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Economic Implications of Cleaning Barley in the United States

Mark S. Ash
Mack N. Leath

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Abstract

The costs of cleaning barley beyond the current level of cleanliness would outweigh the potential benefits. There is little commercial interest in the cleaning of barley moving into domestic malting and feed barley markets. The export market demand is primarily for feed barley. Dockage is not a major concern for foreign feed barley users, but buyers need an accurate certification of how much dockage is present so they can properly value the grain. Cleanliness objections are mostly an information problem rather than a technical problem. Therefore, enhancing cleanliness becomes an issue of changing the way that information about barley's dockage content is communicated in the market.

Keywords: Barley, dockage, grades and standards, cleaning

Acknowledgments

The authors appreciate reviews, suggestions, and contributions of William Lin of the Economic Research Service; John Giler and David Shipman of the Federal Grain Inspection Service; and members of the ERS-FGIS Grain Cleaning Study Steering Committee. The authors are also grateful for technical reviews of this product by Jack Q. Pettus of the National Barley Growers Association and John Mittleider of the North Dakota Barley Council. Special acknowledgment is given to William W. Wilson, Daniel J. Scherping, David W. Cobia, and D. Demcey Johnson of North Dakota State University who cooperated with ERS in the conduct of this study.

Washington, DC 20005-4788 November 1996

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 shrunken and broken kernels, dockage, and foreign material 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 at current levels. On the other hand, 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 the information currently available was insufficient to support either claim. Therefore, the Food, Agriculture, Conservation, and Trade Act of 1990 mandated that the Federal Grain Inspection Service (FGIS), now part of the Grain Inspection, Packers and Stockyards Administration (GIPSA), 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 the Economic Research Service (ERS) in USDA to coordinate and conduct studies of the costs and benefits of cleaning wheat, corn, soybeans, sorghum, and barley.

This report presents an overview and implications of the study results for barley. Reports for the other commodities have already been published by ERS. The content of this report is based primarily on special studies conducted by contractors representing trade associations and State agricultural experiment stations.

ERS received valuable input and advice from the 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, and they are also recognized for their efforts and cooperation. As with all ERS studies, however, the content of this report is the sole responsibility of ERS.

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Summary

The costs of cleaning barley beyond the current level of cleanliness would outweigh the potential benefits. There is little commercial interest in the cleaning of barley moving into domestic malting and feed barley markets. The export market demand is primarily for feed barley. Dockage is not a major concern for foreign feed barley users, but buyers need an accurate certification of how much dockage is present so they can properly value the grain.

Each handler in the barley-marketing process (farmers; country, terminal, and export elevators; feed processors; and maltsters) has an opportunity to perform cleaning services, contingent on customers' requirements and market-determined quality premiums and discounts. The estimated net economic costs (cleaning costs minus benefits) of cleaning total U.S. barley production at country elevators in the 10 major barley-producing States ranged from $3.9 million to $7.2 million, or from 1 to 2 cents per bushel.

The studies were mandated by Congress because of concerns about the quality of grain exported from the United States. The studies did not estimate the costs and benefits of cleaning barley at export elevators. Such cleaning would be more costly than cleaning at country elevators because of higher labor costs and property values at ports, and the need to install high-capacity cleaners to match load-out capacity. In addition, higher prices of barley at ports due to additional transportation and handling costs would increase the value of barley loss during cleaning. Value of barley loss accounts for up to four-fifths of the estimated costs.

Selling cleaner barley in international markets might help maintain U.S. market share but would not likely result in premiums paid by foreign buyers for cleaner barley. Nor would it likely expand U.S. barley exports. Most exported barley is of feed quality, for feeding livestock and poultry. Feed manufacturers in those markets, like their counterparts in the United States, are satisfied with the current cleanliness of U.S. barley.

Only a combination of lower barley prices, higher screening prices, higher transportation costs, and higher initial dockage levels (all matter other than barley—chaff, stems, stones, etc.—that can be removed by screening) would lower the net cost of cleaning to the point where a positive net benefit would be possible.

Dockage levels in U.S. barley exports have not significantly improved or worsened in recent years. Most export barley is purchased on the basis of grade U.S. No. 2 or better. Barley dockage seldom has an explicit market price premium or discount, which is often in effect for other quality characteristics, such as protein, test weight, foreign material, and thin barley. Dockage is not a grade-determining factor in the U.S. grades and standards for barley.

Maltsters, who process barley to obtain malt intended for human consumption, routinely clean all barley they use to obtain a product free of dust, insect parts, and other materials that would affect the taste and sanitary quality of the malt. Feed

manufacturers, in contrast, are likely to run the barley only through a rock-catcher, to remove stones.

Some maltsters do not deduct for dockage less than 1 percent. This practice is followed to encourage farmers not to skin malting barley in harvesting and elevator operators not to overclean, which can result in skinning the kernels.

Maltsters' cleaning operations are more carefully tuned to avoid skinning the barley hull. Skinned kernels either do not germinate or germinate too quickly, which lessens malting quality.

Without price discounts for dockage, farmers have little incentive to remove dockage. Farmers are able to minimize dockage content through closer monitoring of combine settings; timely harvest; planting certified seeds; using herbicides and tillage practices to minimize weeds in fields; and cleaning of storage, handling, and transport equipment that is also used for other crops.

Alternative policy options were considered for improving the cleanliness of U.S. barley and for better meeting the needs of foreign buyers: (1) change the FGIS dockage reporting/recording methods, (2) change the U.S. grades and standards for barley by including dockage as a grade-determining factor, and (3) include grain cleanliness as a tertiary objective of the Export Enhancement Program.

Foreign buyers rely heavily on the accuracy of FGIS inspections. Accurate measurement and recording of dockage can only help enhance the reputation of U.S. grain standards as being objective and fair, although such a rule change might make only a minimal change in the actual dockage content of U.S. barley exports. An accurate reporting of dockage may help U.S. barley compete with foreign barley exporters and against competing feed grains by providing buyers with information on the portion of the nongrain material that could be easily removed with simple screen cleaners (dockage) and what portion could not be removed easily (foreign material).

Making dockage a grade-determining factor would not necessarily result in a significant overall improvement in barley cleanliness or a higher price except for the export markets that bought the top grade exclusively. Cleanliness would improve only to the extent that the new standard facilitated the exchange of information between those better able to supply clean barley and the importers more willing to pay for it.

Making the export bonus payable on the basis of the grain weight net of dockage rather than the gross weight may remove any incentive for allowing dockage to reach its maximum contract limit and may encourage more cleaning, although its trade benefit could be countered by other exporting countries through higher subsidies or lower prices.

Economic Implications of Cleaning Barley in the United States

Mark S. Ash
Mack N. Leath

Introduction

In recent years, concern over the quality of grain exported from the United States versus the quality of competitors' grain has risen. The issue was raised during debate on the Food Security Act of 1985. To gain more information, Congress amended the act and directed 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 that contains higher levels of dockage and foreign material than that of our competitors has reduced U.S. competitiveness in the world grain market. Advocates of tighter U.S. grain standards related to cleanliness argue that improving grain cleanliness will either increase the U.S. market share in the world market or will be necessary to maintain it at current levels. On the other hand, many traders and handlers argue that tighter cleanliness standards will increase marketing costs, reduce profits, and diminish U.S. competitiveness.

In the 1990 farm bill debate, Congress recognized that the information available at that time was insufficient to support either claim. Therefore, Congress included a Grain Quality Title (XX) in the Food, Agriculture, Conservation, and Trade Act (FACTA) of 1990 entitled "Grain Quality Incentives Act of 1990." The Act mandated a comprehensive commodity-by-commodity study of economic costs and benefits of cleaning grain. The title requires the U.S. Department of Agriculture's (USDA) Federal Grain Inspection Service (FGIS) to establish or amend grain grades and standards to include "economically and commercially practical levels of cleanliness" for grain meeting the requirements of grade U.S. No. 3 or better. Prior to implementing tighter "cleanliness" standards, however, USDA is required to conduct a comprehensive commodity-by-commodity study of technical constraints and economic costs and benefits associated with any such changes. Studies were mandated for wheat, corn, soybeans, sorghum, and barley.

In response to this mandate, FGIS entered into a reimbursable research agreement with USDA's Economic Research Service (ERS) to coordinate and conduct the economic studies. ERS in turn contracted with researchers at North Dakota State University to assist in studying the costs and benefits of cleaning barley. This report provides an overview of the costs and benefits of cleaning U.S. barley and presents implications and policy options to enhance U.S. barley's competitiveness in both cleanliness and quality in the world market.[2]

[1] The results of this study were published in three reports: *Enhancing the Quality of U.S. Grain for International Trade*, OTA-F-399 [8]; *Enhancing the Quality of U.S. Grain for International Trade: Summary*, OTA-F-400 [9]; and *Grain Quality in International Trade: A Comparison of Major U.S. Competitors*, OTA-F-402 [10] (Washington, DC: U.S. Government Printing Office, February 1989).

