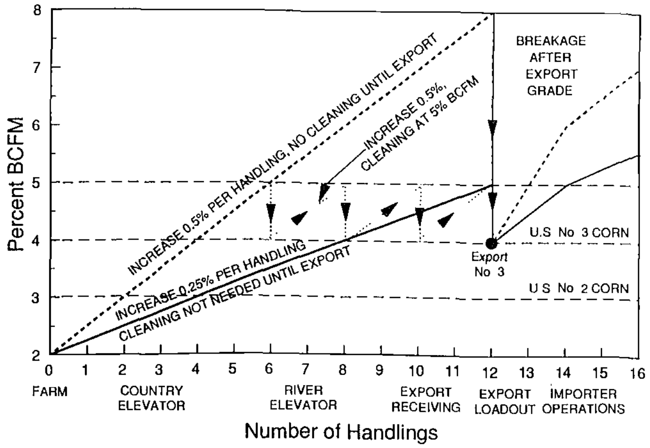

Figure 2–An example of handling breakage in corn, as affected by breakage susceptibility.

Table 5. Theoretical amount and composition of corn cleanings under two FM definitions and the current grades

Number of Handlings (Increase in BCFM)	Grain Weight Discountable or Removed to Avoid Discount* (%)					
	No 2 Yellow Corn			No. 3 Yellow Corn		
	6/64 FM	8/64 FM	Current Grades	6/64 FM	8/64 FM	Current Grades
0 (0)	0.0 (-)	0 2 (100)	0 0 (-)	0 0 (-)	0 2 (100)	0 0 (-)
4 (2%)	0.5 (60)	1 0 (100)	1.0 (20 or 37)	0 3 (100)	1 0 (100)	0 0 (-)
10 (5%)	3 5 (24)	3.5 (59)	4 0 (20 or 37)	2 5 (34)	2.5 (8 3)	3 0 (20 or 37)
20 (10%)	8 5 (12)	8 5 (46)	9 0 (20 or 37)	7.5 (24)	7 5 (52)	8 0 (20 or 37)

* *Number in parenthesis is percent share of FM in cleanings, calculated from* Meinders and Hurburgh (1992a)

Assumptions: Corn harvested with 2 0% BCFM, FM is weight-deductible starting at 0.5%, BC factor limits are the same as current BCFM limits, 100% cleaner efficiency at all particle sizes.

susceptibility does not change after the initial value determined by genetics, harvest, drying, and storage moisture practices.

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