Chapter 1
Summary

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Chapter 1
Summary

More competitors exist in the international grain market now than ever before, and grain quality has become an extremely important competitive factor. In a mere decade, growth in grain suppliers has been phenomenal. In the 1970s, one-third of the world supplied grain to two-thirds of the world's people. Today, the reverse is true: two-thirds of the world supplies grain to the other third. This competitive environment has made foreign buyers increasingly sensitive about the quality of grain they receive.

During the debate on the Food Security Act of 1985, many Members of Congress expressed concern about the quality of U.S. grain exports, Grain elevator operators and export traders were accused of adultering loads of grain shipped to foreign buyers; these allegations were supported by a sharp increase in foreign complaints about quality. Grain traders and handlers maintained that they have been shipping grain according to specifications, and that most complaints were motivated by buyers' desires to obtain a higher grade of grain at a lower price.

The debate often focused on the adequacy of today's grain standards, developed over 70 years ago. Critics argue that the standards themselves are to blame for customer complaints. They claim that standards have not kept pace with the changing world marketplace and are frequently misunderstood by foreign buyers.

By focusing on standards, those debating about U.S. grain quality are seeing only part of the picture. Improving quality—or even the perception of quality—will be much more complicated than tinkering with the criteria for standards. Grain is vulnerable to quality deterioration at virtually every stage of production and marketing. Before changes can be contemplated, full understanding is needed of the complex, interrelated system of:

- developing varieties of grain,
- producing grain,
- harvesting grain,
- storing grain,
- handling grain, and
- testing grain,

Understanding these relationships is the main goal of this assessment.

First, it is important to clarify what is meant by grain quality. Webster defines quality as an essential character, a degree of excellence, or a distinguishing attribute. In grain, such a definition has come to mean a variety of things—being free of foreign material, not cracked or spoiled, or having the proper characteristics for a particular end use, No one definition of quality as it relates to grain has been accepted.

For the purpose of this assessment, quality is defined in terms of physical, sanitary, and intrinsic characteristics.

- *Physical quality* characteristics are associated with outward visible appearance of the kernel or measurement of the kernel. Included are kernel size, shape and color, moisture, damage, and density.
- *Sanitary quality* characteristics refer to the cleanliness of the grain. They include the presence of foreign material, dust, broken grain, rodent excreta, insects, residues, fungal infection, and nonmillable materials. These are essentially characteristics that detract from overall grain value,
- *Intrinsic quality* characteristics are critical to the end use of the grain. They are nonvisual and can only be determined by analytical tests. In wheat, for example, such characteristics refer to protein, ash, and gluten content. The characteristics depend on the grain and the end use within a grade,

MAJOR FINDINGS

The U.S. grain marketing system has a number of important characteristics. Handling (including exporting) and transport industries are highly competitive and there is relatively limited government intervention in the system. **One key principle throughout the U.S. system is that of self-selection.** producers plant varieties perceived to be in their best interest; users (domestic and importers) specify and purchase certain qualities that are in their interest, given a range of alternatives and prices; handlers and exporters condition and move grain in their own interest. Each decision is based on the sovereignty of the individual decisionmaker, and takes into account incentives and disincentives reflected in market premiums and discounts for quality characteristics,

Fundamental Advantages of the U.S. Grain System

An important component of this study was a comparison of the U.S. grain system with the systems in other exporting countries. OTA collected information on production and distribution in Canada and sent study teams to Argentina, Brazil, France, and Australia to document their systems. **Five fundamental advantages of the U.S. marketing system are apparent: efficiency, productivity growth, wide range of qualities, the grading and inspection system, and market-determined premiums and discounts.**

efficiency

The U.S. marketing system performs a number of complex functions—it assembles, handles, conditions, and allocates different qualities to domestic buyers in many locations and for export from a multitude of ports. Indeed, given the quantity produced, the many differences in qualities at different locations, and numerous locations of end-users and ports, the U.S. marketing system is more complex and performs more challenging functions than the marketing system of any other exporter. Yet the efficiency of the U.S. grain handling and transport system exceeds that of nearly all other countries, assuring lower marketing margins and higher prices to producers.

Productivity Growth

Plant breeding in the United States is relatively unfettered, compared with other countries, in terms of regulations over variety development and release. Ultimate success of varieties is determined by the market for seed stocks. Producers make choices in response to market incentives. Where comparisons are appropriate (i.e., in wheat), productivity growth as measured by yield exceeds that of most other exporters, with the exception of France. Productivity differences are affected by a multitude of factors including environment, soils, other inputs, relative prices, institutions, and policies. Thus, it is impossible to attribute yield differences to the institutional environment affecting varieties, but growth rates are influenced by variety release procedures.

A Wide Range of Qualities

No **other country can offer such a wide range of intrinsic differences in grains to customers.** This is obvious given the class differences in wheat, which is facilitated by production regions of differing environments and soils. Also, a wider range of physical and sanitary qualities exists in the United States than elsewhere. This is an advantage in the sense that more alternatives are available to buyers, some at lower costs, but it may be viewed as an externality in the sense that reputation is affected. The uniformity problem (discussed later) is a direct result of the multitude of qualities available. In addition, given such an unfettered system, importers need a certain amount of expertise to benefit fully from the wide range of qualities.

Grading and Inspection System

The U.S. grading and inspection system provides grade determination by an independent agency (i. e., one not having financial stakes in the transaction), Factors and limits in factors in the grade standards are relatively stable across crop years (i.e., the definition of No. 2 corn does not change from year to year). Similarly, the definition of No. 2 Hard Red Winter wheat does not change, although intrinsic differences not measured in the standards may change. This is not necessarily the case in other countries. Major changes to the U.S. system cannot be implemented in less than a year after they are promulgated. Some other exporters adjust factor limits with each crop year.

Market-Determined Premiums and Discounts

Premiums and discounts and/or regulations in all countries are used to provide quality incentives to market participants. **Those established in the United States are via the interaction of supply and demand for measurable quality characteristics,** i.e., the market for quality characteristics. Consequently, U.S. values perhaps reflect true values better than do premiums and discounts administered in several other exporting countries. A notable exception is France, Efficient determination of price differentials is important because they essentially allocate grain across end-users and provide signals throughout the production and marketing system. Through these differentials the system responds to market needs.

Competitors' Policies

The institutions, policies, and trading practices in the marketing system of the major grain exporting countries differ considerably. The extent of market intervention varies from highly regulated throughout (e. g., Australia and Canada), to partial, or no regulation. Differences exist in procedures for seed variety development and release, the use of variety identification in the marketing system, and the use of grain receival standards (table l-l). **In addition, a number of other countries address grain quality problems as part of an integrated agricultural policy.** Major foreign wheat exporters have more extensive controls at first point of sale than U.S. exporters. Wheat from other countries is probably preferred over comparably priced U.S. wheats due to these mechanisms.

The policy and institutional structure of the U.S. grain system provides the framework for various grain-handling practices. **Technologies for producing and handling grain are quite similar among competing countries.** The main difference is that the United States is slightly more efficient in using these technologies. But points in the marketing channel at which they are used differ.

A case in point is cleaning. Outside the United States, most exporters clean grain at the first point of receipt. Canada and Australia are two exceptions, although for different reasons. Canada, however, is studying the economic feasibility of cleaning grain in the country versus at export and will probably change. Australian farmers deliver grain that does not need to be cleaned, unlike the situation in the United States. Basically, no economic incentive exists to clean grain at the first point of receipt in the United States.

The other major handling practice in which the United States differs from other exporters is blending. Blending U.S. grain over wide ranges of quality to create a uniform product for sale is necessitated by the lack of any minimum receival standard. Blending exists outside the United States but not to the same extent. In other countries it is done over very narrow ranges in quality. These exporters basically have grain of uniform quality moving throughout the system. The U.S. system lacks uniformity in quality throughout the market channel. At export, grain is blended in an attempt to produce a uniform quality that meets buyers' specifications. The OTA survey of foreign and domestic buyers of U.S. grain clearly indicated that lack of uniformity between shipments is the buyers' biggest complaint.