[2] For a more detailed analysis on the costs and domestic benefits of cleaning barley, see Wilson, William W., Daniel J. Scherping, David W. Cobia, and D. Demcey Johnson, *Economics of Dockage Removal in Barley: Background, Cleaning Costs, Handling, and Merchandising Practices*, Agricultural Economics Report No. 310, Dept. of Agricultural Economics, North Dakota State University, Nov. 1993 [17].

The Role of Cleanliness in Marketing Barley

The Marketing Channel for Barley

Country elevators traditionally have been the primary outlet for barley sold from U.S. farms. These firms inspect, clean, condition, and store the barley until it is shipped to terminal elevators, feed processors, maltsters, and exporters (fig. 1). Most barley handled by terminal elevators is shipped primarily from country elevators; however, some producers near terminal elevators sell directly to the terminal elevators. Each handler in the marketing process has an opportunity to perform cleaning services, contingent on customers' requirements as well as market-determined premiums and discounts for various grades and quality factors.

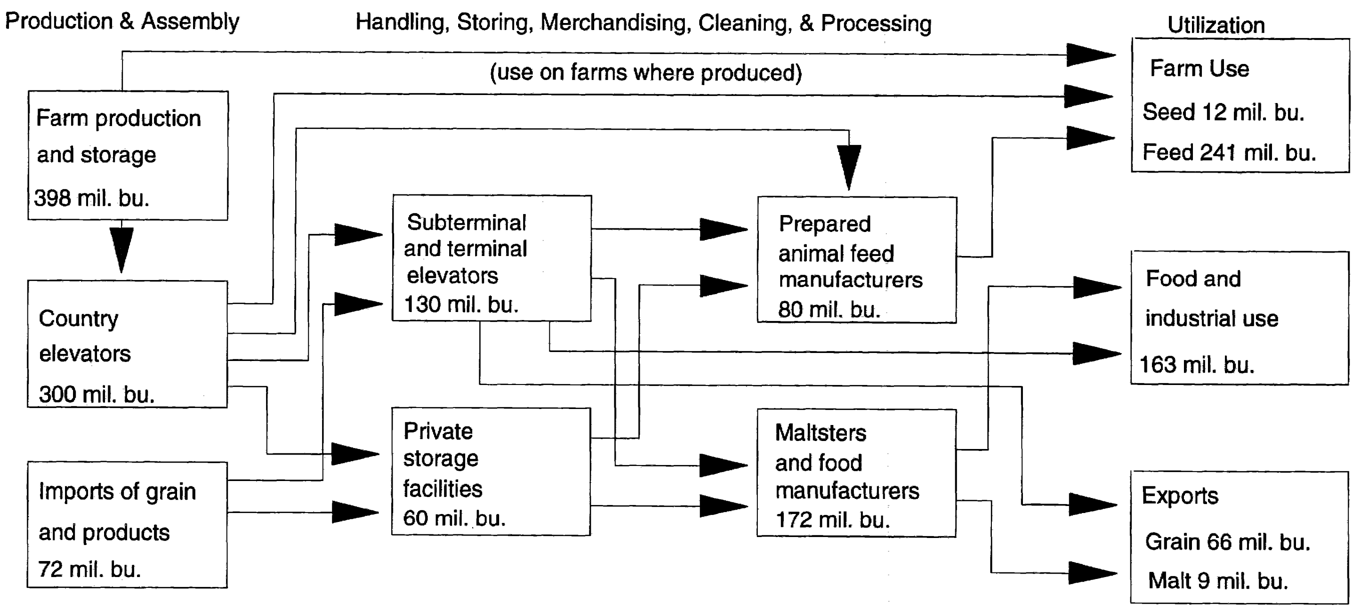
Barley Quality

Barley quality has two dimensions: physical condition and composition (fig. 2). Physical condition is further broken down into soundness and purity. Soundness measures the physical condition of barley (moisture, test weight, kernel size, etc.) and rates kernel defects, which include heat damage, insect damage, mold damage, sprout damage, and skinned or broken kernels. Purity measures the quantity of non-barley material. Its components include dockage, foreign material, mycotoxins (especially vomitoxin), fungi, pesticide residues, toxic weed seeds, live and dead insects, other grains, and wild oats (selected quality terms are defined in the glossary).

Because malting involves a germination process, a germination level (percentage of live, viable kernel) above 95 percent is desired by maltsters. Kernel blight can produce a slow and uneven germination, thereby reducing malt extraction and potentially affecting beer taste. Similarly, stained and weathered barley may affect the malting process. However, in some cases, a little stain may be desirable since it means there is less glue binding the hull to the kernel.

Other physical characteristics include moisture content, test weight, color, kernel size, and plumpness. Maltsters prefer barley with a high proportion of plump kernels and a low percentage of thin barley. This is

Figure 1
The marketing channel for barley, United States, 1993/94 marketing year

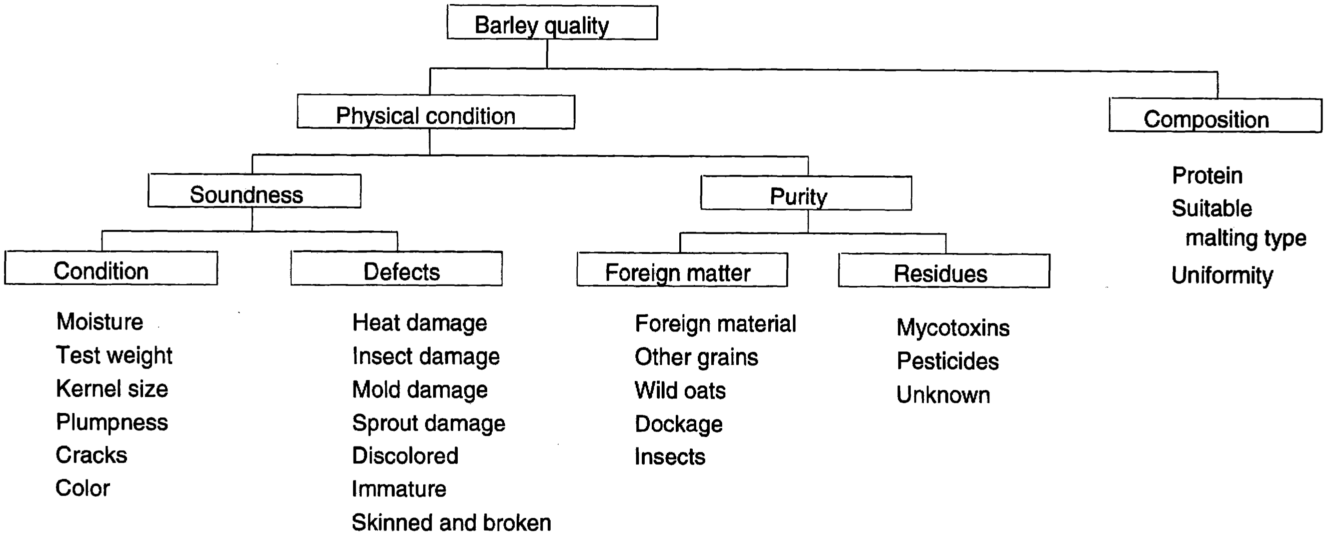


Note: Totals are approximations based on information from secondary sources. Products included in totals are expressed in grain-equivalent units.

Source: Adapted by ERS, USDA from Heid and Leath.

Figure 2

Catagories of barley quality: physical condition and composition



Source: Adapted by ERS, USDA from Grain Insect Interagency Task Force.

why the maximum limit for thin barley is lower for the malting subclasses six-rowed malting and two-rowed malting barley compared with the limit for the non-malting classes and subclasses that move into the feed market. Maltsters usually size barley before it is used in malt production. The thin kernels removed are sold as feed barley. Maltsters also prefer barley that has a bright, uniform color.

Protein content is the most important intrinsic characteristic for maltsters. Maltsters desire barley with protein levels under 13.5 percent. The major difficulty with using high-protein barley is its effect on malt extraction; approximately 0.8 percent of malt is lost for each 1 percent of additional total protein. Extremely low protein levels can also affect the malting process, but the impact on extraction is less [17, p. 24].[3]

Uniform barley quality is especially important for the malting barley and brewing industry. Uniformity covers varietal purity, protein, plumpness, thins, germination, skinned, mold damage, blight damage, and color. The North Dakota study documented the importance of varietal purity as follows:

> "Varietal purity is probably the most important 'because each variety of barley germinates and modifies at its own rate. Mixtures of varieties will cause a non-uniform conversion to malt. Malting conditions may be optimal for one of the varieties, but cause others to grow more slowly or more quickly. The major analytical parameters impacted by varietal impurities are: malt uniformity, endosperm modification and, depending upon the degree of varietal contamination, can affect all malt parameters. Also affected will be malt process efficiency and brewhouse performance' (Fleischmann-Kurth Malting Company)." [17, p. 24].

