STAFF PAPER

GRADING GRAIN UNDER THE U.S. GRAIN STANDARDS

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Department of Agricultural Economics
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INTRODUCTION

Grain quality standardization is an essential marketing function, which facilitates the movement of grains through the marketing channel. Standardized grain is easier to move and results in reduced transaction costs. When grain standards and grades are discussed, we assume 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 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. 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

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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.

terminology and measurements of important characteristics, buyers and sellers can establish relative values among the various 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 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 many possibilities exist 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, 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 purpose be expanded.

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

The 1986 objectives of the U.S. Grain Standards Act were expanded from four to six in a section of the 1990 U.S. Farm Act, known as the Food, Agriculture, Conservation, and Trade Act of 1990. This section is titled the "Grain Quality Incentives Act of 1990." The last two new objectives listed below provide increased emphasis on recognizing the measurement of quality for end-use purposes. The six objectives of the U.S. Grain Standards Act are:

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.
4. To create the tool for the market to establish quality improvement incentives. [3]/
5. To reflect the economic value-based characteristics in the end uses of grain.
6. To accommodate scientific advances in testing and new knowledge concerning factors related to, or highly correlated with, the end-use performance of grain. [4]/

In the United States, grain standards are legally mandated so that users of 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, then the administrator of the Federal Grain Inspection Service (FGIS) of the U.S. Department of Agriculture 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, unless circumstances require a lesser time period.

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

[4]/ Public Law 101-624--Nov. 28, 1990, "Grain Quality Incentives Act of 1990," TITLE XX -- GRAIN QUALITY, Sec. 2004. Classification, Grades and Standards Design Framework.

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 a post-harvest system. Merchants want dry, insect free, undamaged grain that will store well. Processors want grain that will 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 classification easy. Each class will have an important quality from an end-use point of view, for example, yellow and white 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 commercial yeast-type bread production. The following is a list of quality factors that will be defined as standards 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 weight per unit volume (density). Test weight is determined by taking weight in a given volume of the original sample minus the dockage. (Dockage is defined on page 15.) Test weight 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. However, the relationship between test weight and product yield is not always accurate. 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, weather can materially discolor or damage kernels or pieces of kernels. Heat damage is caused by the heat 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, stinkbug-stung damage also is included. [5/] In wheat, damaged kernels are determined after the shrunken and broken kernels and dockage are removed from the sample.

The Sample Grade Limits for wheat incorporate a designation of the number of insect-damaged kernels. The sample grade definition for wheat includes a limit of 32 insect-damaged kernels per 100 grams of a representative 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

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[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.

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.

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, the factor includes broken kernels, foreign material, and other grains (BNFM). In corn, BCFM consists of kernels and pieces of kernels of corn and all matter other than corn that will readily pass through a 12/64th (0.1875) inch round-hole sieve and all matter other than corn that remains in the sieved sample. A similar requirement exists for broken kernels, foreign material, and other grains in sorghum. BNFM is defined as all matter, other than dockage, that passes through a 5/64 triangular-hole sieve size, i.e., equilateral triangle perforations and inscribed circles of 0.0781 or 5/64 inch in diameter, and all matter other than sorghum that remains in the sieved sample. 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.

FGIS has a criterion for determining foreign material in corn and grain sorghum to be used with the grain handling rules that are designed to implement the grain quality law. The stipulations of this law are that dockage and foreign material, once removed from grain, shall not be recombined with any grain and no dockage or foreign material of any origin can be added to any grain. Thus, broken kernels can be recombined with grain, but foreign material and dockage cannot.

To separate BCFM into two factors, broken corn is defined as all material that passes through a 12/64th-inch round-hole sieve and remains atop a 6/64th-inch round-hole sieve. Foreign material is defined as all material (which could include broken corn) that passes readily through the 6/64th-inch round-hole sieve and all material other than corn that remains atop the 12/64th-inch round-hole sieve. [6]/

Broken (sorghum) kernels include all matter that passes through a 5/64-inch triangular-hole sieve and over a 2.5/64-inch round-hole sieve. The foreign material is defined as all matter except sorghum that passes over the number 6 riddle and all matter other than sorghum that remains on the top of the 5/64-inch triangular-hole sieve. [7]/ The percentages of BC and FM in corn and BN and FM in sorghum are reported upon request as informational factor on the grade certificates.[8]/

Shrunken and Broken Kernels and Total Defects

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 percentages 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

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[6]/ "Official United States Standards for Grain--United States Standards for Corn," Washington, D.C., U.S. Department of Agriculture, Federal Grain Inspection Service, May 1, 1988, page C-1.

[7]/ "Official United States Standards for Grain--United States Standards for Sorghum," Washington, D.C., U.S. Department of Agriculture, Federal Grain Inspection Service, May 1, 1988, page H-1 and H-2.

