STAFF PAPER

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by

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INTRODUCTION

Grain standardization and grading are essential marketing functions and among the facilitating functions that make the movement of grains through the marketing channel easier and less costly. When grain standards and grades are discussed, it is assumed that grain quality is being discussed also. But what is quality? Quality, like beauty, is in the eye of the beholder.

The developmental stage of an economic system affects the structure and sophistication of the grain standards and grades. Producers in underdeveloped economies tend to classify their grain as food for the family, seed to be planted, grain for animals, or grain for sale. The buyers of this surplus grain are usually the processors, who buy only the quality that will make products to be sold. These buyers determine how much they will pay for the different grades or qualities of grain, because they are responsible for the quality of the products produced. Consumers rely on the consistent quality of the grain products and buy them as long as the quality is within their consumption preferences. The buyers have a direct link of knowing what products their consumers will buy and the different grades available to them locally. This can lead to a very specialized type of grain quality to satisfy this local demand.

As an economy develops further, the grain marketing system, with government support, often works toward a perfectly competitive market. This requires having a homogeneous or uniform product to facilitate price

comparisons by buyers. This requirement can be met by a market that encourages standardization of products, whereby the products of different companies or firms are interchangeable in the preference pattern of consumers. If the characteristics of different products are such that their relative value in use can be established on a fixed, known ratio, then the homogeneity criterion can be met for purposes of competition among buyers and sellers. [1/] With uniform terminology and measurements of important characteristics, buyers and sellers can establish relative values among the various forms or grades of grain.

As marketing systems develop to the point at which the buying and selling progresses beyond personal inspection before buying, sellers offer and purchasers inspect only samples of grain, instead of all the grain, before negotiating price. Further down the road of economic development, where long distances may exist between sellers and buyers, third party officials sample and certify the grade of grain based on agreed-upon standards.

A grain grading system administered by an impartial party, such as a governmental agency, offers to both buyer and seller a standardized method for evaluating the quality and value of a grain. Standardized grading permits trading to take place without the cost of personal inspection of every lot of grain or sampling of each grain lot by parties to the transaction. Grading also permits individual lots of the same grain to be commingled (or mixed) with others of similar quality for bulk transportation and storage. This reduces marketing costs.

Marketing is complex and there are many possibilities for waste, confusion, and downright trickery or deception. Grain standards and grades will help to keep these practices to a minimum. As one author phrased it,

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[1/] Lowell D. Hill, L.J. Norton Professor of Marketing, Department of Agricultural Economics, University of Illinois, Urbana, Illinois, USA in Grain Marketing Economics, Cramer, Gail L. and Walter G. Heid, Jr., editors, (New York: John Wiley & Sons, 1983), page 120.

standardization furnishes the ethical basis for making a transaction. Without such a system, the rule of caveat emptor ("let the buyer beware") must prevail along with all of its confusion and unfairness. [2/]

BASIC PURPOSES OF GRAIN STANDARDS

The usual or traditional purpose of grain standards is to characterize physical and biological properties of grain at the time of inspection. However, as buyer sophistication increases, new technologies and competitive pressures demand that this basic and traditional purposes be expanded.

Uniformity or standardization of grain grades serves three basic purposes: (1) to permit buying and selling grain by description rather than by inspection of each lot offered for sale, (2) to permit commingling of grain from many sources into a few categories or grades having (reasonably) uniform characteristics, thereby reducing the need for segregated storage, and (3) to provide a method for buyers to estimate the value of a particular lot and to communicate this value back through a complex marketing system to handlers and producers. [3/]

In 1986 a group of producers, grain merchants, and university professors met to evaluate U.S. grain quality and the standards that measure grain quality. After a series of meetings, they issued a report titled "Commitment to Quality." In that report, the group listed four reasons or objectives for grain grades and standards:

1. To define uniform and accepted descriptive terms to facilitate trade.
2. To provide information to aid in determining grain storability.

[2/] E.A. Duddy and D.A. Revzan, Marketing: An Institutional Approach (New York: McGraw-Hill, 1947), page 59.

[3/] Op. Cit., page 120.

3. To offer end-users the best possible information from which to determine end-product yield and quality.

4. To create the tool for the market to establish quality improvement incentives. [4/]

These four objectives include some of those listed previously, but have expanded the purpose of grain standards. Based on these objectives, the workshop participants had suggested some changes that might be considered in the standards for U.S. grain. In the United States, grain standards are legally mandated so that users of the grain grades can submit comments to the government on any proposed changes in the standards. Before any changes are made, the legal process requires considerable time to permit the development of proposals for discussion by the public including farmers, merchants, processors, and exporters, and then a formal proposal is published for public comment. All comments are evaluated by the government, and the administrator decides whether or not a change will be adopted. If adopted, a final rule is published and there is a one year waiting period before it can be made effective.

The United States has established standards for barley, corn, flaxseed, mixed grain, oats, rye, sorghum, soybeans, sunflower seed, triticale, and wheat. In this report, the standards related to corn, sorghum, soybeans, and wheat will be discussed.

QUALITY FACTORS

As mentioned above, the definition of quality will vary among the different users within the post-harvest system. Merchants want dry, insect free, undamaged grain that will store well. Processors want grain that will

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[4/] "Commitment to Quality" -- A consensus report of the grain quality workshops June 1986, page 3.

yield a high percentage of finished products. Consumers are concerned with other factors including appearance and cooking and flavor characteristics. The problems and desires of all persons in the marketing system (producers, merchants, processors, and consumers) must be considered in determining which qualities to include in the grain standards and which ones affect the overall value of a grain.