Problem Areas

Genetics and Variety Release

Genetically, yield and important intrinsic quality characteristics are often inversely re-

Table 1-1.—Comparison of Institutions and Policies Affecting Grain Quality of Major Grain. Exporting Countries

Activity/Policy	United States	Argentina	Brazil	France	Canada	Australia
Seed variety control	No State or Federal control. Release of varieties influenced to some extent by land-grant universities. Largely the market determines adoption of varieties.	Committee of government and industry must approve agronomic properties. Quality factors of minor influence.	Committee with broad representation directs research and approves varieties. Quality is potential criterion but not currently effective.	Formal mechanism exists that regulates release of varieties based on agronomic and quality criteria.	Formal mechanism used to license new varieties. Agronomic and quality criteria given equal weight in testing new varieties.	Formal mechanism followed as a prerequisite for release Of varieties. Quality and agronomic criteria are used.
Grain receival standards	None. All types of quality are accepted with appropriate discounts for low-quality grain.	Grain not meeting a specified minimum quality (Condition Camara) is rejected at first point of sale.	Soybeans not meeting a minimum quality are rejected at first point of sale.	Grain not meeting export contract specifications can be rejected by surveying company or receiving elevator.	Developed eight grades for CWRS to differentiate quality. Lowest grade goes to feed market.	Wheat must meet minimum quality standards. If not it is allocated to feed market.
Marketing by variety	No mechanism exists for variety identification.	Variety is not identified in marketing channel.	Variety is not identified in marketing channel.	Very common. Variety often specified in wheat contracts.	Licensed grain must be visually distinguishable.	Very common-use variety control scheme to facilitate segregation by classes.
Price	Loan rate is principal price policy. Includes premiums and discounts for major grains but has not been responsive to market conditions.	Government establishes minimum prices for farmers and exporters. Government also establishes premiums for high-quality grain.	Government establishes a minimum price prior to planting. it is adjusted during the year to account for inflation and political pressure.	Key policy is European Community intervention price, which includes premiums and discounts for quality factors. Lower qualities of wheat equated to feed values.	Initial producer price is the principal price policy. Separate prices established for each grade of grain. Lower qualities of wheat equated to feed values.	Guaranteed minimum price (GMP) is key price policy. It is established by class and provides differentials for quality. Lower qualities of wheat equated to feed values.
Farm Storage	Farm policy in past decade has encouraged extensive on-farm storage and inter-year storage.	Government policy through pricing does not encourage on-farm or inter-year storage.	No incentive for farmers to store on farm.	Farm policy through the Common Agricultural Policy (CAP) has not encouraged development of extensive on-farm storage. Also relatively limited inter-year storage due to CAP.	Producer deliveries are regulated to primary elevators via quotas. On-farm storage is substantial.	Use of GMP provides no incentive for delivery in post-harvest period, leading to minimal use of on-farm storage.

SOURCE **Office of Technology Assessment, 1989**

lated in each of the major grains. In the case of wheat, it is well recognized that yield and protein quantity are inversely related. In corn, the trade-off is between protein, starch, and yield; in soybeans, it is between protein and yield. Breeding programs generally aim to improve yield and disease resistance and to satisfy apparently desirable intrinsic quality goals.

In the case of corn, most breeders have always sought to increase yield and improve harvestability, with intrinsic quality not being a priority. **The potential for improving quality through genetics is quite high.** However, many quality factors are traits known to be influenced by many genes, This makes enhancing quality more difficult than altering a trait influenced by a small number of genes, The task is further complicated by the fact that genetic alteration of one trait frequently leads to undesirable changes in other plant traits.

New crop varieties require approximately 9 to 12 years for development and release. If there were a change in plant breeding program objectives in 1989, such as development of new varieties with enhanced quality factors, it could be the end of the century before these new varieties were commercially available.

The emphasis on yield in many cases is due to the fact that though intrinsic quality characteristics may be important, they are not measured in the market. Incentives to improve intrinsic quality characteristics therefore are not transmitted through the market as readily as those associated with agronomic characteristics, such as yield, disease resistance, and harvestability.

Individual breeders or their institutions can exercise tremendous discretion regarding release of varieties. This is tempered, however, by the market system, which determines the success of any release. Market efficiency requires measurement of relevant intrinsic quality characteristics, which is absent in many cases. For example, a variety with lower yield but an improved intrinsic characteristic (e.g., bake test) not measurable in the marketing system would fail to survive in the seed market, Variety release procedures as currently practiced are not applied uniformly across States (or firms, in the case of private breeding) or over time.

No **effective national policy exists on variety release that would assure uniformity in application of release criteria.** In the case of wheat, in which public breeding is more important, the State Agricultural Experiment Stations maintain variety release procedures. These are in turn guided by the Experiment Station Committee on Organization and Policy. However, since no legally binding procedures for controlling the release of varieties exist, individual States can and do vary from this policy. Thus the criteria for variety release may not be uniform across States or consistent over time, Ultimately a particular class of wheat, corn, or soybeans produced in different States may differ in intrinsic quality.

Technologies Affecting Quality

Grain is a living organism and as such is a perishable commodity with a finite shelf life. Drying, storing, handling, and transporting technologies cannot increase quality once the grain is harvested. Each technology is a self-sustaining operation, but the way each is used has an impact on the ability of the others to maintain quality, For example, if grain is harvested wet, not only will this lead to increased breakage during harvesting, but it means the grain must be dried. Improper drying can lead to more breakage and to nonuniform moisture content. Moisture content, moisture uniformity, and the amount of broken grain and fine material affects storability and can have an impact on the technologies used to maintain quality during storage. Therefore, decisions made at harvest, as well as at each step thereafter, affect the system’s ability to maintain and deliver a quality product.

Moisture.—Moisture at harvest directly affects the amount of kernel damage produced through combining. Since cereal grains and oilseeds are harvested in the United States at moisture levels too high for long-term storage or even short-term storage and transportation, these commodities must be dried to acceptable moisture levels. Corn, which is harvested at 20 to 30 percent moisture, must be dried to 14 to 15 percent for safe storage. Wheat and soybean harvest moistures are substantially lower than corn, with safe storage levels marginally lower than harvest moisture. In certain regions of the United States, wheat and in some cases corn and soybeans dry naturally in the field.

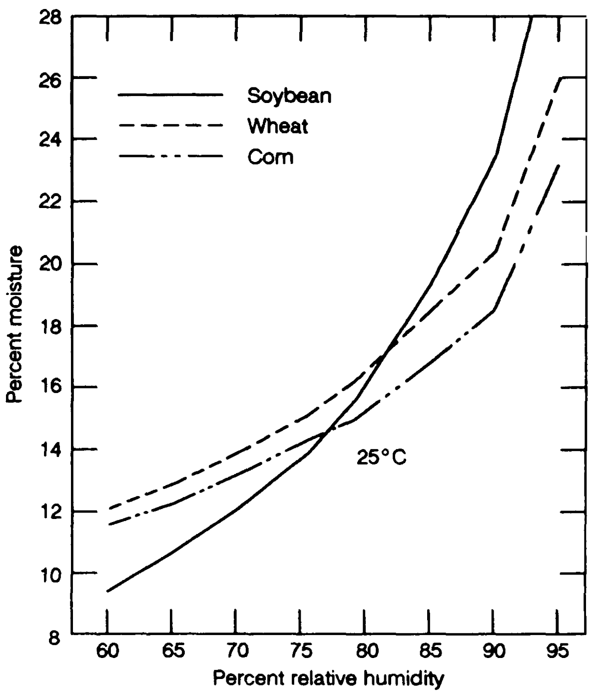
The process of drying has a greater influence on grain quality than all other grain handling operations combined. If superior grain quality is to be produced, it is imperative to optimize the dryer type and its operation since half the corn crop is dried in continuous-flow, portable batch, and batch-in-bin dryers. Of particular concern is the increase in breakage of corn and soybeans and the decrease in milling quality of wheat from improper drying. Artificial drying of wheat and soybeans, however, is not frequently required.

The main dryer operating factors affecting grain quality are air temperature, grain velocity, and airflow rate. A dryer operator is able to adjust the first two on every dryer and, on some units, can adjust all three. Collectively, the three conditions determine the drying rate and maximum temperature of the grain being dried, and thus establish the quality of the dried lot.

At least 80 percent of the U.S. corn crop is dried on-farm. On-farm dryers fall into three categories—bin, non-bin, and combination dryers. **Bin dryers generally are low-capacity, low-temperature systems, able to produce excellent quality grain. Non-bin dryers, the most popular type in this country, are high-capacity, high-temperature systems that frequently overheat and overdry the grain, and thereby cause serious grain-quality deterioration.** Combination drying reaps the advantages of both systems (i.e., high capacity and high quality) but requires additional investment, and is logistically more complicated. **A switch by farmers from non-bin drying to combination drying would significantly improve U.S. corn quality.**

Three classes of off-farm dryers are used—crossflow, concurrent-flow, and mixed-flow dryers. Off-farm dryers are high-capacity, high-

Figure 1-1.—Moisture, Temperature, and Relative Humidity Interactions



SOURCE: Office of Technology Assessment, 1989

temperature units. Crossflow models are the most prevalent type used in the United States; they dry the grain nonuniformly and cause excessive stress-cracking of the kernels. Mixed-flow dryers are common in other major grain-producing countries; the grain is dried more uniformly in these dryers and is usually of higher quality than that dried in crossflow models. Concurrent-flow dryers produce the highest quality grain; their main disadvantage is the relatively high initial cost. A change from crossflow to mixed-flow or concurrent-flow dryers would benefit U.S. grain quality.

