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Agricultural Economic Report Number 688

# Costs and Benefits of Cleaning U.S. Corn

## Overview and Implications

William Lin
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Mack Leath

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**Costs and Benefits of Cleaning U.S. Corn: Overview and Implications.** By William Lin, Chin-Zen Lin, and Mack Leath. Commodity Economics Division, Economic Research Service, U.S. Department of Agriculture. Agricultural Economic Report No. 688.

## Abstract

Although foreign buyers show a strong preference for clean corn, cleaning is not the solution to the U.S. corn cleanliness issue. The cost of cleaning corn above and beyond the current level at the least net-cost locations, at both inland subterminals and river elevators, would exceed all benefits by $49 million per year. Costs of additional cleaning would exceed benefits in both domestic and international markets at all points in the production-marketing system. Corn price, not quality, was regarded as the most important criterion in importers' purchase decisions in most importing countries included in this study. The best way to address the corn cleanliness issue is to reduce breakage susceptibility in corn through carefully selecting drying systems and developing genotypes or hybrid varieties that are less prone to breakage.

**Keywords:** Broken corn and foreign material (BCFM), corn, costs, benefits, breakage susceptibility, mechanical cleaning

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# Foreword

In recent years there have been increasing concerns over the quality of grains exported from the United States versus the quality of competitors' grain. Some observers believe that selling grain that contains higher levels of broken kernels, foreign material, and dockage than that of our competitors has reduced U.S. competitiveness in the world grain market. Advocates argue that improving the cleanliness of U.S. grain will increase market share or is necessary to maintain U.S. market share. Critics argue that improving the overall cleanliness of U.S. grain will increase marketing costs, reduce profits, and diminish U.S. competitiveness.

Congress recognized that available information was insufficient to support either claim. Therefore, the Food, Agriculture, Conservation, and Trade Act of 1990 mandated the Federal Grain Inspection Service (FGIS) to determine the costs and benefits associated with cleaning U.S. grain. Title XX of the act, entitled "Grain Quality Incentives Act of 1990," called for a comprehensive commodity-by-commodity study of economic costs and benefits of cleaning grain. In response, FGIS signed a cooperative research agreement with ERS in September 1990 to conduct an economic study of the costs and benefits of cleaning U.S. grains. The agreement specified that the project cover five commodities: wheat, corn, soybeans, sorghum, and barley.

This report presents an overview and implications of the study results for corn. ERS's corn study produced two additional reports. The first, *Economic Implications of Cleaning Corn in the United States*, focuses on the costs and domestic benefits of cleaning corn. The second, *The Role of Quality in Corn Import Decisionmaking*, focuses on importers' preferences with respect to cleanliness and other quality factors, and assesses benefits from cleaning export corn. The first report is based primarily on special studies conducted by contractors representing trade associations and State agricultural experiment stations. Reports for wheat were recently completed, and reports for other commodities (soybeans, sorghum, and barley) are forthcoming.

ERS received valuable input and advice from a steering committee comprised of representatives of many industry associations and commodity organizations. The authors of reports prepared under research agreements with ERS also made important contributions. As with all ERS studies, however, the content of this report is the sole responsibility of ERS.

Kenneth L. Deavers
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# Summary

Although foreign buyers have shown a strong preference for clean corn, there is no economic justification to mandate additional cleaning. Costs of additional cleaning to lower the level of broken corn and foreign material (BCFM) below the current level would exceed benefits by $49 million per year. The best strategy for addressing the corn cleanliness issue is to prevent kernel breakage in the first place.

Concern over the quality of grain exported from the United States versus the quality of competitors' grain has increased in recent years. Advocates believe that selling grain that contains higher levels of foreign material than that of our competitors has reduced U.S. competitiveness in the world grain market. (Foreign material includes dirt, weed seeds, pieces of cob, other grains, leaves, stalks, and finely broken corn.) They argue that improving the cleanliness of U.S. grain will increase or retain market share. Critics argue that improving cleanliness will increase marketing costs, reduce profits, and diminish U.S. competitiveness.

In response to a request from Congress, the Economic Research Service (ERS), in cooperation with researchers at land-grant universities and the U.S. grain industry, conducted a study on the costs and benefits of cleaning U.S. grain. *Costs and Benefits of Cleaning U.S. Corn* presents an overview and summarizes two other ERS reports produced in response to this study. The first, *Economic Implications of Cleaning Corn in the United States*, focuses on the costs and domestic benefits of cleaning corn. The second, *The Role of Quality in Corn Import Decisionmaking*, focuses on importers' preferences with respect to cleanliness and other quality factors, and assesses the benefits of cleaning export corn for international markets.

Selling cleaner corn in the international market could help maintain U.S. market shares, but would not likely result in premiums paid by foreign buyers for clean corn. Nor would it likely expand U.S. corn exports. Most exported corn is used for livestock and poultry feed. Feed manufacturers in those markets, like their counterparts in the United States, are tolerant of broken corn if aflatoxin (mold) and insects are not present. Dry millers in those markets use locally produced corn. Wet millers are more stringent in their cleanliness requirements than feed manufacturers, because they must remove BCFM prior to processing. Some are buying the U.S. No. 2 grade, but their quality preferences are not strong enough to induce them to pay a premium for cleaner U.S. corn, or switch their corn purchases from the current grade to better-grade corn.

Corn price, instead of quality, was the most important factor affecting foreign buyers' purchase decisions. Within the general category of quality factors, most buyers regarded BCFM, moisture, and aflatoxin to be the most important quality characteristics. BCFM was the paramount quality consideration in Japan, Russia, Spain, and South Korea, where food and industrial uses account for a larger proportion of the imported corn.

The corn cleaning issue cannot effectively be addressed apart from other related quality issues, especially moisture and breakage susceptibility. Corn is harvested with a moisture content that is usually too high for safe storage, and thus must be artificially dried. High-temperature drying systems, usually used to lower the moisture content, create stress cracks in the corn kernels. These cracks create the potential for breakage when the corn is handled by farmers and grain marketing firms. Thus, policy options to reduce the level of BCFM must simultaneously address BCFM, moisture, and breakage susceptibility. The best strategy for addressing the corn cleanliness issue is to prevent kernel breakage rather than to remove BCFM through mechanical cleaning after the breakage.

Policy options to address the corn cleanliness issue include (1) changing the U.S. grades and standards for corn, (2) continuing research and development activities to improve technologies for measuring breakage susceptibility, and (3) incorporating breakage susceptibility as a criterion in the development and release of new hybrids.

Technologies to manage breakage and reduce breakage susceptibility, such as low-temperature drying systems, already exist in the marketplace. In addition, producers in the Midwest have begun to adopt the low-temperature drying system under existing market conditions. To induce producers to adopt these technologies more rapidly, so that cleaner corn or corn with low-breakage susceptibility can be delivered to buyers, will require greater economic incentives.

# Costs and Benefits of Cleaning U.S. Corn

## Overview and Implications

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## Introduction

In recent years, there have been concerns over the quality of U.S. grain exports versus the quality of competitors' grain. During debate on the Food Security Act of 1985, the issue of U.S. grain quality was raised. In an effort to gain more information for effective decisionmaking, Congress included a provision in the act directing the Office of Technology Assessment (OTA) to conduct a comprehensive study of the technologies, institutions, and policies that affect U.S. grain quality and to prepare a comparative analysis of the grain systems of major export competitors of the United States.[1]

The OTA study did not end the debate over grain quality, in part because it did not provide information on the costs and benefits of cleaning U.S. grain. Some observers believe that selling grain with higher levels of dockage, broken kernels, and foreign material (FM) than that of our competitors has reduced U.S. competitiveness in the world grain market. Advocates of tighter U.S. grain standards in terms of cleanliness argue that improving grain cleanliness either will increase U.S. share in the world market or is necessary to maintain U.S. market share at current levels. On the other hand, many traders and handlers argue that tighter grain cleanliness standards will increase marketing costs, reduce profits, and diminish U.S. price competitiveness.

### Defining Cleanliness in Corn Quality

For the purposes of this study, corn cleanliness refers to the measured level of broken corn and foreign material (BCFM) present in corn. BCFM is defined as "kernels and pieces of kernels of corn and all matter other than corn which will pass readily through a 12/64-inch sieve, and all matter other than corn which remains in the sieved sample."[2] The matter other than corn that remains in the sieved sample includes pieces of cobs, stalks, and other coarse foreign material.

The amount of BCFM present in U.S. corn is affected by harvesting practices, drying and conditioning methods, and handling methods commonly used in the U.S. grain production-marketing system. The moisture content at harvest is a major determinant of the amount of damage caused by combines. The high-temperature grain dryers used on a majority of U.S. corn farms create stress cracks in the kernels. These factors contribute to an increased level of breakage when corn is subjected to high-speed handling methods commonly used to move corn through the marketing system.[3]

Corn quality, a much broader concept than cleanliness, has three dimensions: (1) physical condition,

[1]The results of this study were published in three reports titled: (1) *Enhancing the Quality of U.S. Grain for International Trade*, OTA-F-399; (2) *Enhancing the Quality of U.S. Grain for International Trade: Summary*, OTA-F-400; and (3) *Grain Quality in International Trade: A Comparison of Major U.S. Competitors*, OTA-F-402 (Washington, DC: U.S. Government Printing Office, February 1989).

[2]An Illinois study of the physical properties of BCFM revealed that it is made up of corn (kernels and pieces of kernels)--87.4 percent; dust and inert matter--0.3 percent; weed seeds--1.7 percent; and corn byproducts--10.5 percent (Hill and others, 1982). Names in parentheses refer to sources listed in the references at the end of this report.

[3]Sound, ear-dried corn will break to some extent when dropped into a storage bin or ship hold against concrete or steel. Over 90 percent of corn grown in the United States are dent hybrids, which are more susceptible to breakage than the harder, flint genotypes grown elsewhere in the world.

The issues being debated that relate to corn cleanliness include:

- Members of Congress, grain handlers, exporters, and producers are concerned that U.S. competitiveness in the world market may be hampered by higher levels of BCFM and other quality differences in U.S. export corn compared with corn exported by major competitors.

- The U.S. grain industry is concerned that any policy changes that require additional cleaning of corn would force producers or elevator operators to incur higher costs. These higher costs might not be recovered in the marketplace, and this could put the U.S. grain industry at a competitive disadvantage.

