Chapter 8
Analysis of
U.S. Grain Standards

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Chapter 8
Analysis of U.S. Grain Standards

The evaluation of the current U.S. inspection system, possible alternatives, and proposed changes in grain standards requires principles on which to base the criteria for change. This chapter sets forth those principles. No attempt has been made to assess the economic consequences of the alternatives because they depend on the market response to the actions of many individual companies involved in marketing grain, Uniform, accurate, and objective quality measurement should be based on the logic and consistency of the system, not on the economic benefits to individual companies or sectors (2).

Marketing efficiency requires a system of descriptive terms that enable purchase and sale by description. The sale of millions of bushels of grain by telephone and telex would not be possible without the common language on quality and value provided by U.S. grain standards. Since most commercial transactions use only one or two grades, the many diverse qualities produced by nature and varying farm practices are combined into a few relatively uniform standardized categories during the marketing process. The move toward a uniform product, however, conflicts with the profit-maximizing principle of product differentiation,

private gains from product differentiation are offset by aggregate losses in the efficiency of market transactions, It is not surprising to find individual exporters and domestic grain handlers unwilling to support change despite evidence that it would benefit the industry as a whole. Measures of oil and protein in the soybean standard may logically meet opposition from individual firms whose profits depend on being the first to identify sources of soybeans with oil content above the average for that crop year,

Uniform grain standards provide all buyers and sellers with equal access to information on value. This forces competition on the basis of operating efficiency, rather than on control of information, The inability to gain acceptance of voluntary standards prior to the 1916 United States Grain Standards Act (USGSA) can be traced to conflict between market opportunity for individual firms through product differentiation and the efficiency of marketing associated with product uniformity. Only through nationally enforced grain standards could individual firms reap the benefits of industrywide market efficiency emanating from uniform standards.

The 1916 USGSA and subsequent amendments and regulations have established two areas of responsibility for the Federal Grain Inspection Service (FGIS) of the U.S. Department of Agriculture (USDA):

- to establish uniform grades and standards, and
- to implement national inspection procedures to assure accurate and unbiased results.

INSPECTION AND TESTING

Grain can be inspected many times as it moves from the farm to its ultimate destination, as demonstrated by figure 2-2 in chapter 2. Normally grain is tested for one or more important characteristics each time it is moved into or out of a grain elevator. The number and type of tests performed vary from those provided for in the grain standards to specific end-use tests, such as breakage susceptibility in corn, to laboratory tests like dough handling properties of flour.

No single national policy outlines what tests will be performed or who will perform them. The USGSA requires that grain standards be developed and used when marketing grain. The standards provide tests covering such items as moisture content, bulk density, and amount of impurities, but do not specify who will perform the tests or what tests will be conducted on grain moved within the United States. In fact, two USDA agencies have been authorized by Congress to provide testing services, using the grain standards, on grain moving domestically. Except for protein content in wheat, other tests such as for protein/oil quantity and quality and specific end-use tests are performed at the discretion of the ultimate user. The only mandatory testing is performed by FGIS on export grain.

In practice, grain traded between two companies is normally tested by FGIS or one of its affiliated agencies, using tests contained in the grain standards. However, some domestic processors and nearly all grain companies that buy farmer-owned grain purchase it on the basis of tests performed by their own personnel. These groups, except in cases where a particular buyer requires additional tests, normally use some or all of the tests provided for in the grain standards. In other cases, in-house testing is used by grain companies on shipments moving between their own facilities.

FGIS Inspection

The inspection system mandated by USGSA currently consists of FGIS offices with Federal inspectors located at major ports, 72 designated State and private agencies located in the interior of the United States, and 8 delegated State agencies at ports not serviced by FGIS. FGIS administers field offices throughout the country to oversee the activities of State and private inspection agencies.

All nonfederal employees employed by State and private agencies authorized to perform inspection on behalf of FGIS must pass examinations on grading proficiency and must be licensed. These individuals can be licensed to inspect one or more of the grains for which standards have been established. In no instance, however, can individuals perform official inspections unless they hold a valid license for that grain.

In addition to developing standards and providing inspection services, FGIS:

- develops and publishes inspection procedures,
- evaluates and approves equipment for use during inspection,
- monitors inspection accuracy of FGIS employees and licensed inspectors,
- periodically tests sampling and inspection equipment for accuracy,
- provides appeal inspection, and
- responds to complaints regarding service.

FGIS also audits its own activities to ensure that service is being provided on a nondiscriminatory basis and that no licensed individual has a conflict of interest.

Non-FGIS Inspection

Inspection services using grain standards established under USGSA may be performed by grain company employees or by private companies not affiliated with FGIS. Grain received from farmers is seldom graded by FGIS or FGIS-licensed inspectors but by employees of the elevator or processing firm.

The standards established under USGSA are generally used as the basis for inspection by company employees. FGIS procedures may or may not be followed, based on individual company policy. Equipment and inspection accuracy are not monitored unless the company has established an internal monitoring program. In many cases, company inspectors compare their test results to those obtained by FGIS or FGIS-licensed inspectors on the same grain in an effort to ensure accuracy. Either buyer or seller may request FGIS or an FGIS-licensed inspector to check the grain if the results of the private inspection are in question. However, neither party is required by law to abide by the inspection results.

Export Inspection

USGSA requires that all grain being exported be inspected by FGIS or a FGIS-delegated State agency. The only exceptions are for grain moving into Canada and Mexico by land carrier and for small exporters who ship less than 15,000 metric tons in a given year.

Notwithstanding this requirement, importers often request private companies in the United States to represent their interests and inspect the grain as it is being loaded. Such inspections can include checking for grade as defined by USGSA grain standards or for factors not covered by these standards, such as falling number in wheat or oil and protein in soybeans. When private companies perform inspections using the grain standards, two groups issue certificates—FGIS and the private company.

Samples obtained by private companies are often submitted to FGIS for analysis and grade, and results from FGIS are then used as the basis for the private company's certification. In other instances, private company inspectors actually perform the inspection. Settlement in most instances is based on the results provided by FGIS or a FGIS-delegated State agency. In rare cases settlement has been based on the private inspector's results or destination grades.

Testing Technologies

Since no single policy exists for inspecting grain, no one group is responsible for developing and overseeing the tests and equipment used. FGIS provides independent, third-party services using tests contained in the standards. Other tests such as for protein content and falling number tests in wheat, aflatoxin in corn, and ethylene dibromide residue are also provided, All tests done under the authority of FGIS are regulated in that the equipment must be approved, procedures for its use developed, and the accuracy of results monitored.

Tests provided under the authority of the Warehouse Division of the USDA, on the other hand, are not regulated to the same degree. No requirements for type of equipment, procedures for its use, or monitoring of equipment accuracy have been developed under this program.

In some instances, individual States have developed criteria for approving equipment and monitor the equipment's accuracy. Professional societies such as the American Oil Chemists' Society and American Association of Cereal Chemists develop criteria for approving tests, publish performance procedures, and establish programs to ensure equipment accuracy. Many tests covered by professional societies are not in the grain standards.

Regardless of which tests are performed and who performs them, several factors are important. These include instrument precision and standardization, calibration, the choice of reference methods and traceability to standard reference methods when developing rapid objective tests, and natural error resulting from sampling.

Standardization

The term standardization means that a measuring device has been adjusted to be in fundamental agreement with a universally accepted standard and that ongoing efforts are made to keep it in agreement (4). Standardization is vital to fair trade and will be even more important as technologically advanced testing equipment is introduced into the marketplace. The validity of a commercial measurement is judged by comparing it with a more stringent method that is accepted as determining the true value. The standard is the base method defined as being the true value. Working standards are devices and methods used to actually validate an individual test instrument. For dimensional measures such as mass, time, and volume, the reference standards are very precise. The procedure of matching routine devices against working standards and working standards against reference standards introduces little variability.

Probably the most visible example of standardization is the weights and measure program coordinated by the National Bureau of Standards (recently renamed the National Institute of Standards and Technology* (NIST)) of the Department of Commerce in conjunction with the National Conference of Weights and Measures. NIST develops specifications for instru-

*The National Bureau of Standards was recently renamed the National Institute of Stand ards and Technology (NIST) with the passage of the Omnibus Trade and Competitiveness Act of 1988 (Public Law 100-418) as of August 1988.

ment precision and accuracy along with scale tolerances, and maintains national standards. Scale testing agencies follow NIST procedures in performing periodic testing using field standards that can be traced back to the NIST national standard. In the case of grain measures other than weight, no single national organization exists for standardizing tests.

Measuring grain quality is difficult to standardize because the true answer is not always known, as in the case of characteristics such as moisture, protein, and oil content. The reference method is therefore defined rather than proven. Choosing the reference method, however, can be difficult since it can also be as variable as the instruments themselves. For moisture, the standard reference is the air-oven method; for protein, it is the kjedahl procedure.

The kjedahl procedure for determining protein is internationally accepted and used. Currently, protein can be determined rapidly by using near-infrared-reflectance analyzers (NIR). These instruments measure reflectance readings at various wavelengths. The precision (repeatability) of the kjedahl procedure is+ 0.15 and for NIR it is ± 0.10. Therefore the NIR is more precise than the kjedahl, but after standardizing NIR to the kjedahl procedure, the results obtained with NIR are ± 0.2 to the kjedahl.