Moisture content and uniformity within a storage facility is critical to maintaining grain quality. The interaction between moisture, temperature, and relative humidity may spur mold growth, increase insect activity, and cause other quality losses (figure l-l). Basically, grain moisture in equilibrium with 65 percent relative humidity will support mold activity, but different grains will create the equilibrium with relative humidity at different moisture levels. That is why wheat and soybeans cannot be stored at the same moisture content as corn. When controlling insects, high moisture content increases absorption of fumigants such as methyl bromide, requires an increase in dosage, and accelerates the breakdown of pesticides such as malathion.

The equipment and methods used to fill a storage bin affect the performance of aeration systems used to control the effects of moisture/temperature/humidity. Dropping grain into the center of a bin causes a cone to develop, with the lighter, less dense material concentrating in the center (in spoutlines) while the heavier, denser material flows to the sides. This impedes airflow during aeration, and fosters mold growth.

In large horizontal storage areas, loading from the center or from a loader that is gradually moved backward through the center of the building as the pile is formed causes similar problems. If grain is piled over aeration ducts on the floor by moving the loading device back and forth, airflow will be greatly increased. However, airflow distribution is not as uniform as in upright bins. Some methods of filling piles also result in segregation of fine materials. These accumulations are more subject to insect and mold growth, and they divert airflow. But piles are difficult to aerate and the shape of some restricts uniform airflow.

Nonuniform moisture levels can lead to spoilage in localized areas within a storage facility. Moisture and temperature within a grain mass will not remain uniform over time. Moisture will migrate in response to temperature differentials. If the outside air is warmer than the grain, the circulation reverses, and the area of condensation shifts to several feet below the grain surface, although still in the center.

The effect of moisture migration on storage is that grain assumed to be in a storable condition is not. Cold weather migration primarily affects grain in land-based storage, causing deterioration as temperatures rise in the spring. Warm weather migration is particularly vexing for grain in transit from cold to warm areas of the United States and from the United States through warm waters to foreign buyers. A barge or ocean vessel is basically a storage bin and will experience the same migration phenomena as land-based storage facilities.

Broken Grain and Fine Materials.—Some grain damage or breakage generally occurs whenever grain is harvested. Overall, damage is always much greater in extremely wet or extremely dry grain. When grain is harvested at high moisture levels, the kernel is soft and pliable. Moist kernels deform easily when a force is applied and greater force is needed to thresh wet kernels than dry ones. Thus, wet kernels suffer more damage than drier ones. However, drier kernels can break when the same force is applied. Different optimal conditions thus exist for each grain,

In addition to grain breakage, factors such as weed control and kernel density, especially in wheat, also affect a combine's ability to harvest and deliver clean grain. Cutting below the lowest pod or wheat head inadvertently introduces some soil into the combine. Most soil is aspirated from the rear of the combine unless the soil particles are about the same size as the kernel, in which case they pass through the cleaning sieves with the grain.

Harvesting technologies normally separate and remove material larger than the grain (such as plant parts) and material significantly smaller (like sand and dirt). Sloping terrain, however, can affect this process. Side slopes also create problems since the tendency is for material to congregate on the downhill side of the cleaning shoe,

The main factor affecting the combine's cleaning performance is the amount and type of weeds present in the field during harvest. Weed control is one of the most serious problems facing many U.S. wheat producers. This is also true for Southeastern U.S. soybean-producing areas, where a warm, wet climate is conducive to weed growth. The amount of weeds affects not only grain yield, but also the amount of foreign material present in the harvested grain and the combine's ability to remove this material.

Combines are being modified to improve their performance in weedy fields. In the case of wheat, kernel size has been decreasing, which complicates this modification. The trend toward smaller kernel size is a concern because the seeds of most grassy weeds are smaller and lighter than wheat. Thus, smaller wheat kernel size reduces the margin between wheat and weed size and, therefore, increases the difficulty of cleaning within the combine.

Rapidly drying moist grain with heated air causes stress cracking. The drying operation itself does not cause grain breakage, but can make grain more susceptible to breakage during handling later. **Cleaning grain before it reaches the dryer can improve dryer efficiency.** Introducing clean grain to the dryer:

- results in a more uniform airflow in the dryer and thus a more uniform moisture content of the dried grain;
- decreases the static pressure (airflow resistance) of the grain, thus increasing the airflow rate and dryer capacity; and
- eliminates the drying of material that detracts from final grain quality.

Obviously, precleaning also has disadvantages. It requires additional investments in cleaners; the handling of wet, broken grain and fine material; and the rapid sale of wet, easily molding material; and it results in some dry-matter loss. Although the advantages of precleaning wet grain are fairly well understood by dryer operators, most avoid precleaning. The quality of the U.S. grain crop would improve substantially if precleaning were adopted.

Mechanical damage during handling results in grain breakage, which produces broken grain and fine materials. This causes a decrease in quality, greater storage problems, and an increase in the rate at which mold and insects tend to invade stored grain.

Research shows that breakage in handling is more significant for corn than for wheat and soybeans. Higher moisture content and higher temperatures prove to be the best conditions to minimize breakage but are opposite of the optimal safe storage moisture and temperature. The effect of repeated handlings on grain breakage is cumulative and remains constant each time grain is handled or dropped. This is true whether or not the broken material is removed before subsequent handlings.

The impact of grain breakage and fine materials on all aspects of the system has resulted in the need to clean grain. Cleaning wheat in commercial handling facilities is normally limited to removing dockage, insects, and, to a limited degree, shrunken and broken kernels. For corn, cleaning regulates the amount of broken kernels and foreign material; for soybeans, it affects the amount of foreign material and split soybeans,

Cleaning corn to remove broken kernels and foreign material is required at each handling in order to meet contract specifications and avoid discounts. For wheat, however, most dockage is generated during harvest, and normal handling does not cause significant increases. Therefore, cleaning is not required at each handling. Soybeans, on the other hand, fall somewhere in between regarding their breakage susceptibility and the amount of cleaning required at each handling.

The amount of grain cleaning required prior to storage involves the factors of risk to grain deterioration as a result of mold and insect invasions and the costs associated with maintaining quality. Broken grains, grain dust, and other fine materials have the greatest effect on the performance of insect control interventions. When a protective treatment is applied, grain dust may absorb much of the insecticide, which reduces the effectiveness. Likewise when a fumigant is applied, concentrations of dust and fine material may require increased dosages to penetrate the grain mass. Dust also inhibits penetration of fumigant gases causing nonuniform penetration.

Ability of System to Maintain Quality.—Technologies are in place to harvest, maintain, and deliver high-quality grain. Each technology must be used, however, in a manner that is conducive to maintaining quality.

Although the data indicate that nearly any combine can deliver acceptable grain quality, farmer-operated combines tend to record more damage than the combine should deliver. From a technology standpoint two areas need emphasis:

1. increased education to help operators better understand the interactions of cylinder/ rotor speed, concave openings, fan speed, and sieve openings with grain quality and losses; and
2. more monitoring devices and possibly automatic controls on combines to help operators adjust or fine-tune the combine.

Weed control and its relationship to kernel size and density are critical to optimum combine performance. Unless new technologies addressing this area are developed or improved weed control measures are forthcoming, the combine's ability to harvest and clean grain will continue to present problems.

A significant improvement in grain quality can be obtained by optimizing the dryer operating conditions of existing crossflow dryers, by precleaning wet grain, by selecting the best grain genotypes, and by installing automatic dryer controllers.

Molds will grow on any kernel or group of kernels that provide the right conditions. Therefore, moisture content and uniformity within storage facilities are critical to maintaining grain quality. **Maintaining low temperatures and moisture levels in grain is the principal way to preserve grain quality and prevent damage from molds and insects.** Aeration is also a very effective tool. The rate of development of both molds and insects is greatly reduced as temperature is lowered.

Many storage bins, especially on the farm, are equipped with aeration systems but often are not used effectively. Farm storage bins, especially smaller and older ones, generally are not aerated. Small bins will cool or warm quickly enough with the changing season that moisture condensation may not be a serious problem. A majority of farm aeration systems are either not operated at all or not used enough. The most common problem is not running the fans long enough to bring the entire grain mass to a uniform temperature level. If a cooling front is moved through only part of the grain, a moisture condensation problem is likely at the surface where the warm and cold grain meet.

In addition to aeration, the turning and transfer process mixes grain and contributes to a more uniform moisture and temperature. In facilities not equipped with aeration, turning has been the traditional means of grain cooling. This approach requires much more energy than aeration does, however, and it can contribute to physical damage by breaking the kernel.

Grain in horizontal or pile storages cannot be turned because of the difficulty in unloading and moving it. In order to turn grain, a handling system must have empty bins that are connected by a conveying system. This is not the case on most farms.