[8]/ FGIS proposed on April 2, 1991 in the "Federal Register," Vol. 56, No. 63, page 13420 to separate BNFM into its component parts, BN and FM, and establish grade limits as follows:

Grade	BN (percent)	FM (percent)
No. 1	3.0	1.0
No. 2	5.0	2.0
No. 3	7.0	3.0
No. 4	9.0	4.0

All public comments are to be submitted by June 3, 1991, after which FGIS will evaluate the comments and subsequently promulgate the rule as proposed or a modification of the proposal.

the grain cannot contain the maximum amount of each factor allowed and thereby assures a higher level of quality than if no limitation were specified for Total Defects.

Wheat Classes

There are eight classes for wheat: Durum wheat, Hard Red Spring wheat, Hard Red Winter wheat, Soft Red Winter wheat, Hard White wheat, Soft White wheat, Unclassed wheat, and Mixed wheat (see Figure 1). Durum and Hard Red Spring wheats have subclasses based upon the percentage of the kernels that are vitreous. For Durum, there are three subclasses: Hard Amber Durum wheat with 75 percent or more of hard and vitreous[9/] kernels of amber color; Amber Durum wheat with 60 percent or more but less than 75 percent of hard and vitreous kernels of amber color; and Durum wheat with less than 60 percent of amber color.

For Hard Red Spring wheat, the three subclasses are: Dark Northern Spring wheat with 75 percent or more of dark, hard, and vitreous kernels; Northern Spring wheat with 25 percent or more but less than 75 percent of dark, hard, and vitreous kernels; and Red Spring wheat with less than 25 percent of dark, hard and vitreous kernels.

Soft White Wheat varieties are classed into the following three subclasses: Soft White wheat with not more than 10 percent of white club wheat; White Club wheat with not more than 10 percent of other soft white wheat; and Western White wheat with more than 10 percent of white club wheat and more than 10 percent of other soft white wheats.

Hard Red Winter, Soft Red Winter, Hard White, and Unclassed wheat classes are not divided into subclasses. Unclassed wheat is any variety of wheat that is not classifiable under other criteria provided in the wheat standards and includes Red durum wheat and any wheat that is other than red or white in color. Mixed wheat is a mixture of wheat that consists of less than 90 percent of one

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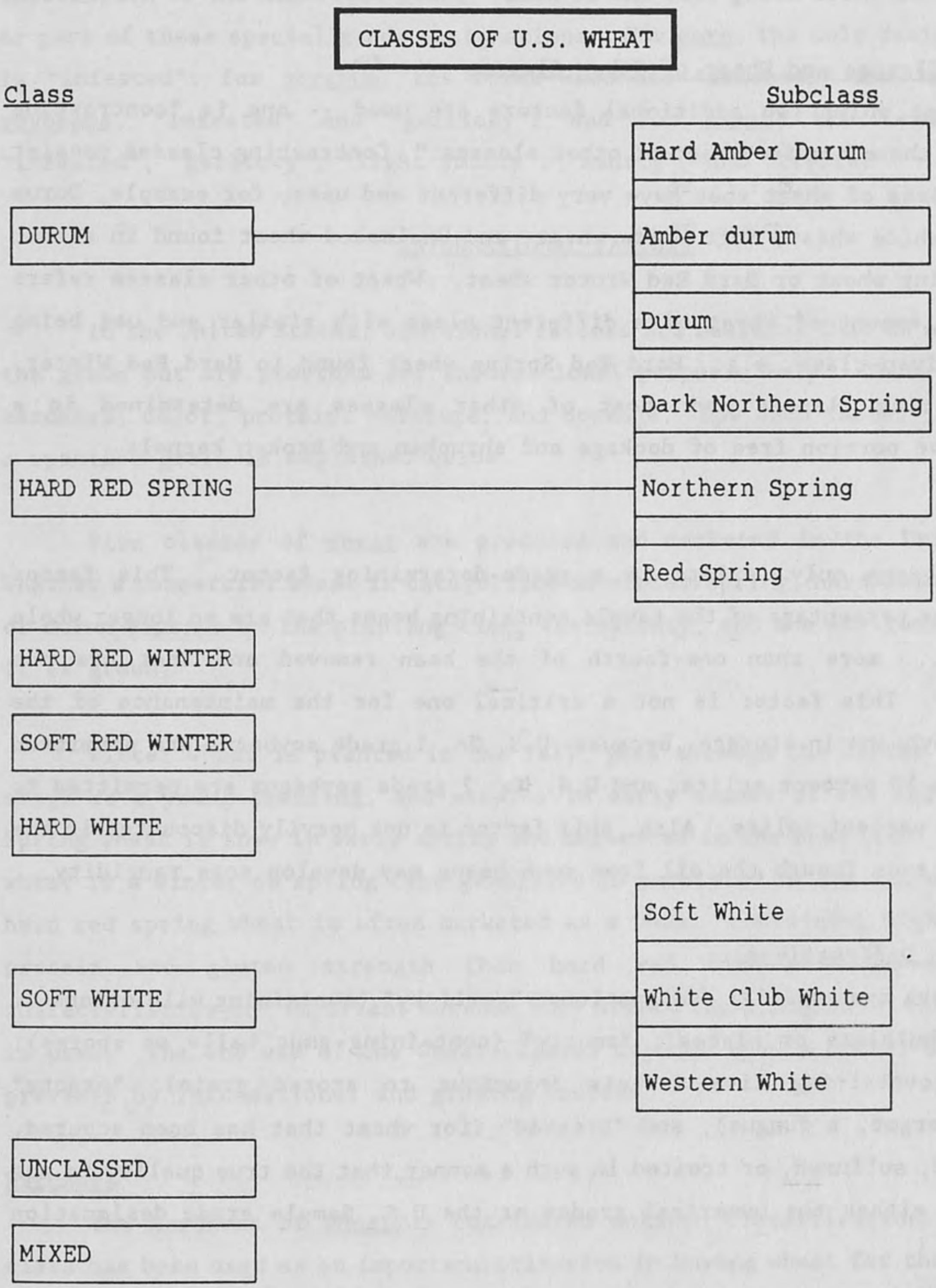
[9/] In hard red winter and spring wheats, the external appearance of the kernels is very dark without white or yellow spots and, upon cross-sectioning, the kernels have a glassy appearance. For vitreousness in durum wheat, cross-sectioned kernels will be of amber color.