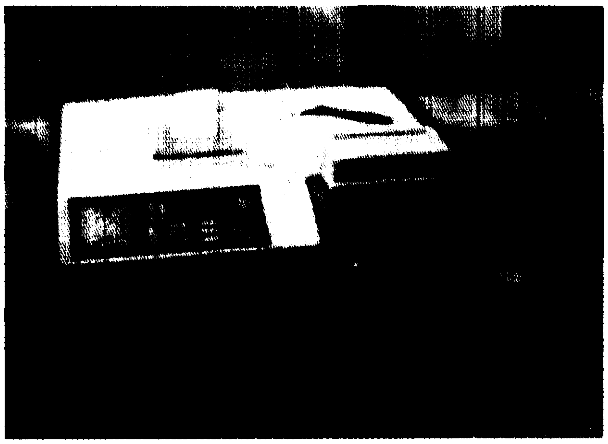
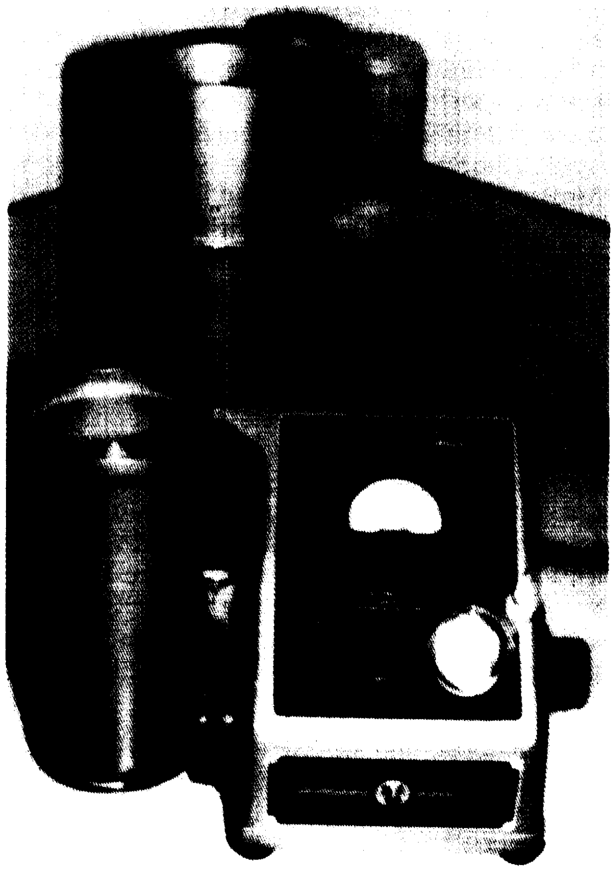


Photo credit: OTA Staff Photo

The near-infrared-reflectance analyzer (NIR) is the most advanced rapid objective testing technology. It currently is used to measure protein content in wheat. It will soon be used to measure oil and protein content in soybeans and corn protein.

In the case of moisture, choosing a reference method is more difficult since no one method is universally accepted. As on electronic moisture meters, FGIS has approved the Motomco brand meter for its testing program and calibrates it to the air oven. In States that do not enforce moisture meter accuracy or that allow different sets of calibrations to be used, several types of meters test 1.0 to 1.25 percentage points higher than the air oven and the Motomco. In addition, some meters used on farms are less accurate than those used by industry (5). This could result from the fact that not all manufacturers standardize to the air oven since there



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is no legal requirement to do so. As all oven methods are empirical, relying on weight loss that is assumed to be water, varying oven parameters will give varying results. Most international buyers use an oven method standardized to the Karl Fisher titration method. In the United States, this is not the case, and some feel that the United States is underestimating corn moistures by as much as 0.7 percent.

Further difficulties arise in standardizing tests when subjective measurements are involved. Results for many of the current tests contained in the grain standards are performed by visual and sensory evaluation and rely on human judgment. FGIS monitors its own accuracy and has developed visual aids as the basis for determining many visual tests, such as the degree of damaged kernels. These types of tests are difficult to standardize, and accuracy can vary widely especially when the same tests are performed without using FGIS visual aids or being subjected to FGIS oversight.

Calibration

In addition to having standardized tests, the equipment used to determine grain quality must be calibrated to standard reference methods. The calibration must always contain the full range of properties and equipment variations that will be encountered in general use, so that the instrument will not be overly sensitive to inevitable variations. However, the major calibration issue in grain testing is the pervasive variability of these tests. Calibration is further complicated by having to use actual grain samples to calibrate instruments, which introduces sampling variation independent of analytical error. As discussed, both the instruments to be calibrated and standard reference methods are subject to error. Changes in grain properties due to climatic variables complicate the problem of obtaining truly representative sample sets. In addition, as with NIR analyzers, units of the same brand are not identical, which means that the same calibration constants cannot be universally used. It should be noted that NIR calibrations require continuous monitoring for accuracy. Lack of monitoring contributed to the recent controversies over the accuracy of FGIS wheat protein testing.

The chain between the instrument used in the field to the standard reference method is referred to as traceability. The more steps there are in the traceability chain, the more chance there is for compounding random errors from one step to the next. In the case of moisture, for example, a standard meter in the main laboratory is standardized to the air oven, standard meters in the field can then be checked to the standard meter in the main laboratory, and field-standard meters can be used to check individual meters. Minimizing the number of comparison steps in the traceability chain may or may not maximize accuracy, depending on the actual size of the random variations.

Source of Testing Errors

Since any test result is based on a small sample that represents the entire population, test sample portions are subject to bias and variability, and any test result is really only an estimate of the properties of the entire population. The types of variation can be described as random and nonrandom. Nonrandom variation occurs from uneven distribution of grain properties, improper sampling procedures, and inaccurate measurement. Random variation is natural and unavoidable, since each grain kernel differs from all others.

If a load of grain is homogeneous, the closeness of the test result to the actual condition is governed by the laws of probability. The sample size required to produce a result that has the desired probability of approaching the actual condition of the grain can be calculated. To increase the probability, additional quantities of grain must be obtained or the size of the sample actually tested must be increased. For example, at a 90-percent confidence level a test portion size will produce results within a defined range. To narrow the range, a larger portion is required or more than one analysis must be performed to increase the accuracy of the result.

When setting portion sizes, the frequency of occurrence within a grain mass must also be considered. For example, aflatoxin in corn can affect only a few kernels in a grain mass and in order to detect levels of 20 parts per billion, which is the limit established by the Food and Drug Administration (FDA), 10 pounds of corn should be examined. This compares to only 2.5 pounds of grain required to determine the weight per bushel. (For additional information on aflatoxin testing technologies see box 8-l.)

Uneven distribution in a load of grain is more of a nonrandom error problem with some characteristics than others. For example, variance in weight per bushel—even though it can fluctuate within a load—is normally not that great. Moisture, on the other hand, can vary due to mixing or flow characteristics of damp and wet corn. Other factors, such as fine material, segregate and cause uneven distribution within a load. The method and type of sampling is therefore critical to obtaining a truly representative sample. Other nonrandom errors involve inaccurate measurements from incorrectly calibrated and maintained instruments, from human error, or from not following correct procedures.

Knowledge of the source of the variation is critical for assessing and improving the accuracy of test results. For example, improving moisture meter precision is an unnecessary effort because it contributes less than 10 percent of the total variability associated with the test (4). Moisture measurement errors arise mainly

Box 8-1.—Testing Technologies for Aflatoxin

Aflatoxin, a known carcinogen, appeared in a large proportion of the corn crop for the first time in many years due to the extremely dry weather conditions in 1988. The principles discussed in this section are very germane to the ability to test for aflatoxin.

Aflatoxin is a secondary metabolize produced by the fungus, aspergillus flavus, which infects the corn during field growth. Environmental conditions that favor the production of the mold are high temperatures coupled with dry, drought type conditions during kernel maturation. Aflatoxins are particularly important metabolizes because they are toxic and potent animal carcinogens in excess of certain threshold levels.

It is not uncommon for some of the corn crop in the South and Southeast to be infected with aflatoxin at levels that exceed FDA guidelines. Due to the stress this year's crop underwent, the incidence of aflatoxin extended well beyond these regions into the corn belt, especially the Eastern corn belt.

At the present time, testing technologies are not adequate. The rapid test used at the country elevator or terminal is not always reliable. And the more reliable tests are not conducive to elevator environments. The most common and rapid test is examination of corn under an ultra-violet light. This is a screening method which does not quantitate the aflatoxin. Contaminated corn will have spots on the kernel that fluoresce a bright greenish-yellow (BGY). But the presence of BGY does not necessarily mean aflatoxin is present. The possibility therefore exists of false positive test results.

Corn can also be tested with the Holaday-Velasco minicolumn or thin-layer chromatography methods. The minicolumn test, which takes about 45 minutes, gives indications of whether the corn exceeds the 20 parts per billion guideline established by FDA. Thin-layer chromatography, which takes between 3 and 4 hours, provides quantitative results of aflatoxin levels.

The minicolumn and thin-layer chromatography tests are most suited to laboratory environments. Both use chemicals that must be controlled and are not suited to the normal grain elevator environment. Recently, several new technologies, such as methods based on enzyme immunoassay or rocket immune assay techniques, have been developed to detect aflatoxin that require less chemicals and are more suited for use in grain elevators. They also produce results in a more timely manner. These technologies are currently being reviewed by the American Association of Cereal Chemists. As with any method, adequate sampling must be used because aflatoxin is not uniformly distributed among kernels.

from differences in electrical properties of grain samples, not from the meter's precision. When examining the variability of any test made with an instrument, it is essential to know the relative contribution of instrument error.