Most grain storage facilities provide a natural habitat for certain harmful insects even when the facility is empty. Grain residue trapped in floor cracks and crevices, in wall and ceiling voids, and on ledges provides an ample supply of food to sustain several insect species. Thorough cleaning is the first and most effective step toward preventing insect infestation of freshly harvested grain. Because insects live from season to season, cleaning and removing trash and litter is important, Also, a thorough cleaning should precede any insecticidal treatment of storage facilities if the full value of the treatment is to be gained.

For several reasons, such as remoteness of facilities, small amounts of grain to be treated, and lack of information, farm storage facilities are often the inappropriate site for insect control treatment. Grain that has not received a properly applied treatment can become mixed with noninfested grain when marketed, magnifying the problem and creating greater loss and the need for more expensive and time-consuming remedies later.

The high-speed, low-cost U.S. grain system does not readily accommodate special quality needs. While these needs can be met by slowing belt speed, installing and using cleaning equipment, eliminating unneeded handlings, and preserving the identity of grain, most of these actions increase costs.

All factors affecting quality just discussed—nonuniform moisture, moisture migration, temperature and humidity, insect invasion, and mold development—have an impact on grain quality during shipment. No mode of transportation is equipped with aeration, nor can grain temperatures and corrective actions be taken during shipment. Moisture migration can be more dramatic since grain may undergo several outside air temperature and humidity changes. This is especially true when grain is loaded in a cold climate and transported through warm waters rather quickly to a warm, humid climate. Therefore, moisture uniformity is critical to maintaining quality during shipments.

The interactions between technologies regarding moisture content and breakage on grain quality are evident. Each technology is capable of preserving grain quality. Once inert material such as weed seeds, dirt, stems, cobs, and so on are removed from the grain, no further cleaning is required. But grain, especially corn, must be cleaned to overcome breakage that is inevitable due to handling in the system. Once grain quality deteriorates at any step in the process, it cannot be recovered.

Grain Standards

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

Current grain standards are limited in four important ways:

1. They create incentives for practices inconsistent with good management and efficiency.
2. They fail to identify many of the characteristics related to value in use.
3. They fail to reward producers and handlers for improved drying, harvesting, handling, and variety selection.
4. Grade limitations on many factors are arbitrary, sometimes not reflecting real differences in value, and in some cases are not consistent with statistical principles.

No **ideal standard will be found, and any revisions would have to consider trade-offs.** To move toward an ideal system, grain standards should be changed to include:

- grade-determining factors;
- non-grade-determining factors; and
- definition and measurement technology for official criteria.

Grade-determining factors should relate to sanitary quality, purity, and soundness (absence of imperfections). Grade would be based on factors such as impurities, foreign material, total damage, and heat damage. The lower the values of any of those defects, the greater the value of the product.

Non-grade-determining factors would address properties such as broken kernels, moisture, oil and protein content, and other intrinsic characteristics or physical properties that influence values for major processing uses. Higher or lower percentages for those do not necessarily mean higher end-use value. Many chemical and physical properties that influence the quantity and quality of products derived from grain probably are yet to be identified. More research may add to the list of properties. The criteria for inclusion should be that the cost of obtaining the information is less than the value of that information to users who need it. By starting with the major products generated from each grain, a list of physical and chemical properties can be developed that are correlated with the value in use. New rapid testing technology is also a requirement prior to inclusion.

Official criteria factors would be those requested by buyers and sellers. These would be developed only after evidence of sufficient demand to cover the cost.

Grain can be inspected many times as it moves from the farm to its ultimate destination. Normally it is tested for one or more important characteristics each time it is loaded into and out of a grain elevator. The number and type of tests varies, from those provided for in the grain standards to measures of intrinsic characteristics not covered by the regulations.

The U.S. Grain Standards Act (USGSA) requires that standards be developed and used when marketing grain, **Even though the tests provided for in the grain standards must be used, no requirement exists on who will perform the tests and what tests will be performed on grain moving domestically in the United States.** In fact, two U.S. Department of Agriculture agencies are authorized to perform testing services using the grain standards on domestic grain movements. The only mandatory testing is performed by the Federal Grain Inspection Service (FGIS) on export grain.

Since no single policy on inspecting grain exists, no one group is responsible for developing and overseeing the tests and equipment being used. Regardless of which tests are performed and who performs them, several factors are important to testing. These include instrument precision, instrument standardization, the choice of reference methods and traceability to standard reference methods when developing rapid objective tests, calibration, and natural error resulting from sampling.

As the relevance of additional tests performed on an ongoing basis becomes clearer, the need for standardizing equipment and procedures becomes more critical. Also, criteria must be established to govern the design of rapid test equipment. However, development of rapid tests must meet the basic criteria associated with standardization, traceability to standard reference methods, and calibration. In addition, rapid tests must be evaluated in terms of speed, cost, accuracy, durability, and capability of handling wide ranges in quality.

Buyers' Attitudes

An extensive survey of domestic and overseas grain buyers was conducted for this study to determine their attitudes toward quality, grain standards, and merchandising practices. Several general points of importance were clear.

First, to determine what is considered quality for any given grain, the ultimate use must first be known. Each domestic and overseas industry has defined quality in terms of the areas important to its markets.

Regarding key attributes not currently covered by grain standards, no one set of quality attributes for wheat meets the demands for all wheat products. Differences in what are considered important attributes exist between domestic and overseas wheat millers and by region of the world. Protein, hidden/dead insects, falling number, pesticide residue, mycotoxins, and dough handling tests were considered the most important. Falling number and pesticide residue were identified by both groups as tests that should be included in the wheat standard. Hidden or dead insects were also identified by domestic millers for inclusion.

For corn, the determination of important attributes is industry-dependent except in areas regarding wholesomeness, health, and safety. Items such as stress cracking, breakage susceptibility, and hardness are more important to wet and dry millers than to the feed industry. However, attributes such as pesticide residue, mold, mycotoxin, and hidden/dead insects are important to all those surveyed.

Commonality of important attributes is more evident in soybeans than in wheat or corn between domestic and overseas processors. The most important attributes are protein, oil, and free fatty acid content.

Second, the grain system's ability to deliver important quality attributes consistently is as important as the attributes themselves. Problems with uniformity are especially acute in wheat and corn. As processing technologies become more sophisticated, the demand for uniformity will become more critical.

U.S. Farm Policy

Two important features of U.S. farm policies have an impact on several aspects of quality. **The inverse relationship between yield and intrinsic quality (e.g., protein in wheat) means the target price program) has a negative long-term impact on intrinsic quality.** This is because the target price typically exceeds the market price, creating an incentive to expand yields. Impacts vary by grain and region, depending on the extent of the inverse relationship. When target prices, which are based on yield, exceed market prices and if the premiums associated with the measure of intrinsic quality are unchanged, there are incentives to increase yield at the expense of intrinsic quality. This effect has been exacerbated in previous farm bills, which used different methods of determining yield. The total impact in the case of wheat has been to force market premiums for wheat protein to relatively high levels in order to neutralize producers' decisions.

Administration of the loan rate program also has an impact on intrinsic quality, as well as on physical and sanitary quality. **In particular, the market for measurable quality characteristics is distorted due to the fact that premiums and discounts on forfeited grains, especially wheat, are less than those determined in the market.** Poorer quality grain is put under storage, and market differentials are depressed.

Changing Role of Demand

Wheat, by its very nature, is the most complex of the three grains for defining quality because of the vast array of products and processing technologies used to produce the products. Corn is somewhat less complex in that fewer products are produced and quality concerns can be traced to the individual industries. On the other hand, the quality required by one corn industry is not necessarily important to others. This creates a situation whereby decisions regarding corn quality must be assessed in terms of major usage. Quality concerns of different industries using wheat are somewhat overcome by the fact that different types of wheat exhibit different properties. Soybean quality is the least complex issue because the vast majority of soybeans are used to produce oil and meal.

The varying quality requirements exhibited by these industries highlight the need for the United States to become more aware of individual industry requirements if the goal is to produce and deliver high-quality grain. The United States has developed the reputation as a consistent supplier for any type and quality of grain desired. **To become a supplier of high-quality grains, it must become more quality-conscious and develop a reputation as a high-quality supplier.** The Nation must understand the specific quality requirements of its customers in order to match them with the quality delivered, and must become more aware of the dynamic issues surrounding the qualities required by the marketplace. Areas such as technological advancements in processing technologies, government policies, customer preference, development of new finished products, and consumption patterns all affect customers' purchasing decisions and their definition of quality at any one point in time,

Quality in the Marketplace

Quality attributes required by individual industries directly relate to the processing technology used and the needs of the various finished products. In the case of corn, what may be considered high quality to feed manufacturers is not necessarily high quality for the wet and dry milling industries. Wheat, used in a multitude of products, has quality requirements that differ not only by type and individual product, but between mills using the same type of wheat to produce flour for the same type of product. Baking technologies for wheat flour vary not only in the United States, but also within and between countries using wheat purchased from the United States; so defining one set of wheat quality characteristics for even one type of wheat or flour is not useful,

High quality, as defined by the specific attributes required by each industry, is constantly changing. However, the ability to produce and deliver high-quality grain can mean more than just providing grain that meets specific test results. What constitutes high quality from the customer's point of view can range from special handling (low-temperature drying of corn) to the uniformity of specific attributes within and between shipments.