Some kinds of grains have unique characteristics that make it easy to class them. Each class will have an important quality from an end-use point of view, for example, white and yellow corn and red and white wheats. Among the red wheats, such as grown in the United States, the durum wheat class has special characteristics desirable in making pasta products. The hard wheats are considered good for yeast-type bread production. The following is a list of quality factors that will be defined as standards used in the United States. These factors are used to determine the specific grades 1, 2, 3, 4, 5, or sample grade.

Test Weight

Test weight measures density per unit volume. Test weight is determined by taking weight in a given volume of the original sample minus the dockage. It is reported in pounds per bushel. In the United States, the Winchester bushel is used. It has a 2,150.42 cubic inch capacity. Test weight per bushel is rounded to the nearest tenth of a pound.

Test weight is intended to provide an indication of the potential flour or product yield of the commodity. It has been criticized, however, on the grounds that the relationship between test weight and product yield is not an accurate one. Test weight may vary with moisture content, plumpness of grain, and the amount of foreign material. As moisture content increases, sample test weight decreases. Drier grain has a higher test weight than wetter grain

because the size of the higher moisture kernels increases faster than the grain weight.

Damaged Kernels

There are several reasons why a kernel of grain may be damaged. For example, can materially discolor or damage kernels or pieces of kernels. Heat damage is caused by the heat of fermentation of grain in which bacterial action is present and also by artificial drying when kernel temperatures become sufficiently high to cause discoloration or charring.

In wheat and grain sorghum, damaged kernels include damaged kernels of other grains and damaged kernels and pieces of kernels of the specific grain. Damaged kernels in corn and soybeans include pieces of kernels only of that specific grain. Damaged kernels include: badly ground-damaged, badly weather-damaged, diseased, frost-damaged, germ-damaged, heat-damaged, insect-bored, mold-damaged, sprout-damaged or otherwise materially damaged. Only in soybeans, stink-bug stung damage also is included. [5/] In wheat, damaged kernels are determined after the shrunken broken kernels and dockage are removed from the sample.

Damaged material may increase the acidity and rancidity of wheat and affect the color, flavor, texture, and yield of end products. For example, bread made with flour from sprouted wheat may have decreased loaf volume and slicing problems. The dough may not absorb water properly and mixing times may differ from those normally expected. Damage in other grains also may affect the quantity and quality of end-products.

[5/] "Official United States Standards for Grain", Washington, D.C., U.S., Federal Grain Inspection Service, Federal Register, Vol.52, Vol. 52, No. 125, June 30, 1987, pages 24423, 24427, 24428, and 24431.

Foreign Material

In wheat, foreign material (FM) is any material other than wheat that remains in a sample that has had dockage and shrunken and broken kernels removed. Common foreign materials in wheat are other grains and weed seeds. In corn, there is a factor known as broken corn and foreign material (BCFM) and in grain sorghum, broken kernels, foreign material, and other grains (BNFM). In corn, these are kernels and pieces of kernels of corn and all matter other than corn that will readily pass through a 12/64th (0.1875) inch sieve and all matter other than corn that remains in the sieved sample. The same requirement exists for sorghum using a 5/64 triangular-hole sieve size, i.e., equilateral triangle perforations and inscribed circles of 0.0781 or 5/64 inch in diameter. Foreign material in soybeans is determined with a 8/64 round-hole sieve. This is a metal sieve 0.032 inch thick perforated with round holes 0.125 (8/64) inch in diameter.

Shrunken and Broken Kernels

In wheat only, there is a category known as shrunken and broken kernels. These are materials taken from a dockage-free sample that can pass through a 0.064 by 3/8 inch oblong-hole sieve. The percentage of shrunken and broken kernels, damaged kernels, and foreign material in wheat are totaled to determine total defects. The percentage of total defects permitted for each grade is less than the sum of the maximum allowed for each individual factor. This means that the grain cannot contain the maximum amount of each factor allowed and thereby assures a higher level of quality than if there were no limitation specified for Total Defects.

Contrasting Classes and Wheat of Other Classes

In wheat only, two additional factors are used -- one is "contrasting classes" and the other is "wheat of other classes." Contrasting classes consist of other classes of wheat that have very different end-uses, for example, durum wheat, white wheat, and unclassed wheat found in either Hard Red Spring wheat or Hard Red Winter wheat. Wheat of other classes refers to a certain amount of wheat of a different class with similar end use being found in a given class, e.g., Hard Red Spring wheat found in Hard Red Winter. Both contrasting classes and wheat of other classes are determined on a portion free of dockage and shrunken and broken kernels.

Splits

In soybeans only, splits is a grade-determining factor. This factor identifies the percentage of the sample containing beans that are no longer whole by having "... more than one-fourth of the bean removed and that are not damaged." [6/] This factor is not a critical one for the maintenance of the quality of soybeans in storage, since U.S. No. 1 grade soybeans are permitted to have up to 10 percent splits and U.S. No. 2 grade soybeans are permitted to have up to 20 percent splits. Also, this factor is not heavily discounted in the marketplace, even though the oil from such beans may develop some rancidity.