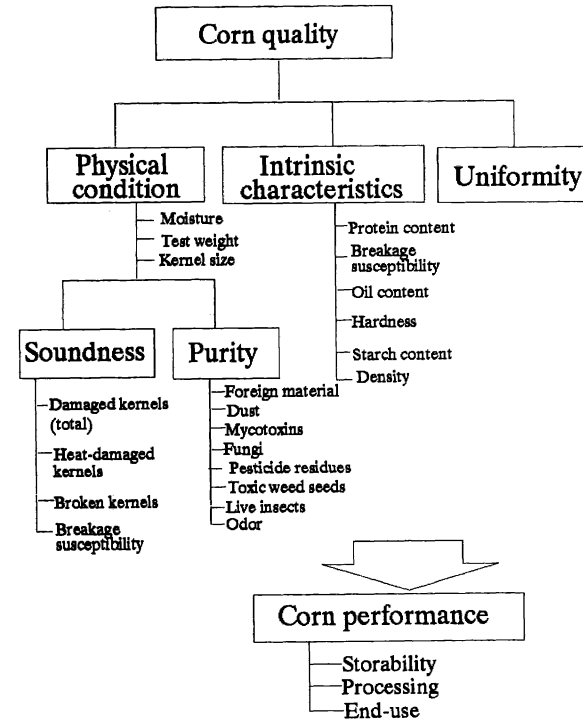
- Would the export of cleaner U.S. corn result in benefits in the form of price premiums (or the switch of purchases to better grade corn) or expand export sales to major importing countries? If yes, are these benefits enough to compensate for the costs of additional cleaning?

- Foreign buyers specifying U.S. No. 3 (the base grade, the grade most commonly traded) have sometimes complained of receiving U.S. corn with BCFM levels that exceed the 4-percent grade limit. Likewise, buyers purchasing U.S. No. 2 corn usually receive corn with BCFM levels above the 3-percent grade limit. Are policy options available that would mitigate or eliminate this problem?

including purity and soundness; (2) intrinsic characteristics; and (3) uniformity (fig. 1). Soundness relates to physical defects or damaged corn kernels, while purity measures the amount of noncorn material present in a corn lot. Other physical characteristics, not included in the soundness and purity subcategory, are moisture, test weight, and kernel size. Intrinsic characteristics are the structural and biological attributes inherent in corn. Uniformity measures the degree of variation in the physical and intrinsic characteristics both within and among shipments. The soundness, purity, and intrinsic characteristics of corn all affect its performance in terms of storability, processing, and end-use properties.

U.S. grades and standards for corn address cleanliness through the inclusion of BCFM as a grade-determining factor. The maximum limit for BCFM in grade

Figure 1
**Corn quality dimensions that affect end-use performance**



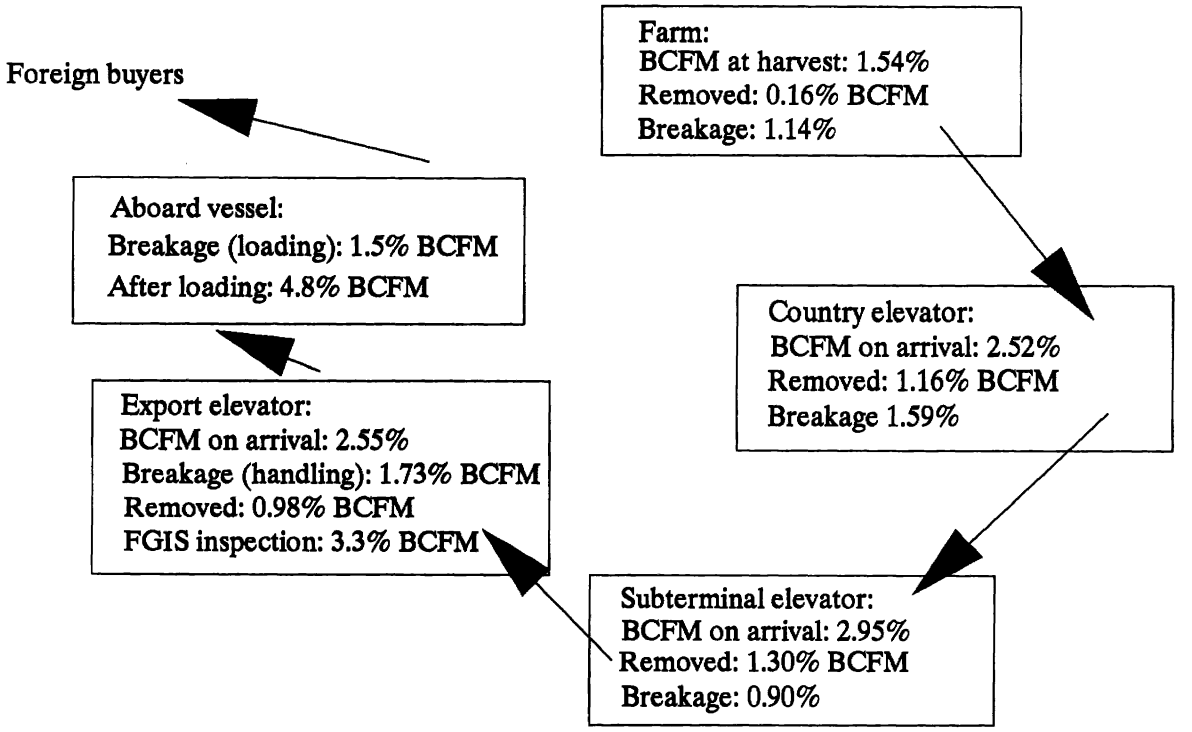

Source: Adapted from the ERS domestic wheat cleaning study.

U.S. No. 2 (the base grade traded in domestic markets) is 3 percent. The predominant export grade is U.S. No. 3 and its maximum limit for BCFM is 4 percent. U.S. No. 3 corn is normally priced lower than U.S. No. 2 to reflect the lower value associated with higher limits for heat-damaged kernels, total damaged kernels, and BCFM allowed in the standards.

## Corn Cleanliness in the United States

The BCFM level in U.S. corn increases as corn moves from the field to domestic processors and export elevators. Corn kernels are damaged during harvesting, drying, and handling. The level of BCFM at harvest averages 1.54 percent, well within the 3-percent limit for the base grade of domestic sales, U.S. No. 2. Although cleaning occurs at each stage of the marketing system, typically, the BCFM level in corn delivered to country elevators averages 2.5 percent, 3.0 percent upon arrival at subterminal elevators, and 2.6 percent by the time it arrives at export elevators (fig. 2). During 1989-91, the BCFM level of U.S. corn exports averaged 3.3 percent, as reported on U.S. inspection certificates at loading. This BCFM level would decline to 1.8 percent if additional cleaning to remove 1.5 percentage points of BCFM occurred at

Figure 2
**BCFM: At arrival, removed, and breakage**




subterminal elevators--the least net-cost location (Lin and Lin).

Breakage of kernels during handling generally exceeds the amount of BCFM removed at each market point. For example, while about 1.2 percentage points of screenings are usually removed at country elevators, an additional 1.6 percentage points of breakage will occur there. Most subterminal and port terminal elevators clean corn to keep the BCFM level below the U.S. No. 2 grade limit at time of shipment. A survey of interior elevators revealed that 64 percent have a cleaner installed and 79 percent of those with cleaners used them in 1988 or 1989 (Hill, Bender, and Beachy, p. 6).

Breakage also exceeds the amount of BCFM removed through cleaning at export elevators. At this point, while 1 percentage point of BCFM is removed, additional breakage of 1.7 percentage points occurs during handling, and an estimated 1.5 percentage points of additional BCFM will be generated during loading aboard vessels following official inspection. The level of BCFM in U.S. export corn is even higher by the time it reaches foreign users because of the additional breakage caused by unloading and handling at foreign ports.

U.S. corn is very susceptible to breakage when it is handled with the high-speed, efficient equipment commonly used to move corn from U.S. farms to foreign markets. This situation will not improve much until the breakage susceptibility of U.S. corn is reduced.

## Costs of Cleaning U.S. Corn

This study measures the costs and benefits of cleaning U.S. corn to lower the BCFM content of export grain by 1.5 percentage points. Five scenarios that would allow the attainment of this objective were evaluated: (1) clean all corn marketed by producers on the farm, (2) clean all corn received at country elevators, (3) clean a quantity equivalent to total exports at country elevators, (4) clean all corn received at both inland subterminals and river elevators, and (5) clean all ex-

port corn at export elevators. Scenario 1 assumes that additional corn cleaning applies to all corn marketed by producers because they cannot differentiate between corn destined for domestic sales and corn destined for export markets. Scenarios 2 and 3 are presented to illustrate the range of economic outcomes that are associated with cleaning options ranging from cleaning only export corn to cleaning all corn handled by country elevators. Scenario 2, the most realistic option, reflects the fact that most country elevators do not have perfect knowledge about the destination of their corn shipments. Thus, additional cleaning of all export corn may require additional cleaning of the total volume handled by country elevators. In contrast, scenario 3, an optimal situation that is less likely to occur, assumes that country elevators have perfect knowledge about the destination of their corn shipments so that additional cleaning can be applied only to outbound corn shipments for export, not to the entire volume handled. Scenarios 4 and 5 represent options for cleaning corn during the final stages of the production-marketing system.