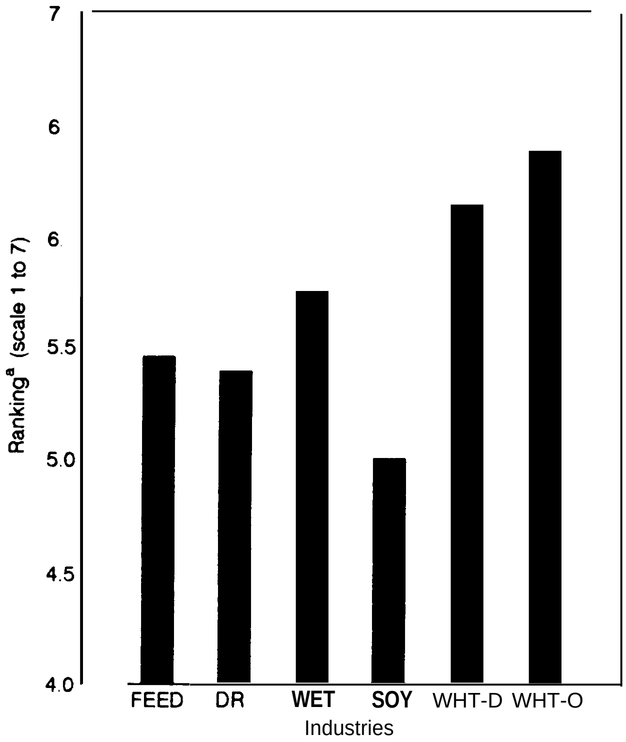
The OTA survey specifically asked respondents to rank the importance of uniform quality between shipments (figure I-2). Domestic and overseas respondents considered uniformity between shipments as being important even though they differed on which attributes were more critical. The results from the question regarding overseas millers' preference for U.S. wheat compared to that of other exporters further demonstrates the importance of uniformity. Canada and Australia stress uniformity between shipments and this fact generally accounts for wheats from these countries being ranked as first choice.

To further complicate the task of identifying important quality attributes for specific industries, some traditional measuring technologies are not accepted by certain industries producing the same product. This fact stood out in OTA survey results for domestic and overseas wheat millers. Tests for theological properties (extensograph, alveograph, and mixograph) were considered more important by overseas wheat millers than by domestic millers, And even though overseas millers considered these tests important, their importance varies by region of the world.

As processing technologies become more sophisticated through automation or as more demanding qualities are required for finished products, the need for specific attributes within well-defined ranges becomes more critical. Technologies for baking bread, rolls, and similar products in large bakeries have advanced significantly. While bread can be made by hand using low-protein wheat, large dough-mixers and other equipment found in large automated bakeries place too much stress on low-protein flour, resulting in unacceptable finished products. The differences in how flour will be baked plays a very important role in determining the specific values for the various attributes required of the flour.

In addition to advances in processing technologies, technological advances in other areas can have an impact on the quality required by different industries. For many years, high-protein wheats have been blended with low-protein wheats to strengthen flour, More recently, vital wheat gluten, a product contain-

Figure 1-2. - **Importance of** Uniformity **Between Shipments**



ABBREVIATIONS:

FEED = Feed manufacturers
DRY = Dry millers
WET = Wet millers
SOY = Soybean processors
WHT-D = Wheat millers (domestic)
WHT-O = Wheat millers (overseas)

[a],O Neutral
50 Slightly Important
60 Moderately important
70 Extremely important

SOURCE. Office of Technology Assessment, 1989 ing 75 to 80 percent protein, has been used as a flour fortifier. The recent expansion of vital wheat gluten production is the result of technological improvements in breadmaking, rapid population growth, and increasing trend toward urbanization in some countries.

Many countries striving to become self-sufficient in wheat Production are producing vital wheat gluten to fortify locally produced low-protein wheat. Some European processors are also producing isoglucose, a sweetener and sugar substitute, from wheat starch (that portion of the wheat kernel remaining after the gluten is extracted) to produce something similar to corn sweetener in the United States.

Corn, which has always been considered mainly as an animal feed, is beginning to experience pressures in areas similar to those affecting wheat. As feed manufacturing becomes more sophisticated and automated, and as customers (especially in the poultry industry) need strictly controlled and balanced diets, the demand for quality attributes and consistency in delivering these attributes is taking on increased importance. In other cases, individual corn dry and wet milling companies are placing more stringent demands on the quality of corn they purchase. Companies are contracting with farmers to grow certain varieties and perform special handling, such as low-temperature drying.

Traditional quality attributes, even though varied, may be influenced by technological advances, economic concerns, and government policies here and abroad. For the United States to produce and deliver high-quality grain, it must not only **become increasingly aware of concerns over quality expressed by domestic and overseas industries and match quality to their wishes, but it must understand the reasons why countries purchase grain in the first place.** Knowledge of customer preference, consumption patterns, and the role of government policies is critical when considering steps the United States should take to enhance the quality of grain in international trade.

POLICY OPTIONS

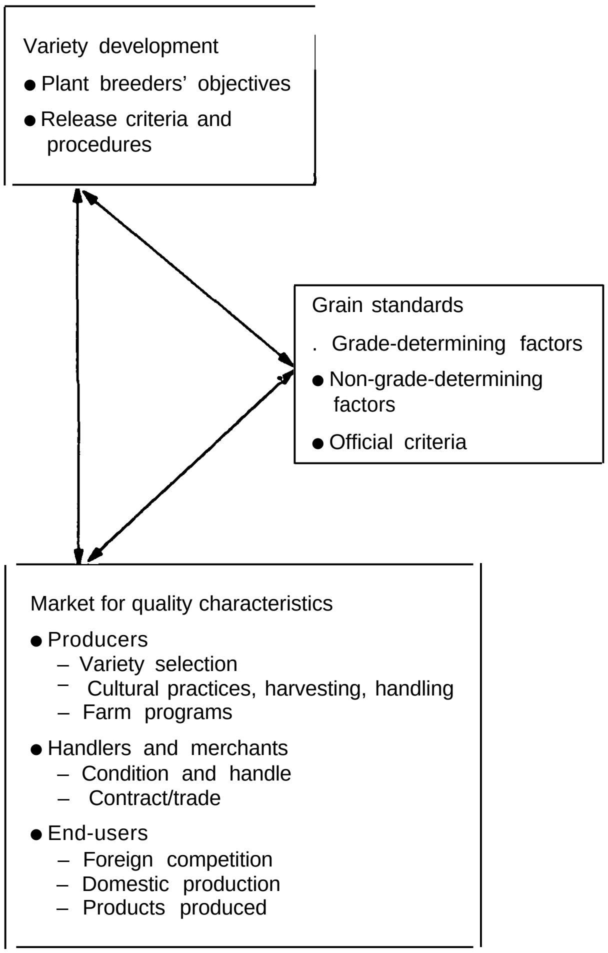
The overall purpose of any policy change related to this grain issue must be to create an environment that enhances grain quality. In general, the important features of the U.S. grain system are breeding, handling, grain standards, and the market for quality characteristics. Each has an effect on grain quality. Institutions, policies, and trade practices have an impact on these sectors, and therefore on quality. Policy discussion in this country has traditionally focused on only one component of the system—grain standards. Yet given that it is the operation of the overall system that influences grain quality, a far greater number of policy options exist than are normally discussed.

The notion of interdependence in the production and marketing system with respect to quality is illustrated in figure 1-3. This triad could be viewed as a three-legged stool; each leg has an impact on quality as well as on the system.

Premiums and discounts for quality characteristics are determined in the market, where buyers and sellers interact. producers make varietal and agronomic decisions in response to incentives. These, however, are also influenced by farm programs. The demand for characteristics is influenced by end-use needs and foreign competition. Merchants and handlers procure, handle, condition, and blend grain to meet contract specifications. In addition, they make offers on what they can sell, and at what price differentials, based on the availability of quality characteristics and their conditioning capabilities. Each activity is influenced by the incentives established in the market, by trading rules, and by grain standards, which provide a description that is useful for transactions and which therefore facilitate trade. Relevant end-use characteristics generally are not included in grain standards, however.

The objectives of public and private plant breeders in variety development include yield, disease resistance, harvestability, and quality. In addition, participants have procedures and

Figure 1-3.—Components of the Interdependent Grain System



SOURCE: Office of Technology Assessment, 1989

criteria for variety release, Ultimately, the market for seed determines the success of varieties. Some characteristics, e.g., yield, are more easily measured than others by market participants. Breeders also have some control over intrinsic quality characteristics that are not easily measured in today's marketing system.