Special Grade Designations

There are some special designations: "garlicky" (containing wild onions or wild garlic bulblets or pieces); "smutty" (containing smut balls or spores); "infested" (containing live insects injurious to stored grain); "ergoty"

[6/] "Official U.S. Standards for Grain", Washington, D.C., Federal Register, Vol. 52, No. 125, Tuesday, June 30, 1987, page 24426.

(containing ergot, a fungus), and "treated" (for wheat that has been scoured, limed, washed, sulfured, or treated in such a manner that the true quality is not reflected by either the numerical grades or the U.S. Sample grade designation alone).

These designations are noted on grade certificates and are supplemental information to the numerical grade. Each of the four grain standards may use all or part of these special grade designations. For corn, the only designation used is "infested"; for sorghum, the terms used are "infested" and "smutty"; for soybeans, "infested" and "garlicky"; and for wheat, the terms used are "infested", "garlicky", "light smutty", "smutty", and "treated".

INFORMATION FACTORS

In the United States, grain is inspected and graded according to factors that do not affect the grade level for the grain. These factors are hardness, color, protein, moisture, and dockage. How each factor is related to a specific grain is explained below.

Five classes of wheat are produced and marketed in the United States. Whether a commercial wheat is categorized as winter/spring, hard/soft, white/red, or durum depends on the planting time, the variety, and the environment in which it is grown.

Winter wheat is planted in the fall, goes through the winter in a dormant stage as a young seedling, and matures in early summer of the following year. Spring wheat is sown in early spring and harvested in the same year. Whether the wheat is a winter or spring wheat generally is unrelated to the end-use of the wheat, although hard red spring wheat is often marketed as a wheat containing higher levels of protein and gluten strength than hard red winter wheat. These two characteristics of protein and gluten strength are important because they affect the products in which the flour is used. The end-use of

the wheat classes depends upon a number of conditions provided by informational and grading factors.

Hardness

The hardness of wheat is considered only in wheat classification, since the class of wheat has been used as an important criterion in buying wheat for the desired end-use. Hard wheat yields a coarse flour that is easily sifted because of the regularly shaped endosperm cells and is good for making bread flour or semolina for pasta. The vitreous endosperm causes the flour to be coarse. The endosperm is that portion of the grain kernel containing the starch, and "vitreous" refers to the appearance of the kernel under a light; a vitreous kernel is translucent and hard. The vitreous endosperm itself is the result of the variety of wheat and the environment in which it is grown. A soft wheat gives very fine flour that is more difficult to sift because of the irregular shape of the endosperm cells. It is best suited for pastry flour. Very fine flour results from nonvitreous endosperm; it is chalky when compared to the kernel of a hard wheat. Equally important as these characteristics is the fact that hard wheats, in general, have more protein than soft wheats. Some customers use hardness as a proxy for a desired milling quality in order to produce the required end product.

Hardness is not considered in corn, sorghum and soybean standards. Most corn grown in the United States is dent type, which basically has a soft pericarp compared to flint type corn; however, under the corn standards there are special grades for "flint" corn with harder pericarp and "flint and dent" corn. The dent corn receives its name from the indentation at the top of the kernel, which occurs during maturation. Different varieties of dent corn have different tendencies to break during the handling process, as they are moved through the marketing system.

Research has been conducted to evaluate whether it is technically and economically feasible to measure the breakage susceptibility of corn by using two available breakage testers. The results of the research have been provided to FGIS. Before incorporating a breakage susceptibility into the corn standards, a considerable amount of public discussion will occur.

Color

The bran surrounding the wheat kernel provides the color, whether it is red or white. Color of the bran is part of the wheat class. In the U.S., the white wheats, usually as soft wheat, are used to make crackers, cakes, cookies, and cereal food for breakfast. In the Orient, to which the major portion of U.S. white wheat from the Pacific Northwest is exported, they are used to make noodles. Three-fourths of the wheat grown in Michigan is white and is used primarily in making breakfast cereals. The soft red wheats in the United States are used for making crackers, cookies, and cakes. Hard red wheats are used to make bread and hard dinner rolls. The milling yield must be kept around 74 or 75 percent in order to prevent discoloration of white flour with portions of red bran. There are currently breeding and marketing investigations on the feasibility of producing, marketing, and milling a hard white wheat in the state of Kansas. Since white wheat it will start out as a small quantity, the method of marketing it is uncertain in a system that is dominated by red wheat. A small amount of hard white wheat is grown in California.

For corn, the predominant class is yellow corn, which is defined as "yellow-kerneled and contains not more than 5.0 percent of corn of other colors. Yellow kernels of corn with a slight tinge of red are considered yellow corn." [7]/

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[7]/ Ibid., page 24423.