Some important quality characteristics of barley, such as protein content, are not grade-determining factors. Other important characteristics, such as color, are not currently measurable.

Barley Cleanliness

Cleanliness is defined by the amount of nongrain material in a grain sample. In this report, cleanliness refers to the level of dockage and foreign material. Dockage generally is the easiest nongrain material to remove because it is either larger or smaller than normal barley kernels. Foreign material consists of matter other than barley that is similar in size to barley kernels and is more difficult to separate. Foreign material is a grade-determining factor, while dockage is not.

Foreign material in the U.S. grading standards for six-rowed malting barley and six-rowed blue malting bar-

[3] Numbers in brackets refer to specific publications and references presented in the References section.

ley includes wild oats but excludes other grains, which are measured as a separate factor. The U.S. grading standards for two-rowed malting barley consider other grains to be foreign material but measure wild oats as a separate factor. The grading standards for feed barley include wild oats and other grains in the measurement of foreign material. The foreign material content of U.S. barley exports has averaged about 0.1 percent in recent years, well below the 0.5- to 5.0-percent maximum allowed for various grades of barley.

Dockage is the primary concern for barley cleanliness, although it is usually correlated with the foreign material level. A 1992 survey, conducted by the Department of Cereal Science and Food Technology, North Dakota State University, determined that the level of dockage in barley averages about 2.2 percent at harvest for three midwestern producing States. Average dockage levels reported for individual States in 1992 were 1.7 percent in Minnesota, 2.2 percent in North Dakota, and 3.8 percent in South Dakota [7, p. 26].

The level of dockage in U.S. barley tends to decline as it is moved from producing regions to terminal elevators, processors, and port elevators. Cleaning performed at country elevators is the major factor causing the reduction. The North Dakota study also analyzed official inspection information contained in the Grain Inspection Monitoring System (GIMS) data base maintained by FGIS [17, p. 28]. The analysis included inspection results for submitted samples, samples submitted for reinspection, and official FGIS samples inspected between June 1986 and January 1993 in three major production regions:

Midwest: Minnesota, North Dakota, and South Dakota;
Mountain: Colorado, Idaho, Montana, and Wyoming; and
Pacific: California, Washington, and Oregon.

The predominant barley classes produced in each region and included in the analysis were:

Midwest: six-rowed barley;
Mountain: two-rowed barley and six-rowed barley; and
Pacific: six-rowed barley.

The analysis revealed that the average dockage levels in the three regions for the major class produced were:

Midwest six-rowed barley: 0.96 percent;
Mountain six-rowed barley: 0.84 percent;
Mountain two-rowed barley: 0.87 percent; and
Pacific six-rowed barley: 1.18 percent.

Average dockage levels were found to be higher in the Pacific region. Average dockage levels in the Midwest and Pacific regions declined during the study period. It is difficult to draw specific conclusions regarding these averages since the specific origin of samples and the history of the lots represented regarding cleaning and blending were unknown.

Most barley exported from the United States grades U.S. No. 2 or better. Analysis of data from FGIS' Export Grain Inspection System (EGIS) data base indi-

Table 1--Mean dockage, standard deviations, dockage range in U.S. barley exports, FY 1985-92

Fiscal year	Mean dockage	Standard deviation	Range: Minimum	Range: Maximum
	Percent			
1985	1.22	0.72	0.50	2.95
1986	1.55	0.53	0.63	3.36
1987	1.37	0.52	0.50	2.83
1988	1.48	0.50	0.45	3.14
1989	1.40	0.54	0.30	3.00
1990	1.20	0.38	0.28	1.91
1991	1.38	0.48	0.32	2.45
1992	1.32	0.48	0.41	2.72
Combined sample	1.37	0.50	0.28	3.36

Source: Compiled by ERS, USDA from Federal Grain Inspection Service [15].

Table 2--Mean dockage level of U.S. barley, by importing country, FY 1985-92

Importing country	Inspections	Mean dockage	Standard deviation
	Number	*Percent*	
Japan	26	0.98	0.35
Saudi Arabia	220	0.92	0.56
Jordan	27	1.04	0.82
Tunisia	23	0.77	0.75
Israel	67	1.06	0.75
Cyprus	23	1.34	0.82
Algeria	72	1.31	0.69
Poland	21	1.14	0.99
Romania	14	2.07	0.64
Other	73	1.19	0.78
Combined sample	757	1.37	0.50

Source: Compiled by ERS, USDA from Federal Grain Inspection Service [15].

Table 3--Mean dockage levels of barley: Selected effects, 1985-92

Class effect		Grade effect		Export region effect	
Class	Average dockage	Grade	Average dockage	Export region	Average dockage
Barley (feed)	1.34	U.S. No. 1	1.38	East Coast	1.00
Six-rowed barley	1.85	U.S. No. 2	1.36	Gulf	1.68
		U.S. No. 3	1.51	Great Lakes	1.52
				West Coast	1.04
Total sample					1.37

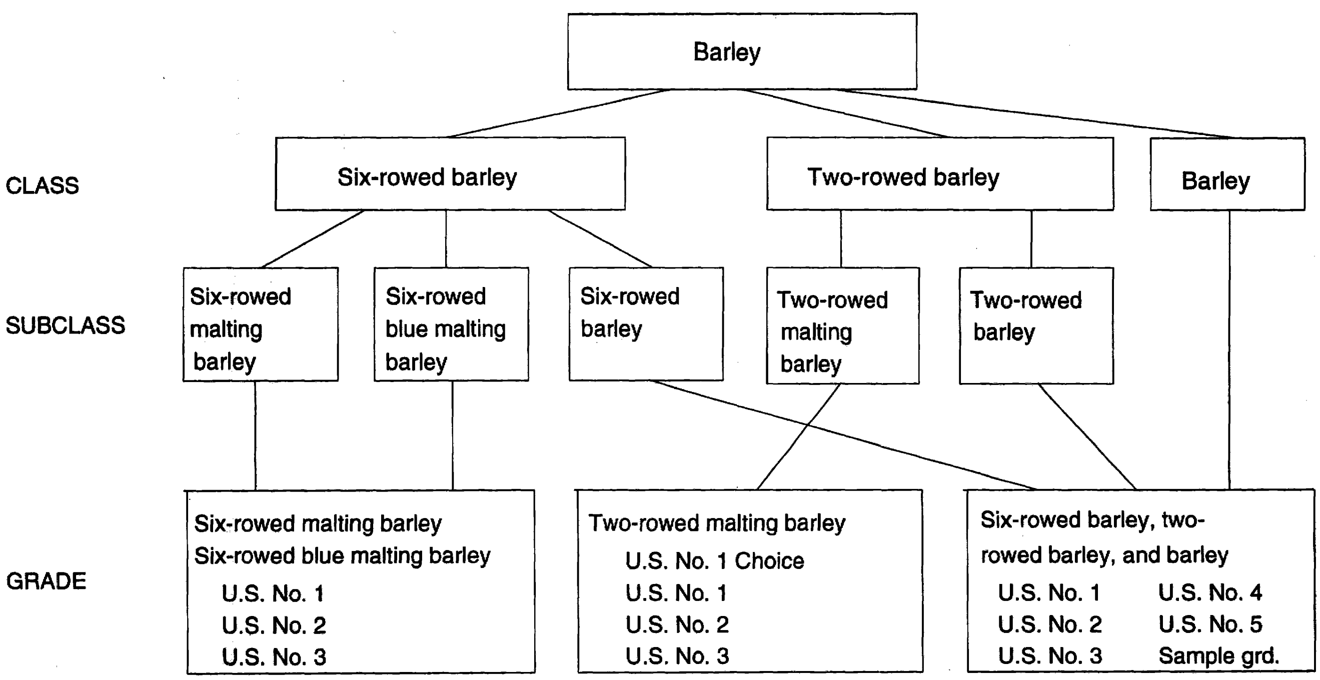
Source: Compiled by ERS, USDA from Federal Grain Inspection Service [15].

cates that actual dockage levels did not significantly change from 1985 to 1992. The average dockage content of ship-lots exported from the United States ranged from 1.2 percent in 1990 to 1.55 percent in 1986 (table 1). The average for all years was 1.37 percent.

The average dockage levels in shipments to selected importing country during 1985-92 were also analyzed. The country means ranged from 0.77 for Tunisia to 2.07 for Romania (table 2).

The dockage content was found to be the lowest for barley originating from East Coast ports (1.0 percent) and highest for exports from Gulf ports (1.68 percent). Dockage content in shipments from the West Coast ports and Great Lakes ports averaged 1.04 percent and 1.52 percent, respectively (table 3). Virtually all barley

Figure 3
Barley classes, subclasses, and special grades



SPECIAL SUPPLEMENTAL GRADE DESIGNATIONS: Blighted, Ergoty, Garlicky, Smutty, and Weevily.