The interdependence of the system's components must be recognized in the evaluation of policy options with the objective of establishing a more integrated relationship among them. In a number of other grain exporting countries, the policies are more integrated and better coordinated. In fact, the United States has made **no effort to coordinate or integrate policies affecting these activities.** Any policy on grain standards will affect varietal development and the efficiency of the market for quality characteristics. Similarly, any policy affecting the market (e.g., incentives) will have an impact on variety development and grain standards. The inability to measure intrinsic characteristics in grain standards has implications for policies affecting the market and variety development.

Policy changes could be focused on any system component, but the effectiveness must include impacts elsewhere. A number of phenomena that influence quality (e.g., weather) cannot be affected by policy and a number of policies are short-run and only treat symptoms. Policies developed here aim to affect underlying causes of the problem, which over the long term would result in improved quality. Thus the policy options are limited to three general categories—variety controls, market intervention, and grain standards (table 1-2). Within each are a multitude of alternatives, and only selected ones are presented. Policies available are a continuum within each category rather than discrete choices, as implied by the table. The emphasis here is that policy should take the long view, and it should have the objective of coordinating policies across the three sectors.

Variety Controls

Three important considerations lead to the policy options listed under variety controls. First, with few exceptions grain standards do not measure important intrinsic characteristics. Second, intrinsic quality characteristics differ significantly across some grain varieties. Third, varieties are not visually distinguishable, thus segregation in the market system is precluded, resulting in increased uncertainty in end-use quality. These three points apply to some extent to each of the grains. The classic case is that of wheat, in which performance varies across varieties, and increasingly it is becoming difficult to differentiate wheat in the marketing system. In some of these cases it may be easier to identify variety, or groups of varieties, than intrinsic characteristics. Further,

Table 1-2.—Fundamental Policy Alternatives

Variety controls	Market intervention	Grain standards
No change	Marketing board	Mandatory USGSA inspection
Variety identification/ categorization	Export bonus	Single agency to approve testing
Variety licensing	No change in loan policy	Mandatory USGSA inspection in conjunction with NIST equipment approval
	Increased differentials in government policies	
	Minimum quality specifications for farmer loans	

SOURCE: Office of Technology Assessment, 1989

identity of a variety provides more comprehensive quality information than any subset of measured quality characteristics.

Domestic processors attempt to resolve problems of varietal differences, to some extent, by purchasing by location or region. Foreign buyers, however, or in general any buyers using purely grade specifications are precluded from this alternative.

No Change

Maintaining the status quo has four main implications. ***First,*** **intrinsic quality characteristics will continue to lack uniformity among States/regions/shipments.** In the current system, with only informal, uncoordinated variety release criteria, many basic characteristics differ among varieties. These characteristics lose their identity in a market incapable of measuring end-use characteristics. Consequently, important intrinsic quality differences existing regionally are not detected in the marketing system.

Second, **problems will be created elsewhere in the system due to the inability to measure intrinsic quality.** In particular, increased pressure would be placed on grain standards to measure intrinsic quality within the marketing system.

Third, **the current lack of information on intrinsic quality in some grains will continue, reinforcing current inefficiencies in the market.**

Fourth, **productivity growth would be facilitated to a greater extent given complete freedom on variety release and selection.**

If there is no change from the current system of administering variety release, the pressure on grain standards to introduce measures of intrinsic quality will increase. Other countries use variety identification and release procedures in part to reduce the pressure on grain standards to measure intrinsic quality. Alternatively, by incorporating intrinsic quality into farm program policies (discussed later), at least some incentive could be built into the system to improve intrinsic quality.

Variety Identification Categorization

Any sort of variety identification or control scheme would pose administrative challenges. One alternative would be to provide a mechanism in which varieties can be identified in the market system. Such mechanisms currently exist and are used in other exporting countries. These consist of an affidavit system, random testing using electrophoresis, and categorization. Producers would declare the variety at the point of first sale or loan application. This would provide information to handlers on segregation based on grain categories or groups of varieties. Categories would be developed according to end-use similarity and could become part of the grain standards.

Alternatively, variety or groups of varieties could become part of the contract governing the transaction, as is the case in the French system. The number of categories established would vary by grain, depending on the three considerations just discussed and on end-use specificity. Thus, for example, if only one end use existed and the varieties did not differ sufficiently with respect to intrinsic quality, only one category would be necessary. On the other hand, for wheat, in which there are intrinsic differences across varieties and a multitude of end uses, there would be a larger number of categories. The intent here would be to formalize a mechanism not dissimilar from the current system of classification for wheat. The difference, however, is that the current system for classification relies on visual distinguishability, and categorization is based on fairly imprecise criteria.

A variety control scheme would increase information (by category of varieties), thus increasing the efficiency of the market in its allocative role. For most grains, variety is a better indicator of quality than are selected tests for quality. Thus, buyers' information regarding quality would be improved. The increase in information would raise the efficiency of the market, resulting in improved signals being transmitted to producers, breeders, and end-users.

Such a program would pose a challenge for administration in the United States, especially given the numerous varieties currently grown. It would be further complicated by the fact that intrinsic quality depends not only on variety but also on where it is grown and on local climatic factors.

Contract specifications would increase in complexity. The informational requirements for contract specification would increase, particularly of foreign buyers. Depending on the extent of categorization, however, this complexity could be reduced.

Introduction of a variety identification scheme would result in incentives and disincentives being readily associated with varieties with desired/undesired intrinsic characteristics. In addition, using a variety identification scheme would reduce pressure on the grain standards to measure intrinsic performance in the marketing system. Categorization of varieties would serve that function.

Variety Licensing

A more restrictive approach would be to institute a variety licensing scheme. Varieties would be subjected to criteria administered at a national level for release into the market system, Licensing of varieties takes various forms in different exporting countries—from quite restrictive, such as in Canada and Australia, to fairly neutral, as in France. The intent of each, however, is to provide some mechanism that assures certain intrinsic characteristics, given that they cannot be easily detected in the market system, and to apply uniform criteria throughout the country, i.e., to reduce uncertainty of intrinsic characteristics through uniform application of release criteria. Administration would require procedures similar to those of the variety identification system just described. In addition, some criteria would have to be established for categorization (i.e., to license varieties by end use), and for administration.

Licensing varieties would increase uniformity and raise the ability to control intrinsic quality, A formal mechanism could be provided for categorization relative to a simple variety identification scheme. Due to locational differences in quality, varieties would have to be licensed by location and by end use.

Depending on administration, this scheme could be viewed as restrictive, i.e., of productivity growth. However, this is not necessarily the case, as the situation in France indicates, This approach would be difficult to implement, complex to enforce, and likely to create a bureaucracy.

A stricter variety licensing system would have similar effects on other parts of the system as just discussed under variety identification. In particular, licenses could act as surrogate grain standards for intrinsic characteristics.

Market Intervention

Marketing Board

Central to the U.S. system is the market in which prices are established. Embedded in this market, and all prices, are premiums and discounts for measurable characteristics, which allocate grain across different users. In addition, these quality characteristics provide incentives and disincentives for participants throughout the marketing system. Several other countries accomplish this by some form of board control. Thus, **one** option would be **to** introduce **a** marketing board system in the United States **to** resolve quality problems. The emphasis of the discussion here is on the implications of a board for quality, in particular, and the coordination of policies on quality. Other aspects of a board operation are more far-reaching (e.g., bargaining power, resource allocation, impacts on non-board grains, impacts on physical coordination) and are not discussed here.

A primary benefit of a marketing board would be to coordinate the many aspects of the production and marketing system that have an impact on quality. Quality would be improved to the extent that only two transactions—one between producer and board, and another between board and buyer—would take place. This is in contrast to the multitude of current transactions, all requiring measurement of quality.

Administration of price differentials would be more subjective and judgmental in such a system since transactions would take place without an active market. Indeed, market determination of price differentials is an important advantage and role of the U.S. marketing system.

Operating a grain marketing board in the United States would be costly, given the complexity and breadth of the system. Countries with boards operate in relatively simple logistical systems, and with few grains. When either of these increases, as would be the case in the United States, the problems associated with bureaucratic allocation decisions intensifies, The highly efficient U.S. grain handling and distribution system, due in part to the competitive environment, would be lost in a board-type system. Thus, it is likely the costs of imposing a board system in the United States would outweigh the benefits of quality improvements.

Imposition of a board system could reduce the emphasis on grain standards at the point of export, and for that matter throughout the system. This is presuming that sufficient earlier controls were imposed to resolve grain quality problems, thereby reducing the importance of quality measurement at the point of export. In addition, variety release procedures could be easily administered in a board system. Incentives could be administered rather than having to rely on market determination.

Export Bonus

An alternative policy would be to establish a bonus payable to exporters who deliver grain having quality superior to that specified in the contract. Conceptually, this addresses the system’s merchant-handler component, This policy is discussed in the context of being applied at the point of export, but in general it could be applied elsewhere in the marketing system.