For sorghum, four color classes are designated. They are white, yellow, brown, and mixed. The predominant one is yellow, which is defined as "sorghum with yellow, salmon-pink, red, white or translucent pericarps, that contains not more than 10.0 percent of sorghum with brown pericarps or pigmented subcoats, and that does not meet the requirement for the class White sorghum." [8/]

For soybeans, there is essentially one class (yellow) although there is a mixed class. The definition of yellow soybeans is --"Soybeans that have yellow or green seed coats and which in cross section, are yellow or have a yellow tinge, and may include not more than 10.0 percent of soybeans of other colors." [9/]

Protein

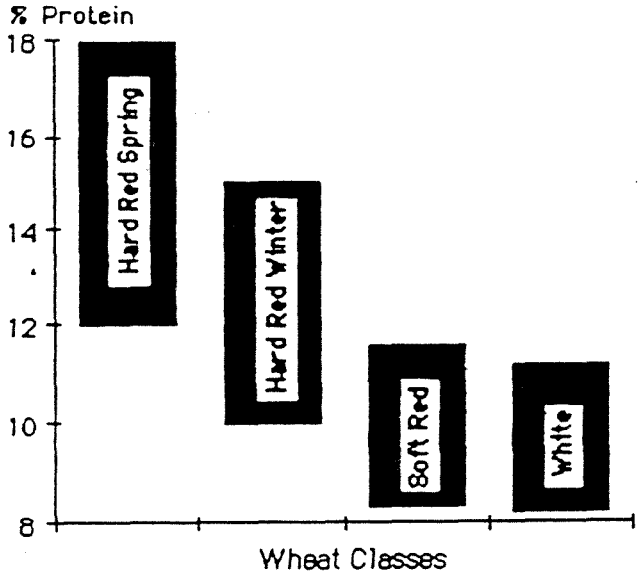
Protein percentage in wheat is related to classification and also affects the end-use. Yeast bread requires higher protein and gluten content than crackers, muffins, or oriental noodles. Figure 1 shows this relation between protein range and flour uses of major wheat classes. High-protein bread wheats generally have a higher monetary value than ordinary-protein wheat of the same grade. This value is reflected in a "protein premium" in the marketplace. Conversely, soft wheat with a protein content lower than that of ordinary hard wheat may sell at a discount. However, because the supply and demand for protein affects price premiums and discounts, buyers sometimes are able to purchase high protein wheat at little or no premium to ordinary protein wheat or soft wheat. From Figure 1, it should be evident that considerable opportunity for substitution exists among wheat classes for a specific end-use. In the other grains, protein is not measured under the grain standards.

[8/] Ibid., page 24427.

[9/] Ibid., page 24428.

However, it has been recommended that practical tests and methods meaningful in determining end-product yield and quality, such as protein and oil content of soybeans and the nutrient content of corn, should be developed. [10]/

FIGURE 1



Moisture

Moisture content is a measure of the percent of total wheat, corn, grain sorghum, or soybeans weight that is composed of water and is an important factor for storage and milling. The level of moisture provides an indication of the storability of the grain. However, it goes without saying that grain quality cannot be improved during storage. Marketing expenses are increased if grain has to be dried to a more desirable and storable moisture level. Most of the hard wheat class in the United States is grown in semi-arid areas and, as a result, is relatively low in moisture at harvest time. Consequently, artificial drying often is not needed for hard wheats. Corn typically needs to

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[10]/ Op. Cit., "Commitment to Quality", page 21.

be artificially dried, and wheat that is grown in more humid areas of the country also may need to be artificially dried.

Until recently, moisture was not a factor used to determine a grade in corn, sorghum, and soybeans. This requirement was dropped in September 1985 because moisture itself does not determine quality. Moisture levels in wheat also are not used in determining a wheat grade. However, moisture content is measured in the grading process, and the level is stated. Quality may be affected, if the grain is stored at too high a level of moisture. Consequently, moisture is always measured and is placed on a certificate but is not used to determine the grade itself.

Dockage

The last informational factor is dockage. Dockage in wheat and sorghum is a difficult concept to comprehend. Federal Grain Inspection Service (FGIS) describes this as "All matter other than wheat (or sorghum when grading sorghum) which can be removed readily from a test portion of the original sample by use of an approved device in accordance with procedures (which is generally the Carter Dockage Tester) prescribed in FGIS (Federal Grain Inspection Service) instructions. Also, underdeveloped, shriveled, and small pieces of wheat (or sorghum when grading sorghum) kernels removed in properly separating the material other than wheat (or sorghum when grading sorghum) and that cannot be recovered by properly rescreening or recleaning." [11/] The remaining non-wheat (or non-sorghum) material is foreign material which was described above.

[11/] Ibid., pages 24431 and 24427.

The Determination of a Specific Grade Number

Determining grades in the United States is based on the ratings of quality factors for a sample of grain. For example, in using the following wheat standard table, the specifications for U.S. No. 1 are: test weight for hard red winter, no less than 58 pounds per bushel and soft red winter (all other classes and subclasses) is to be no less than 60.0 pounds per bushel. Heat damage cannot exceed 0.2 percent. Damaged kernels, that is all damaged kernels, cannot exceed 2.0 percent; foreign material cannot exceed 0.5 percent; shrunken and broken kernels cannot exceed 3.0 percent; and the accumulation of damaged kernels, foreign material, shrunken and broken kernels for total defects cannot exceed 3.0 percent. Contrasting classes cannot exceed 1.0 percent, and wheat of other classes cannot exceed 3.0 percent to receive a grade of No. 1.

However, do not let this be misleading as to the quality of grade U.S. No. 1. Seldom is there any heat damage in grade U.S. No. 1. Damaged kernels should be well below 2.0 percent. Certainly if 3.0 percent in shrunken and broken kernels exists in a sample, there could not be any foreign material or damaged kernels to maintain a 3.0 percent for total defects. For contrasting classes and wheat of other classes, the actual levels usually are substantially below the percents allowed.