Source: Adapted by ERS, USDA from Held and Leath.

going through Gulf and Great Lakes ports originated in the Dakotas and Minnesota; most West Coast port exports originated in Washington, Montana, Idaho, Oregon, and California. Exports of the class six-rowed barley had a higher average dockage content than exports of the class barley (feed). The official grade had little effect on the dockage content.

Barley Inspections, Grades, and Standards

U.S. grain grading standards provide all buyers with equal access to information on factors that affect the value of grain. Grades allow market participants to quickly understand the characteristics of the grain without inspecting it. In the domestic market, most farmers' grain is traded on the basis of "in-house" testing. FGIS-licensed inspectors often inspect grain sold between domestic companies, but all exports must be inspected by FGIS or an FGIS-approved agent.

Although importers may request that private inspectors also sample the grain, foreign buyers rely on FGIS's accuracy and settle on the basis of the official grade assigned by FGIS inspectors.

Barley is divided into three classes: six-rowed barley; two-rowed barley; and barley. The first two classes are designated for either malting or feed uses, depending on variety and physical characteristics (fig. 3). The American Malting Barley Association (AMBA), an influential consortium of the malting and brewing industry, recommends varieties suitable for malting purposes. Maltsters with special needs may also contract with producers to grow varieties that are not recommended by AMBA or they may promote special varieties that they are not yet willing to contract for. The malting subclasses are six-rowed malting barley, six-rowed blue malting barley, and two-rowed malting barley. Grades and grade requirements for six-rowed malting and blue malting barley are presented in table

Table 4--U.S. grades and grade requirements for the subclasses six-rowed malting barley and six-rowed blue malting barley[1]

	Grade[2]				
Grade-determining factor	U.S. No. 1	U.S. No. 2	U.S. No. 3	U.S. No. 4	U.S. No. 5
MINIMUM LIMITS OF:			*Pounds*		
Test weight per bushel	47.0	45.0	43.0	n.a.	n.a.
			Percent		
Suitable malting types	95.0	95.0	95.0	n.a.	n.a.
Sound barley[3]	97.0	94.0	90.0	n.a.	n.a.
MAXIMUM LIMITS OF:			*Percent*		
Damaged kernels	2.0	3.0	4.0	n.a.	n.a.
Foreign material	1.0	2.0	3.0	n.a.	n.a.
Other grains	2.0	3.0	5.0	n.a.	n.a.
Skinned and broken kernels	4.0	6.0	8.0	n.a.	n.a.
Thin barley	7.0	10.0	15.0	n.a.	n.a.

[1] Six-rowed barley that meets the requirements of U.S. No. 1 to U.S. No. 3, inclusive, for the subclasses six-rowed malting barley and six-rowed blue malting barley is classified and graded according to these requirements. Otherwise, it will be graded according to the requirements for the subclasses six-rowed barley and two-rowed barley, and the class barley (table 6).

[2] Six-rowed malting barley and six-rowed blue malting barley may contain not more than 1.9% of injured-by-frost kernels that may include not more than 0.4% of frost-damaged kernels; not more than 0.2% of injured-by-heat kernels that may include not more than 0.1% of heat-damaged kernels; that is not blighted, ergoty, garlicky, infested, or smutty; and that otherwise meet the grade requirements of the subclasses six-rowed malting barley and six-rowed blue malting barley; and may contain unlimited amounts of injured-by-mold kernels; however, mold-damaged kernels are scored as damaged kernels and against sound barley limits.

[3] Injured-by-frost kernels and injured-by-mold kernels are not considered damaged kernels or scored against sound barley.

n.a.—Grades not applicable for these subclasses.

Source: Compiled by ERS/USDA from Federal Grain Inspection Service [14].

Table 5--U.S. grades and grade requirements for the subclass two-rowed malting barley[1]

Grade-determining factor	Grade[2]				
	U.S. No. 1 Choice	U.S. No. 1	U.S. No. 2	U.S. No. 3	U.S. No. 4
MINIMUM LIMITS OF:			*Pounds*		
Test weight per bushel	50.0	48.0	48.0	48.0	n.a.
			Percent		
Suitable malting types	97.0	97.0	95.0	95.0	n.a.
Sound barley[3]	98.0	98.0	96.0	93.0	n.a.
MAXIMUM LIMITS OF:			*Percent*		
Wild oats	1.0	1.0	2.0	3.0	n.a.
Foreign material	0.5	0.5	1.0	2.0	n.a.
Skinned and broken kernels	5.0	7.0	10.0	10.0	n.a.
Thin barley	5.0	7.0	10.0	10.0	n.a.

[1] Two-rowed barley that meets the requirements of U.S. No. 1 choice to U.S. No. 3, inclusive, for the subclass two-rowed malting barley is classified and graded according to these requirements. Otherwise, it will be graded according to the requirements for the subclasses six-rowed barley and two-rowed barley, and the class barley (table 6).

[2] Two-rowed malting barley may contain not more than 1.9% of injured-by-frost kernels that may include not more than 0.4% of frost-damaged kernels; not more than 1.9% injured-by-mold kernels that may include not more than 0.4% mold-damaged kernels; not more than 0.2% of injured-by-heat kernels that may include not more than 0.1% of heat-damaged kernels; that is not blighted, ergoty, garlicky, infested, or smutty; and that otherwise meet the grade requirements of the subclass two-rowed malting barley.

[3] Injured-by-frost kernels and injured-by-mold kernels are not scored against sound barley.

n.a.—Grade not applicable for this subclass.

Source: Compiled by ERS, USDA from Federal Grain Inspection Service [14].

4, and for two-rowed malting barley in table 5. The grades and grade requirements for the class barley (table 6) apply to all grain that is either not an accepted malting variety or does not otherwise meet the grade requirements for the above subclasses (see glossary for a definition of various classes and grading terms).

Six-rowed malting barley varieties constitute the majority of malting barley varieties produced and used in the United States and are grown primarily in North Dakota, South Dakota, and Minnesota. A Farm Costs and Returns Survey conducted by ERS determined that 39 percent of the barley acres planted in 1992 were seeded to malting varieties [1, p. 47]. Not all barley planted to malting varieties is used for malting. Some grain may be too high in protein or otherwise deficient in other quality characteristics and will end up as feed. Excess supplies of high-quality malting barley may force good-quality malting barley into feed markets. The North Dakota State University survey of Midwest country elevators determined that 61 percent of the barley handled was six-rowed malting varieties and 4 percent was two-rowed malting varieties. In comparison, 40 percent of the barley sold by those country elevators was six-rowed malting varieties and 1 percent was two-rowed malting varieties. Thus, a significant percentage of the malting barley handled by those Midwestern elevators was eventually sold in feed markets [17, p. 36].

Barley grown in Western States is mostly two-rowed varieties used for feed. These States are generally deficit in feed grains, and producers raise two-rowed varieties because they yield better than six-rowed varieties. Some of these two-rowed varieties are exported to Asian markets. Most maltsters in Asian markets desire two-rowed malting varieties, which most of the world's German-trained brewers use. Brewers will not switch readily between classes and varieties of barley because they desire consistency of taste for their end products. Brewers instruct maltsters regarding their taste and preferences.

Table 6--U.S. grades and grade requirements for the subclasses six-rowed barley and two-rowed barley, and the class barley

Grade-determing factor	Grade[1] U.S. No. 1	U.S. No. 2	U.S. No. 3	U.S. No. 4[2]	U.S. No. 5
MINIMUM LIMITS OF:			*Pounds*		
Test weight per bushel	47.0	45.0	43.0	40.0	36.0
			Percent		
Sound barley	97.0	94.0	90.0	85.0	75.0
MAXIMUM LIMITS OF:			*Percent*		
Damaged kernels[3]	2.0	4.0	6.0	8.0	10.0
Heat-damaged kernels	0.2	0.3	0.5	1.0	3.0
Foreign material	1.0	2.0	3.0	4.0	5.0
Broken kernels	4.0	8.0	12.0	18.0	28.0
Thin barley	10.0	15.0	25.0	35.0	75.0

[1] U.S. Sample grade is barley that: (a) Does not meet the requirements for the grades U.S. Nos. 1, 2, 3, 4, or 5; or (b) Contains 8 or more stones or any number of stones which have an aggregate weight in excess of 0.2 percent of the sample weight, 2 or more pieces of glass, 3 or more crotalaria seeds (Crotalaria spp.), 2 or more castor beans (Ricinus communis L.), 4 or more particles of an unknown foreign substance(s) or a commonly recognized harmful or toxic substance(s), 8 or more cocklebur (Xanthium spp.) or similar seeds singly or in combination, 10 or more rodent pellets, bird dropping, or equivalent quantity of other animal filth per 1-1/8 to 1-1/4 quarts of barley; or (c) Has a musty, sour, or commercially objectionable foreign odor (except smut or garlic odor); or (d) Is heating or otherwise of distinctly low quality.