Estimated total costs of additional cleaning of U.S. corn to reduce the BCFM content by 1.5 percentage points totaled $116 million on a yearly basis at the farm, $245 million at country elevators if cleaning applies to all corn received, $77 million combined at both inland subterminals and river elevators, and $90 million at export elevators (table 1). These estimates assume that the targeted BCFM content after additional cleaning was 2.5 percent (1.5 percentage points below the current U.S. No. 3 limit) for export elevators and 1.5 percent (one-half of the current U.S. No. 2 grade limit) for farms, country elevators, and subterminal elevators. The 2.5-percent BCFM content at export inspection is a cleanliness level commonly tolerated by cleanliness-conscious foreign buyers (after allowing for additional 1.5-percentage-point breakage during loading at export elevators), and it is comparable with that of the "clean" corn exported by competitors. Weight loss (the loss of revenues resulting from the removal of BCFM and small whole-kernels of corn during the cleaning process, which can only be sold as screenings) was the largest

**Table 1--Costs and domestic benefits of additional cleaning to remove 1.5 percentage points of BCFM, 1991**

| Point of cleaning | Volume cleaned | Costs | Benefits | Net costs |
|---|---|---|---|---|
| | *Million bushels* | *-----Aggregate (million dollars)-----* | | |
| Farms[1] | 4,645 | 116.4 | 42.0 | 74.4 |
| Country elevators: | | | | |
| Volume handled[2] | 4,645 | 245.2 | 149.2 | 96.0 |
| Volume exported[3] | 1,591 | 83.8 | 27.6 | 56.2 |
| Inland subterminals | 608.5 | 31.6 | 9.2 | 22.4 |
| River elevators | 868.6 | 44.9 | 18.3 | 26.6 |
| Export elevators | 1,591 | 90.3 | 26.9 | 63.4 |
| | | *-----Cents per bushel-----* | | |
| Farms | | 2.5 | 0.9 | 1.6 |
| Country elevators: | | | | |
| Volume handled[2] | | 5.3 | 3.2 | 2.1 |
| Volume exported[3] | | 5.3 | 1.7 | 3.6 |
| Inland subterminals | | 5.2 | 1.5 | 3.7 |
| River elevators | | 5.2 | 2.1 | 3.1 |
| Export elevators | | 5.6 | 1.7 | 3.9 |

[1]Additional corn cleaning applies to all corn marketed by producers because they cannot differentiate corn sold for domestic markets from that destined for export markets. [2]This is the worst possible scenario wherein additional cleaning applies to the total volume sold by producers. Farm sales to subterminals are included because some subterminal elevators classified themselves as country elevators. This scenario reflects the fact that most country elevators do not have perfect knowledge about the destination of corn shipments from this market point. Thus, additional cleaning of all export corn may require additional cleaning of the total volume handled by country elevators. [3]This is an optimal scenario where additional cleaning applies only to the volume of corn received by export elevators (1,591 million bushels in 1991). This scenario is not likely to occur. It assumes that country elevators have perfect knowledge about the destination of corn shipments from this market point so that additional cleaning can apply only to outbound corn shipments for export, not the entire volume handled.
Source: Hill, Bender, and Beachy.

cost component of cleaning corn at elevators, accounting for 55-70 percent of the total costs of cleaning.[4]

Corn cleaning costs, as addressed in this section, were easier to identify and estimate than the potential premium and trade benefits reported in the next section. The cost estimates were based on the economic-engineering studies--an approach that assesses the cost-output relationship for a production process by separating the production activities into stages and then estimating the input-output relationships at each stage of the production operation.[5] Marginal cleaning costs could potentially decline over time as cleaning technologies become more efficient. In contrast, the estimates of benefits from premiums for cleaner corn and increased trade volumes were largely derived from interviews with foreign buyers. The estimates reflect how they think they would react if the United States exported cleaner corn.

### Producer Practices

About 80 percent of corn producers responding to an on-farm survey indicated they could not deliver cleaner corn by changing production, harvesting, or conditioning practices without incurring additional costs (Hill, Bender, and Beachy).[6] The additional costs incurred by changing these practices would likely exceed economic benefits from delivering corn with a lower BCFM content.

The survey of farmers revealed that cleaners are more prevalent on farms growing primarily corn than on farms growing wheat and other grains--46 percent of corn producers owned grain cleaners, compared with 24 percent of wheat producers. Most corn producers clean corn primarily for long-term storage, such as corn under the farmer-owned reserve (FOR). Even though cleaner ownership is quite common for corn producers, lowering the BCFM level through additional cleaning is somewhat limited. The net costs of additional on-farm cleaning were estimated to total $74 million for cleaning all corn marketed by producers in 1991 (table 1).

In addition to mechanical cleaning, producers could deliver cleaner corn by altering their production, harvesting, and drying practices. Breakage can be managed by selecting hybrid genotypes with low breakage susceptibility, harvesting at ideal moisture levels to reduce combine damage, carefully adjusting combine settings, and adopting low-temperature drying systems. However, each one of these activities has an associated cost.

Corn hybrids differ in their hardness, kernel density, length to maturity, yield, and other agronomic characteristics. Farmers select hybrids that will perform best in their particular growing conditions. While an early-maturing hybrid may reduce the need for drying and lead to a less breakable corn, there may be tradeoffs in potential yield. Fast-drying corn, for example, is more susceptible to damage from rain before harvest because the ear ends are exposed to the elements.

Crop rotations, such as a corn-soybean rotation, can break the life cycle of some pests, aid in the control of weeds and certain insects, and reduce disease problems. Increased application of herbicides to control weeds offers little potential to reduce the level of BCFM at harvest. Weed seeds are a very small component of BCFM typically found in the marketplace, and improving corn cleanliness by reducing the amount of weed seeds from such small levels would be costly and impractical (see footnote 2). Some farmers are substituting cultivation for chemicals as a means of controlling weeds. This practice has some appeal from an environmental perspective but increases energy use.

Farmers can alter harvesting practices and drying methods to eliminate stress cracks and reduce breakage susceptibility. Adjusting combines is the most common method of altering harvesting practices to lower the BCFM level. The cylinder speed must be adjusted to the moisture content of the corn. In general, threshing speed should be decreased as moisture content decreases in order to minimize breakage and pericarp damage. The ideal moisture content for combine harvesting is 23-24 percent at harvest. Kernel damage increases significantly when moisture content exceeds that range. Most farmers begin harvesting when the moisture content in the field drops below 30 percent. The moisture content usually declines to

[4]In comparison, the value of weight loss in cleaning wheat was 80-85 percent of the total costs of cleaning. The higher value of weight loss in wheat cleaning reflects higher market prices for wheat.

[5]These studies were conducted by a group of agricultural engineers and agricultural economists at the University of Illinois and Iowa State University.

[6]This survey of producers was conducted by the National Corn Growers Association through a postcard insert in the newsletter to all members of the association. Although the response rate was only 1 percent, this response rate is not unusually low for this kind of survey.

around 18 percent by the time harvest is completed. Consequently, most corn must be dried to reduce the moisture to a level that is considered safe for storage--about 14-15 percent. Greater use of low-temperature drying systems or adoption of combination drying systems could reduce stress cracks and lower breakage susceptibility of U.S. corn.[7]

Producers have begun to adopt low-temperature dryers under the existing market incentives. In 1986, over 15 percent of dryers in the Midwest were low-temperature systems (including solar dryers)--18.1 percent in Indiana, 22.2 percent in Iowa, and 25.4 percent in Illinois (Hill, Brophy, Zhang, and Florkowski). Low-temperature drying systems require more time as well as better storage management practices. For more widespread and faster adoption of low-temperature dryers, the marketplace must offer more incentives for cleaner corn or reduce farm drying costs.

The combination drying system is another alternative to the popular high-temperature drying system. Combination drying, mainly used for on-farm drying, is a system which uses high-temperature/high-speed drying followed by low-temperature, slower in-bin drying and cooling (U.S. Congress, 1989a). The combination drying system captures the advantages of the higher drying capacity of the high-temperature drying system and lower breakage susceptibility of the low-temperature system.

## Country and Subterminal Elevators

The costs of additional corn cleaning at country elevators to achieve a reduction in the BCFM level from the current 3-percent limit to the 1.5-percent targeted BCFM limit are estimated to average 5.3 cents per bushel. Weight loss is the highest cost component of additional cleaning, accounting for about 70 percent of total cleaning costs. The estimated total cost of cleaning all corn received at this location is $245 million per year; however, the cost would be lower if country elevators had some knowledge of the destination of corn shipments. The cost of cleaning a volume equivalent to annual exports is estimated to be $84 million if country elevators had perfect knowledge of the destination of their corn shipments so that additional cleaning could apply only to corn shipments for export, not to the entire volume handled.

Country elevators purchase most of the corn they handle from producers and sell to subterminal elevators, domestic processors (feed manufacturers, dry millers, and wet millers), and export elevators. They generally do not offer premiums for clean corn; however, price discounts are often used to discourage the delivery of corn with a BCFM content higher than the 3-percent limit for U.S. No. 2. Country elevators avoid discounts for BCFM on their sales by mechanically cleaning or blending lots with different BCFM contents. The choice depends on market incentives, costs of cleaning, market prices for screenings, and transportation costs.

Country elevators' cleaning decisions are affected by market mechanisms used by buyers or end-users to communicate demands for cleaner corn. Dry millers and wet millers tend to demand higher cleanliness standards than feed manufacturers. These requirements are often satisfied by entering purchase contracts with producers and/or elevators. Dry millers require stringent quality specifications because sound, clean kernels are necessary to attain high yields of primary products. While cleanliness levels for corn demanded by feed manufacturers tend to be less stringent, low-BCFM corn is preferred. Although exporters ship mostly U.S. No. 3 corn, they generally purchase U.S. No. 2 and apply market-determined discounts if BCFM exceeds the 3-percent limit. Exporters perform additional cleaning as needed to ensure that export corn is in compliance with contract specifications when it is inspected prior to loading.

Corn cleaning is more common than wheat cleaning in country elevators. According to a 1991 survey of elevators conducted by the National Grain and Feed Association (NGFA), 64.2 percent of the country elevators handling corn owned cleaners, and 50.4 percent of them cleaned corn as part of normal operations. Overall, country elevators that owned cleaners reported removing, on average, 2.2 percentage points of BCFM during cleaning.

Inland subterminals and river elevators are the least net-cost point of cleaning U.S. export corn beyond the current level because they have a smaller cleaning volume than farms or country elevators, and their value of weight loss is less than export elevators. The net cost of cleaning averages 3.4 cents per bushel of corn cleaned at both of these subterminals. In contrast, per-bushel net cost would be as high as 3.9 cents if cleaning occurred at export elevators. The total net cost of cleaning export corn at both inland subtermi-

[7]A combination drying system typically utilizes high-temperature air to bring the moisture down to about 20-22 percent and then low-temperature air to complete drying.

nals and river elevators is $49 million per year. This estimate assumes that the volume of corn received at the subterminals would later be destined for export markets. To the extent that a small proportion of the volume received at these market points is sold to domestic markets, additional cleaning of some export corn might have to occur at the second lowest net-cost point of cleaning, such as export elevators.

The segregation of cleaned corn at country and subterminal elevators for shipment to export elevators would reduce operating efficiency to some extent. Segregating clean corn may not be practical for elevators that have limited storage space for two reasons: (1) quick assembly of corn from producers is required at harvesttime, and (2) segregation based on other quality factors (such as moisture) could offer greater profit potential in blending operations. In addition, cleaning during loading, which is more common at terminal elevators, would require more cleaning capacity. Cleaning during unloading, which is more common at country elevators, is more practical after the harvesttime pressure has passed.