The grade of a grain is determined by the lowest rated factor, as shown in the following example. Assume that a representative sample of a shipment of hard red winter wheat had 58.0 pound test weight, 0.1 heat damage, 1.0 percent of damaged kernels, 1.0 percent foreign material, 5.0 percent broken and shrunken kernels (resulting in a 7.0 percent total defects), contrasting classes at 1.0 percent, and wheat of other classes at 3.0 percent. In this

case the factor that is rated lowest is total defects of 7.0 percent, so the total lot from which this sample was taken would be graded U.S. No. 3.

At the bottom of the table are the factors that identify the shipment grade as U.S. sample grade. This is grain that does not meet the above requirements for the lowest grade or has some other deleterious or commercially objectionable characteristic. Sample grade is seldom shipped in export trading and is undesirable even in domestic trade.

Often it is asked, why are two factors of dockage and foreign material used to describe non-wheat material or non-sorghum material? In wheat for example, having the two factors permits better definition of the non-wheat material. Material removed by the Carter Dockage machine is one type of foreign material, and the remaining non-wheat material in the representative sample is foreign material, which has different characteristics. For example, in wheat, any corn kernels would be taken out by the Carter Dockage machine and would be called dockage. However, grain sorghum kernels would remain in the wheat sample after going through the Carter Dockage machine. These kernels would be separated out by hand picking and would be called foreign material. Thus, there is a description of different types of materials based mostly on size determination.

In corn and sorghum, the broken kernels and foreign material are combined and considered as one factor. At times there have been proposals to separate this into two factors, one as broken kernels and one as foreign material. Currently, the Federal Grain Inspection Service is measuring those two factors separately and identifying them as extra information at the bottom of the inspection certificate. Separating the broken corn and foreign material into two separate factors was a recommendation by the consensus group mentioned earlier, in order to have more market information and perhaps develop improved

UNITED STATES GRADES AND GRADE REQUIREMENTS FOR CORN

Grades	Minimum test weight per bushel (percent)	Maximum limits of--		
		Damaged kernels		Broken corn and foreign material (percent)
		Heat damaged kernels	Total (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 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 objectional foreign odor; or

(d) Is heating or otherwise of distinctly low quality.

Source: "Rules and Regulations", Washington, D.C., Federal Register, Vol. 52, No. 125, Tuesday, June 30, 1987, pg 24423.

UNITED STATES GRADES AND GRADE REQUIREMENTS FOR SORGHUM

Grades	Minimum test weight per bushel (pounds)	Maximum limits of--		
		Damaged kernels		Broken kernels, foreign material and other grains (percent)
		Heat damaged (percent)	Total (percent)	
U.S. No. 1	57.0	0.2	2.0	4.0
U.S. No. 2	55.0	0.5	5.0	8.0
U.S. No. 3[1]	53.0	1.0	10.0	12.0
U.S. No. 4	51.0	3.0	15.0	15.0

U.S. Sample grade is sorghum that:

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

(b) Contains 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), 8 or more cockleburs (Xanthium spp.) or similar seeds singly or in combination, or in combination, 10 or more rodent pellets, bird droppings, or equivalent quantity of other animal filth per 1,000 grams of sorghum; or

(c) Has a musty, sour, or commercially objectional foreign odor (except smut odor); or

(d) Is badly weathered, heating or distinctly low quality.

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1 Sorghum which is distinctly discolored shall be graded not higher than U.S. No. 3.

Source: "Rules and Regulations", Washington, D.C., Federal Register, Vol. 52, No. 125, Tuesday, June 30, 1987, pg 24427.

UNITED STATES GRADES AND GRADE REQUIREMENTS FOR SOYBEANS

Grades	Minimum test weight per bushel (pounds)	Maximum limits of--				
		Damaged kernels		Foreign material (percent)	Splits (percent)	Soybeans of other colors (percent)
		Heat damaged (percent)	Total (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[1].....	52.0	1.0	5.0	3.0	30.0	5.0
U.S. No. 4[2].....	49.0	3.0	8.0	5.0	40.0	10.0

U.S. Sample grade is soybeans that:

(a) Do not meet the requirements for the grades U.S. Nos. 1, 2, 3, or 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 objectional foreign odor (except garlic odor); or

(d) Are heating or otherwise of distinctly low quality.

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1 Soybeans that are purple mottled or stained are graded not higher than U.S. No. 3.

2 Soybeans that are materially weathered are graded not higher than U.S. No. 4.

Source: "Rules and Regulations", Washington, D.C., Federal Register, Vol. 52, No. 125, Tuesday, June 30, 1987, pg 24428.

UNITED STATES GRADES AND GRADE REQUIREMENTS FOR WHEAT

Grades	Minimum limits of--		Maximum limits of--						
	Test weight per bushel		Damaged kernels					Wheat of other classes[4]	
	Hard Red Spring Wheat or White Club Wheat[1] (pounds)	All other classes and subclasses (pounds)	Heat damaged kernels (percent)	Total[2] (percent)	Foreign material (percent)	Shrunken and broken kernels (percent)	Defects[3] (percent)	Contrasting classes (percent)	Total[5] (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 is wheat 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 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

(c) Has a musty, sour, or commercially objectional foreign odor (except smut or garlic odor); or

(d) Is heating or otherwise of distinctly low quality.

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1 These requirements also apply when Hard Red Spring wheat or White Club wheat predominate in a sample of Mixed wheat.