[2] Barley that is badly stained or materially weathered shall be graded not higher than U.S. No. 4.

[3] Includes heat-damaged kernels. Injured-by-frost kernels and injured-by-mold kernels are not considered damaged kernels.

Source: Compiled by ERS/USDA from Federal Grain Inspection Service [14].

The Economics of Cleaning Barley

Farmers

Producer surveys revealed that few farmers cleaned the barley that they sold in the feed or malting markets, although some cleaned grain that was intended to be used for seed on the farm. Without price discounts for dockage, there is little incentive for farmers to remove dockage, though they are capable of it. Closer monitoring of combine settings, planting certified seed, timely harvest, use of herbicides and tillage practices that effectively control weeds in fields, and cleaning of storage, handling, and transport equipment used for other crops all can reduce dockage in barley delivered to the marketplace. Some of these actions can be taken at little or no additional cost. Others may delay harvest, increase the costs of production, or result in lower harvest yields. Adjusting the combine settings to minimize dockage could result in loss of small, but just as valuable, barley kernels. More damaged or skinned kernels may also result, making the barley unsuited for malting. As a consequence, the price premiums that malting barley usually commands in the marketplace would be lost.

Even with higher discounts for dockage, relatively few farmers could economically justify the purchase of grain cleaners for their farms. The ownership and operating costs would outweigh the benefits because the cleaning equipment would not be in use for more than a few days during the year. Only the very largest farms could recover their investment. By contrast, commercial elevators handling larger volumes of grain throughout the year can utilize a grain cleaner closer to its rated annual capacity.

Commercial Elevators

The National Grain and Feed Association (NGFA) mailed a survey to 6,237 elevators that had grain storage agreements with the Commodity Credit

Corporation (CCC). Responses from 180 elevators that handled barley were returned, predominantly from country elevator operators in the Midwest. NGFA asked questions concerning source of purchase, dockage and foreign material levels received, amounts of dockage and foreign material removed through cleaning, premiums and discounts, costs associated with cleaning, storage and sales of screenings, and reasons for cleaning or not cleaning.

Elevator operators in the Midwest had the highest rate of ownership and use of grain cleaners for cleaning barley (97 percent) of all regions. Cleaning capacity averaged 3,461 bushels per hour per elevator in this region. Sixty-three percent of respondents in Mountain region had a cleaner, compared with 29 and 12 percent in the Central Plains and Pacific Northwest. Elevator operators that cleaned barley were generally the same ones that also cleaned wheat. This means there is sufficient cleaning capacity to clean the barley crop, although cleaning to a much lower dockage level will increase hours of use and operating costs. The NGFA survey made no distinction between "barley cleaners" and "general grain cleaners."

Country elevators in the Midwest cleaned 37 percent of barley handled, compared with 28 percent in the Pacific region and 9 percent in the Mountain region. This suggests that country elevators handling malting barley undertake more cleaning than those handling feed barley since most of the barley varieties grown in the Midwest are a malting type. In the Midwest, elevators specializing in malting barley cleaned more frequently (45 percent) than did elevators specializing in feed barley (32 percent).

Survey respondents in the Midwest indicated that barley received from farmers contained 1.47 percent dockage, compared with 1.18 percent and 0.56 percent in the Mountain and Pacific regions. Dockage content of barley received was an important criterion for whether respondents cleaned or not.

Unlike dockage content, other quality characteristics—such as protein, test weight, foreign material, and thin barley—usually have a market price discount. Most elevator managers do not segregate barley in storage on the basis of dockage content. Dockage is a non-grade determining factor. Most market transactions treated dockage in one of two ways. A gross-weight purchase means that the elevator manager pays on the basis of the total weight of barley and dockage—an implicit discount of zero for barley dockage. A net-weight purchase means that the elevator manager pays on the gross-weight of grain less the weight of dockage (or dockage exceeding a specified allowance). The effective discount for dockage equals the difference between the actual dockage percentage and the allowable dockage percentage times the barley price.

Eighty-six percent of Midwest elevator managers made purchases on a net-weight basis when purchasing malting barley, compared with 69 percent and 43 percent of Pacific and Mountain managers. Alternatively, fewer Midwest elevators and more Pacific elevators handling feed barley deducted the weight of dockage at the point of purchase.

Maltsters

Cleanliness was low on the list of attributes that maltsters seek, behind varietal purity, high germination, plumpness, low protein, and low damage. Maltsters can and do clean barley, but they cannot alter intrinsic quality characteristics through handling and conditioning. Some maltsters make pre-planting contracts with producers to ensure a supply of specific barley varieties. Contracting is more common in the Mountain region because feed varieties generally yield more than malting varieties and other higher-valued crops compete with barley for acreage in that region.

Maltsters clean all barley prior to malting to reduce dockage and foreign material to levels that will not compromise the taste and sanitary quality of the end product. Maltsters generally purchase on a net-weight basis; however, malting companies generally did not deduct for the first percentage point of dockage. This margin of error reduces skinned kernels in harvesting and elevator cleaning. Maltsters' cleaning operations are performed in a manner that avoids skinning the barley kernels. Skinned kernels either do not germinate or germinate too quickly, which lessens malt quality.

Feed Industry

Feed manufacturers generally run barley through a rock-catcher to remove stones. This is done to protect mill equipment from large nongrain materials such as stones, straw, or metal. Feed millers purchase barley net of dockage. During years when malting barley is in oversupply, barley of acceptable malting quality may be sold in feed markets.

The Costs of Cleaning Barley

Elevators do not clean when initial dockage levels are relatively low, when premiums and discounts for dockage are low or absent, and when the cost of owning a cleaner is too high compared with its expected use. This section outlines the major fixed and variable costs involved in owning and operating a representative reciprocating air screen cleaner (see glossary for definition of different grain cleaners).

Fixed-Cost Components

Ownership of a capital asset (grain cleaner) carries certain costs that are fixed regardless of the number of hours the cleaner is operated. Consequently, average fixed cost declines as the cleaner's rate of use approaches the cleaner's rated capacity. Increasing cleaner use from 50 days to 100 days reduced average costs (excluding grain loss) by 55 percent [17]. The two major fixed-cost components of owning a grain cleaner are depreciation and opportunity cost of the investment, although others (insurance, taxes) may also add to total cleaning cost.

Depreciation

Depreciation is the decline in value over time of a durable asset because of age or wear from use. Depreciation in NDSU's economic-engineering study was determined using a straight-line schedule for 25 years. This means that the value of the cleaner would decline by 4 percent each year after purchase and have zero salvage value after 25 years. This simplified case is assumed even though cleaners differ in their useful life, depreciation may occur more rapidly in early years rather than at the uniform rate, and tax laws that allow depreciation write-off well before the end of the useful life may change, making the year of purchase a factor in the true cost of owning that asset. An alternate method that allocates depreciation based on hours of use (with an expected useful life of 175 million bushels) rather than time would lower total cleaning costs by about 0.2 cent per bushel.

Opportunity Cost of Capital

The opportunity, or interest, cost represents the interest income forgone by purchase (and installation) of the cleaning system. The NDSU study used the existing long-term loan rate of 6.85 percent per annum from the St. Paul Bank for Cooperatives, which serves many country elevator operators. This opportunity cost was charged against one-half of the purchase price and installation cost of the cleaning system.

Variable-Cost Components

These costs increased with hours of use or bushels cleaned. Average variable costs per bushel increased as the working capacity decreased. This occurs when cleaning to a lower dockage level. The major variable-cost components were barley loss, energy, maintenance, and labor.

Barley Loss

Barley loss is marketable barley (small, saleable kernels) inadvertently removed with dockage during the cleaning operations. It may also include grain lost through additional handling required to perform cleaning operations. Although barley loss is one of the most critical components of variable cleaning cost, little research or industry data exist on this topic. Cleaner manufacturers claim that no plump barley is lost in the cleaning process, but the results from controlled experiments are not comparable with real-world, practical applications. Loss of thin kernels still represents a loss of saleable barley. Also, an economic loss occurs if the additional handling of barley causes skinned and broken kernels in two-rowed malting barley, six-rowed malting barley, and six-rowed blue malting barley to increase to levels that are discounted in the malting barley markets. If barley loss and damage to the kernels were truly zero, then nearly all market participants would have an incentive to clean to very low dockage levels. In reality, some elevators do not clean at all and few to dockage levels below 0.5 percent. Wilson and others estimated that barley loss accounted for 85-89 percent of total costs of cleaning [17]. Barley loss is affected by the cleaner's efficiency, beginning and ending dockage levels, type of dockage, moisture, kernel size, and test weight.