### Export Elevators

The cost of cleaning at export elevators to remove an additional 1.5 percentage points of BCFM is estimated to average 5.6 cents per bushel, higher than that at country and subterminal elevators. Per-bushel costs of cleaning at this point are the highest because of greater value of weight loss and higher costs of transporting screenings back to feeders and livestock feeding areas. In addition, the increased cleaning capacity required would result in a 50-percent increase in the cost of operating the cleaner. The aggregate cost of additional cleaning for all export corn at export elevators is estimated to be $90 million, $66 million of which is in weight loss. Higher corn price at port terminals is the primary reason for the greater value of weight loss.

Export elevators clean corn during loadout operations to meet contract specifications, not to avoid discounts. Discounts are primarily applied to nongrade-determining factors, such as moisture content. An average of 1 percentage point of BCFM was removed to meet the BCFM limit for the U.S. grade specified in the export contract.

## Benefits of Cleaning Corn

Cleaning corn has potential benefits in both domestic and international markets. Domestic benefits occur in the form of improved storability. In addition, revenues generated from sales of screenings offset a proportion of the weight loss. International benefits, either in terms of premiums that foreign buyers would be willing to pay for cleaner corn or potential increases in the volume of U.S. corn exports, appear to be negligible based on information obtained from interviews with buyers in the eight importing countries selected for case studies. Egypt, Japan, Mexico, Russia, South Korea, Spain, Taiwan, and Venezuela were selected because they represent a cross-section of major importers of corn in terms of income levels and corn end-uses. A series of interviews conducted in-country by a team of Economic Research Service analysts in 1992 formed the basis for each country study.

### Domestic Benefits

Improved storability is an important reason for corn cleaning at farms and country elevators. As a result of cleaning, revenues generated from sales of screenings, while not the main reason for cleaning, would offset a proportion of the weight loss. In addition, corn cleaning would reduce price discounts for high levels of BCFM and, in some rare cases, would result in premiums from buyers demanding cleaner corn.

Cleaning could improve storability and reduce the loss of dry matter (shrink) during storage. The removal of foreign material and fines extends the safe storage time of corn by improving airflow during aeration, which, in turn, can reduce mold growth and lessen insect damage.[8] Enhanced storability was cited by producers as the most important reason for cleaning corn. It also was an important benefit associated with corn cleaning at country elevators. Benefits from improved storability as a result of reducing the level of BCFM from 3.0 to 1.5 percent at country elevators are estimated to be 4.3 cents per bushel (Hurburgh and Meinders). Country elevators realize greater benefits from improved storability because they assemble a large volume of corn from producers, approximately 85 percent of sales by producers. Export elevators and processors generally do not benefit from enhanced storability because corn is only temporarily stored at these facilities.

[8]Cleaner corn reduces the power requirement by reducing the resistance to air flowing through the grain mass.

Revenues from screening sales to feeders and feed manufacturers would offset some of the value of weight loss that occurs during the cleaning process.[9] However, screenings are priced lower than corn. In 1990/91, screenings averaged nearly 80 percent of the national average farm price of corn. This was not atypical compared with other years. Additional cleaning would lower the relative market price of screenings because of the increase in the supply of screenings. However, the price of screenings depends on the price of corn and its feeding value compared with that of corn.

Avoiding discounts was cited by producers as the second most important reason for cleaning corn. Discounts for corn containing 3.0-4.0 percent BCFM average 1.3 cents per bushel for producers and 1.9 cents per bushel for commercial elevators. Discounts received by commercial elevators are higher than those for producers because of the competitive market structure at the country elevator level. In the interest of generating customer loyalty, local elevators sometimes reduce or forgive price discounts to producers. Benefits from cleaning are estimated to be nearly 1 cent per bushel at the farm, which is not enough to compensate for the costs of additional cleaning.

Gross benefits from additional cleaning of export corn are the highest at country elevators. These benefits include: the greatest potential for savings from reduced transportation costs, improved storability, and a higher value of screening sales. Per-bushel domestic benefits from cleaning all corn received at country elevators are estimated to be 3.2 cents. Gross domestic benefits from cleaning all corn received at country elevators total $149 million on a yearly basis. Benefits from additional cleaning at both inland subterminals and river elevators are estimated to be $27.5 million, which is less than that at country elevators, because of smaller volume handled and minimal benefits from improved storability.

Cleaning corn at export elevators would result in less benefits than at country elevators because benefits from improved storability would not be realized. Per-bushel benefits of cleaning at export elevators are estimated to average 1.7 cents, and aggregate benefits of cleaning all export corn at this market point are estimated to total $26.9 million per year, which is primarily derived from revenues of screening sales.

## International Benefits

The international component of this study examines the role of quality in corn importers' decisionmaking and assesses the potential economic benefits of selling cleaner U.S. corn in the world market. Millers, feed processors, traders, trade associations, livestock cooperatives, and government officials in eight key corn importing countries (Egypt, Japan, Mexico, Russia, South Korea, Spain, Taiwan, and Venezuela) were interviewed in 1992. These eight countries typically account for over 80 percent of all U.S. corn exports and about 60 percent of global corn imports.

The interviews revealed that selling cleaner U.S. corn in the international market would not result in any significant additional benefits. Thus, cleaning U.S. corn could only help to maintain U.S. market shares. Seventy percent of U.S. corn exports to the countries included in the study were used for livestock and poultry feed. These feed compounders were not overly concerned about existing BCFM levels.

### *U.S. Corn Prices*

None of the buyers interviewed indicated a willingness to pay premiums for U.S. corn with reduced levels of BCFM under the current market structure (Mercier). To many of them, the price difference between U.S. No. 2 and U.S. No. 3 exceeds the value of a 1-percentage-point decrease in BCFM and the lower level of damaged kernels associated with U.S. No. 2 corn. Despite foreign buyers' preference for clean corn, especially food and industrial users, these buyers are unwilling to pay a premium for cleaner U.S. corn above current prices or upgrade corn purchases, regardless of the end-use.

Although the BCFM level of U.S. corn unloaded at foreign ports generally exceeded the limits for the grade shown on the inspection certificates, feed manufacturers were generally tolerant of the level of BCFM received. The presence of broken corn does not have a great effect on the quality of feed products, but corn is usually screened to remove certain types of foreign material that can be damaging to milling equipment. Feed manufacturers were more concerned with moisture and aflatoxin than with BCFM.

[9]The survey of commercial elevators conducted by NGFA indicated that elevators sell nearly 95 percent of their screenings directly to livestock feeders (Ash and others).

In contrast, wet millers and dry millers in the case study countries were more stringent in their cleanliness requirements than feed manufacturers. Because many of them already purchase U.S. No. 2, they are less inclined to pay premiums for clean corn. Dry millers mainly use locally produced corn and are thus less likely to pay a premium for cleaner imported corn. Japanese starch millers prefer to purchase U.S. corn shipped from Pacific Northwest (PNW) ports rather than Gulf ports because PNW shipments are perceived to arrive with less BCFM. Even at higher costs, Mexican wet millers preferred rail shipments from the Midwest to shipments by vessel from the Gulf ports because of lower corn breakage (Mercier). None of the respondents indicated any potential gains from contracting for a better grade U.S. corn with a correspondingly lower BCFM level.

### *U.S. Exports*

None of the buyers in the countries visited indicated a willingness to purchase additional U.S. corn even if cleaner corn could be delivered at the same price. The lack of interest is due to four main reasons: (1) the United States already dominates the world coarse grain market; (2) relative prices are much more important than quality and cleanliness in the corn feed submarket, which accounts for at least 70 percent of all corn imports; (3) many foreign buyers who are concerned about BCFM levels already purchase U.S. No. 2 corn rather than U.S. No. 3; and (4) many of those same importers typically find greater additional breakage occurring in U.S. corn than in corn from other origins between loading at export ports and unloading at destinations.

Prospects for growth in the export demand for U.S. corn for use in manufacturing food and industrial products, the more quality-conscious market segments, are not encouraging. The main reasons are: (1) as a food staple, corn is being displaced by wheat products as income grows in many importing countries, and (2) imports of corn for food and industrial uses are often restricted to protect domestically produced corn (Mercier). These factors limit prospects of expanding U.S. corn exports in the dry milling and wet milling submarkets even if the United States offers to deliver cleaner corn. The Uruguay Round agreement under the auspices of the General Agreement on Tariffs and Trade (GATT) is expected to lessen restrictions imposed on commodity imports, which could boost the growth prospect of U.S. corn exports.

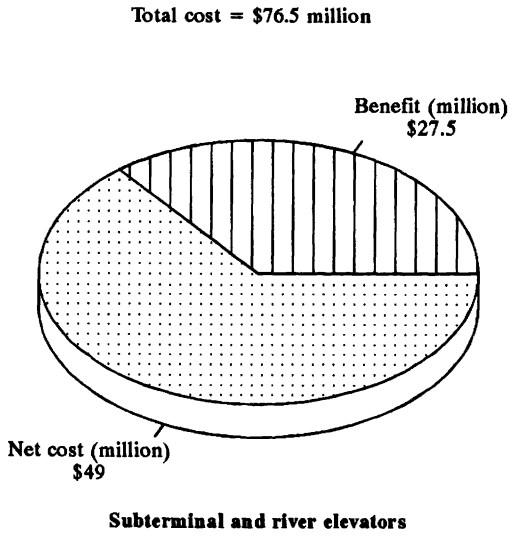
## Net Costs of Cleaning Corn

Would international benefits (combined premium benefits and trade effects) from selling cleaner corn be sufficient to compensate for the $49 million domestic net cost for additional cleaning of U.S. exported corn at both inland subterminals and river elevators--the lowest net-cost locations?

The international benefits from cleaning are negligible. The potential sources of benefits that were evaluated in this study are: (1) premiums that foreign buyers would be willing to pay for a lower BCFM level, and (2) potential increases in the volume of U.S. corn exports. The $27.5 million in annual domestic benefits that would result from additional cleaning of export corn at both inland subterminals and river elevators is not enough to compensate for the $76.5 million it would cost to perform additional cleaning of export corn at these locations annually. The benefits and net costs of cleaning at both inland subterminals and river elevators are illustrated in fig. 3. The data clearly indicate that cleaning all U.S. export corn beyond the current level is not economically feasible, even if the additional cleaning is performed at the least net-cost locations.