2 Includes heat-damaged kernels.

3 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.

4 Unclassed wheat of any grade may contain not more than 10.0 percent of wheat of other classes.

5 Includes contrasting classes.

Source: "Rules and Regulations", Washington, D.C., Federal Register, Vol. 52, No. 125, Tuesday, June 30, 1987, pg 24431.

quality of these grains for the domestic and export markets. Additionally, research information has been provided to FGIS about the feasibility of measuring the breakage susceptibility of corn. If breakage susceptibility can be determined and used effectively, the marketing system may be able to encourage delivery of corn that does not break easily as it is handled through marketing channels.

The standards tables for corn, sorghum, and soybeans that precede this discussion show the factor limits for each grade. The grade number is determined in the same way as the wheat example. [12]/

OTHER COUNTRIES' GRADING SYSTEMS

There are other grading systems that differ from that of the United States. The following information on Australia, Canada, and Argentina is taken from Wheat Export Trade Resource Handbook published by the Wheat Export Trade Education Committee (WETEC), Washington, D.C.

Australia [13]/

Of the six classes of Australian wheat, the first four represent milling wheat classes, which may be exported. Test weight and amylase activity (falling number test) are used to determine the basic classification. Grades are often based on test weight, variety (state of production), protein content, grain hardness, milling quality, and dough properties. Although the Australian

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[12]/ Ibid., pages 24423, 24427, and 24428.

[13]/ WETEC, Wheat Export Trade Education Committee, Suite 301, 415 Second Street, N.E., Washington, D.C. 20002, (202)547-2004, Appendix A, page 3.

grading system is formalized, it remains quite flexible, and grades may change from year to year depending upon the quality of the crop or market demands.

Canada [14]/

Separate grade schedules are established under the Canada Grain Act for each class of wheat grown in Canada. These schedules are designed to provide individual grade tolerances of various factors such as test weight, variety, soundness, purity of class, minimum percentage of hard, vitreous kernels, wheat of other classes or varieties, and foreign material. No. 1 and No. 2 Canada Western (C.W.) grades of Red Spring Wheat are segregated on the basis of protein content; however, protein content is not a numerical grade determining factor. Red Spring Wheat is straight grade if its moisture content is 14.5 or lower. The levels tough, damp, moist, and wet apply to higher amounts of moisture. In contrast to U.S. exports, all wheat shipped from Canadian terminals is required to be "essentially free of dockage" before it can be assigned to the grade for which it qualifies.

Argentina [15]/

The main grading factors in the Argentine system are test weight, vitreous kernels, broken or damaged kernels, and foreign material. Supplementary quantities of specific factors such as the minimum protein level are provided by shippers in export sales contracts. Since live insects are not permitted in bread wheat, chemical treatment for control of insect infestation is allowed at port terminals.

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[14]/ Ibid., Appendix, page 3.

[15]/ Ibid., Appendix A, page 3.

Other Countries

On the other hand, there are other countries which do not use a system of numerical grades. Rather, each quality factor is discounted according to the amount by which factor falls below a set buying limit. Some of the factors used in this type of grading or inspection system are: moisture, the level of impurities, which in the U.S. is called foreign material (and dockage in wheat and sorghum), and damage factors such as insect, mold, and other damage. Some others use only test weight, broken kernels, and odors.

The Dominican Republic in the 1970's used a system of grading factors as in the United States. The tolerances allowed for the factors in No. 1 corn were approximately the same as those for No. 3 corn in the U.S. When the difference was questioned, the answer was that the in-country production fits these conditions and there is no grain that would meet U.S. No. 1 and U.S. No. 2 grade standards. Therefore, there seemed to be no reason to use the same criteria as the United States. It should be noted that foreign material and moisture content did not enter into the grading of corn. These were discounted according to the amount present. [16/]

COMMENTS ON SOME GRADING FACTORS

Moisture

Merchants are concerned about moisture from two points of view -- one relates to quality and the second is to avoid buying excess moisture above a desirable level for milling or processing into food or feed products. In other

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16/ "Development of Grain Standards in Developing Countries", by Kenneth Steinke and Dr. Harry B. Pfost, published by the Food and Feed Grain Institute, Manhattan, Kansas 66506, Grain Storage, Processing and Marketing, Research Report No. 12, June 1978, p. 14.

words, excessive moisture not only adds unwanted weight to the grain but also affects the storability.

Once the moisture level is measured, how are excessive moisture levels discounted? Moisture discounts can serve several purposes: (1) as a basis for price adjustments that compensate for different portions of water and dry matter, (2) to cover the cost of conditioning, (3) to adjust the quantity of drying capacity to the demand for drying, and (4) sometimes to cover the risk involved in handling high moisture grain. In the U.S., the high-moisture grain normally is corn.

There are several methods to calculate moisture discounts to compensate for the excessive amount of water in the grain. Adjustments can be made on a dry matter basis or to achieve a common moisture content. The weight of grain with a high moisture level can be converted to a common buying moisture percentage by using a specified or buying moisture formula.