Energy

Electric motors produce the motion needed to shake or rotate the screens. Horsepower varies with the cleaning capacity and type of cleaner but a motor's draw on electricity is about 0.746 kilowatt-hour per horsepower per hour of operation. The representative cleaner had 23.5 horsepower. Electricity was priced at 7 cents per kilowatt-hour, which includes a facility charge, a peak demand charge, and quantity discounts.

Labor

Grain cleaners require relatively little labor to operate. Most elevator managers surveyed stated that 10-15 minutes per hour of operation were devoted to starting, inspecting, and adjusting the cleaner. Wage rates were based on results of a 1981 survey of North Dakota grain elevator employees' compensation, which was indexed to the Consumer Price Index for the current wage ($7.71 per hour). Labor requirements were assumed to be 12 minutes per hour of cleaner operation. However, if labor at the elevator is already under utilized, the additional labor costs due to cleaning operations could be overstated. Labor costs at terminal and export elevators would be higher as prevailing wage rates in these areas exceed those found in more rural locations.

Maintenance

Maintenance costs are expenses incurred from the upkeep of cleaning equipment in regular use. Such costs include lubrication; cleaning; and replacement of disks, cylinders, motors, bearings, and screens. Maintenance costs were based on cleaner manufacturers' recommendations. For example, maintenance cost for a reciprocating air screen was $3.75 per 8 hours. A replacement screen for this cleaner has a useful life of 10 million bushels and costs about $1,070.

Economic-Engineering Costs at a Country Elevator

Economic-engineering costs for cleaning dockage from barley were derived from information obtained from surveys of cleaner manufacturers and country elevators and interviews with elevator managers, manufacturer representatives, and agricultural engineers. Screen cleaners were used for two reasons. First, these were the only cleaner types represented in NDSU surveys. Second, manufacturers indicated that this was the predominant cleaner type.

Barley-cleaning costs using a reciprocating air screen were estimated and converted to an annual and per-bushel basis (table 7). Engineering costs were estimated assuming an initial dockage of 2.5 percent and ending dockage levels of 1.0, 0.8, 0.5, and 0.2 percent. The 0.2-percent level illustrates the impact on costs of more precise cleaning, assuming the cleaner was operated 100 days per year at 7 hours per day.

The cleaner had a purchase price of $49,000 and an installation cost of $30,000. It had a built-in dust removal system. Depreciation cost per unit, when cleaning 1.4 million bushels per year from an initial dockage level of 2.5 percent to a final dockage level of 0.8 percent, was estimated to average 0.26 cent per bushel. Cleaning to final dockage level of 0.2 percent would have reduced the number of bushels cleaned and would have increased depreciation cost to 0.37 cent per bushel.

These estimates illustrate the importance of barley loss relative to other operating costs. A reciprocating air screen cleaner used for 700 hours to reduce dockage from 2.5 percent to 1 percent would clean 1.5 million bushels of barley. Even with a low rate of barley loss (at 1.5 percent), the cost of barley loss totaled about $38,000 when barley was valued at $1.75 per bushel. This would average about 2.6 cents per bushel cleaned. By comparison, energy, maintenance, and labor costs together would be less than 0.2 cent per bushel cleaned. A higher rate of barley loss (at 4 percent) when barley is cleaned to a final dockage level of 0.2 percent would increase the cost of barley loss to about 7 cents per bushel.

The Benefits of Cleaning Barley

The benefits of cleaning barley are categorized into domestic benefits and international benefits. The components of each are discussed in this section.

Domestic Benefits

Midwestern country elevators often clean barley to meet contract specifications on dockage, and this would be the only reason for cleaning barley at export elevators. However, additional benefits from cleaning

Table 7--Economic engineering barley-cleaning costs at a country elevators[1]

Item		Cleaned from 2.5-percent beginning dockage to an ending dockage of: 1.0 percent	0.8 percent	0.5 percent	0.2 percent
Variables:					
Volume cleaned (million bushels)		1.463	1.386	1.232	1.001
Barley loss (percent)		1.50	2.10	2.70	4.00
Barley loss (bushels)		21,945.00	29,106.00	33,264.00	40,040.00
Value of barley loss (dollars)		38,403.75	50,935.50	58,212.00	70,070.00
Fixed costs:	*Dollars/year*	*Cost of cleaning in cents per bushel*			
Depreciation	3,672	0.25	0.26	0.30	0.37
Opportunity cost	3,144	0.21	0.23	0.26	0.31
Total fixed	6,816	0.46	0.49	0.56	0.68
Variable costs:					
Energy	1,006	0.07	0.07	0.08	0.10
Labor	1,079	0.07	0.08	0.09	0.11
Maintenance	328	0.02	0.02	0.03	0.03
Total variable	53,349	0.16	0.17	0.20	0.24
Total operating costs	60,165	0.62	0.66	0.76	0.92
Barley loss	Varies	2.63	3.68	4.73	7.00
Total cleaning costs	Varies	3.25	4.34	5.49	7.92

[1] Cleaning costs are based on the following assumptions: use of a reciprocating air screen cleaner with 2,200-bushel-per-hour capacity and 23.5-horsepower motor; cleaner investment of $79,000 (including installation and a dust collection system) depreciated straight-line method over 25-year useful life; operated for 700 hours per year; barley loss of 1.5 percent, 2.1 percent, 2.7 percent and 4.0 percent, respectively, when cleaning from 2.5-percent beginning dockage to 1.0 percent, 0.8 percent, 0.5 percent and 0.2 percent dockage, respectively; expected useful life of 10 million bushels for the screens; 7.5 hours of labor to change the screen; 12 minutes per hour labor; wage rate of $7.71 per hour.

Source: Compiled by ERS/USDA from Wilson, Scherping, Cobia, and Johnson [17].

barley at the country elevator include transportation cost savings, improved storability, and potential price premiums (discount avoidance) through upgrading. The sale of screenings in domestic feed markets also offsets the cost of cleaning.

Transportation Cost Savings

Purchasers typically deduct dockage from the gross weight of grain to determine the quantity purchased, but elevators, as the seller, pay transportation costs based on the gross weight of the shipment. By reducing dockage, elevators can reduce their freight charges. Removing dockage increases the amount of grain that can be shipped in a rail car so the per-car charge is spread over a larger quantity of grain. The higher the transportation rate, the greater the potential savings from removing the dockage from barley. Or, the higher the dockage level, the higher the transportation savings from cleaning. Freight costs used in the estimates are based on medium-haul shipments (500-600 miles). These range from 20 cents per bushel in California to 50 cents per bushel in the Dakotas.

Transportation cost savings are not available to export elevators. Foreign buyers normally purchase grain free-on-board (FOB) at U.S. ports and make arrangements for ocean freight. Because of the potential savings in transportation cost, foreign buyers may be willing to pay a slightly higher price for low-dockage grain. Offering cleaner barley for export could enhance the competitive position of U.S. barley in international markets since barley offered by some competing exporters has a lower dockage content.

Improving Storability

Cleaning barley can reduce insect damage during storage. However, cold winter temperatures in the major barley-producing regions generally prevent significant insect damage in grain stored during the marketing season. Uniformly low-moisture grain stores better, and clean barley is easier to dry. Barley expected to be stored longer, or with much higher initial dockage, would produce larger storage benefits if cleaned. This would pertain more to farmers and country elevators as terminal and export elevators generally do not hold barley long or in great quantity.

Midwestern country elevators responding to the NGFA survey rated improved storability as a "somewhat important" reason for cleaning barley. Previous research on the costs and benefits of cleaning wheat [5] revealed that the insect management benefits from cleaning winter wheat was about 0.2 cent per bushel when stored for 6 months. Benefits for spring wheat and barley are believed to be smaller and were not estimated in the NDSU studies.

Upgrading Feed Barley to Malting Barley

Cleaning, sizing, and blending can reduce the proportion of thin barley and broken kernels enough to upgrade from feed barley to malting barley. The extent to which this is done depends on the difference between the additional operating costs for cleaning and the market-determined premium for malting barley. During the 1985-94 crop years, the average price premium for malting barley ranged from $0.21 per bushel in 1991/92 to $1.79 in 1988/89 and averaged $0.62 for the period.[4] A high premium for malting barley may induce more elevators to clean barley.[5] Cleaning barley at commercial elevators is practical to the extent that thin barley can be reduced to a level that meets the grading standards for malting barley without skinning more kernels. However, cleaning barley that would not make the malting grades for other reasons may result in a larger loss in the value of feed grain than would be gained from a lower discount for thin barley.

Screenings Revenue

Screenings are a byproduct that partially offset the cost of cleaning. Revenue from screening sales may help determine whether cleaning is economically feasible or not. The higher the value of screenings relative to the price of barley, the lower the beginning dockage at which cleaning becomes practical. The NDSU study indicates that screenings prices would need to be at least 38 percent of the barley price to break even at a 2.5-percent initial dockage cleaned down to 0.8 percent.