FIGURE 1


CLASSES OF U.S. WHEAT
Class
Subclass
Hard Amber Durum
DURUM
Amber durum
Durum
Dark Northern Spring
HARD RED SPRING
Northern Spring
Red Spring
HARD RED WINTER
SOFT RED WINTER
HARD WHITE
Soft White
SOFT WHITE
White Club White
Western White
UNCLASSED
MIXED

class and more than 10 percent of one other class or a combination of classes that meets the definition of wheat.

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, Hard White wheat, Soft 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 in a representative 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." [10/] This factor is not a critical one for the maintenance of the quality of soybeans in storage, because 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" (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).

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

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".

INFORMATIONAL FACTORS

In the United States, additional factors are measured that do not determine the grade but are provided for informational purposes only. 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 type generally is unrelated to its end use, 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 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 classification, because the class 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 (starch particles) 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. Vitreous endosperm itself is a result of a 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 (or an approximation) for a desired milling quality in order to produce the required end product.

Grain inspectors visually inspect wheats to determine the class. Hard wheat varieties are generally grown in the Great Plains area under harsher and drier climates than in areas where soft wheat varieties are grown. However, plant breeders have crossed hard and soft wheat varieties to develop new varieties that have resistance to specific diseases. A new hard wheat variety may exhibit external characteristics that sometimes make it look like a soft wheat yet have intrinsic characteristics of a hard wheat. FGIS is investigating and gathering data for developing an objective procedure to distinguish hard from soft wheats. Until an objective procedure is developed, visual inspection will continued to be used.

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; however, under the corn standards there are special grades for "flint" corn with harder pericarp. 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 the technical and economic feasibility of measuring the breakage susceptibility of corn by using two available breakage testers. The results of the research have been provided to FGIS. Before incorporating 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, which are usually soft wheats, are used to make crackers, cakes, cookies, and cereal foods 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.

With the recent development of white wheat varieties with hard endosperms, the FGIS revised the U. S. Standards for wheat and promulgated standards for hard white wheat. The newly established hard white wheat (HWW) class was effective on May 1, 1990. Hard White Wheats are being produced, marketed, and milled in the states of Kansas, Montana, California, and Washington.

The soft wheats in the United States are used for making crackers, cookies, and cakes. Hard wheats are used to make bread and hard dinner rolls. The milling yield of red wheats must be kept around 74 or 75 percent in order to prevent discoloration of white flour with portions of red bran. The quantity of hard white wheat varieties is small and the method of marketing it is uncertain in a system that is dominated by red wheat. At the present time, hard white wheat that is being grown and marketed in Kansas is being contracted into the domestic market on an identity-preserved basis.

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." 11/

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." 12/ 13/

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." 14/

Protein

Protein percentage in wheat is related to classification and also affects the end use. With the enactment of the "Grain Quality Improvement Act," protein

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11/ Ibid., page 24423.

12/ Ibid., page 24427.

13/ FGIS proposed on April 2, 1991 in the "Federal Register," Vol. 56, No. 63, page 13420 to amend two of the four classes of sorghum. "Sorghum" is low in tannin in the subcoat, contains less than 98.0 percent White sorghum and not more than 3.0 percent Tannin sorghum, and has pericarp color of white, yellow, pink, orange, red, or bronze. "Tannin sorghum" is high in tannin content in the subcoat contains not more than 10.0 percent non-Tannin sorghum, and has pericarp color usually of brown but also of white, yellow, pink, orange, red, or bronze. The definitions of white and mixed sorghum remain the same. All public comments are to be submitted by June 3, 1991, after which FGIS will evaluate the comments and subsequently promulgate the rule as proposed or a modification of the proposal.