Figure 3

**Aggregate cost, benefit, and net cost of cleaning U.S. export corn at least-cost location, 1991/92**



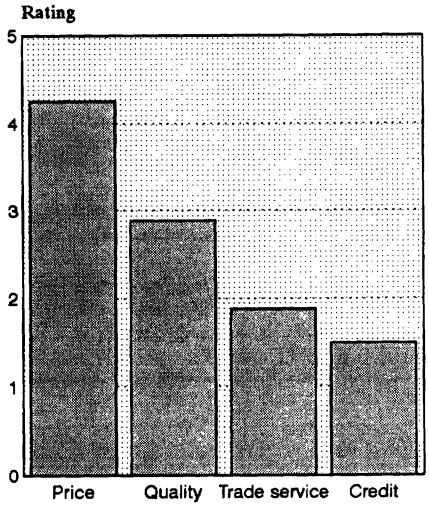
## Importers' Purchase Decisions

Buyers' decisions in choosing corn suppliers are influenced by price considerations, quality (including cleanliness) considerations, and other competitive factors. Interviews with foreign buyers revealed that quality is not the most important criterion; it is generally second to price (Mercier). However, the importance of quality differs between feed manufacturers and food and industrial product processors. Overall, quality concerns were directly related to how imported corn is used. Feed manufacturers emphasized the importance of reliable and year-round supply, which is especially important in countries where storage capacity is limited.

### Price Versus Quality Considerations

Prices and the perceived quality of corn imported, although separate factors in the importer's decision criteria, are often strongly related and treated as tradeoffs by many buyers. Price was regarded as the most important sourcing factor affecting importers' purchase decision in most importing countries studied (table 2).[10] The relative importance of factors influencing importers in selecting suppliers of corn is illustrated in figure 4 where a ranking value of 5 is given to the No. 1 sourcing factor, a ranking value of 4 is given to the No. 2 sourcing factor, and so forth. The average ranking of each sourcing factor is computed by dividing the sum of ranking values for that sourcing factor by the number eight (the number of countries interviewed). Buyers purchasing corn primarily for manufacturing livestock feed were less concerned about quality, and therefore less inclined to pay higher prices for better quality corn. In contrast, the importance of quality to wet millers prompts many to pay higher prices for better grades of corn than that used by feed manufacturers in the same country.

Figure 4
**Average rating of most important sourcing factors identified by corn importers as influencing purchase decisions, 1991**




Rating values assigned: 5 = most important; 1 = least important.

Preferential trade agreements affect importers' choices of suppliers and influence the price paid for imported corn. The Enlargement Agreement between the European Community (EC) and the United States is the prime determinant in Spanish wet millers' choice of the United States as a supply source. The terms of this Agreement and how the EU implements it delay the majority of Spanish imports of reduced-levy corn until January through April, a period when Argentina is not an active exporter because its corn is not harvested until mid-March. In contrast, U.S. corn can be reliably supplied year round.

The cost of transportation also influences the price of imported corn. Because U.S. Gulf ports are proximate to Mexico and Venezuela, the United States has a cost advantage over all competitors in these two markets. Freight rates from the U.S. origins to Mexico are $15 to $20 per ton lower than other exporting countries (Mercier). The freight advantage of U.S. shipments to Venezuela is not as large.

Credit was very important for some buyers, especially in Russia. Credit was also identified by buyers in Mexico and South Korea as an important consideration when selecting a supply source. The availability of credit through Export Credit Guarantee Programs (GSM) is the primary reason importers in South Korea are willing to pay higher prices for U.S. corn rather than the lower priced corn offered by other exporters, such as China.

Foreign buyers expressed their quality preferences by paying premiums for corn exported by certain suppliers. South African corn was preferred to U.S. corn for its intrinsic quality characteristics (hardness and higher starch content) and lower BCFM levels. Japanese starch processors were willing to pay higher prices for South African corn, if available, than corn from the United States. In addition, Taiwanese import-

[10]Statistics on market share and imported volume are mostly for 1991.

**Table 2--Importers' ranking of corn sourcing factors by country**

| Importing country | Market share | Imported volume | Ranking of sourcing factors #1 | #2 | #3 | #4 |
|---|---|---|---|---|---|---|
| | | *Million tons* | | | | |
| Egypt | U.S. 73%<br>Argentina 12%<br>EC 4%<br>Other 11%<br>(1991-92 average) | 1.5 | Price | Quality | Source diversification | |
| Japan | U.S. 86%<br>China 9%<br>South Africa 5% | 16.6 | Price | Quality | Trade servicing | End-user needs/ Safety[1] |
| Mexico | U.S. 90%<br>Argentina 5%<br>South Africa 5% | 1.8 | Price | Credit | Trade servicing | Quality |
| Russia | U.S. > 90% | 5.5<br>(1991) | Credit availability | Price | | |
| Spain | U.S. > 90% | 1.7<br>(1990-91 ave.) | Enlargement Agreement | Trade servicing | Quality | |
| South Korea | U.S. 53%<br>China 47%<br>(1991) | 6.7 | Price | Quality | Credit | Service reliability |
| Taiwan | U.S. 95%<br>South Africa 3%<br>Argentina 1% | 5.5 | Price | Quality | Reliability of supply | |
| Venezuela | U.S. > 90%<br>Argentina < 10% | 0.5 | Price | Timely, reliable supply | Trade servicing | Quality |

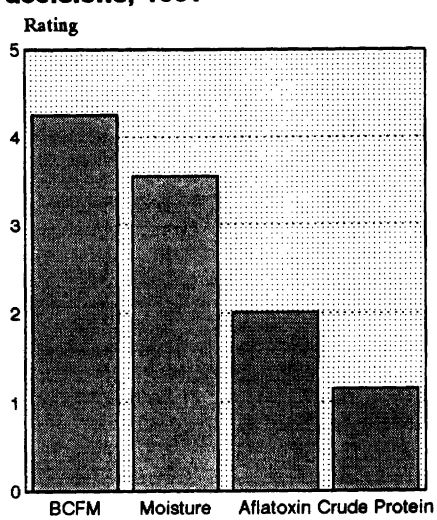
[1]Buyers in the respective country ranked the two factors shown as being equally important in influencing purchasing decisions.

ers were willing to pay a quality premium of $1-$3 per metric ton for South African corn, if available, because of its superior quality. For certain end-uses, buyers in South Korea paid a higher price ($3-$7 per metric ton) for U.S. corn than for corn from China due to the lower test weight of Chinese corn and perhaps the lower price marketing strategy of the China National Cereal, Oils, and Foodstuffs Import/Export Corporation (CEROILS).[11] Selling cleaner corn may help maintain the U.S. competitive position, but a lower BCFM content alone will not induce foreign buyers to pay a quality premium.

Within the general category of quality factors, most countries regard BCFM, moisture, and aflatoxin to be the most important quality characteristics (table 3).[12] The relative importance of various quality factors is illustrated in figure 5. BCFM is the most important quality factor to four out of the eight case-study countries. Foreign feed manufacturers identified BCFM, moisture, aflatoxin, crude protein, kernel hardness, and breakage susceptibility as the major quality factors. They were concerned with these quality characteristics because of their effects on storability and product quality. Characteristics that affect storability are especially important to buyers in humid climates. Wet millers identified BCFM as their prime concern, and starch content, crude protein content, hardness, total damaged kernels, and moisture as additional factors affecting purchase decisions. Although Egyptian dry millers rely mainly on domestic sources, they were often concerned with kernel size and uniformity in imported corn, as well as these other factors. Small kernels are more difficult to degerm than large kernels in the dry milling process.

Figure 5

**Average rating of most important quality factors identified by corn importers as influencing purchase decisions, 1991**




Rating values assigned: 5 = most important; 1 = least important.

## Importance of Broken Corn and Foreign Material

BCFM and moisture were the most important quality characteristics influencing importers' buying decisions. BCFM was rated the most important by feed processors, especially when the dust component of BCFM is high. Dust is discouraged because of the respiratory risks to workers and the greater risks of dust explosions. High levels of dust also slow down feed milling operations. Broken kernels do not steep properly in the wet milling process and must be removed prior to milling.

U.S. No. 3 corn dominates the U.S. export market in terms of volume; however, many smaller importers purchase U.S. No. 2 (fig. 6). Buyers in Egypt, Mexico, Spain, and Taiwan purchased mostly U.S. No. 2 in recent years. Buyers in Japan, Russia, South Korea, and Venezuela import primarily U.S. No. 3. Most countries receive U.S. corn with a BCFM level (including breakage that occurs during loading and unloading) that is higher than the grade limit. Loadout operations at U.S. ports can create up to 1.5 percentage points of BCFM, and unloading and handling operations at foreign ports create additional breakage. Consequently, the level of BCFM in U.S. corn when it arrives at a foreign processor may be more than twice the level indicated on the U.S. inspection certificates.[13] Although corn exported by competitors also experiences breakage during loading, unloading, and handling at foreign ports, the breakage is not as severe as that in U.S. corn.

The BCFM level in U.S. corn in many export markets has gradually improved in recent years. For example, the BCFM level in U.S. corn exported to Japan at loading averaged 3.31 percent in 1991, down from

[11]CEROILS is the sole state trading agency that purchases all of China's corn, other grains, and oilseed imports.

[12]Statistics on use breakdown are mostly for 1991.

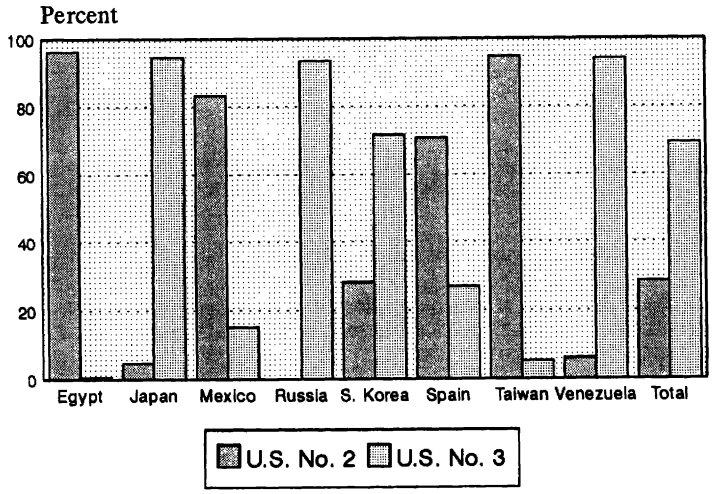
[13]An independent study by Hill and others (1990) verified this conclusion. This study found BCFM in U.S. No. 3 corn shipments to Japan in 1985 reached 7.68 percent at final destination, compared with 3.45 percent BCFM at loading. Similarly, in 1986, U.S. No. 3 corn shipments averaged 9.28 percent BCFM by the time the corn arrived in Japan, compared with 3.86 percent at loading. Similar patterns in BCFM changes for U.S. corn shipments to Rotterdam, Mexico, and England have been reported.