The regional average screenings price from the 1991 NGFA survey ranged from $33 per ton in the Midwest to $45 per ton in the Mountain States to $73 per ton in the Pacific. These values will be used later to calculate the net costs and benefits of cleaning barley in the major producing States. Elevators usually sell directly to the feed market or use the screenings in their own feed mills. Screenings are typically used locally, and Midwest elevators reported an average shipping distance of 46 miles.

International Benefits

Nearly all U.S. exports of barley are of the class barley, which is used for livestock feed. Less than 8 percent of U.S. barley exports are six-rowed malting barley. The United States has also exported an increasing volume of barley malt in the last decade but still has only a 2.5-percent world export share. The major importers of U.S. barley during the last decade have been Saudi Arabia, Japan, Israel, Algeria, Jordan, Cyprus, and Tunisia. The European Union, Canada, and Australia are the other major barley exporters.

While the United States continues to dominate the world coarse grain market, U.S. exporters have been under more pressure to remain competitive in the last decade [7]. U.S. barley exports, although small in comparison to corn exports, are no exception. While world barley exports have more than tripled since 1960, U.S. exports have stagnated. Most of the export gains were made by the European Union countries. The U.S. market share of world barley exports declined from 17 percent in the 1960's to 8 percent in 1980-94. However, average dockage levels in U.S. barley exports remained fairly constant during the study period, averaging about 1.4 percent (table 1), suggesting relative price was the main cause of fluctuating exports. The increasing amount of world trade in feed wheat and corn exert far more effect on total U.S. barley exports than any quality factor.

Cleanliness of barley is much less critical than of wheat because U.S. barley exports are primarily used

[4] Average differential between the cash prices for barley, No. 3 or better malting, 65% or better plump, Minneapolis; and barley, No. 2 or better feed, Duluth.

[5] High premiums for malting barley may reflect a number of factors, including a tight supply of plump, low-protein malting varieties; problems with vomitoxin, etc. These factors will limit the potential for upgrading through cleaning operations.

for feed. In most cases, the lower feed value of dockage is accounted for by deducting dockage from the gross grain weight. Foreign buyers always have the option of specifying a level of cleanliness that would match that of competitors' barley in their contracts, because dockage is not a grade-determining factor for U.S. barley. Most foreign buyers are aware that they can obtain low-dockage barley (about 0.2 percent) from Canada and Australia. Importers purchase from U.S. exporters when they can get the best price from them. While quality and cleanliness requirements of importers for malting barley are more stringent than for feed barley, the United States exports little malting barley. Foreign buyers have not registered official complaints with FGIS regarding excessive dockage in barley. Price or other quality factors are usually more important for them. Consequently, the trade impacts were assumed to be negligible and were not included in the cost/benefit analysis.

Net Benefits of Barley Cleaning

The net benefits derived from cleaning barley are calculated as:

Value of screenings sales
\+ Transportation cost savings
\+ Avoidance of market discounts
\+ Malting premium through upgrading
\- Costs of cleaning (fixed and variable)
\- Market value of barley loss.

The value of screenings sales and potential savings in transportation costs vary substantially across locations and through time. Market discounts for excess dockage and the possibilities for upgrading barley from feed to malting quality were excluded from the calculation of net benefits because the variables are difficult to quantify. Dockage discounts for barley are not a standard industry practice in the current marketing system, although buyers specify them in individual transactions. Upgrading barley (which typically involves cleaning, sizing, and blending operations) is a more common practice at country elevators, and it is driven by the price spread between feed and malting barley and is constrained by the quality and quantity of available supplies of barley with desirable levels of protein, sound kernels, and thin barley.

Base Case Assumptions Used in the Analysis

The net benefits of cleaning barley beyond the current level were estimated under a set of base assumptions and data based on surveys. Operating costs (excluding barley loss) were 0.63 cent (per bushel), 0.67 cent, 0.75 cent, and 0.92 cent when reducing dockage levels from 2.5 percent to 1.0, 0.8, 0.5, and 0.2 percent (table 8). Barley loss was assumed to total 1.5 percent, 2.1 percent, 2.7 percent, and 4.0 percent of the volume cleaned for the respective ending dockage levels.

The NDSU study evaluated how much the base assumptions would have to change to make cleaning profitable. Value of barley loss was the highest cost

Table 8--Summary of economic engineering costs and benefits of cleaning barley at country elevators to various ending dockage levels using base case assumptions[1]

	Ending dockage			
	1.0 percent	0.8 percent	0.5 percent	0.2 percent
	Cents per bushel cleaned			
Net benefit per unit	-0.46	-0.80	-1.10	-2.05
Cost components:				
Value of barley loss	-2.63	-3.67	-4.73	-7.00
Operating costs	-0.63	-0.67	-0.75	-0.92
Benefit components:				
Sale of screenings	1.30	1.64	2.03	2.72
Transportation savings	1.50	1.90	2.35	3.15

[1] Assumes an initial dockage level of 2.5 percent, a barley price of $1.75 per bushel, a screening price of $18.00 per ton, and transport costs of 50 cents per bushel.

Source: Compiled by ERS, USDA from Wilson, Scherping, Cobia, and Johnson [17].

Table 9--Variables used for calculation of aggregate net benefit, 10 major producing States

State	1991 barley price[1]	1991 production	Value of screenings	Transport cost
	Dol./bu.	*Mil. bu.*	*Dol./ton*	*Cents/bu.*
California	2.54	9.4	73	20
Colorado	3.14	10.4	45	35
Idaho	2.77	59.3	45	35
Minnesota	1.79	43.8	33	50
Montana	2.34	85.8	45	50
North Dakota	1.77	138.7	33	50
Oregon	2.25	12.6	73	20
South Dakota	1.74	17.9	33	50
Washington	2.25	37.1	73	20
Wyoming	2.24	10.5	45	35

[1] Prices are 1991/92 marketing year prices received by producers. Wyoming price is based on reported Utah price.
Source: Compiled by ERS, USDA from Wilson, Scherping, Cobia, and Johnson [17].

component, and it depended on the price of barley and the percent lost during cleaning. Barley loss had to be near zero percent at various levels of ending dockage to make cleaning universal. Lowering the barley price to $1.25 per bushel from the base level of $1.75 made cleaning profitable when other parameters were held constant. Lowering the barley price reduces the value of barley loss sufficiently that net benefits from cleaning are positive. Higher barley prices would raise the value of barley loss, thereby reducing the net benefit of cleaning. Using these assumptions, cleaning was profitable only when reducing dockage from a high level (4 percent) to a level of not less than 0.5 percent.

At a transportation rate of 50 cents per bushel, cleaning to a final dockage level of 0.8 percent becomes profitable only when beginning dockage exceeds 3.25 percent. Higher transportation rates would be needed to lower the beginning dockage level and make cleaning economical.

The $18-per-ton screenings price used in the analysis was about one-quarter of the value of barley at $1.75 per bushel. If screenings bring $18 per ton, beginning dockage would have to exceed 3 percent to break even on cleaning. At higher screening values, cleaning becomes profitable at lower levels of initial dockage. It is unlikely that screenings values could appreciate while holding the price of barley (and barley loss) constant.

Aggregate Net Benefit of Cleaning Barley by State

This analysis assumed an initial dockage level of 1.5 percent in all States. This is slightly higher than the national weighted-average dockage level of 1.1 percent derived from the NGFA survey. The survey data on dockage levels were not used at the State level because responses from individual States were too few to justify the use of State averages in this analysis. Barley prices, production, value of screenings, and freight rates for each barley-producing State were derived from secondary sources and survey results (table 9).

The NDSU researchers estimated the aggregate net cost of cleaning all barley produced for the 10 major barley-producing States (comprising about 90 percent of U.S. production) at $3.9-$7.2 million, depending on ending dockage (from the 1.5-percent initial dockage) (table 10). Barley loss was the largest variable cost associated with cleaning, accounting for up to four-fifths of total costs (table 11, fig. 4).

Aggregate Net Benefit of Cleaning Barley by Cost and Benefit Component

Per bushel marketed, net economic costs range from -0.9 cent to -1.7 cents, depending on ending dockage. Costs and benefits of cleaning barley were not estimated for export elevators, but costs would have been higher than for country elevators because of (1) higher value of barley loss during cleaning (the price of barley

Table 10--Aggregate net benefit of cleaning barley from 1.5 percent dockage to various ending dockage levels, 10 major producing States, 1991/92 marketing year

State	Ending dockage level			
	1.0 percent	0.8 percent	0.5 percent	0.2 percent
	Thousand dollars			
California	-52.03	-47.92	-33.60	-65.68
Colorado	-259.91	-336.41	-407.18	-610.76
Idaho	-1,151.89	-1,456.22	-1,727.86	-2,602.67
Minnesota	-328.63	-344.59	-342.53	-527.98
Montana	-856.26	-972.25	-1,027.83	-1,608.51
North Dakota	-1,000.04	-1,033.96	-1,010.80	-1,562.57
Oregon	-14.63	12.77	53.82	58.50
South Dakota	-121.30	-122.46	-116.24	-180.62
Washington	-37.47	45.35	168.25	186.82
Wyoming	-122.58	-143.81	-159.24	-243.53
10 State total	-3,944.74	-4,399.50	-4,603.21	-7,157.00

Source: Compiled by ERS/USDA from Wilson, Scherping, Cobia, and Johnson [17].