14/ Op. Cit., "Official U.S. Standards for Grain", page 24428.

measurements were to be certified on a 12 percent moisture basis instead of an "as-is" moisture basis.

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 affect 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. Figure 2 clearly shows 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. 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. [15]/

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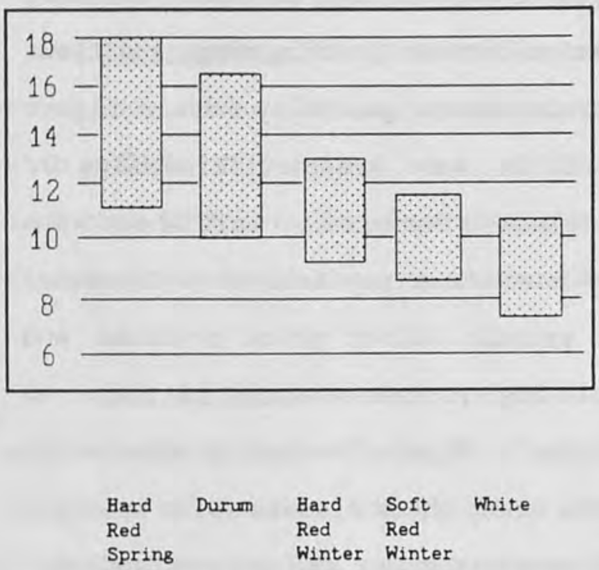
[15]/ Op. Cit., "Commitment to Quality", page 21.

FIGURE 2

PROTEIN RANGE AND FLOUR USES OF MAJOR WHEAT CLASSES

Percent of Protein



Flour Uses

* Used to blend with weaker wheats for bread flour
* Whole wheat bread, Hearth breads
* Egg noodles (U.S.), macaroni, and other alimentary pastes
* White bakers' bread, bakers' rolls
* Waffles, muffins, quick yeast breads, all-purpose flour
* Noodles (Oriental), kitchen cakes and crackers, pie crust, doughnuts, cookies, foam cakes, and very rich layer cakes

Flour uses relate to approximate level of protein required for specified wheat products. Durum is not traded on basis of protein content.

Moisture

Moisture content is a measure of the percent of total wheat, corn, grain sorghum, or soybean 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 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 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. Quality may be affected, if the grain is stored at too high a level of moisture. Consequently, moisture is always measured and 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. 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 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." [16]/ The remaining non-wheat (or non-sorghum) material in the sample is defined as foreign material (BNFM in sorghum).

The "Grain Quality Improvement Act," which became law on November 10, 1986, required that measuring and certifying dockage percentages were to be done in 0.1 percent intervals. The requirement was instituted on May 1, 1987.

Infested [17]/

Effective May 1, 1988, the tolerances for the presence of live insects were tightened. For wheat, rye, and triticale, the commodity is designated as Infested, if it contains two or more live weevils or OLIs (Other Live Insects) injurious to stored grain. In other words, all live insects injurious to stored wheat, rye, and triticale are counted with equal value.

For feed grains, including corn, sorghum, soybeans, barley, oats, sunflowers, and mixed grain, the official grade standards require that an Infested designation be given to commodities that contain two or more live weevils, one live weevil and five or more OLIs, or 10 or more OLIs.

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

[17]/ "Grain Merchandising and Storage in 1987-88," Washington, D.C., National Grain and Feed Association, August 1987, page 195.

The insect infestation standards are applied to representative samples, lots as a whole (grain in stationary conveyances, excluding submitted samples and ship lots), and samples as a whole (continuous loading and unloading of ship lots and barges). For ship lots and barge lots, the minimum size of samples as a whole taken during continuous loading and unloading is 500 grams for each 2,000 bushels. In applying these insect infestation standards to continuous loading and unloading, the tolerances apply to each component of the sublot, rather than to the entire sublot.

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 (Tables 1-4). For example, in using the wheat standard table (Table 4), the specifications for U.S. No. 1 are: test weight for hard red spring is to be no less than 58 pounds per bushel and for 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 summation of damaged kernels, foreign material, and 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.

However, do not let this be misleading as to the quality of grade U.S. No. 1. Seldom is there any heat damage in that grade. 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 bottoms of the tables 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.

The question often 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 that 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 sorghum kernels would be separated out by hand picking and would be called foreign material. Thus, a description of different types of materials is based mostly on size determination.

The standards tables for corn, sorghum, and soybeans (Tables 1, 2, and 3, respectively) that follow show the factor limits for each grade. The grade number is determined in the same way as in the wheat example above. [18]

[18]/ <u>Ibid.</u>, pages 24423, 24427, and 24428.

TABLE 1

UNITED STATES GRADES AND GRADE REQUIREMENTS FOR CORN

Grades	Minimum test weight per bushel (percent)	Maximum limits of--		
		Damaged kernels		
		Heat damaged kernels (percent)	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 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 cocklebururs (*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: GRAIN INSPECTION HANDBOOK, Book II, Grain Grading Procedures, Chapter 4, Corn, 10/1/90, page 4-1.