The following is a dry matter formula to calculate shrink, remaining bushels, or moisture content and is based on a simple relationship in the formula labeled (1).

$$(1) \quad DM_w = DM_d$$

$$(2) \quad (100 - \%M_w)\, Q_w = DM_w$$

$$(3) \quad (100 - \%M_w)\, Q_w = (100 - \%M_d)\, Q_d$$

$$(4) \quad \frac{100 - \%M_w}{100 - \%M_d} \times Q_w = Q_d$$

$$\frac{100 - 25}{100 - 15} \times (1{,}000 \text{ pounds}) = Q_d$$

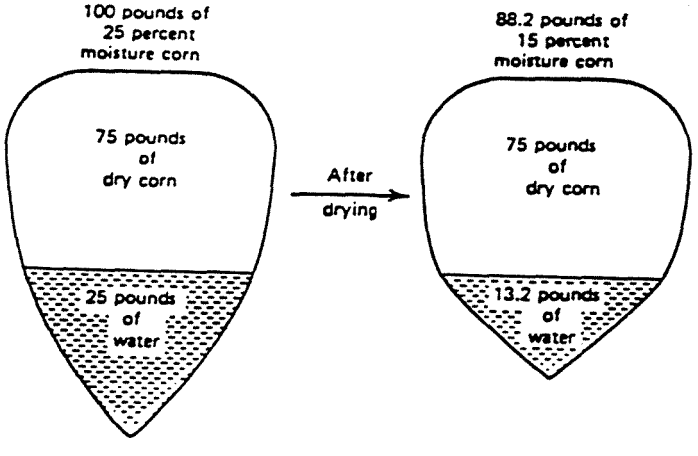
$$\frac{75}{85} \; (1{,}000 \text{ pounds}) = 882.4 \text{ pounds}$$

Dry matter wet equals dry matter dry, where the subscripts w stand for wet grain before drying and d for dry grain after drying. This relationship states that drying grain removes only water and doesn't affect the quantity of dry matter. There will be some additional losses from commercially or artificially drying grain, which will be mentioned later.

To solve the quantity of grain dried to 15 percent, the original pounds of wet grain are multiplied by the fraction that is determined by dividing the percent dry matter at the original moisture level by the percent of dry matter at the desired or lower moisture level. In the original 1,000 pounds (the original wet sample), there were 750 pounds of dry matter. In the corn that is dried to 15.0 percent there are still 750 pounds of dry matter but only 132.4 pounds of water instead of 250 pounds of water.

The formula used is based on the concept illustrated in the following diagram.

FIGURE 2



Water Loss During Drying

Water Loss during Drying

If on the left hand side of the formula there is 100 pounds of 25 percent moisture corn, there are 75 pounds of dry corn or dry material and 25 pounds of water. After drying to 15 percent moisture, the corn still has 75 pounds of dry corn or 88.2 total pounds with 13.2 pounds of water. This doesn't mean that when something is dried from 25 percent moisture to 15 percent moisture, 10 pounds of water have been lost. For example, if 10 pounds of water were removed from 100 pounds of 25 percent moisture corn, the resulting weight would be 90 pounds with a moisture percentage of 16.7 percent. That is, 15 pounds of water divided by 90 pounds of total weight after removing only 10 pounds of water gives a new moisture of 16.7 percent (15 divided by 90 equals 16.7 percent). This is a comparison of the remaining pounds of water to the total weight of the product.

When high moisture grain is dried, there is an additional loss. This loss occurs regardless of which grain is being considered. Therefore, it is possible to develop tables that show the shrink or conversely that show the pounds or bushels remaining when a certain quantity of grain is dried. When drying occurs, small particles are lost in handling and drying. The loss varies with management practices, but a rule of thumb is to designate this invisible loss as equal to one-half of one percent of the net weight. Thus, 0.005 times the original quantity would be subtracted from the remaining pounds or bushels. Using the above example where 75 divided by 85 times 1,000 pounds gives 882.4 pounds, another half percent times the original wet quantity of a 1,000 pounds results in an additional five pounds subtracted, for a net 877.4 pounds.

Discounts of either price or weight may also be calculated by d equals m_1 minus m_2 divided by 1 minus m_2, as shown below. [17]/

-- Weight discount

$$D = \frac{M_1 - M_2}{1 - M_2}$$

D = Discount factor; M_1 = Original moisture; M_2 = Final moisture; all in decimal format.

$$D = \frac{.25 - .15}{100 - .15} = \frac{.10}{.85} = .1176$$

.1176 X 1000 pounds original weight or (Q_w) weight to be subtracted from Q_w: 1000-117.6 = 882.4 pounds at 15 percent moisture.

-- Price discount

1 - D = Discount factor X Price.
1 - .1176 = .8824 X $0.036 per pound = $0.0318 per pound.

$0.0318 is the price to pay for the higher moisture grain X 1000 pounds (Q_w) equals $31.77, which equals 882.4 bushels (Q_d) at 15 percent moisture, for $0.036 per pound or $31.77.

Grain could be bought and sold also on a dry moisture basis or zero moisture basis. Then the buyer will not have to deal with situations when sellers request a premium for grain that is delivered with a moisture content lower than the buying standard.