Sampling

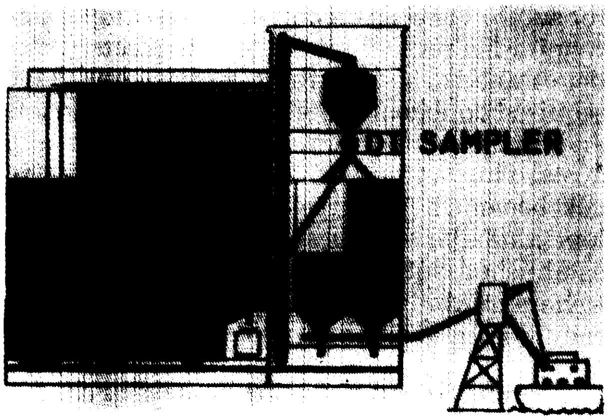
Grain samples are obtained with either on-line or stationary methods. On-line sampling can be done manually, using an Ellis cup or a pelican sampler, or mechanically, using a diverter-type mechanical (D/T) sampler. This equipment allows samples to be drawn from a moving stream of grain being carried on a belt or within a spout, or from a free-falling stream. Samples drawn on-line are generally considered to be most representative since the grain is sampled more frequently and is more homogeneous in nature than stationary grain.

Export cargoes must be sampled with a D/T. Many barge and railcar shipments are also sampled with this method even though there is no requirement to do so. D/Ts provide quite large samples that must be reduced in a secondary sampler to more workable sizes. The smaller samples are further divided in a laboratory divider to the prescribed test portion sizes. It is important to recognize that every subdivision as well as the initial sample collection contributes potential errors. Shippers must therefore allow for sampling variations as well as established testing procedure errors when loading grain of a desired quality.

Stationary sampling is usually performed with a grain probe. Because a probe obtains samples from only one point in the grain mass at a time, multiple probings are crucial in obtaining representative samples. Probing patterns have been developed to ensure representative samples are obtained and to counteract the segregation of fine material in grain at rest in a carrier. However, probes cannot reach the bottom of barges or hopper railcars, which affect the representativeness of the entire grain mass.

Probing grain is time-consuming and labor-intensive, and current probing patterns only obtain about 5 pounds of grain. Mechanical truck probes have been developed and are being used in some locations to reduce the cost and labor requirements. But, in many locations, such as country elevators, only one or two probings per truckload are taken or a pan full of grain is taken as the truck is unloaded. This compares to the five-to-nine probings required under FGIS procedures. Limited sampling makes the test results more vulnerable to nonuniformity within the grain mass.

As indicated, the sample size used has a direct bearing on the test result's accuracy. For aflatoxin, the 10 pounds required to accurately



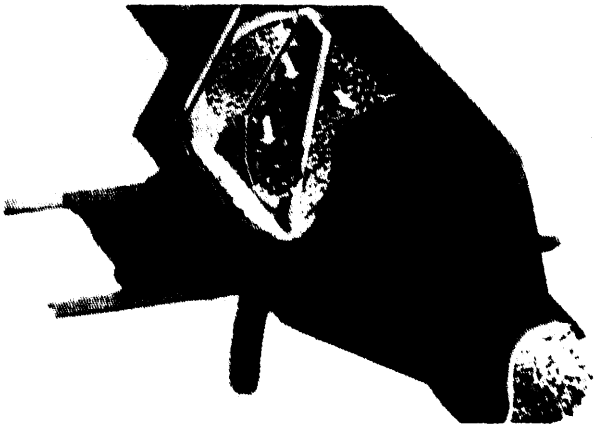


Photo credit: U.S. Department of Agriculture

The diverter-type mechanical (D/T) sampler allows grain to be drawn from a moving stream. Samples drawn from a D/T sampler are considered to be most representative since grain is sampled more frequently and is more homogeneous than stationary grain.

Photo credit: OTA Staff Photo

Stationary sampling is performed by a grain probe. Multiple probings are crucial in obtaining a representative sample. In many locations, such as country elevators, only one or two probes are taken compared to the five to nine probes required under FGIS procedures.

detect aflatoxin requires that a truck be sampled twice using the current five-to-nine probing pattern, which only yields 5 pounds. Getting 10 pounds from a D/T sampler is simpler since large quantities are obtained through the normal course of sampling. If increased accuracy is required, or as additional tests are adopted requiring larger sample sizes, the impact on the test's accuracy must be weighed against the cost of obtaining the sample. This will be especially relevant to samples obtained at the first point of sale from trucks.

Criteria for New Technologies

As additional tests on an ongoing basis become more relevant, criteria must be established to govern the design of rapid test requirements. Yet, development of rapid tests must meet the basic criteria associated with standardization, traceability to standard reference methods, and calibration. In addition, rapid tests must be evaluated in terms of speed, cost, accuracy, durability, and capability of handling wide ranges in quality.

The most notable advance in rapid objective testing technology has come from using NIRs to measure protein content in wheat. This technology has been discussed to some degree throughout this section. Considerable work is being done to develop additional tests with NIR, which will be particularly important at the first point of sale. Calibrations for barley protein are being developed. Work is also being done on developing calibrations for determining soybean oil and protein along with corn protein. The ability of NIR to determine wheat hardness, along with other important tests for wheat, is also being investigated.

The first point of sale will probably be the most difficult place to introduce new technologies, The time constraints are severe and the resources, both human and capital, are limited. Yet, the demands of testing at this point should be paramount in designing new tests. As these are developed and introduced, the impact of the amount of sample required to perform not only the particular test but more importantly all the tests required at the first point of sale must be evaluated in terms of practicality.

Many of the potential new tests require the grain be ground or processed before testing, while the tests currently in the grain standards are performed on the grain as a whole. As more tests are introduced that require processing, the impact of the sample size required to provide accurate results versus the quantity of sample obtained through stationary sampling becomes critical. For example, FGIS introduced a test for sunflower seed oil content, The sample size required to predict oil content accurately was determined to be 250 grams, which would have required double probing of stationary grain lots and consequently increased testing time and costs. Thus a trade-off between accuracy and cost became necessary. To overcome this problem, a smaller sample size (45 to 50 grams) was established but duplicate tests were required to help minimize the impact of lowered accuracy due to smaller sample size.

Establishing Grain Standards

Standards are established by FGIS under the authority of Section 4 of USGSA. In the case of corn and wheat, the factors contained in the standards were selected in the early 1900s. Soybean standards were established in 1922 as voluntary and brought under the USGSA by congressional amendment in 1941. No changes were made in the number of factors included until moisture was removed as a factor from wheat in 1934 and from corn and soybeans in 1985, The grade limits and factor definitions have been changed frequently during the years, however; tables 8-1,8-2, and 8-3 contain the current standards for wheat, corn, and soybeans.

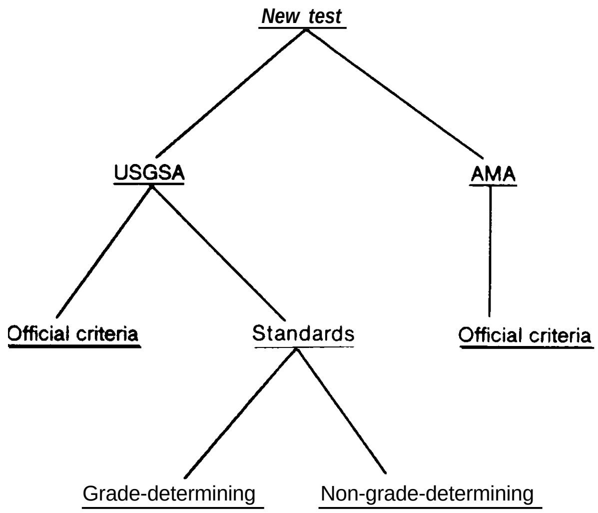
The procedure for changing grades is clearly specified in USGSA. Proposed changes require publication in the Federal Register, solicitation of comments, and, in the case of the new or amended policies, a 1-year waiting period before becoming effective.

Introducing new factors requires an understanding of the alternatives available to FGIS for implementing a new test or quality factor. The agency operates under two authorities—USGSA and the Agricultural Marketing Act (AMA)–and new tests can be implemented under either one (figure 8-l).

Three methods for implementing tests are available under USGSA. The category "official criteria" is used for tests provided only at the request of buyer or seller. Factors contained in the category of "standards" must be determined for each inspection. However, non-grade-determining factors are always reported but have no maximum or minimum associated with assigning a numerical grade, whereas grade-determining factors establish a numerical grade according to the lowest factor approach. Examples of current tests are given in table 8-4.

The Food and Drug Administration also has responsibility for grain quality issues as they relate to health and safety. Under the Federal Food, Drug and Cosmetic Act (FDCA), grain is deemed to be adulterated if it bears or contains an added or a naturally occurring poisonous or deleterious substance that may render it injurious to health. Aflatoxin-contaminated

Figure 8-1.– Alternative Authorities to FGIS for Implementing New Tests



SOURCE: Office of Technology Assessment, 1988

corn is one example. It was an FDA ruling that the addition of water to grain to increase its weight or value was adulteration and subject to prosecution. FDA also regulates color additives mixed with grain for identification purposes and the adhesives and coatings that may come in contact with grain transported in railcars and barges,

The FDCA prohibits food products containing whole insects, insect parts, and excreta. Fumigation or treatment of grains already infested does not make grain legal under the act. Chemical treatment may be used as a preventive to keep grain from becoming infested, but residues from these chemicals must not exceed permissible tolerance levels. Grain is illegal if it contains residues of pesticides not authorized or in excess of safe tolerances set by the Environmental Protection Agency and enforced by FDA.