TABLE 2

UNITED STATES GRADES AND GRADE REQUIREMENTS FOR SORGHUM[19]/

Grades	Minimum test weight per bushel (percent)	Maximum limits of-- Damaged kernels: Heat damaged kernels (percent)	Maximum limits of-- Damaged kernels: Total (percent)	Maximum limits of-- Broken kernels, foreign material and other grains (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 cocklebers (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.

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

Source: GRAIN INSPECTION HANDBOOK, Book II, Grain Grading Procedures, Chapter 9, Sorghum, 10/1/90, page 9-1.

[19]/ FGIS proposed on April 2, 1991 in the "Federal Register," page 13420 to separate BNFM into its component parts, BN and FM, and establish grade limits as follows:

Grade	BN (percent)	FM (percent)
No. 1	3.0	1.0
No. 2	5.0	2.0
No. 3	7.0	3.0
No. 4	9.0	4.0

All public comments are to be submitted by June 3, 1991 after which FGIS will evaluate the comments and subsequently promulgate the rule as proposed or a modification of the proposal.

TABLE 3

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: GRAIN INSPECTION HANDBOOK, Book II, Grain Grading procedures, Chapter 10, Soybeans, 10/1/90, page 10-1.

TABLE 4

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 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 objectional foreign odor (except smut or garlic odor); or

(e) 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: GRAIN INSPECTION HANDBOOK, Book II, Grain Grading Procedures, Chapter 13, Wheat, 10/1/90, page 13-1

GRAIN INSPECTION EXPORT LADING PLAN

FGIS has a Cumulative Sum (Cu-Sum) loading plan to allow for sampling and grading variability without undue cost to the U.S. grain industry, to the U.S. producers, and/or to its overseas customers. This is an on-line acceptance sampling plan that provides continuous quality information during loading an ocean vessel or loading unit rail trains in U.S. domestic commerce with the objective of obtaining a consistent minimum quality throughout the lot. This is called a sampling plan because the quality of a ship lot, which could contain as much as 2.7 million bushels of grain, is determined on the basis of a series of samples. [20]/

Some export elevators use what are called shipping bins, which are extra bins placed after the weighing and sampling equipment. These elevators usually have enough shipping bins to allow them to hold a sublot while waiting for the grade. In the meantime, elevator personnel are able to begin filling another shipping bin. Grain in shipping bins is loaded to the vessel when inspectors determine that the quality is acceptable.

FGIS first implemented the Cu-Sum Plan in 1980 to replace other inspection plans in use. FGIS promulgated regulations in 1990 to revise the Cu-Sum Plan. The Cu-Sum Plan establishes statistically based factor tolerances (breakpoints) for accepting occasional portions of a lot when, because of known sampling, equipment, and inspection variations, inspection results exceed the grade limit and grade below the desired lot quality. The inspection process requires continuous sampling during loading or unloading. The grain sampled is accumulated in a systematic process and is examined at periodic intervals: (1) subsamples, (2) component samples, and (3) sublot samples. Subsamples represent up to 5,000 bushels. Several subsamples are combined to form a component sample, which represents a minimum of approximately 10,000 bushels for ships and lash barges. For unit trains, each railcar is considered a component. Component

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[20]/ Hawk, Arvid, "Marketing and Grading Grain for Export," Cereal Foods World, The American Association of Cereal Chemists, Inc., 1988, Vol. 33, No. 8, page 612.

samples are combined to form a sublot sample, which may represent as much as 60,000 bushels for ships and lash barges or five cars in a unit train. Ship sublot samples may represent as much as 120,000 bushels, if component sample analysis is requested as an optional inspection service. [21]/

If the subsamples are within the prescribed limits, the inspector then examines the component samples, and they must be comprised of at least two subsamples. A 60,000 bushel sublot consists of not more than six component samples. Component samples are examined by the inspector to determine if any grade factor exceeds the declared grade by more than one numerical grade. If it appears to exceed this limit, then the inspector must actually grade the sample for that factor. [22]/

If the component samples are within the prescribed limits, they are combined to form the basis for sublot sample. The sublot sample is graded to determine if the sublot meets the requirements of the Cu-Sum loading plan. There is no limit to the amount of better quality grain permitted in a lot.

Each subsample, component sample, and sublot sample are analyzed for specific quality criteria in accordance with the Official U.S. Standards for Grain and the sales contract. The results for individual sublot factors are compared to the grade limit, and the cumulative sum of the differences is monitored and applied to the acceptance tolerance. For example, if the grade limit for foreign material is 2.0 percent and the sublot foreign material result is 2.2 percent, the difference for the sublot is +0.2. The difference for each sublot by factor is added together during loading to derive what is known as the Cu-Sum. If the next sublot had a +0.1 difference, the Cu-Sum would be +0.3 (the sum of 0.2 + 0.1). Negative values are also added to the Cu-Sum, but the overall Cu-Sum value cannot go below zero. [23]/

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[21]/ GRAIN INSPECTION HANDBOOK, Book III, Chapter 2, 9-11-90, page 2-1.