An export bonus program could have immediate results, especially if tied to a physical or sanitary quality characteristic. It would result in an increase in quality perception, or in attention to the issue, Longevity should be a concern, however, in that if terminated, the effects likely would not last.

Administration would be costly. Several important administrative points would need to be considered, First, which quality characteristic(s) would be tied to the bonus—physical, sanitary, or intrinsic? Quality would improve on whatever characteristic received a bonus. Depending on longevity, however, the bonus would likely not influence intrinsic quality, Second, should the bonus be applied at the point of export or origin? One risk is that importers may manipulate the system by specifying a lower grade in order to receive the same grade they traditionally purchase, but at a lower price,

An export bonus program, by definition, would be oriented to the merchants and handlers in the system. It would provide incentives for them to improve the quality on particular attributes and for particular shipments to which the bonus was applied, Due to competition within the industry, any benefits would be distributed to appropriate decisionmakers so as to provide incentives. **More information would not be provided to the market, however, nor would there be a reduction in information uncertainty, so the efficiency of the market would**

not be improved. Breeders' objectives and release criteria would be affected only to the extent that the bonuses were applied to intrinsic characteristics, and over very extended time periods.

No Change in Loan Policy

Another option is to leave unchanged the current administration of the policy on loan forfeitures and grain stored for the Commodity Credit Corporation (CCC). The fundamental problem is that price differentials for loan forfeitures and transactions on CCC-owned grain are substantially less than those in the market. The market for quality characteristics is therefore distorted. The loan and CCC storage practices would continue to support the price of lower quality grains. In addition, there would be essentially no change in intrinsic, physical, or sanitary quality from that of the current system.

Lower quality grain under extended storage could deteriorate more than if it were of superior (physical and sanitary) quality. Growers would remain isolated from the market and therefore incentives for improving quality would be masked.

The market is distorted in general in the allocation between storage and commercial sales, with superior quality grain going to the latter. Since the program does not effectively distinguish intrinsic quality, loan rate disincentives are not effective at transmitting signals to producers. Thus, a major impact of not changing the policy would be to increase the role and function of grain standards in measuring quality.

Increased Differentials in Government Policies

The administration of premiums and discounts for loan forfeitures and transactions involving CCC-owned grain could be revised to provide incentives to maintain or enhance quality. These could be attached to intrinsic as well as other physical and sanitary quality characteristics. In a number of other countries, quality problems are addressed as a matter of agricultural policy, These take the form of incentives by using regulations and substantial premiums and discounts for quality deviations. Realigning the incentive system via farm policy addresses one component of the system, i.e., the market for quality characteristics, That market already exists and develops premiums and discounts. But it is distorted somewhat by administration of the farm program. This policy option would thus be eliminating a distortion, which would allow the market to function more efficiently. Alternatively, farm policy could take the lead by providing price differentials at least equal to market differentials, to provide incentives throughout the system.

CCC administers programs for handling and storing CCC-owned grain. Different rules are applied to country and terminal elevators. CCC requires that terminal elevators deliver the quality represented by the warehouse receipts and it discounts individual railcars. CCC does not pay terminal elevators for overdeliveries in quality. This is not the case for country elevators, which are not subject to the same rejection rules if the quality delivered is inferior to the warehouse receipts and which receive payment for overdeliveries.

One of the few ways to legislate incentives into **the system,** particularly for intrinsic qual**ity, is via the** price differentials in **the** loan program. This alternative consists of differentials associated with loans to be greater than or, alternatively, equal to the market. They could be applied as currently done, on grades, or on specific physical and sanitary quality criteria. A very simple example would be a 4-cents/bushel price differential for clean wheat (i.e., less than 0.5 percent dockage). In addition, measures of intrinsic quality (e. g., falling number in wheat, oil content in soybeans, or protein content in corn) could be incorporated, as in other countries.

Because the relationship between market prices and loan values varies across grains, and because the participation rates vary, this policy would have a greater impact on wheat than on other grains. In addition, its impact would only be periodic due to the loan not being effective all the time.

If the loan supported prices of higher quality grain, lower value grain would be forced into the market, as opposed to into the loan program, as currently happens. Thus, there would be an increase in the amount of grain going into alternative uses, with lower end value. The most vivid example is the use of wheat as animal feed. Incentives for intrinsic quality could be relatively easily incorporated into the loan program (i.e., relative to measuring them in the marketing system).

Some type of mechanism for quality measurement would have to be developed for grain going under loan, e.g., through farmers submitting samples. Establishment of the optimum price differentials would be difficult to administer. This is especially true given the large number of U.S. markets and given that—at least in the past—loans have to be announced long before crop quality is determined.

Country elevators would be forced to become more concerned with maintaining quality, and CCC would be guaranteed that the quality of grain received into the country elevator would be delivered out of the elevator. This change in policy would also relieve the pressure of maintaining discount schedules that reflect the market, in that CCC would not accept quality below that specified in the warehouse receipts.

This particular alternative addresses the market for quality characteristics, and provides incentives in an important market for some grains. **Changing the current system would have a number of system benefits. First, to the extent that intrinsic characteristics are used, variety development would be favorably affected.** Signals from this important market would be transmitted directly to breeders and would affect their breeding objectives and release criteria. Thus, this provides somewhat of a surrogate for variety control. **Second, there would be somewhat reduced pressure to measure intrinsic quality in grain standards.** In the extreme of a proactive farm policy, together with variety identification/licensing, the role and function of grain standards could be reduced to some extent toward measuring physical and sanitary quality characteristics.

Minimum Quality Specifications for Loans

An alternative used in many countries is that of minimal receival standards on grain entering the marketing system. Normally grain marketing is integrally related to prices and policies (e.g., initial payments) and therefore it is difficult to isolate physical marketing from pricing. **As developed here, minimum quality specifications would be applied to grain entering the loan program as opposed to grain entering the marketing system.** The global application of minimum quality specifications to the U.S. marketing system would be next to impossible to implement since a majority of grain under loan is stored on farms.

The concept of setting minimum quality specifications for loans is similar to the option just discussed, except that a constraint, rather than a price incentive, is used for entry into the loan. Minimum quality specifications could be applied to physical characteristics (e.g., minimal dockage) or intrinsic characteristics (e.g., variety, protein, falling number, oil, or meal protein). If these were integrated into the loan program, the potential exists for grain not meeting those specifications to be diverted to the export market. One way to help minimize this would be to use whatever quality specification has been established for government programs as a basis for rejecting grain going into an export elevator. This would have the added benefit of reducing the spread of qualities available for blending within the export elevator.

This policy option would have many of the same advantages as increased differentials in government policies. But the minimums would be difficult to establish and maintain in today's political environment. The desirable quality characteristics to be incorporated in the loan program could also be those not easily measured in the marketing system. Depending on the minimum quality specifications (physical, sanitary, intrinsic, or variety), farmers could be required to certify the variety planted or to submit samples of the grain being stored for testing as directed by the U.S. Department of Agriculture.

Use of minimum quality specifications could also solve, or contribute to, the resolution of problems elsewhere in the system. Desirable varieties or intrinsic characteristics, if used, would transmit signals to breeders. These would influence their objectives and release criteria. In addition, the role and function of grain standards in the marketing system as they pertain to measuring intrinsic quality could be reduced to some extent.

Grain Standards

The U.S. Grain Standards Act states that it is Congress' intent to promote the marketing of high-quality grain to both domestic and foreign buyers, and that the primary objective for grain standards is to certify grain quality as accurately as practicable.

Mandatory USGSA Inspection

The Federal Grain Inspection Service establishes grain standards, which includes developing technology to measure the factors contained in the standard. The agency also develops and publishes sampling and inspection procedures, evaluates and approves inspection equipment for use during inspection, monitors the inspection accuracy of its employees and licensed inspectors, and periodically tests sampling and inspection equipment for accuracy. Mandatory export inspection is required and a system of delegated and designated agencies, along with FGIS oversight, is in place to perform domestic inspections upon request. **Therefore, a basic structure is in place for approving and overseeing all equipment and procedures used for measuring grain quality characteristics.**

Having mandatory inspection on interstate grain shipments would ensure that the factors covered by the standards are tested using approved equipment and procedures. It would provide consistency in test results in that the identical procedures are used for each inspection in the marketplace and are performed by independent, government-sponsored agencies.

Mandatory inspection would focus the primary responsibility y for grain quality measurement on one government agency. The basic framework is in place through the delegated and designated agencies, which already own approved equipment and have trained employees who use FGIS-published procedures. Even though these agencies are in place, their ability to cover the wide areas required to meet the needs of country elevators receiving trucks is severely limited. This fact, coupled with past problems of regulating truck movement, makes this policy option only applicable to railcar and barge shipments.