The separation of responsibilities between FGIS, FDA, and other government agencies is somewhat vague in principle, For example, grain dust is a health and safety issue covered

Table 8-1.—Wheat Standards

	Minimum limits of—		Maximum limits of—						
	Test weight per bushel		Damaged kernels					Wheat or other classes[d]	
Grade	Hard Red Spring wheat or White Club wheat[a] (pounds)	All other classes and subclasses (pounds)	Heat-damaged kernels (percent)	Total[b] (percent)	Foreign material (percent)	Shrunken and broken kernels (percent)	Defects[c] (percent)	Contrasting classes (percent)	Total[e] (percent)
U.S. No. 1	58.0	60.0	0.2	2.0	0.5	3.0	3.0	1.0	3.0
U.S. No. 2.	57.0	58.0	0.2	4.0	1.0	5.0	5.0	2.0	5.0
U.S. No. 3.	55.0	56.0	0.5	7.0	2.0	8.0	8.0	3.0	10.0
U.S. No. 4.	53.0	54.0	1.0	10.0	3.0	12.0	12.0	10.0	10.0
U.S. No. 5.	50.0	51.0	3.0	15.0	5.0	20.0	20.0	10.0	10.0

U.S. Sample grade:

U.S. Sample grade is wheat that:

a. Does not meet the requirements for the grades U.S. Nos. 1, 2, 3, 4, or 5; or

b. Contains 32 or more insect-damaged kernels per 100 grams of wheat; or

c. Contains 8 or more stones or any number of stones which have an aggregate weight in excess of 0.2 percent of the sample weight, 2 or more pieces of glass, 3 or more crotalaria seeds (*Crotalaria* spp.), 2 or more castor beans (Ricinus *communis* L.), 4 or more particles of an unknown foreign substance(s) or a commonly recognized harmful or toxic substance(s), 2 or more rodent pellets, bird droppings, or equivalent quantity of other animal filth per 1,000 grams of wheat; or

d. Has a musty, sour, or commercially objectionable foreign odor (except smut or garlic odor); or

e. Is heating or otherwise of distinctly low quality.

[a] These requirements also apply when Hard Red Spring or White Club wheat predominate in a sample of Mixed wheat.
[b] Includes heat-damaged kernels.
[c] Defects include damaged kernels (total) foreign material, and shrunken and broken kernels. The sum Of these three factors may not exceed the limit for defects for each numerical grade.
[d] Unclassed wheat of any grade may contain not more than 10.0 percent of wheat of other classes.
[e] Includes contrasting classes.

SOURCE: Federal Grain Inspection Service, U.S. Department of Agriculture, 19SS.

Table 8-2.-Corn Standards

Grade	Minimum test weight per bushel (pounds)	Maximum limits of— Damaged kernels: Heat-damaged kernels (percent)	Damaged kernels: Total (percent)	Broken corn and foreign material (percent)
U.S. No. 1	56.0	0.1	3.0	2.0
U.S. No. 2	54.0	0.2	5.0	3.0
U.S. No. 3	52.0	0.5	7.0	4.0
U.S. No. 4	49.0	1.0	10.0	5.0
U.S. No. 5	46.0	3.0	15.0	7.0

U.S. Sample grade:
U.S. Sample grade is corn that
a. Does not meet the requirements for the grades U.S. Nos. 1, 2, 3, 4, or 5; or
b. Contains 8 or more stones which have an aggregate weight in excess of 0.20 percent of the sample weight, 2 or more pieces of glass, 3 or more crotalaria seeds (*Crotalaria* spp.), 2 or more castor beans (**Ricinus communis** L.), ***4*** or more particles of an unknown foreign substance(s) or a commonly recognized harmful or toxic substance(s), 8 or more cockleburs (**Xanthium** spp.) or similar seeds singly or in combination, or animal filth in excess of 0.20 percent in 1,000 grams; or
c. Has a musty, sour, or commercially objectionable foreign odor; or
d. Is heating or otherwise of distinctly low quality.

SOURCE Federal Grain Inspection Service, U.S. Department of Agriculture, 1988.

Table 8-3.—Soybean Standards

Grade	Minimum test weight per bushel (pounds)	Maximum limits of— Damaged kernels: Heat damaged (percent)	Damaged kernels: Total (percent)	Foreign material (percent)	Splits (percent)	Soybeans of other colors (percent)
U.S. No. 1	56.0	0.2	2.0	1.0	10.0	1.0
U.S. No. 2	54.0	0.5	3.0	2.0	20.0	2.0
U.S. No. 3[a]	52.0	1.0	5.0	3.0	30.0	5.0
U.S. No. 4[b]	49.0	3.0	8.0	5.0	40.0	10.0

U.S. Sample grade:
U.S. Sample grade is soybeans that:
a. Do not meet the requirements for U.S. No. 1, 2, 3, 4; or
b. Contain 8 or more stones which have an aggregate weight in excess of 0.2 percent of the sample weight, 2 or more pieces of glass, 3 or more *crotalaria* seeds (*Crotalaria* spp.), 2 or more castor beans (**Ricinus communis** L.) 4 or more particles of an unknown foreign substance(s) or a commonly recognized harmful or toxic substance(s) 10 or more rodent pellets, bird droppings, or equivalent quantity of other animal filth per 1,000 grams of soybeans; or
c. Have a musty, sour, or commercially objectionable foreign odor (except garlic odor); or
d. Are heating or otherwise of distinctly low quality.

[a]Soybeans that are purple mottled or stained are graded not higher than U.S. No. 3.
[b]Soybeans that are materially weathered are graded not higher than U.S. No. 4.

SOURCE: Federal Grain Inspection Service, U.S. Department of Agriculture, 1988.

Table 8-4.—Examples of Quality Measures Under USGSA and AMA

Authority	Example factors
USGSA:	
Grade-determining standards	Foreign material Damage Test weight
Non-grade standards	Moisture
Official criteria	Protein in wheat
AMA:	
Official criteria	Aflatoxin Falling number Pesticide residue (EDB)

SOURCE: Office of Technology Assessment, 1989.

by the Occupational Safety and Health Administration (OSHA) but prohibiting its reintroduction into grain falls to FGIS. A Memorandum of Understanding between FGIS and FDA has enabled the two agencies to work together in several areas. FDA has established action limits for many factors, such as aflatoxin in corn and pesticide residues in grain. The agreement between agencies requires that FGIS report to FDA whenever inspection results for the items identified in the agreement exceed FDA's limits.

EVALUATION OF GRAIN STANDARDS

Recent debates over grain standards, foreign buyers' complaints, and the numerous proposals for regulatory and legislative changes echo earlier calls for change. Recent complaints concerning certificate final contracts, excess foreign material at destination, spoilage, and heating during transit are nearly identical to those of the late 1800s. (Certificate final in the export/import contract means that grade is determined at the point of loading and the buyer has no legal recourse regardless of delivered quality, unless it can be proved the origin grade was incorrect at the time of loading.)

These problems have been documented repeatedly in congressional hearings in 1908, 1928, 1975, and 1986 (3). Even the wording is almost identical, despite a span of some 75 years. The Senate Report 988, of July 27, 1912, criticized the current system for rewarding adulteration:

> Under the present conditions an enormous system of mixing or adulteration of grain is forced on all the home markets and also the foreign market, destroying all confidence in our grades and working to the detriment of the grain trade.

In 1986, Representative Byron Dorgan (D-ND) used similar phrases:

> In short, the U.S. system being what it is allows and encourages dockage to be added back into wheat shipments . . . unless we confront this problem, we will further erode our export potential,

Historical Review

The legislation establishing Federal grain standards was passed in 1916 following more than 50 years of debate and repeated attempts by the grain industry, trade associations, and boards of trade to establish private and regional measures of grain quality. Private firms can increase profits by individually differentiating quality from that of other firms. As noted earlier, this self-interest blocked every attempt at obtaining voluntary adoption of uniform standards even though the trade associations recognized that the industry as a whole would benefit.

After many years of educational efforts and attempts to obtain support, the National Grain and Feed Dealers Association agreed to endorse a compromise bill for Federal standards. The compromise garnered reluctant support from the two opposing positions of voluntary adoption of inspection and grain standards versus full Federal control. The compromise allowed Federal supervision of uniform standards and inspection by private firms, many of which were already in business in 1916.

More than 150 bills and amendments have been submitted to Congress since Senator Paddock first proposed Federal legislation in 1890 to establish measures of quality that would be uniformly and objectively applied. Yet the basic premises and procedures of the Grain Standards Act of 1916 remained intact until 1986. Further, the complaints and persistent problems regarding quality have continued for over a century despite all the legislative, administrative, academic, and industry efforts spent on improving quality measurement. Several obstacles to a permanent solution must be recognized and dealt with if current efforts of Congress and industry are to succeed:

- The changing nature of the industry in terms of technology and genetics results in quality characteristics that change from one crop year to the next and from one part of the country to the next. All these diverse qualities enter the marketing channels and must be handled.
- Industry and government have often refused to accept that problems exist. Faith in the infallibility of a market system has made it difficult to accept that government agencies have a function in setting uniform grain standards in order to facilitate an efficient market.
- Most of the participants in the debate have seen themselves as adversaries since the beginning of the discussions. Each group– farmers, processors, grain merchandisers,

and government—has expended considerable public effort trying to blame one or more of the other groups.

- The USGSA and the regulatory agencies implementing the act have focused on one objective— "to facilitate marketing." Economic principles have not been incorporated into the grade factors, factor limits, or the many seemingly arbitrary changes.

Objectives of Grain Standards

Since the beginning of Federal regulation in ***1916,*** the official purpose has been to provide uniform standards for promoting and protecting grain moving in interstate and foreign commerce "so that grain can be marketed in an orderly and timely manner and that trading in grain maybe facilitated. " It has seldom been recognized that the lack of an economic justification in that directive has caused much of the difficulty in arriving at a consensus on grain standards and standardization within the grain industry. Although early researchers frequently referred to "intrinsic value" and "value in end use," these criteria were seldom in evidence when developing standards, or in the numerous changes that were introduced in subsequent years.