**Table 3--Importers' ranking of corn quality factors by country**

| Country | Use breakdown | Ranking of quality factors | | | | |
|---|---|---|---|---|---|---|
| | | #1 | #2 | #3 | #4 | #5 |
| Egypt | Feed 82%<br>Food 12%<br>Industrial 4%<br>Seed 1% | Kernel size/ Uniformity[1] | Broken corn | Insect damages | Foreign material | Aflatoxin/ Weed seed[1] |
| Japan | Feed 72%<br>Industrial 28% | BCFM | Crude protein | Moisture | Starch | Hardness/ Breakage[1] |
| Mexico | Food 75%<br>Feed 12%<br>Industrial 6%<br>Other 7% | Aflatoxin | BCFM | Moisture | | |
| Russia | Feed 85-90%<br>Industrial 5-10%<br>Food 5% | BCFM (especially dust) | Moisture | Breakage susceptibility | Aflatoxin | Noxious weed seeds |
| Spain | Feed 84%<br>Industrial 16% | BCFM | Moisture | Hardness | Heat damage | |
| South Korea | Feed 80%<br>Industrial 20% | BCFM | Moisture | | | |
| Taiwan | Feed 97%<br>Other 3% | Moisture | Aflatoxin | BCFM | Crude protein | |
| Venezuela | Feed 90%<br>Food 10% | Moisture | BCFM/ Aflatoxin[1] | Crude protein | | |

[1]Buyers in the respective country ranked the two factors shown as being equally important in influencing purchasing decisions.

Figure 6
**Share of U.S. corn exports to selected countries grading U.S. No. 2 and U.S. No. 3, 1986-91 average**




Source: Federal Grain Inspection Service.

about 3.60 percent in the late 1980's. The problem of breakage in U.S. corn during handling cannot be solved solely with additional cleaning at U.S. ports. Producing and marketing corn with lower breakage susceptibility appears to be the only longrun solution.

### Cleanliness and Quality as Competitive Factors

While the United States dominates the world corn market, some competitors' corn is perceived to be cleaner and of higher quality than corn exported by the United States. South African corn was preferred to U.S. corn because of its lower BCFM level, higher starch content, lower moisture, fewer stress cracks, and larger kernels. Argentine corn was also preferred for its lower BCFM level, lower moisture content, golden color, hardness, and higher crude protein. However, buyers in some case-study countries indicated that Argentine corn had greater risks of aflatoxin. Many buyers indicated that corn shipped from Argentina and South Africa was less susceptible to breakage during handling.[14] However, some breakage does occur when corn from those countries is subjected to high-speed bulk handling operations.

U.S. corn was generally perceived to be of superior quality than Chinese and Thai corn. Chinese corn was typically perceived to have lower test weight. Thai corn was perceived to have a chronic problem of aflatoxin. Some buyers indicated that EC corn was less desirable because of its generally higher moisture content.

## Policy Implications

Breakage susceptibility is the crux of the issue. Policies designed to enhance the cleanliness of U.S. corn must address the issue of lowering breakage susceptibility. If breakage susceptibility is not reduced, breakage will continue to occur during handling, loading, and unloading regardless of how much BCFM is removed. This is especially significant because it is not economical to perform additional corn cleaning at any point in the marketing channel.

The corn cleaning issue cannot be addressed effectively without considering other quality factors, such as moisture and breakage susceptibility. Due to its high moisture content at harvest and the corn breakage that occurs each time corn is handled, policy options dealing with corn cleanliness must address BCFM, moisture, and breakage susceptibility simultaneously. The best strategy for improving cleanliness

[14]The supply of corn from South Africa may be unreliable due to frequent droughts.

is to prevent kernel breakage rather than to remove BCFM after the breakage has occurred.

The net cost of additional cleaning of export corn is estimated to total $49 million per year if the additional cleaning occurs at both inland subterminals and river elevators--the locations with the lowest net cost. No appreciable international benefits from additional cleaning in terms of premiums for low-BCFM corn or increased U.S. corn exports were identified in this study.

It would be impractical to clean all export corn only at inland subterminals and river elevators, even though cleaning additional corn would be most cost-effective at these market locations. Export corn is also handled by country and export elevators. Because of the breakage susceptibility of corn, additional breakage occurs at these locations. Thus, additional cleaning at the subterminal elevators would not guarantee a lower level of BCFM in U.S. corn by the time the corn arrives at foreign destinations. Producers and country elevators would have to continue their current cleaning practices. Export elevators would also have to continue cleaning at the current level to ensure BCFM levels within the lower limit at inspection. Thus, if lower BCFM levels for export corn are to be achieved, cleaning would need to occur at every point in the marketing channel in addition to increased cleaning at the subterminal elevators.

Marketing corn with a BCFM content below the current level requires more incentives than currently exist in the marketplace. These incentives must come from domestic and foreign buyers as premiums or in increased trade. Technologies to reduce breakage susceptibility, such as low-temperature drying systems, exist in the marketplace. Producers in the Midwest have begun to adopt the low-temperature drying system under existing market conditions. This drying method would be adopted more rapidly if there were more price incentives for delivering corn with fewer stress cracks and less breakage than currently exists in the marketplace.

## Policy Options

This report extends beyond the context of the domestic and international reports by examining various policy options to improve the cleanliness of U.S. corn and to better meet the quality needs of domestic and foreign buyers. Policy options to reduce the level of BCFM in U.S. corn must include a consideration of breakage susceptibility since this factor affects the amount of broken corn throughout the marketing channel. The most effective options are those that enable the U.S. corn industry to provide export corn with low breakage susceptibility to buyers interested in low-BCFM corn. Some policy options included in this section, such as including breakage susceptibility as a nongrade factor, may not be viable because of technological limits; that is, the ability to measure breakage susceptibility. Other options, such as lowering the grade limits for BCFM, are not economically viable because the costs exceed the benefits. Options to reduce breakage must be evaluated for their cost-effectiveness before serious consideration is given to adopting them.

This section does not explicitly address changes in drying methods nor does it address an information (outreach) program in detail. However, adoption of alternative drying methods may potentially reduce breakage. An information program could effectively convey foreign buyers' quality preferences to the U.S. corn industry, convey information on drying technologies to producers and handlers, and familiarize foreign buyers with the intrinsic quality characteristics, especially breakage susceptibility, of U.S. corn.

### Changing U.S. Grades and Standards for Corn

The U.S. grades and standards for corn and other grains are intended to describe and certify as accurately as possible the physical condition of grain sold in domestic and international markets. Grading standards facilitate grain marketing by providing a uniform language that producers, marketers, exporters, and purchasers can use to communicate the quality and condition of the grain being bought and sold.

U.S. export corn is sold on the basis of "certificate final" with respect to quality. Unless specified in their contracts, foreign buyers often have little choice except to accept the additional BCFM created during loading and unloading. Buyers may use destination grades, but the risk of breakage for the exporter would greatly increase the price. This option is seldom used. Most buyers recognize that handling causes breakage and do not expect the BCFM content upon arrival to be below the certified grade limit. However, they do recognize that the corn offered by our competitors is less susceptible to breakage. Some competitors export corn using a "fair average quality" (FAQ) concept. FAQ guarantees quality to be at least equal to the average of all such grain shipped during a

specified period as set by contract specification (Hill, 1983). The FAQ contract does not cover all factors but only those that are least likely to change in transit, such as appearance, odor, and moisture content.

A number of options for improving cleanliness of U.S. export corn within the grades and standards framework were examined. These included proposals investigated by the Federal Grain Inspection Service in recent years and competitors' current practices. The corn breakage issue is also addressed even though it would not directly involve changes in the standards for BCFM.

### *Separating the BCFM Factor Into BC and FM Factors*

In recent years there has been a call to separate the BCFM factor into BC and FM factors. When the U.S. grades and standards for corn were first created, there was no need to separate broken corn from foreign material. Because producers dried corn on the ear and harvested with corn pickers, very little breakage occurred. The 1914 voluntary grades for corn contained two separate factors for noncorn materials: (1) foreign material, including "dirt, pieces of cob, other grains, finely broken corn, etc.," and (2) cracked corn, including all broken kernels passing through a 16/64-inch sieve except finely broken corn (Hill, 1990).[15]

When the mandatory corn grades were promulgated in 1916, following the passage of the Grain Standards Act, a 14/64-inch sieve was adopted because of widespread dissatisfaction with the use of two sieves. In 1921, the USDA adopted a 12/64-inch sieve to measure BCFM, and this sieve size remains in use today (Hill, 1990).

When farmers began using high-temperature drying systems, the portion of broken corn in the BCFM component increased. In contrast, coarse foreign material (CFM), which is nongrain material (such as cobs and stalks) that can be readily removed by mechanical sieving, is a very small component--generally less than 0.2 percent at any point in the market channel.

The argument for separating broken corn and foreign material is based primarily on the fact that FM differs dramatically in chemical composition and physical properties from broken corn. Separating the BCFM factor into BC and FM can take various forms with different definitions and factor limits. Some believe this alternative is aimed primarily at separating this grade-determining factor into two components. Others favor this action in conjunction with the adoption of lower grade limits for the factors (Hill, 1990).

Although FGIS grain inspectors record BC and FM separately, foreign buyers do not see this information. The export certificate shows BCFM as one number. Separating the BCFM factor into two components would allow buyers to differentiate between the BC and FM components, which may be of interest to some foreign buyers. Feed manufacturers do not like FM in the corn they buy; however, they seem to tolerate current levels of BC if aflatoxin is not present.

Since the FM fraction of BCFM is usually a very small component, separating the BCFM grade factor may not be practical or justifiable. Nevertheless, there is a certain degree of support for this option among U.S. corn producers and handlers. According to a three-State survey, about 30 percent of producers in Iowa, Illinois, and Indiana favored either changing or removing BCFM as a grade-determining factor in corn. This attitude may relate to the fact that a majority of producers favored legislative initiative, such as the Grain Quality Improvement Act of 1986, which prohibits addition or recombination of FM to grain once it is removed. Managers of interior elevators generally supported the separation of BCFM into the two components (Hill and others, 1988). Many of them felt that separating the BCFM into BC and FM would not affect them in any significant way.