Imposing this requirement on the market will increase costs associated with obtaining inspection of grain that would not normally have to be inspected (i.e., grain moving from one facility to another owned by the same company).

Approval of Testing by a Single Agency

The National Institute of Standards and Technology* (NIST), through the National Conference of Weights and Measures, standardizes weights and measures by developing specifications for instrument precision and accuracy along with scale tolerances. Currently, NIST addresses neither grain measures other than weights nor sampling equipment. In some instances, individual States have developed criteria for approving inspection equipment and monitored equipment accuracy. (Moisture meters and mechanical truck probes are prime examples.)

NIST, in consultation with FGIS, could take the lead in developing and maintaining equipment specifications and maintenance tolerances. These actions could be in conjunction with developing new tests that would be included in the standards by FGIS. All equipment used to measure grain quality attributes would then be standardized and traceable to national standards. Variations in testing results introduced by a wide range of equipment accuracies would be minimized. **Only approved equip-**

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

ment could be used to provide testing results, and NIST oversight would ensure accurate testing.

The basic framework is in place for this policy option in that NIST already has established approval procedures, publishes user requirements, and enforces its provisions through State organizations. Having NIST be ultimately responsible for approving grain testing equipment that serves as the basis for the grain standards has the advantage of placing responsibility in an agency that does not have a vested interest in the equipment's use. Yet, NIST does not cover tests that are subjective in nature, such as odor, wheat classing, and the determination of damaged kernels. Nor does the bureau have any experience in basing a national standardization program on reference methods that are defined rather than proven.

Other than equipment approved by FGIS or individual States, no other equipment is approved. Converting to approved equipment would result in increased costs for those having to dispose of unapproved equipment and purchase other equipment. This policy option does not address who will use the equipment and when it will be used.

Mandatory USGSA Inspection in Conjunction With NIST Equipment Approval

A policy that requires mandatory USGSA inspection on grain moving in interstate commerce and a broadening of NIST involvement into grain sampling and testing equipment captures the advantages of both these options while minimizing many of the disadvantages of either.

The advantages of mandatory inspection on railcars and barges moving in interstate commerce ensures that consistent sampling and testing are performed on both subjective as well as objective factors and that one agency is responsible for grain testing as well as standards development. The inability to perform USGSA testing on trucks and at country elevators can be offset to some extent by involving NIST and its related support systems in the grain testing area. Even though USGSA inspection would not be performed, those groups that do perform testing would be required to use approved equipment and to follow user requirements spelled out in the NIST approval. This would be the same equipment and user requirements that USGSA inspectors use.

This policy option would allow country elevators to continue to perform their own testing services on grain received from the farmer, thus reducing the potential increase in costs associated with mandatory **USGSA inspection.** However, it would create more uniform testing since anyone performing grain quality testing will be required to use NIST-approved equipment and to follow published user requirements. Coupled with the NIST State support systems already in place to oversee equipment accuracy and ensure that user requirements are followed, NIST involvement would provide oversight in previously uncovered areas.

Interaction Between Standards, Variety Control, and Market Intervention

The interdependence between variety control, market intervention, and grain standards is complex. The debate over grain quality has focused primarily on grain standards, but physical, sanitary, and intrinsic grain qualities are a function of the variety planted, farmer practices, environment and geographic location, handling practices, end-user preferences, marketing, government policies, and the system's ability to measure these factors accurately. Therefore, policy options have an impact on many areas, not just on grain standards.

Policy alternatives outlined in the variety control section address intrinsic quality characteristics, since physical and sanitary quality cannot be addressed through such programs. Policy choices discussed in the market intervention section can address the easily measurable factors for physical and sanitary quality, and can be expanded to deal with intrinsic quality attributes once technology is developed to measure them in the marketplace.

In both the variety control and market intervention sections, an option for no change in present policies has been provided. Such an approach places the responsibility for physical, sanitary, and intrinsic quality solely on grain standards. For the physical and many sanitary quality concerns, relying on the grain standards is a relatively simple matter that does not involve adoption of new technology. It involves taking existing factors and applying appropriate criteria. Several factors could be combined (as is the case of foreign material and dockage in wheat, as many have suggested, as either grade-determining or non-grade-determining) or factors could be separated (as is the case with broken kernels and foreign material in corn) to describe quality more accurately. In addition to rearranging existing factors into grade-determining, non-grade-determining, or official criteria, fixed percentages could be established for certain factors that transcend all grades (e.g., maximum level of dockage in wheat or maximum moisture levels in corn and soybeans). Limits for current factors (e.g., stones or live insects) could also be tightened.

Making no change to variety control systems or market intervention has a dramatic impact on grain standards, however, in that they must be able to address the buyer's desire for information on important intrinsic characteristics and take the lead in establishing signals regarding quality for the entire system. At the moment, technology to measure intrinsic attributes easily in the marketplace is not available. If standards are to be the vehicle for providing information on intrinsic and many new sanitary quality characteristics (e.g., pesticide residue), resources must be provided to develop the technologies needed to measure them accurately and easily before the market can respond. It will take many years to research and develop new tests that could be put on-line before signals begin to be transmitted back through the system.

In addition to identifying what factors the standards should measure and whether factors are grade-determining, non-grade-determining, or official criteria, the way the standards are implemented can also have a dramatic impact on grain quality. **One of the major problems facing the United States in terms of grain quality—whether physical, sanitary, or intrinsic—is that all grain, no matter the quality, is accepted into the system and marketed.** This places enormous strain on the system's handling and inspection capabilities and is the cause of most of the blending controversies.

Conclusions

The production and marketing of grain in the United States is a highly interdependent system of activities. Any policy designed to enhance grain quality—physical, sanitary, or intrinsic—must address this interdependence. Traditional policy discussions, however, have focused on only one component—grain standards. But a properly functioning market can solve many grain quality problems. Therefore, a fundamental policy alternative would be one that creates an environment that would improve market efficiency. In addition, appropriate quality information must be provided so that relevant incentives and disincentives can be established to improve market efficiency.

Evaluating policy options in terms of their strengths and weaknesses as well as their interdependence is a complex task. One possible policy path that maximizes the strengths of the various options as well as minimizes their weaknesses is to adopt variety identification/categorization, increase the differentials in loan policy and specify minimum quality for farm loans, and introduce mandatory USGSA inspection in conjunction with NIST equipment approval.

Introducing a variety identification scheme would improve information on intrinsic quality characteristics, thus reducing the pressure on grain standards to measure intrinsic performance in the market. For most grains, variety indicates quality better than selected tests do. The increased information resulting from variety identification would raise the efficiency of the market, resulting in incentives/disincentives being transmitted to producers, breeders, handlers, and end users. Variety identification alone, however, does not address physical or sanitary quality concerns, which must be tackled in other areas.

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Removing the distortion created by the current administration of premiums and discounts for loan forfeitures and applying the same rules to country and terminal elevators storing government grain would allow the market—which has already established premiums and discounts—to function properly. Grain of lower value would be forced onto the market as opposed to entering government programs. To the extent that intrinsic quality characteristics are included, variety development would be affected. Signals from government programs would be directly transmitted to farmers that would affect their decisions on varieties planted, thus influencing breeders' objectives and release criteria.

Setting minimum quality specifications for loans places an additional constraint on entry into the loan program. These could easily be applied to physical and sanitary quality characteristics as well as measurable intrinsic characteristics and, along with the variety identification scheme, would reinforce signals being transmitted throughout the system. Farmers would be required to obtain testing of grain that was going into the loan program and being stored on farm, rather that self-certifying quality as is presently the case.

Implementing such policies on government programs and minimum quality specifications could force lower quality grain into the export market. Therefore, minimum quality specifications established for entry into government programs could be applied to grain entering export elevators. This would transmit signals for improved quality throughout the system and would reduce the spread of qualities available for blending at export locations.

The need for accurate measurement of important characteristics—whether physical, sanitary, or intrinsic—is crucial to providing information for the market to function properly. The vehicle by which quality information is transmitted throughout the system is grain standards. Incentives and disincentives cannot be established unless accurate, consistent, and timely information is provided in the market. This can be accomplished by continued efforts to incorporate the four objectives of grain standards, by implementing mandatory inspection, and by increasing NIST involvement in approving grain sampling and testing equipment.

Mandatory inspection of railcars and barges would ensure that consistent sampling and testing were performed. Used in conjunction with minimum quality specifications on grain entering export elevators, this would ensure that one government agency was responsible for testing quality. The increased presence of NIST in approving grain sampling and testing equipment would ensure that all parties testing grain quality used approved equipment and followed basic user requirements.

Grain quality is a function of the variety planted, farmer practices, environment and geographic location, handling practices, end-user preferences, marketing, government policies, and the ability of grain standards to provide information on important quality characteristics. Present policy does not recognize the interrelatedness of these factors. Policy changes, therefore, must create an integrated policy for enhancing grain quality.