Much of the disagreement over specific changes is the result of explicit or implicit disagreement over the objectives of standards. Each group held a different view. Many in industry and government viewed standards as a convenience for merchandisers. Processors wanted the standards to indicate yield of processed products. Farmers wanted assurance that discounts associated with grade factors were based on differences in real value in use. Congress often viewed the standards as a cause of foreign complaints and lost export markets. Clearly, if grain exporters, grain processors, Congress, and farmers hold divergent views on what grain standards are intended to accomplish, they cannot be expected to agree on which grade factors would meet their diverse and conflicting purposes.

The lack of clear goals, objectives, and criteria inevitably led to reversals as well as arbitrary inconsistencies. For example, test weight limits in corn for grades No. ***1*** and No. 2 were in the original standards in ***1916;*** were added to grade Nos. 3, 4, and 5 in ***1918;*** were lowered in 1934; and were raised in 1959. Throughout all these changes, researchers questioned whether test weight was a relevant measure of value in any grade. Those who argue that the only objectives of standards is to describe physical and biological characteristics have been unable to find a criterion by which they could justify the characteristics chosen. For example, why measure kernel density but not kernel size? Why measure the percent of split and broken beans but not the percent of whole kernels in corn? Grain has many physical and biological properties, and without additional criteria for guidance, the factors and factor limits become arbitrary numbers.

In practice, few markets quote prices for No. 1, 2, and 3 corn, soybeans, or wheat. In nearly all cases, a base price is given for one grade and discounts or premiums attached to deviations on each factor from that base. At the country elevator level, for example, nearly all corn is purchased on a No. 2 base and farmers' prices are established by discounting each factor that falls outside of the No. 2 limits. International markets generally specify No. 2 soybeans or No. 3 corn, and prices in the contract are usually quoted for that one grade with adjustments for deviations.

A set of clearly stated objectives for standards based on sound economic principles was absent in legislative and administrative changes between ***1916*** and ***1986.*** The many changes during that period did little to resolve the basic problems and issues. In *1986* a relatively simple change in the language of the USGSA opened the door to a new era in the identification of quality as a means of efficient communication of information about value.

In June ***1986,*** the North American Export Grain Association submitted a report emanating from a series of industrywide workshops. This report, entitled "Commitment to Quality," presented a consensus to serve as guidelines for Congress and FGIS in revising standards

(6). One of its most important aspects was a new definition for the objectives of grain standards. The four objectives were identified as:

1. to define uniform and accepted descriptive terms to facilitate trade,
2. to provide information to aid in determining grain storability,
3. to offer end-users the best possible information from which to determine end product yield and quality, and
4. to create the tools for the market to establish incentives for quality improvement.

These objectives were incorporated in the ***1986*** Grain Quality Improvement Act with the passage of Public Law ***99-641*** on November ***10, 1986.*** FGIS for the first time had a set of criteria on which to base changes in standards and to evaluate the numerous proposals for change. Each criterion provides a basis for assessing current standards and the recent efforts by FGIS to improve measurements of quality.

Facilitating Trade

Almost any set of factors can meet this criteria. It is important that grain be grouped into a relatively few number of categories to make buying, selling, and classification efficient and inexpensive. Trade is facilitated by having a small number of grades determined by a minimum number of factors. From the standpoint of trading simplicity, three numerical grades in the corn standards may in fact be more desirable than five.

The factors in the current grades are for the most part easily measured and provide a basis on which buyers and sellers can communicate price and appropriate discounts. Some have the additional advantage of being commonly used in international trade and thereby serve to facilitate communication within the international as well as domestic market,

Since almost any set of factors and grade limits can be handled equally well by the grain industry as long as they are universally accepted, recent FGIS changes have made little improvement on this criterion.

The technology and terminology for measuring current factors have been in use for enough time to make the trading of grain on these factors and grades limits extremely efficient. Domestic and international contracts have been written using this terminology for many years. Trading in the marketplace is readily handled with a minimum of specification. These terms are adequate for basic contracts and quotes in the futures market as well as in international trade. Basing price on the numerical grade, millions of bushels change ownership with a simple phone call.

Aid in Determining Grain Storability

The factors that influence storability of grain have been well documented by many scientists, dating as far back as the grain storage studies done in the early 1900s by Dr. Duvel of USDA. These factors are moisture, temperature, air flow, mold, and insect infestation. The more technical attributes of these characteristics are covered elsewhere in this assessment. The length of time grain has been held in storage and the condition under which it has been stored are also important criteria.

Current tests for factors contained in standards provide little information on direct measures of storability. Moisture content is provided in terms of averages, but it has been demonstrated that the range of moisture among individual kernels may be more important than the average. The standards identify damage, but this is an arbitrary determination of a stage of development and storage deterioration that does not provide information on how much longer the grain may be stored before it goes out of condition. Numerical grades alone certainly provide no information on storability. Foreign material, test weight, damage, and moisture are thus indirect indicators at best even though they are reported on every inspection certificate.

Changes in inspection practices and standards have done little to improve measurement of storability since the 1920s, when Dr. Duvel suggested acidity as a measure of storage life and an indication of mixtures of old and new crop grain. The ***1986*** changes in the interpretive line slides used to identify damage in soybeans did not improve the ability of the standards to predict storability. However, the correlation between damaged kernels and levels of free fatty acid better equipped standards to indicate oil quality.

Most current measures for storage life are based on laboratory procedures. No rapid commercial test is available to provide a quick indication of the stage of deterioration or the time remaining before grain's condition worsens.

Measuring Value in Processing Products

Because most grains are used for more than one purpose, it is not a simple matter to identify the characteristics that influence value (see ch. 4). The nutritional composition, starch content, and recovery rate of corn and baking characteristics of wheat are all end-use properties desired by processors. Few of these, however, can be converted directly to measures of physical or intrinsic properties of the raw grain. Research in recent years has identified some factors that relate to value that can be measured in the commercial market channel. For example, hard endosperm corn provides a higher yield of flaking grits. Obviously, high oil and high protein soybeans provide higher yields of oil and soybean meal. Breakage susceptibility tests identify the ability of corn to withstand handling without increasing breakage. Many tests—such as falling number, farinograph, hardness, and baking tests–are available that indicate baking and milling characteristics of wheat and *are* frequently used in laboratories in the United States and Europe. But the industry does not completely agree that these attributes always clearly indicate value.

Factors currently contained in the standards do a poor job of meeting the criterion of end-use value. Soybean standards include little indication concerning oil and protein content. New varieties of wheat have diminished the effectiveness of class and grade for evaluating flour and baking characteristics. Information from corn standard factors is often unrelated to its feeding value or starch yield. In general, those characteristics of raw grain most closely associated with value of products derived ***are*** not currently covered by the standards. Purity and cleanliness in terms of foreign material, numbers of insects, or other grains provide one of the few indications of value in the current standards. Even here, however, there is lack of clarity; the term "foreign material" means different things in each grain, and the term "broken corn and foreign material" (BCFM) does not differentiate between broken corn and foreign material despite the difference in value.

FGIS in the last few years has moved toward improving the measurement of end-use value. For example, even the simple step of rounding dockage percentage to the nearest one-tenth in wheat gives a better indication of the amount of grain versus nongrain being purchased. Compared with the previous method of rounding down to the nearest half-percent, the new approach better reflects true value. FGIS has also taken steps to differentiate more critically on damage in soybeans. The change in the interpretive line slides has been linked to the level of free fatty acid, which is in turn a direct measure of the quality of oil derived from the soybeans. Progress is therefore being made toward finding better measures of value.

Additional measures are available that have not been incorporated in the standards. There is a lack of total industry agreement that these measures are sufficiently accurate and reliable to be introduced. Continued commercialization of measures of breakage susceptibility in corn and soybeans; intrinsic properties of corn, soybeans, and wheat; new measures of baking properties and classification of wheat varieties; and rapid measures of oil and protein in soybeans are all candidates for inclusion in the standards or should at least be made available as information.

Providing Market Incentives

Measurement of factors that result in price differentials in the market provide an incentive for each point in the market channel to make decisions to improve quality and avoid discounts. This incentive works back through the market channel to producers, who may change harvesting, drying, and storing practices (see ch. 7) or may select different varieties (see ch. 6). Preference for varieties with certain quality characteristics will be conveyed to plant breeders who will in turn generate better varieties. In a competitive market, profit is a strong driving force in any company's decisions, whether they be exporters, individual elevator managers, producers, or plant breeders. While the market itself sets incentives in terms of prices and price differentials, the standards are not neutral in this scenario. For example, farmers have an incentive to select corn varieties that weigh at least 54 pounds per bushel in order to avoid discounts in the market. This producer incentive translates into incentives for plant breeders, who have spent significant research funds to develop varieties that will produce a high test-weight corn under normal conditions.

Current grain standards provide incentives in several ways. For example, the allowance of 3-percent BCFM in No. 2 corn, in conjunction with the market practice of paying top price for No. 2 corn, gives farmers an incentive to incorporate 3 percent BCFM in their deliveries. By the same token, elevator managers have an incentive to clean or blend in such a way as to deliver 3 percent BCFM throughout the market channel. Any shipment containing less than 3 percent BCFM is a lost profit opportunity. Shipments containing more than 3 percent BCFM will usually receive a discount. The step functions between the grades create incentives for blending when grain is purchased on grade alone. The wider the range between grades, the greater the number of factors, and the greater the number of grades, the greater is the opportunity for blending when purchasing on grade without specifying factor limits.