[22]/ Hawk, Op. Cit., page 614.

[23]/ Federal Register, Vol. 55, No. 114 / Wednesday, June 13, 1990 / Rules and Regulations, page 24031.

When a subsample exceeds acceptable quality conditions, a component is more than one numerical grade lower than the declared load order grade, or a sublot factor result causes the Cu-Sum value to exceed its breakpoint, the subsample/component/sublot is declared a material portion. Only the subsample/component/sublot that exceeds the inspection plan criteria is considered the material portion.

Once a subsample is designated a material portion and the applicant elects to leave the subsample on board the carrier, it is considered as a separate lot and all factors are analyzed. If the material portion subsample is removed from the lot (returned to the elevator or discharged from the carrier), then the calculated Cu-Sum values are not recorded. Once a component is designated a material portion and the applicant elects to leave the component on board the carrier, it is considered as a separate lot and all factors are analyzed and Cu-Sum values are calculated. [24]/

When a material portion is declared, the inspection applicant can request one field review. The inspection results of material portions are averaged with prior results, unless a material error in the inspection is detected. A material error is defined as a difference of more than two standard deviations.

The current plan includes wheat protein for shipments specifying a minimum or maximum amount of protein. A special certificate statement is issued when the protein range of a wheat lot exceeds 1.0 percentage point. The breakpoint and starting values are not required for average or ordinary protein shipment; however, the inspection certificate will show the range statement if the range exceeds 1.0 percentage point.

The FGIS has an extensive explanation of the Cu-Sum sampling plan. Procedures and information are available in the Grain Inspection Handbook, Book III and the Federal Register publication of June 13, 1990, to which the reader is directed to study for a thorough understanding.

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[24]/ GRAIN INSPECTION HANDBOOK, Op. Cit., page 2-17.

GRAIN HANDLING PRACTICES [25]

FGIS's rules for grain handling practices took effect on July 30, 1987 for domestic facilities and on January 1, 1988 for export facilities. These rules are designed to implement the grain quality law's stipulation that dockage and foreign material, once removed from grain, shall not be recombined with any grain and no dockage or foreign material of any origin can be added to any grain. Although broken kernels can be recombined with grain, foreign material and dockage cannot.

Blending of like grains of different qualities is permitted. Additionally, FGIS allows blending of different grains, if it is for the purpose of creating Mixed Grain, which must be certified as such. FGIS generally prohibits the recombination or addition of grain dust at export facilities. These export facilities may not add or recirculate grain dust that has been removed from the grain and collected in a separate bin or container, as well as dust settling on floors, equipment, and other areas (referred to as dust sweepings). However, this ban does not apply to grain dust sweeping from the cleaning of unloading pits or bins or to grain spills. (See definitions of broken corn, broken kernels, and foreign material earlier in this paper.)

RELATED MATTERS

Other Countries' Grading Systems

Other grading systems exist that differ from the one used in 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.

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[25] Grain Merchandising and Storage in 1987-88, Washington, D.C., National Grain and Feed Association, August 1987. page 197.

Australia [26]/

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 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 [27]/

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 [28]/

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. Because live insects are not permitted

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

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

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

in bread wheat, chemical treatment for control of insect infestation is allowed at port terminals.

France [29]

France has no "official" standards with factor limits and grades. There are European Community (EC) standards, but these are for intervention purposes only. These standards have an indirect impact, because they prescribe the characteristics that are measured, some of which reflect end-use value. EC intervention quality requirements for wheat are: sound basic grain (88%), moisture (14-16% depending upon the year), natural weight (usually 72 Kilogram per hectoliter [Kg/Hl]), broken grains (5%), grain and mixture (12%), impurities (3%), sprouted grains (6%), germination (85% in 1987/88), falling number (180-240 depending upon the year and wheat quality), protein (9.5-14% depending upon the quality of wheat), sedimentation (20-bread wheat and 35-quality wheat), and dough test for bread and quality wheat. It is not uncommon for variety to be specified in contracts as a proxy for end-use quality and, in some cases, certain varieties are excluded. No "official" inspection agency (such as FGIS in the USA) exists, but private surveying companies compete in the provision of this service and, where appropriate, the contract appoints the surveying company.

Grain trading is facilitated in part through the use of the "Paris Contract." This contract prescribes standardization to grain trádes, provides integrity through arbitration, and is used extensively for hedging purposes and procurement in some cases. This contract specifies specific weight of 76 Kg/Hl, 15 percent moisture, 4 percent broken kernels, 2 percent impurities, and 2

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[29] Wilson, William W. and Lowell D. Hill, Fargo, North Dakota, North Dakota Agricultural Experiment Station, Report No. 110, November 1989, pages 29, 37, 41, 42, 55, and 57.

percent sprouted kernels. For comparison, these are greater than those required for EC intervention.

Flour millers will use additional specifications other than those in the Paris Contract. Limits may be specified for gluten strength and falling numbers, and many of these end-use characteristics are represented or captured in the variety specification.