Protein

Since a number of countries measure protein in wheat, it needs to be remembered that the moisture factor is considered in protein determination. The more moisture there is in a sample of grain, the lower the percentage of protein. If one compares protein levels of different lots of wheat with various moisture levels, comparison is easier if the moisture level is the same

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[17]/ Op. Cit., Steinke and Pfost, page 21.

for all protein measurements. Consequently, a formula can be used to determine the protein based on a uniform moisture percentage. If protein is to be determined on a 12 percent moisture basis, the formula to convert protein measurements to a standard 12 percent moisture basis is as follows: (The example uses wheat with 12.0 percent protein at 15 percent moisture and converts it to protein percent based on 12 percent moisture.)

$$\text{Protein at 12\% Moisture} = \frac{\text{Observed Protein percent X 88}}{\text{100 - Observed Moisture percent}}$$

$$= \frac{12 \text{ X } 88}{100 - 15} = \frac{1056}{86} = 12.3 \text{ percent protein at 12 percent moisture}$$

QUALITY ISSUES

There are many things one needs to be aware of in maintaining the quality of grain in storage. A grain storage specialist is needed, but quality can be dealt with from a marketing point of view. One concern with moisture above safe storage levels in grain is the possibility of heat damage caused by fermentation. Other damage is caused by insects and micro-biological activity that occur with unsafe moisture levels.

Some molds that develop in high-moisture, stored grain produce toxins that are unhealthful for human or animal consumption. One of the primary toxins is aflatoxin, produced by the mold Aspergillus flavus. Aflatoxin causes cancer in test animals and death of animals very sensitive to it. Special tests are available to check for aflatoxins. An ultra-violet light test is used as a screening mechanism to determine the potential presence of the toxin. When a sample of the grain (usually corn because it is harvested at higher moisture levels) reflects a bright green-yellow (BGY) fluorescence, the probability that

the kernels of corn contain aflatoxin is indicated. This screening method indicates the need of future quantitative analysis to determine the level of aflatoxin.

If grain goes out of condition in storage, two kinds of losses occur before there is total loss. The first loss is quality and second one is quantity because of insect activity. Insects eat away the germ and endosperm of the grains, as well as leaving their own refuse. Grain that has sour or musty odors is an indication that there has been mold growth, fermentation, or insect activity. Other odors are "commercially objectionable foreign odors", resulting from grain absorbing odors from other commodities or products in the same container.

Additionally, there may be other toxic materials that are unacceptable. These may be seeds that have been treated by mercury compounds or other products to protect them from fungal invasion after planting. Sometimes not all of the treated seed is planted and attempts are made to sell these seeds into the marketplace. This treatment makes the seeds unacceptable for commercial purposes, since they are no longer fit for human or animal consumption.

SAMPLING

Sampling procedure is a very key element in obtaining a representative sample of a lot of grain in order to determine the grade. If an unrepresentative sample of grain has been taken for inspection, the results are not fair to anyone. Even where sampling is done routinely, there are times when the sampling may not be representative.

A representative sample of grain should be obtained by taking a cross section of a grain flow as it is being moved from one location to another.

This can be done by a hand-held pelican or a mechanical device that diverts a portion of a stream of grain into a sample bucket. To obtain samples of grain that are at rest in a bin, a truck, or a rail car, the only way is to probe the grain. The length of probes depends upon the depth of the grain being probed. The probes may be six or 10 feet in length. There are compartments within the probe to take samples at different levels of the grain. Probe sampling should follow a probing pattern across the whole area, so that the sample is representative of all portions of a load of grain.

Sample Size for Quality Factor Determination

The Federal Grain Inspection Service of the U.S. Department of Agricultural has written rules and regulations on how to sample, grade, and certify the grade of a lot of grain. Different sample sizes are used to determine the various factors. These samples, taken from a larger sample may be 25 grams or 50 grams up to 250 grams for determining a particular factor. The size of the sample is balanced against the time and cost of inspection as well as the cost of arriving at an incorrect finding.

ESTABLISHMENT OF A STANDARDS SYSTEM

Kansas State University scientists recommend the following procedures for establishing or revising the existing system of standards in the existing grain marketing system. They recommended the following data be collected and evaluated.

1. Volume of types and classes of grain being marketed and to whom. There is little need to establish standards for grain of marginal economic importance. Efforts should be devoted to major food

products. Grains generally traded in small lots directly between a seller and a buyer should be of little concern, since a third party is seldom involved in selling.

2. Quality factors widely accepted as being important should be measured, and price discounts or premiums should be recorded.

3. The overall level of grain quality must be observed in order to establish reasonable and logical bases. For example, hand-shelled corn in many countries will have a lower level of broken kernels and foreign material than corn in the United States, which is mechanically shelled. On the other hand, in tropical areas, insect control is difficult, and a higher base might be allowed for this factor. [18]/

CONCLUSIONS

Grain standards and grades serve a very useful function in marketing. Standardization and grading have made it easier for different parties to trade grain. The determination of grain quality should be useful, easily understood, and economically justified, as well as fair.

If the marketing system is developed so that there are extreme distances between buyers and sellers, it is very important to have a third party involved in the system to determine the quality of the grain. The third party should not have any vested interest in the outcome of grade determination. Another objective with grain standards is to measure quality factors that are truly related to end-use purposes, so that the value of the quality factors can be

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[18]/ Steinke, Op. Cit., page 18.

communicated through the marketing system back to the handlers and to producers.

Many countries, including the United States, have numerical grades that are a useful communication tool between buyers and sellers. When the grade number is specified, one knows which factors are involved and the limits for each factor. Also, there may be some other factors that are not part of the numerical grade determination, which can make the buying more complicated. Lastly, it is important that the system of rewards and discounts for marketed grain reflect the grain's value; this helps to improve the delivery of desired qualities. A responsive grain grading system aids in the improvement of the grain marketing system of the nation.