The other side of this coin is the lack of incentive for improving quality on those characteristics omitted from the standards. With no price differential for soybeans with high oil and protein, farmers have no incentive to select varieties that will represent greater value to the processor. Yield becomes the primary and in most cases the only criterion on which to select the variety to be planted, A second example is the drying temperature of corn. Although most corn processors object to the use of high temperatures during drying, the market does not differentiate between corn dried at high and low temperatures. The premiums paid by a few dry millers for low-temperature-dried corn indicate that farmers do respond to these incentives when offered. At present the incentives are not offered by means of the standards, but by means of contracts in localized areas. It is especially difficult for buyers some distance from the production point to obtain qualities they desire when those qualities are not incorporated in uniform standards and terminology.

Recent FGIS efforts have had limited effect upon incentives within the market channel. The removal of moisture as a grading factor reduced the number of factors on which blending was required when purchasing on grade only, but the market still generates income from blending wet and dry corn. The change in rounding procedures for dockage percentages in wheat removed the incentive to blend dockage just below the next higher break point. However, the number of grades and the steps between grades have not been significantly altered, and incentives and disincentives still fall short of the ideal.

Measurement and sampling technology or testing is a problem in terms of incentives only so far as the accuracy of the equipment will not accommodate a finer distinction between qualities on certain characteristics. Increased accuracy will permit narrowing the spread between numerical grades, thereby reducing the incentives for blending when purchasing on grade only.

integrating the Four Objectives

Changes in grade-determining factors, or factor limits, should meet the four objectives of grain standards. But, not all alternatives will contribute to all four objectives, and it is likely that conflict between the objectives will develop. For example, complex and lengthy tests for measuring end-use value will slow the inspection process, increase marketing costs, and thereby detract from the purpose “to facilitate trade. ” Similarly, incentives are best created by a continuous discount schedule on each factor, starting from zero. But a zero base requires each buyer to specify factor levels in the contract. Numerous contract specifications increase the number of segregated lots and reduces the interchangeability of shipments, Increasing the amount of information available to users increases the difficulty of merchandising uniform lots.

The “perfect standard” that optimizes all four objectives may not exist. The final solution will be a compromise among some of the objectives (e.g., sacrificing complete information for all users in order to facilitate orderly efficient marketing) and among various buyers and sellers.

Alternatives to the Present System

An evaluation of the alternatives to the current system in the United States illustrates some of the trade-offs inevitable in establishing grain standards. The system today is generally known as “numerical grades determined by the lowest factor.”

The “lowest factor” approach requires that the grade be set by the factor representing the lowest quality. For example, if the test weight of corn is 53 pounds per bushel, that sample is graded No. 3 even though all other factors are equal to No. 2 or better. This method has the advantage of simplicity and is used by many of the major grain-exporting countries. However, it does not always reflect true value since it fails to consider factors above the minimum. Considerable variation in quality can occur between shipments without a grade change. The lowest factor system also encourages blending to bring all factors down to the quality of the lowest factor determining the grade, and therefore does not generate incentives for quality improvement unless limits are established by contract that are more restrictive than the grade limit.

In export trade, most contracts specify that the grade determined at origin is the legal basis for any dispute or arbitration regarding quality. This certificate final system, which was in use prior to the USGSA, provides advantages in terms of efficiency and costs. Other alternatives are currently used in other countries (see ch. 10 and companion report) and variations of the official U.S. system are being used even in the domestic market. Understanding the basics of each alternative can help develop policy for directing future quality regulations,

Total Defects

Under the lowest factor approach, all factors can be at the maximum limit for the determination of a particular grade, For example, No. 2 corn can have 54 pounds test weight, 3 percent BCFM, 4 percent damage, and ***0.2*** percent heat damage. This provides the opportunity to blend on one or more factors to achieve the maximum allowable limit within that grade. A system of “total defects” introduces one more limiting factor that sums the defects in that grade across all factors and places a maximum that would be more restrictive. Thus the accumulated value of the defects would become more restrictive than the individual factors, In the example just given, the defects are BCFM, total damage, and heat damage, Under the total defects system, a maximum value of ***6*** percent might be established, for example, and the corn would be considered No. 3 if the sum of damage, heat damage, and BCFM exceeded 6 percent. Currently, the wheat standard includes a total defects factor with a maximum limit of 3 percent for No. 1. If shrunken and broken kernels, for instance, are at the maximum No. 1 limit, which is 3 percent, all other defects would have to be at O. This approach provides additional information about quality and an incentive to increase quality if the total defects figure is more restrictive.

The total defects approach differs from the lowest factor only by accumulating the sum of individual factor results. The greater restriction it entails could also be achieved by changing limits on the present grade factors. Total defects also contains a logical inconsistency: It establishes limits on three factors for No. 2 wheat but if the sample meets all these criteria, it will be classed as No. 4 on the basis of total defects.

Absence of Imperfections

The "total perfect kernels" approach also sums the percent of defects, but subtracts the total from 100 to obtain the percent of perfect kernels. Each grade has a minimum limit on percent of perfect kernels. Corn grades in China are based on this system, and U.S. standards for oats include a factor for "sound oats." This system differs little from the "total defects" concept except that it reports absence rather than presence of defects.

Weighted Factor

The "weighted factor" approach would include a set of grade-determining factors and factor limits, but each factor would exert a different effect in terms of grade determination. This is in contrast to the lowest factor approach, in which the grade is lowered when any one factor result exceeds the limit. Instead, defects would be divided into major and minor categories and each assigned a weight to be multiplied times the percent of that defect present. The sum of the defects times the weighting factor would determine the grade. Grade would be influenced by the number of factors below grade, the distance each of those factors fell below the grade limit, and the relative seriousness of the defect.

This system would incorporate more information in the numerical grade and allow finer distinction among the combinations of factors. Its disadvantage is its complexity, the arbitrariness of the weighting factor assigned to each defect, and the lack of clear criteria on which to set the break points between grades. In order for the numerical grade to indicate end-use value, the weighting factors would have to differ among uses. The complexity of such a system would probably eliminate this alternative on the criteria of the first objective of standards—" to facilitate trade,"

Contract Specifications

The issue of whether standards are required or whether each buyer may simply specify terms in their contract has been debated since the idea of numerical grades was first presented to merchandisers in the late 1800s. ***So*** long as contracts are legally enforced, buyers and sellers may agree to any set of factors, characteristics, and conditions of shipment they desire. The advantage of numerical grades over contract specifications is that they facilitate communication. When the grain trade became too large for buyers and sellers to physically and simultaneously view the grain being sold, terminology was required that would permit description by factors. The numerical grade was chosen as a way of describing several factors in one number. Each buyer could identify the characteristics and factor limits that best meet the conditions in a particular plant. If the buyer's needs are unique, however, resale in the market becomes difficult and segregation is required for each one's specifications. The efficiency of the current marketing system relies heavily on uniformity for the majority of the crop being marketed.

Although most foreign buyers now use numerical grades for purchasing corn, soybeans, and wheat, they almost always include additional factors besides the numerical grade in their contracts. Numerical grade alone seldom conveys sufficient information to satisfy a buyer's needs. Other factors are therefore specified. It is a small step to go to an entire factor basis system and eliminate numerical grades. The primary disadvantages are a much wider range of quality characteristics between vessels and thus difficulty in resale if other buyers do not want the same specifications, greater difficulty in segregation and blending to a wider range of specifications, and increased complexity in writing contracts.

None of these disadvantages is insurmountable. The problem of reselling uniform lots has become much less important in recent years.

The number of times a vessel is resold after leaving port has fallen compared to the 1970s scenario. The complexity of identification is also less daunting since most buyers are already specifying grade plus two or three factors; they would be specifying only one or two more. There would be greater problems in keeping qualities segregated throughout the market channel if there were no numerical grades.

One of the purposes of blending is to achieve a uniform product, and the first objective of standards is to facilitate merchandising. This purpose is not accommodated by a system where all buyers develop their own set of quality factors, their own definitions, and their own limits. The complexity and inefficiencies of such a market would result in a major reduction in welfare for both buyers and sellers throughout the market chain. Numerical grades therefore are a means of creating uniformity of quality in the market channel. They are most useful if they reflect the needs of the majority of buyers in the market so that additional contract quality specifications are the exception rather than rule.

Fair Average Quality

The contract for fair average quality (FAQ) specifies that the grain shall be equal to the average quality of grain exported or imported at a specific location. The most common FAQ contract in previous years has been the GAFTA (Grain and Feed Trade Association) of London, which specifies that quality delivered will be equal to the average of the quality from the country of export to the importing country for the month in which the delivery was made. Samples are taken from each vessel and stored by GAFTA in their London laboratories. A composite sample at the end of each month is created as the standard, and shippers who think that the quality of their shipments did not meet FAQ submit samples to be judged against the GAFTA standard. Arbitration decisions are based primarily on visual inspection by an arbitration committee. Most GAFTA FAQ contracts are based on delivered quality. The standard varies between months, countries of origin, and crop years. The quality characteristics are few in number and consist primarily of visual observation.

The advantage of FAQ is its simplicity and its flexibility for adapting to changing crop years. This advantage to the seller is, of course, a disadvantage to the buyer. The contract does not cover all factors on which buyers might like information, and the floating standard leaves the buyer uncertain as to what quality may be received for processing. It is often a destination contract (advantage to buyers, disadvantage to sellers) and covers factors not likely to change in transit. Since half the vessels are mathematically below the FAQ standard, it is conceivable that many contracts would require court arbitration. In fact, the system is manageable because FAQ factors and sampling methods are not sufficiently specific to support arbitration action except in cases of extreme deviation from the standard.

The FAQ system provides no incentive for improving quality since it only describes whatever quality is produced. The extent to which the FAQ system describes value to users depends on the factors included. In the case of the GAFTA corn contracts, the factors describe primarily condition of the grain rather than intrinsic value characteristics. Some of the soybean contracts include oil and protein. The simplicity of FAQ facilitates trade but the potential for disputes and arbitration can reduce marketing efficiency.