A major share of the wheat exported to third countries is procured by using the Paris Contract. Sales to some EC countries use the German-Dutch contract (DNV No. 7). This allows for FAQ (Fair Average Quality) or other quality specifications and uses destination grades. Exports to all other EC countries use origin grades and quantity. It is not uncommon for exports to EC countries to exclude varieties.

In sales to third countries, quality specifications are typically those used in the Paris Contract regarding physical factors such as test weight, moisture, broken and sprouted kernels, and impurities. The typical wheat export contract provides for the following factor specifications: test weight (76 Kg/Hl or 59 pounds/bushel), moisture (14.5-15%), broken kernels (4%), sprouted kernels (2%), and impurities (2%, not more than 0.5% may be miscellaneous impurities). A zero insect tolerance is a matter of practice. If a single insect is found, the grain is treated in the ship's holds. However, because of the heterogeneity of buyers, further specifications vary across importers. In the case of the USSR, specifications include 11.5 percent protein and 23 zeleny. For Algeria, the specifications include hagberg falling number, protein, zeleny, alveograph (W), machinability, sprout, test weight, impurities, and ergot.

The point is that no official standards exist for export. Each transaction has the possibility of including a multititude of physical and intrinsic end-use specifications. These are facilitated in part through coordination between buyer and seller and through the use of surveyors/inspectors.

Other Countries

On the other hand, some countries do not use a system of numerical grades. Rather, each quality factor is discounted according to the amount by which that 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 no grain is produced that would meet U.S. No. 1 or 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. [30/]

Comments on Some Grading Factors

Moisture

Merchants are concerned about moisture from two points of view -- one relating to quality and the second to avoid having excess moisture above a

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[30/] "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.

desirable level for milling or processing into food or feed products. In other words, excessive moisture not only affects the storability but also adds unwanted weight to the grain.

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. [31]/

There are several methods to calculate moisture discounts and compensate for an excessive amount of water in grain. Adjustments can be made on a dry matter basis or on a common moisture basis. 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).

$$(1)\quad DM_w = DM_d$$
$$(2)\quad (100 - \%M_w)\, Q_w = DM_w$$
$$(3)\quad (100 - \%M_w)\, Q_w = (100 - \%M_d)\, Q_d$$

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[31]/ Cramer, Gail L. and Walter G. Heid, Jr., Grain Marketing Economics, Chapter 5, "Grain Grades and Standards", by Lowell D. Hill, New York: John Wiley & Sons, 1983, page 129.

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

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

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

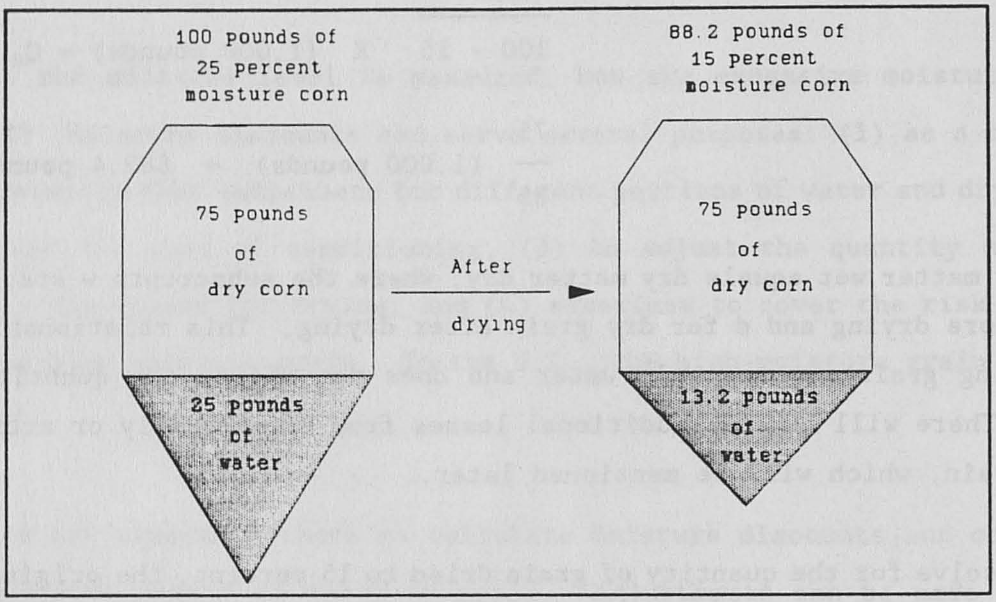
Dry matter wet equals dry matter dry, where the subscripts w stand for wet grain before drying and d for dry grain after drying. This relationship states that drying grain removes only water and does not affect the quantity of dry matter. There will be some additional losses from commercially or artificially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

To solve for 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 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 remain instead of the original 250 pounds of water.

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

FIGURE 3

WATER LOSS DURING DRYING



If on the left hand side of the formula there are 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. 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 5 pounds subtracted, for a net 877.4 pounds.