Separating BCFM into two grade-determining factors will not, by itself, induce significant changes in management practices to lower BCFM. Cleaner corn in the market channel would be generated only if the separation of BC and FM includes a reduction in the combined allowable limits. In addition, the separation of BCFM into two factors would increase costs of segregation in storage as well as inspection costs in the domestic market, and might generate more discounts for producers. The difficulty of separating the two using existing grain cleaners, plus problems in the handling and storage of FM (particles smaller than 6/64-inch), would be major deterrents to marketing BC and FM as separate commodities (Hill and others, Aug. 1992). Thus, separating the BCFM grade factor into two components without any change in grade limits would generate additional costs with little benefit and no improvement in corn cleanliness (Hill and others, May 1991). Providing incentives to change practices to prevent breakage would be a more effi-

[15]Finely broken corn was defined as material passing through a 9/64-inch, round-hole sieve.

cient and cost-effective means of improving corn cleanliness than efforts to remove or reduce the level of BCFM.

### *Lowering the Grade Limits for BCFM*

As noted earlier, most alternatives for redefining the BCFM factor will not induce significant changes in cleaning practices or generate benefits from additional cleaning unless the grade limits for the BCFM factor are lowered concurrently. Thus, lowering the grade limits for BCFM may potentially induce changes in cleanliness practices more effectively than separating the BCFM into the BC and FM components.

Under this option, the grade limits (that is, the maximum allowable levels) for the BCFM factor would be lowered for each numerical grade. For example, the grade limit for U.S. No. 2 corn could be set at less than 3 percent while that for U.S. No. 3 could be set at less than 4 percent. Corn prices for the new base grade under this option would probably be higher than those for the current base grade, but corn with a BCFM level higher than this new, lower grade limit would be subject to price discounts.

There are pros and cons for this option:

Pros:

- Lowering the grade limits for the BCFM factor would probably induce additional corn cleaning because price discounts would begin at lower BCFM levels.

- Additional incentives would be offered for cleaner corn because corn prices for the new base grade under this option would probably be higher.

Cons:

- The total net costs of additional cleaning to remove 1.5 percentage points of BCFM from export corn, under the current market structure, would exceed $49 million per year.

- Lowering the grade limits for BCFM is unwarranted because foreign buyers can purchase cleaner corn (but at higher prices) under the current U.S. grades and standards by specifying U.S. No. 1 or No. 2 in their contracts.

- Lowering the BCFM grade limits may not improve cleanliness of U.S. export corn if foreign buyers shift their purchases to higher numerical grades. This option does not force buyers to choose cleaner corn, and it will not dictate market response (Hill, Bender, and Beachy).

- This option may not resolve the dissatisfaction of foreign buyers because the level of BCFM in U.S. export corn when delivered would probably still exceed the BCFM limit for the grade they purchased.

- It would likely be more cost-effective to prevent breakage from occurring than to remove BCFM after the breakage has occurred.

### *Minimal Receival Standards for Export Corn*

Most competitors require minimum receival standards for export corn delivered at either interior or export points. In contrast, the United States does not require minimal receival standards for export grain. Producers can deliver almost any quality of corn in the marketplace. This U.S. system provides sellers with flexibility; corn arriving at the export elevator is not rejected if the BCFM level exceeds the grade limits. Shipments from inland subterminals and river elevators are usually purchased on an origin-grades basis, and country elevators usually let export elevators apply price discounts to corn with BCFM levels that exceed the U.S. No. 2 grade limit. By setting minimum receival standards for the BCFM level in corn entering export ports, the cleanliness of U.S. export corn may improve.

Minimal receival standards would reject corn not meeting these standards when it arrives at export elevators and return the corn to sellers for additional cleaning. This option has been implemented in some other exporting countries. In Argentina, corn not meeting the standards for foreign material or moisture content is rejected at the port. Similarly, corn not meeting the Chinese standards for moisture content or purity index is rejected when it arrives at the grain station prior to reaching the export port.[16] These requirements along with their harvesting and drying practices have maintained low BCFM levels in export corn from these countries.

[16]The maximum allowable moisture is 18 percent in some provinces and 14 percent in others. While there are no limits on broken kernels, the purity index is based on the percentage of pure sound kernels, free of defects, rather than on limits on the percentage of each individual defect in the sample.

Setting minimal receival standards for corn cleanliness in the United States may improve cleanliness, although some breakage will still occur unless breakage susceptibility is reduced. This option would not improve the cleanliness of U.S. export corn, but it might improve uniformity.

Regulating the cleanliness of corn moving to ports would be considerably more costly in the United States than in Argentina and China. Most corn in these countries is delivered by truck or horse-drawn carts from producers or by first handlers directly to the port. In the United States, however, most corn is sold by producers to local and subterminal elevators first, and is then shipped to export elevators in railcars, trucks, and barges. It would be very costly to return corn to a distant seller for cleaning, and this would increase the BCFM content even more. With greater marketing intermediation in the United States, testing and enforcement of minimal receival standards would be much more difficult and disputes between buyers and sellers would be common. This option would be one of the most expensive alternatives. Testing of corn would occur twice--once on arrival and once prior to shipment. This option would increase costs and discounts, substitute regulations for market forces, but would not solve the breakage problem that occurs when corn is handled at elevators.

Implementing this option would require testing corn upon arrival at the export elevator. The U.S. Department of Agriculture's (USDA) Federal Grain Inspection Service could perform these tests. However, this would double their workload and increase administrative costs that are paid through user fees collected from the grain industry. Farmers would eventually bear the cost through lower prices. If corn is rejected, additional time would be required to contact the seller. An appeal system to challenge the inspection results would also be required. Thus, regulating incoming cleanliness of corn in the United States would take more time, cost more, but would not solve the underlying breakage problem.

### *Including Breakage Susceptibility as a Nongrade Factor*

It would be more cost-effective to prevent breakage rather than remove BCFM after breakage has occurred. Information on the breakage susceptibility of U.S. corn would probably be more useful to buyers than separate grading factors for the BC and FM components based on particle size. Under this option, breakage susceptibility would be included as a nongrade-determining factor. The level of breakage susceptibility would not affect the official grade, but it would be measured and recorded on inspection certificates for export corn.

Measuring breakage susceptibility might encourage the delivery of less breakable corn if market premiums for corn with low breakage susceptibility existed. It would allow buyers to more accurately project the end-use values of corn in most end-uses, and could reduce the amount of dust in U.S. corn. Adoption of a measurement method by first handlers would place the responsibility for improving U.S. corn cleanliness on the producers, who determine hybrid selection, harvesting practices, and drying practices. If the marketplace offers sufficient incentives to deliver corn with less breakage susceptibility, producers would be induced to change harvesting and drying practices to reduce breakage susceptibility. This option would also effectively address foreign buyers' common complaints about receiving corn with BCFM levels exceeding the maximum limit of the grade they purchased.

This option has strong appeal, but it would not be viable until certain difficulties are overcome. First, this option requires support (financial or other types of incentives) for the development of equipment to measure breakage susceptibility economically, rapidly, and accurately on a commercial basis--a prerequisite for segregating corn according to breakage susceptibility. Second, the marketplace would have to offer sufficient incentives beyond the current level to induce the commercialization of the measurement technology. Third, while segregating low-breakage-susceptibility corn throughout the marketing system could help ensure that foreign buyers receive low-BCFM corn from the United States, it would result in segregation costs.[17]

## Continuing Research and Development Activities To Improve Technologies for Measuring Breakage Susceptibility

As noted above, including breakage susceptibility as a nongrade-determining factor is probably the most effective option in addressing the corn breakage issue if: (1) technologies for measuring breakage susceptibil-

[17]Research currently underway in Iowa studies the specific costs associated with segregating grain upon receipt at country elevators and storing it separately. The cost per bushel of segregating and storing grain according to intrinsic characteristics ranges from 1.4 cents to 6.9 cents per bushel (Wheat).

ity become commercially available, and (2) adequate incentives for delivering corn with low breakage susceptibility are offered in the marketplace.

Segregating U.S. export corn according to breakage susceptibility throughout the marketing system would require research to develop equipment to measure breakage susceptibility rapidly, accurately, and economically. Presently, a few breakage testers exist: (1) the Wisconsin tester, a single impact tester; (2) the Stein tester, a multiple impact tester; and (3) the Seedburo tester. The accuracy of these testers must be improved before breakage-susceptibility testing can be performed consistently and on a commercial basis. For example, the Wisconsin tester generally indicates a higher level of breakage susceptibility than really exists. Until breakage susceptibility can be tested and measured properly and commercially, breakage susceptibility might be categorized into high, medium, and low based on visual inspection for stress cracks.

### Incorporating Breakage Susceptibility as a Criterion in Genetics Research and Hybrid Corn Release

An inverse relationship often exists between yields and intrinsic quality characteristics. Corn breeders generally seek to increase yields and disease resistance. Quality characteristics, although important, may be ignored because of the lack of market incentives. Yet, the development and release of hybrid genotypes with both reduced breakage susceptibility and acceptable yield potential could be an effective option for reducing handling breakage in U.S. export corn.

The development of new hybrid genotypes is accomplished by selecting desired plant traits during both inbred development and hybrid evaluation. State Agricultural Experiment Stations and private seed companies are the primary sources of funding corn breeding programs. Most corn breeding is conducted by private seed companies. Quality factors, such as breakage susceptibility, have not received priority attention in the hybrid selection process. Farmers purchase corn hybrids because of enhanced yield, economic traits, and disease resistance, and plant breeding programs recognize this fact. Characteristics such as kernel hardness and breakage susceptibility would have to provide a market advantage for the breakage issue to be effectively addressed.

The 1990 Grain Quality Incentive Act (Title XX) requires that grain submitted for public testing be evaluated for selected specific agronomic performance and intrinsic end-use characteristics. USDA is to disseminate this information to plant breeders, producers, and end-users. The Department is also required to periodically conduct a survey of grain varieties produced in the United States. Appropriate funding for these activities as well as funding for the development and release of varieties with low breakage susceptibility could be beneficial in the long run.

Breeders and institutions exercise tremendous discretion in developing and releasing new corn hybrids. Genotypes with improved quality characteristics but lower yield potential would not be popular and probably would not be released. The marketplace must offer incentives to deliver corn with lower breakage susceptibility. Otherwise, farmers will not demand seed with the desired improvements, and plant breeders will not focus on this area.