Variations on the FAQ system include contracts that specify origin instead of destination. Canada and Australia have sometimes generated a fair average quality based on harvested quality for that crop. The FAQ standard is usually established with respect to selected characteristics of special importance.

In recent years the FAQ contract has been less frequently used. Argentina, South Africa, and Brazil all report exporting primarily on numerical grades. However, European buyers have reported continued use of destination FAQ on soybeans.

Destination Grades v. Certificate Final

Most contracts originating in the United States specify that grade is final at origin. This means that the grade certificate, issued immediately after the vessel is loaded, is the final document on quality and the buyer has no recourse beyond proving incorrect inspection on the origin samples. Foreign buyers must prove that the vessels were improperly loaded or inspected at origin before they can claim restitution for quality. Grain received in poor condition, badly broken, spoiled, sprouted, or insect-infested is not sufficient evidence on which to base claims for damage because the contract specifies origin certificate final.

Certificate final is a highly efficient marketing technique, and enables minimum cost quality guarantees up to the point where the exporter transfers responsibility for quality to the captain of the vessel or to the importer. It has the disadvantage of the ultimate customers' dissatisfaction with the delivered quality and their inability to control quality when several handlers stand between shipper and user. It also enables the shipper to load closer to the quality limits without regard to the inevitable consequences of placing that quality in the vessel.

The alternative is destination grades (often in conjunction with a cargo, insurance, and freight sale). In this case, the seller guarantees delivery to the foreign port and guarantees quality at that destination. This alternative has often been suggested as a solution to the problem of foreign complaints. But many unanswered questions remain about such contracts. For example, who will take the destination samples and how? Second, what type of guarantee can shippers make for a vessel that will be distributed among 10, 20, or even 50 different buyers, each one getting only a small portion from a vessel with a highly variable quality among holds? Third, since the buyer specifies the quality characteristics and frequently requests a moisture content unsafe for long voyages through warm water, how can shippers guarantee quality at destination?

The buyer has always had the alternative of using a contract that specifies destination quality. Few shippers are willing to take that type of risk at a price the buyer would be willing to pay. With no control over unloading or sampling, shippers are in a poor position to guarantee destination quality and the number of contracts taken into arbitration court would undoubtedly rise dramatically, resulting in a significant increase in cost and delays in settlement.

Origin and destination contracts can be used to guarantee quality under any set of standards. Yet, the two systems incorporate different incentives. Destination guarantees place additional responsibility, and thus economic incentives, on the exporter to load grain that will maintain quality during transit as well as meet the contract at time of loading. This alters the loading strategy. Under origin grades, for example, a 14. O-percent moisture contract could be met by blending 8 and ***16*** percent moisture corn. Under destination quality guarantees, this blending would not be a good strategy under most time and temperature conditions. The high-moisture corn would probably result in damage levels and spoilage at destination exceeding the contract limit.

The issue of origin and destination grades must also be considered in the context of domestic markets. The same issues exist as in the export market, but the results are different for two reasons:

1. the time between origin and destination is usually much shorter in the domestic market; and
2. sampling and inspection procedures at origin and destination are subject to a single set of regulations in the domestic market, whereas FGIS has no control over sampling and grading at foreign destinations.

Domestic contracts specify origin or destination grades as well as whether settlement will be based on official or private inspection results. Confidence in accuracy is developed with a large number of transactions over a period of time and by the option of calling for FGIS inspection and an appeal if needed. This confidence often results in acceptance of non-FGIS origin inspection where direct contact between buyer and seller has generated mutual trust. Trade rules and arbitration procedures established by the National Grain and Feed Association also provide an important alternative and supplement for domestic trade.

Dual Grades

A dual grading system could be based on separating domestic and foreign markets or separating use, Separate export standards have often been suggested as a way to compete in international trade with more restrictive quality specifications. The Canadian system establishes separate grade requirements for export wheat and controls purchases, movement, and cleaning procedures between country elevators and the ports to administer this system (see companion report). Separate food grades and feed grades have also been suggested for corn and wheat. Food grades would be more restrictive, especially with respect to sanitary quality factors, and could include more information on value in processing.

Separate standards for different users could provide more information on value. The food grade or export grade could have price differentials that would generate market incentives for improved quality. The market would direct the higher qualities into the higher valued uses. The dual system would create a more complex marketing system and would probably increase the cost of segregation and transport. Probably the greatest difficulty would be determining which standard and discount to apply to the producer. Since ultimate use would not be determined at the time of farmer delivery and, in fact, intended use might be changed more than once in the market channel, the higher discounts on food grade or export grade would have to be applied against the producer. This would generate incentives for quality improvement on all grain at a cost that would not be justified for feed use in domestic markets. Dual standards would thus not facilitate an efficient market.

APPLYING ECONOMIC CRITERIA TO GRAIN STANDARDS

As the four objectives of grain standards specified in the 1986 Grain Quality Improvement Act do not lead directly to a system of grades and standards, an intermediate set of guidelines is required to:

- Define uniform and accepted descriptive **terms to facilitate trade.**

  This requires a small number of categories established by clearly defined factors. The factors must be readily measured in commercial trade and objectively determined by technology that gives repeatable results at each point in the market channel. The factors must be acceptable to and used by most participants in the market. Trade is also facilitated by stability and absence of change, since any change results in uncertainty and adjustment.

- **Provide information to aid in determining grain storability.**

  This purpose would be met by tests that reflect storage history as well as predicting remaining storage life. Information on infestation by molds, fungi, and insects needs to be accompanied by the extent of the development and deterioration. Kind of infestation is also an important measure of storability as a guide to actions required to inhibit further deterioration.

- **Offer end-users the best possible information from which to determine end-product yield and quality.**

  The characteristics of raw grain that indicate the quality and quantity of processed products differ with different industries. Factors selected for inclusion in standards should either be common to several industries or be important to an industry consuming a significant portion of the crop. The more directly the factor measures the desired end product, the more efficiently will the standards reflect value.

- **Create tools for the market to establish incentives for quality improvement.**

  Incentives in standards are created in part by including factors that are economically important. To provide the market the maximum opportunity to establish price incentives the standards should: 1) minimize the distance between factor limits for each numerical grade; 2) report all values as accurately as measurement technology allows, using standard mathematical procedures for rounding to the nearest significant digit; and 3) convey important economic information to producers that will enable them to respond to producer preferences related to value.

Grade-Determining, Non-Grade Determining, and Official Criteria Factors

The factors selected as indicators of value may be included as grade-determining factors, as non-grade-determining factors, or as official criteria. As described earlier in this chapter, grade-determining factors set numerical grade according to the factor limits established. Non-grade-determining factors contained in the standards do not influence grade but must be reported as information whenever an official inspection is made. Factors defined as official criteria are measured and reported only when requested.

Assigning each factor to one of the three categories requires a guideline that can be used objectively. As noted previously, standards should serve the needs of a majority of users and should reflect value for those uses. This suggests that grade-determining factors should be those that relate to sanitary quality, purity, and soundness (absence of imperfections). Using this guideline, the grade would be based on factors such as impurities, foreign material, total damage, and heat damage. The lower the values of any of these defects, the greater is the value of the product. Non-grade-determining factors would be those related to properties such as broken kernels, moisture, oil and protein content, and other intrinsic characteristics or physical properties that influence value for the major processing uses. Higher or lower percentages for these do not necessarily mean higher end-use value over the entire range. For example, the required level of protein in wheat depends on the ultimate product to be made from the flour. Lower moisture content means more dry matter per pound, but 5 percent moisture corn is not generally of greater value than 12 percent because of the effects of overdrying. Usually some optimum value is indicated for each of these factors, but the optimum varies with the use and location in the market channel.

Under Section 4 of the USGSA, factors contained in the standards must be measured during any official inspection. Those considered official criteria are measured upon request. Although the advisability of that particular part of the law is a matter of debate, in its present form it leads to the conclusion that characteristics most important to the largest number of users would be incorporated into the standards. Those of lesser importance, or important to only a few users, would be considered official criteria available upon request to buyers who need them. Thus moisture and basic intrinsic properties—such as protein content, kernel hardness, and falling number tests in wheat; protein and oil in soybeans; and starch in corn—might be incorporated as non-grade-determining factors. Breakage susceptibility and kernel hardness in corn and kernel size in soybeans are examples of factors to be made available under official criteria.

The advantage of putting the major factors in as non-grade-determining factors rather than official criteria is that the characteristics would move into the market channel much more readily. Obligatory measurement throughout the market would spread the cost across the entire industry. The cost per unit would be insignificant and therefore the information would be readily available as an incentive. A characteristic that must be specified by a separate request from each individual buyer would increase the cost of information. For example, the true value of information on test weight is irrelevant under the present system since everyone is required to measure test weight. The marginal cost to the buyer for that information is nearly zero. In contrast, if only one buyer specifies oil content in a soybean contractor falling number in a wheat contract, the cost of information would be much greater because the cost of measurement throughout the market channel would be borne by the single buyer and would be spread over only the bushels that buyer purchased.

Objective criterion based on the four purposes of standards has thus provided a basis for choosing factors and for dividing them among grade-determining, non-grade-determining, and official criteria.

Establishing Grade Limits

As noted earlier, the grade limit on various factors is an automatic incentive throughout the market channel to add materials or to blend to reach that limit. Blending damaged soybeans with good ones does not increase the value of the damaged soybeans, but it does increase their price, for they may now be sold as a higher grade. The criterion of providing incentives for improving quality dictates that the base be set at zero. The overall objective of a standard is "to describe the value of the lot of grain being sold. " If the percent of damaged kernels can change from ***5.0*** to 6.9 percent without changing grade, then numerical grade alone does not provide complete information on differences in value. Current soybean standards allow 1.0 percent foreign material and no discount is applied by the market, implying that any level between ***O*** and 1.0 percent represents equal value. The first 0.5 percent of foreign material in a shipment of soybeans has no more real value than the third ***0.5*** percent, even though the third is discounted and the first is not.