Discounts of either price or weight also may be calculated by D equals m_1 minus m_2 divided by 1 minus m_2, as shown below. 32/

-- 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.

$$D = \frac{.25 - .15}{1.00 - .15} = \frac{.10}{.85} = .117647 = \text{Discount factor per pound.}$$

Q_w - discount factor = purchase weight X price

1000 - 117.647 = 882.353 pounds at 15 percent moisture X $0.035714 ($2.00 per bushel) = $31.51.

-- Price discount

1 - D = Discount factor X Price.
1 - .117647 = .882353 X $0.035714 per pound = $0.0315123 per pound the price to pay for the higher moisture grain.

32/ Op. Cit., Steinke and Pfost, page 21.

Thus, the resulting value of the delivered corn can be calculated in two ways -- by a weight discount or by a price discount.

Weight discount -- 882.353 pounds (Q_d) at 15 percent moisture X $0.035714 per pound ($2.00 per bushel) = $31.51.

Price discount -- 1,000 pound (Q_w) X discounted price of $0.0315123 = $31.51.

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

Protein

Because a number of countries measure protein in wheat, we need to remember 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. Comparison of protein levels of different lots of wheat with various moisture levels is easier if the moisture level is the same 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.)

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

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

Quality Issues

We need to be aware of additional factors in obtaining the desired quality of grain. One concern is to obtain grain free of unwanted levels of molds and toxins, e.g. aflatoxin. Aflatoxin is a naturally occurring mycotoxin produced by two types of mold known as Aspergillus flavus and Aspergillus parasiticus. Aspergillus flavus is very common and widespread in nature and is more likely to occur when certain grains are grown under stressful conditions, such as drought. It occurs in soil, decaying vegetation, hay, and grains undergoing microbiological deterioration. It invades all types of organic substrates whenever and wherever the conditions are favorable for its growth. Favorable conditions include high moisture content and high temperature. At least 13 different types of aflatoxin are produced in nature. Aflatoxin B1 is considered by many as the most toxic.

FGIS tests grain, oilseeds, and related processed products for the presence of Aflatoxin B1, upon request. This testing service provides the marketplace with additional quality information to determine market value and ensure proper disposition of contaminated grain or grain products.

When requesting testing services for corn, applicants must indicate the type of determination required, either screening or quantitative. Screening for aflatoxin involves measuring the level of aflatoxin against a set threshold, such as 20 parts per billion (ppb). Results are reported as being equal to, less than, greater than the threshold. Quantitative testing provides actual aflatoxin concentrations in ppb. FGIS will not use ultra-violet light as a screening process. FGIS has an Aflatoxin Handbook that specifies the procedures in requesting and conducting an aflatoxin test.

Grain that goes out of condition in storage will have two kinds of losses before total loss occurs. The first loss is quality and the 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. Sour or musty odors in grain indicate that mold growth, fermentation, or insect activity has occurred. Other "commercially objectionable foreign odors" result from grain absorbing odors from other commodities or products in the same container.

Additionally, other toxic materials that are unacceptable may be present. 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 illegal attempts are made to sell these seeds into the marketplace. This treatment makes the seeds unacceptable for commercial grain purposes, because they are no longer fit for human or animal consumption.

Measurement of Oil and Protein in Soybeans

The FGIS offered soybean oil and protein testing of soybeans as official criteria effective September 4, 1989.

The oil and protein analysis is performed using near-infrared spectroscopy instrumentations (NIRS). FGIS certifies the results to the nearest tenth of a percent on a 13 percent moisture basis.

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 is at rest in a bin, a truck, or a rail car, only a probe can be used to sample the grain. The length of probes depends upon the depth of the grain being probed. The probes may be 6 or 10 feet (1.8 or 3.0 meters) in length. Compartments within the probe take samples at different levels of the grain. Sampling should follow a probing pattern across the whole area, so that the sample is as representative as possible 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 Agriculture 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 measure the various factors. These samples, taken from a larger sample, may range from 25 grams or 50 grams up to 250 grams for determining a particular grading 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 several procedures for establishing a new system or revising the existing system of standards in the existing grain marketing system. They recommended that the following data be collected and evaluated.

1. The volume of types and classes of grain being marketed and to whom should be determined. 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, because 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. [33]/

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[33]/ Steinke, Op. Cit., page 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. That is, the grain lots or shipments are more homogeneous. The determination of grain quality should be useful, easily understood, and economically justified, as well as fair. Better understanding facilitates buyer and seller transactions by helping them to differentiate between higher- and lower-valued shipments.

If the marketing system is developed so that extreme distances exist 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 communicated through the marketing system back to the handlers and the producers.

Many countries, including the United States, have numerical grades that are useful communication tools between buyers and sellers. Specifying the grade number which factors are involved and the limits for each factor. However, aditional factors that are not part of the numerical grade determination, mau be considered, 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. Thus, a responsive grain grading system aids in the improvement of the grain marketing system of nation.

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