## Conclusions

Cleaning all U.S. export corn beyond the current level is not economically feasible because the costs of cleaning at the lowest net-cost locations--inland subterminals and river elevators--would exceed the benefits by $49 million per year.

The bulk of potential benefits from marketing cleaner corn comes from domestic markets. The removal of foreign material and fines would reduce mold growth and insect infestation. Revenues from screening sales to feeders and feed manufacturers would offset some of the value of weight loss that occurs during the cleaning process. Per-bushel domestic benefits from cleaning were the highest at country elevators because of larger revenues from sales of screenings and improved storability if cleaning were applied to all corn received.

Cleaning U.S. corn beyond the current level would not result in any premiums for cleaner corn (or the switch to purchases of better grade corn) beyond what is currently being paid or any noticeable increase in U.S. corn exports; however, it could help maintain U.S. market shares. Seventy percent of U.S. corn exports to the major U.S. markets included in this study were used for livestock and poultry feed. These uses are not very quality-conscious with respect to BCFM. Dry millers in these countries rely primarily on domestic corn. Wet millers were more stringent in their cleanliness requirements.

The best approach to improving cleanliness is to reduce breakage susceptibility in U.S. export corn by carefully selecting certain drying systems and developing genotypes or hybrid varieties less prone to breakage. Despite their preference for low-BCFM corn, foreign buyers were not willing to pay a premium for cleaner U.S. corn. To them, the price differential between U.S. No. 2 corn and U.S. No. 3 exceeded the benefits of receiving lower levels of damaged kernels and BCFM.

The costs of additional cleaning exceeded benefits in both domestic and international markets at all points in the production-marketing system. Performing additional cleaning of U.S. export corn at both inland subterminals and river elevators had the least net cost because of a smaller cleaning volume than at the farm or country elevators and a lower value of weight loss than at export elevators. The net costs of cleaning averaged 3.4 cents per bushel of corn cleaned at both of these subterminals. In contrast, cleaning at export elevators would cost 3.9 cents.

Unlike cleanliness patterns in U.S. wheat where dockage declines as wheat moves through the marketing system, the level of BCFM in U.S. corn increases as corn moves from the field toward export elevators. Corn kernels are damaged and broken during harvesting, drying, and handling. The level of BCFM at harvest averages 1.54 percent, well below the 3-percent limit for the U.S. No. 2 corn. Breakage of kernels, however, generally exceeds the amount of BCFM removed at each market point. At inspection prior to being loaded onto vessels at the port, the level of BCFM averaged 3.3 percent during 1989-91. Additional cleaning of export corn to remove 1.5 percentage points of BCFM at subterminals would lower the BCFM level to 1.8 percent as recorded on inspection certificates. Breakage during loading could increase by 1.5 percentage points. The level of BCFM in U.S. export corn would be even higher at foreign ports because of breakage during unloading, which may generate an additional 2-3 percentage points of BCFM.

Corn price, instead of quality, was regarded as the most important factor in importers' purchase decision in most importing countries included in the study. Of all quality factors, BCFM, moisture, and aflatoxin were the most important quality considerations for foreign buyers. BCFM was the paramount quality factor in purchase decisions in four of the eight importing countries (Japan, Russia, Spain, and South Korea) covered by case studies. With the exception of Russia, food and industrial processors are relatively more important users of imported corn in these countries. Buyers in Egypt, Mexico, Spain, and Taiwan, while indicating that price was the most important sourcing factor, primarily purchased the U.S. No. 2 grade from U.S. origins. This demonstrates the complicated relationship that exists between economic and quality considerations.

Despite the preference for low-BCFM corn, cleaning is not the solution to the corn cleanliness issue. Policies designed to enhance the cleanliness of U.S. corn should focus on lowering breakage susceptibility. That is the crux of the issue. If breakage susceptibility is not reduced, breakage will continue to occur during handling, loading, and unloading regardless of how much BCFM is removed. Policy options to address this issue include: (1) changing the U.S. grades and standards for corn, (2) continuing research and development to improve technologies for measuring breakage susceptibility, and (3) incorporating breakage susceptibility as a criterion in the development and release of new hybrids.

Technologies to manage breakage and reduce breakage susceptibility, such as low-temperature drying systems, already exist in the marketplace. Producers in the Midwest are already adopting low-temperature dryers under existing market conditions. Greater adoption, so that cleaner corn or corn with low-breakage susceptibility could be delivered to buyers, would require greater economic incentives than exist in the marketplace.

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U.S. Department of Agriculture
Economic Research Service

SUMMARY OF REPORT #AIB-688

# Three Forces Drive World Feed Wheat Trade

February 1994

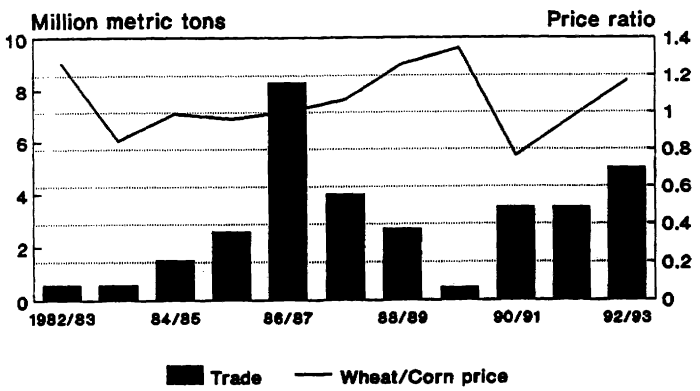
*Contact: Sara Schwartz, 202/219-0825*

Competitive prices and abundant wheat supplies generally increase trade in wheat for feeding. Certain types of market conditions increase the probability that large volumes of feed wheat will be traded. These market conditions include: damaged wheat in exporting countries that leads to heavy price discounts; abundant total wheat supplies that drive down export prices, often aggravated by fierce and subsidized competition among exporters; and a combination of the first two conditions that lowers relative wheat prices. *World Feed Wheat Trade: A Market Analysis*, a recent report from USDA's Economic Research Service, examines the key factors affecting feed wheat trade and thus develops a framework for evaluating the necessary conditions.

While the annual volume of feed wheat trade fluctuates widely, it has been increasing since the mid-1980's. Although much wheat that is traded and fed is low quality, there is no standard definition of feed wheat; any wheat can be used for feeding. Trade accounts for only a small and irregular portion of world consumption of wheat for feed, but feed wheat trade critically affects the volume of total wheat and coarse grain trade.

The world market for feed wheat is relatively small, with few countries importing wheat for feed, even in years when relative prices are attractive. Policy impediments and other factors, such as the irregular availability of low-priced wheat, restrict import demand. The world market is undergoing some structural change because of reduced demand by the former Soviet Union (FSU) and Eastern Europe, major importers in the past. Because of reforms and economic changes, the livestock sectors in these countries are contracting, and feeding of all grains is declining. In the short term, this will further increase the dominance of South Korea, which now has close to monopsony power in the world market. Other countries could import more feed wheat, but this would require more flexibility in imports or policy changes.

World feed wheat trade and wheat/corn ratio 1/




1/ Feed wheat prices unavailable. Ratio comprised of composite milling wheat price to US Gulf f.o.b. corn price.

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Economic Research Service

SUMMARY OF REPORT AER-675

# More Cleaning of All U.S. Export Wheat Does Not Pay; But Targeting Cleaning to Specific Markets Can Pay

December 1993

*Contact: William Lin (202) 219-0840*

Cleaning all U.S. export wheat beyond current practice is not economically feasible, according to a new report by USDA's Economic Research Service. Costs of additional cleaning would outweigh benefits by at least $8 million per year in the short run. The best strategy of promoting cleanliness of U.S. export wheat is to target clean wheat for niche markets, those that use wheat to meet very specific end-use demands for high-quality food products.

Concern over the quality of grain exported from the United States versus the quality of competitors' grain has increased in recent years. Some observers believe that selling grain that contains higher levels of dockage and foreign material than that of our competitors has reduced U.S. competitiveness in the world grain market. (Dockage is all matter other than wheat, such as chaff, stems, and stones. Foreign material is all matter other than wheat after dockage is removed; it is the most difficult material to remove from wheat.) Advocates argue that improving the cleanliness of U.S. grain will increase market share or is necessary to maintain U.S. market share at current levels. Critics argue that improving cleanliness will increase marketing costs, reduce profits, and diminish U.S. competitiveness.

In response to a request from Congress, the Economic Research Service (ERS), in cooperation with researchers at land-grant universities and the U.S. grain industry, conducted a study on the costs and benefits of cleaning U.S. grain. *Costs and Benefits of Cleaning U.S. Wheat* presents an overview and implications of this study and summarizes two other ERS reports produced in response to this study. The first, *Economic Implications of Cleaning Wheat in the United States*, focuses on the costs and domestic benefits of cleaning wheat. The second, *The Role of Quality in Wheat Import Decisionmaking*, focuses on importers' preferences with respect to cleanliness and other quality factors, and assesses the benefits of cleaning export wheat for international markets.

The wheat industry could gain $8 to $10 million in net benefits if it targets wheat cleaning to the cleanliness-conscious markets, which account for about 20 percent of all U.S. wheat exports. These markets include Italy, Venezuela, Togo, Ghana, and possibly Japan and the Philippines. The United States competes with Canada and Australia for these markets. Targeted wheat classes for cleaning are primarily dark northern spring (DNS) and durum wheat exported from the Pacific and Gulf ports.

While selling cleaner U.S. wheat in cleanliness-conscious markets may increase export prices or enhance the U.S. competitive position, cleanliness is not the most important factor affecting importers' demand for wheat. Price considerations, cleanliness, quality considerations, and institutional factors all influence the selection of a supply source in the world wheat market. In the many low-income countries that account for a majority of world wheat imports, wheat price, not quality, is the most important factor in the purchase decision.

## To Order These Reports...

The information presented here is excerpted from ***Costs and Benefits of Cleaning U.S. Wheat: Overview and Implications,*** AER-675, by William Lin and Mack Leath. The cost is $9.00.

Two companion reports, ***Economic Implications of Cleaning Wheat in the United States,*** AER-669, by Bengt T. Hyberg, Mark Ash, William Lin, Chin-zen Lin, Lorna Aldrich, and David Pace, and ***The Role of Quality in Wheat Import Decisionmaking,*** AER-670, by Stephanie A. Mercier, each cost $12.00.

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