Tighter limits on existing grade factor limits would reduce the incentives for blending and provide a more accurate measure of value as long as discounts continue to be applied on the same grade. However, it is as difficult to justify an arbitrary limit of ***0,5*** percent as it is to justify an arbitrary limit of 1.0 percent. The only objective limit is zero, with market discounts being applied for additional levels within the ability of sampling technology to differentiate.

The base for the non-grade factors is of course immaterial, since it is not grade determining, and the market is now free to choose what, if any, price adjustment is to be made for different levels of those factors.

The zero base concept is limited by the freedom of the market to respond. Unless (or until) export contracts and prices are established at zero base, merchandisers could start discounts at any level they desired, including the current factor levels for No. 2 corn and for No. 1 wheat and soybeans.

Number of Grades

The final question in setting standards is the number of different grades required. The number of numerical grades differs among grains—malting barley has three, soybeans and sorghum have four, and corn and wheat have five—and all grains have a sample grade designation. Historical records provide no rationale for these numbers and the justification for the different numbers between standards is not clear. The fewer the numerical grades, the simpler is the marketing and the less space required to segregate these grades in storage.

A single grade would force the foreign buyer to specify the quality characteristics and the level of those characteristics desired. Buyers would no longer receive 4 percent BCFM by default when ordering No. 3 corn. They would be forced to specify the levels desired and would know in advance the trade-off with price.

The market seldom uses more than two grades. More grades increase the complexity for the market and provide no increase in information. The disadvantage of a single grade is that nearly every buyer must use one grade or specify levels on each factor. This would result in increased diversity of contracts, less opportunity to resell uniform lots, and increased transaction costs. The final number of grades to be established for each grain must be a compromise between the purposes of providing incentives, identifying value, and facilitating trade.

EVALUATION OF RECENT LEGISLATION

Optimal Grade

The optimal grade concept proposed a single grade, with low values for selected defects and discounts on any defects above the base. The object was to reduce the incentive for blending built into the current standards by lowering the limits and thereby better meeting the fourth objective of standards. It used the principle of grade factors being required to reflect cleanliness, soundness, and purity. It set low levels for that grade but not at zero. It would have met the criteria of simplicity, facilitating trade, and removing incentives for blending. However, it did not meet the criterion for measuring quality for various uses. Its greatest deficiency was a failure to identify the non-grade-determining factors that would be incorporated in the standards. It also failed to eliminate completely the incentive to blend off large quantities of poor quality grain by not setting the base values at zero. Congressional rejection of the optimum grade was probably more a reflection of problems of implementation than of failure to meet the criteria established by the purposes of grades.

The Grain Quality Improvement Act Of 1986

Perhaps the most important contribution of this legislation was introducing into the USGSA the four explicit objectives for grain standards, including three relating to economic value. Without these objectives, the standards had primarily reflected response to pressure from various groups. Without support from one or more major associations or organizations, it was extremely difficult to make any changes in the standards because the only criterion was that of facilitating trade. As noted, FGIS now has criteria on which to base changes and can justify those changes in terms of what is best for the industry.

Prohibitions v. Market Incentives

Developing solutions to the problems and issues raised by grain standards faces two basic choices:

1. legislative prohibitions against practices that are detrimental to quality; and
2. changes in the economic incentives of standards in pricing practices to allow the market to discipline offenders.

The first alternative focuses on controlling the process by which grain is marketed; the second, on accurately evaluating the product and value of different qualities.

Throughout history numerous bills and amendments have tried to legislate specifics in grain standards. Nearly all legislative attempts have failed. The few successful activities since the late 1800s have focused on setting policy and creating a framework for administrators to implement rather than legislating specifics. During the 1980s numerous bills or amendments have been submitted to restrict the way in which foreign material, dockage, or dust can be handled, particularly in the export markets. The 1986 Grain Quality Improvement Act included a prohibition against reintroducing dust or foreign material into the grain stream once it has been removed. The intent was clear: to improve the quality of the grain being exported and especially to improve the U.S. image in international grain markets. The success of this type of legislation is not yet clear. Yet several difficulties can be identified in implementing prohibitions while leaving intact the standard structure that generated the incentives for blending when purchasing on grade only.

The prohibition in the 1986 Grain Quality Improvement Act focuses on controlling the process rather than the product. Consequently, its enforcement has presented numerous problems, not the least of which is a definition of what constitutes foreign material, which the standards define in many different ways and identify with many different names. For example, in corn only one factor encompasses all nongrain material: BCFM, which is defined as any material passing through the 12/64-inch sieve plus noncom material remaining on top. Wheat includes a factor for foreign material and one for shrunken and broken kernels as well as a category called dockage. Barley standards contain three factors: dockage, foreign material, and broken kernels. In nearly all cases, foreign material is defined in conjunction with particle size, meaning materials that got through a certain size sieve. The sieve size varies among grains. In almost all cases, not all foreign material is actually removed, and in almost all cases the foreign material contains small grain particles that are not "foreign" at all. (For information on problems in defining grain, see ref. 1.)

Another problem with the prohibition approach is that the quantity of foreign material or broken kernels incorporated into a grain shipment is controlled by the contract in conjunction with the grade limit. Therefore, the prohibition does not prevent leaving dirt, dust, and foreign material in the grain, nor does it prevent blending of different lots of grain containing various levels of foreign material to achieve the maximum allowed. It only limits the procedure by which the maximum maybe achieved. In addition, some if not most of the "foreign material" in overseas processing plants is broken grain created during unloading of vessels. Consequently, it is unlikely that the actual amount of "foreign material" delivered to the foreign buyer will change, but it may be more expensive to attain the contract levels at the export elevator.

The most basic problem is one of trying to legislate restrictions to counter the economic incentives built into the standards themselves. Having an allowance of 4 percent BCFM in No. 3 corn builds in an automatic incentive to add that much foreign material to the load when corn is purchased on the grade alone. Removing that incentive would be more efficient than a prohibition. If a set of standards can be established that creates incentives to achieve the desired end product in terms of quality, the legislative prohibition would become unnecessary.

FINDINGS AND CONCLUSIONS

Continual review of grain standards since their inception in the 1916 United States Grain Standards Act has generated numerous changes and proposals for change in factors and factor limits. These have not resolved the problems or foreign complaints related to quality. U.S. grain standards today:

- create incentives for practices not consistent with good management and efficiency;
- fail to identify many of the characteristics related to value in use;
- fail to reward producers and handlers for improved drying, harvesting, handling, and variety selection; and
- include arbitrary grade limitations on many factors that do not always reflect real differences in value, and in some cases are not consistent with statistical principles.

The many regulatory and legislative standard changes have failed to move the industry in a consistent direction. In fact, there have been numerous reversals of previous changes. What has been lacking is a clearly defined goal toward which the system is being moved. With the four objectives for standards now established by legislation, it is possible to develop for each grain a set of "ideal" standards that could provide a direction for future changes and a yardstick against which to evaluate alternatives. If each change adopted moves the operational standards closer to the ideal, repeated reversals should no longer create unnecessary adjustment costs and confusion in domestic and foreign markets.

Conflicts between purposes can be explicitly identified and the trade-offs and economic consequences calculated and recorded as guidance for a long-range consistent policy. The ideal system should include grade-determining factors, non-grade-determining factors, and definition and measurement technology for official criteria.

Existing research is generally adequate to identify grade-determining factors—sanitary quality factors, damage that reduces yield and quality of processed products or value in use, and foreign material including dust. For No. 1 grade, these factor limits should be set as close to zero as measurement technology will allow. Any value above zero violates the third and fourth purposes of grades. The exact definition of these factors, including sieve size for foreign material, still requires additional research to evaluate the alternatives against the criterion of reflecting value accurately.

Non-grade-determining factors should measure value for a majority of users. The preferred level may differ among uses. For example, splits in soybean reduce oil quality only in proportion to the time in storage. Thus, domestic processors buying for immediate use may allow high levels of splits with no discounts. Foreign buyers, whose processing of the soybeans may lag harvest by 12 to 18 months, may place much more restrictive limits and discounts on splits.

Many of the intrinsic and physical properties that influence the quantity and quality of products derived from the grain have not been identified. More research may add to the list of properties to be included. The criteria for inclusion should be that the cost of obtaining the information is less than the value of that information to users who need the information. By starting with the major products generated from each grain, a list of physical and intrinsic properties can be developed that correlates with value in use. New, rapid objective testing technology is also a requirement prior to inclusion.

The list of factors to be measured under official criteria is almost unlimited except by measurement technology. Any properties that can be accurately measured can be requested by buyers and sellers. These would be developed only after evidence of sufficient demand to cover the cost. Information on the factors of interest for the various users could be provided by private laboratories and would be added to official criteria only after rapid objective technology is developed and when there is sufficient demand by domestic or foreign buyers to justify including them.

Standards should be designed to reward positive actions, such as genetic improvement, and sound harvesting, drying, and marketing practices. They should also be designed to provide the best information available on the value of each shipment by descriptive terminology. All changes must be evaluated against the criterion of providing information that is worth the cost of obtaining it. Optimum information, not maximum information, is the goal. Proposals for change must also be tempered with current capabilities of the industry, the cost of adjustments v. potential benefits, the realities of international trading rules, and the historical sequence by which the industry has attained the present situation. Measurement and description of quality is only one part of the problem. Quality must be evaluated in the context of technology, competition, foreign demand, and processing requirements.

CHAPTER 8 REFERENCES

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