Table 11--Components of aggregate net benefit of cleaning barley production from 1.5 percent beginning dockage to various ending dockage levels, 10 major producing States, 1991/92 marketing year[1]

	Ending dockage			
	1.0 percent	0.8 percent	0.5 percent	0.2 percent
	Million dollars			
Total net benefit	-3.9	-4.4	-4.6	-7.2
Cost components:				
Value of barley loss	-13.7	-19.1	-24.6	-36.5
Costs of cleaning	-2.8	-2.8	-3.2	-3.9
Benefit components:				
Sale of screenings	8.9	12.4	16.4	23.5
Transportation savings	3.7	5.1	6.8	9.7

[1] Estimates calculated using the data on production, prices, screening values, and transportation charges presented in table 9.
Source: Compiled by ERS, USDA from Wilson, Scherping, Cobia, and Johnson [17].

at ports is higher since it includes additional transportation and handling costs); (2) higher fixed costs due to the higher property values at ports, and the need to either match cleaning and load-out capacity or to acquire additional storage capacity; and (3) higher labor costs because wage rates are generally higher in port cities. Likewise, potential benefits would be less at export elevators because of (1) reduced market opportunities for screenings (there are fewer nearby livestock operations, and higher transportation and handling costs would reduce the net price of screenings); and (2) no opportunity to save transport cost because foreign buyers pay for ocean freight.

Table 12 shows how much the estimates of total net cost would change from the base case given a change in one of the parameters, holding all others constant. The analysis indicates that only a combination of lower barley prices, higher screenings prices, higher transportation costs, and higher initial dockage levels would yield a positive net benefit from cleaning.

Policy Options

This section explores alternative policy options for improving the cleanliness of U.S. barley and for better meeting the quality needs of foreign buyers. Policy

Table 12--Sensitivity of aggregate total net benefit of cleaning U.S. barley production from 1.5 percent beginning dockage to various ending dockage levels using varying assumptions

	Ending dockage			
	1.0 percent	0.8 percent	0.5 percent	0.2 percent
	Million dollars			
Base case assumptions	-3.9	-4.4	-4.6	-7.2
Alternative assumptions				
Lower Initial dockage: (1%)	N/A	-7.6	-7.8	-10.4
Higher Initial dockage: (2%)	-0.7	-1.2	-1.4	-3.9
Barley price: 10 % lower	-2.6	-2.5	-2.1	-3.5
Barley price: 10 % higher	-5.3	-6.3	-7.1	-10.8
Screenings value: 20 % lower	-5.7	-6.9	-7.9	-11.9
Screenings value: 20 % higher	-2.2	-1.9	-1.3	-2.5
Transportation cost: 20 % lower	-4.7	-5.4	-6.0	-9.1
Transportation cost: 20 % higher	-3.2	-3.4	-3.2	-5.2

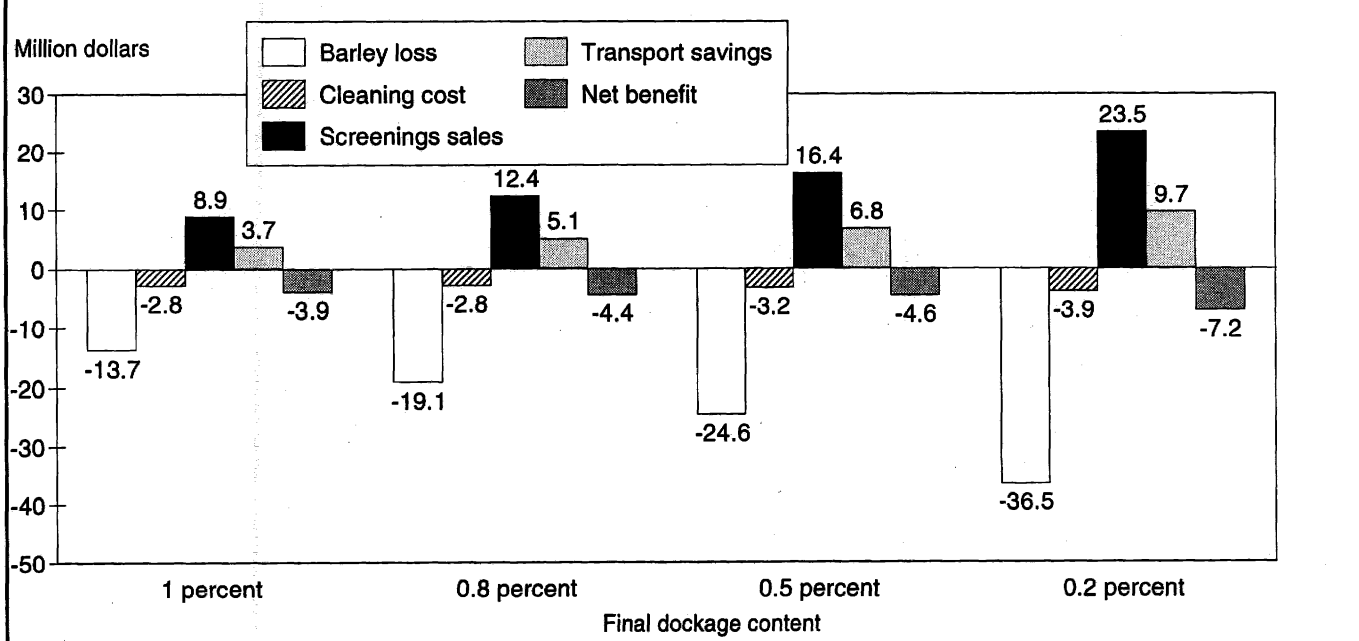
N/A = Not applicable.
Source: Compiled by ERS, USDA from Wilson, Scherping, Cobia, and Johnson [17].

options included in this section must be further evaluated in terms of their cost-effectiveness before any serious consideration. Three sets of policy options are considered: (1) change the FGIS dockage reporting/recording methods, (2) change the U.S. grades and standards for barley by including dockage as a grade-determining factor, and (3) include grain cleanliness as a tertiary objective of the Export Enhancement Program.

Changing Dockage Reporting Methods

Currently, dockage in barley is measured and recorded by FGIS inspectors in hundredths of a percent, but cer-

Figure 4
Components of total net benefit of cleaning barley from 1.5 percent dockage, base case assumptions



Source: Compiled by ERS, USDA.

tified officially in truncated whole percents. For instance, if the dockage tester measures between 0-0.99 percent dockage, the certificated dockage is 0 percent. Similarly, 1.00-1.99 percent dockage is recorded as 1 percent dockage. When the maximum nondeductible level is exceeded, the seller is "penalized" by a weight reduction equal to the difference between the reported dockage level and the maximum nondeductible level. The seller benefits from this procedure because this method of reporting always understates the actual dockage levels. Also, there is little motivation to reduce dockage within a given 1-percent range, except at the lower ends of the range so as to evade the penalty. While domestic buyers generally perform their own dockage determination, foreign buyers rely more heavily on the accuracy of FGIS inspection.

Dockage in wheat was recorded in truncated half-percents prior to 1987. However, in May 1987, FGIS instituted new cleanliness rules for wheat that required dockage to be reported in tenths of a percent. Wheat dockage has noticeably declined since the change. In April 1991, FGIS recommended that dockage be reported in tenths of a percent for barley and sorghum. However, the proposal met with opposition from grain handlers and merchants, and FGIS elected to investigate alternative options regarding dockage prior to possible action at a later date.

Under the current policy, sophisticated blending procedures allow grain merchandisers to combine barley lots with dockage levels slightly exceeding a given percentage with cleaner barley so as to bring the former lots under a given percentage "ceiling" and avoid a 1-percent weight reduction. During 1988-92, the measured dockage in 535 lots of barley inspected for export averaged 1.4 percent. Only 21 lots (3.9 percent) were shipped with dockage levels exceeding 2 percent. However, 31 lots had dockage levels between 1.90 and 1.99 percent, and 40 lots were between 1.80 and 1.89 percent.

If penalties (weight reductions) had been imposed for any measured dockage, total barley exports of 8.9 million metric tons during 1988-92 would have been reduced by 0.55 percent (48,780 metric tons). At a barley price of $2 per bushel, this quantity reduction would have resulted in a $4.5-million loss of sales to barley exporters. Thus, barley importers were charged $4.5 million over this 5-year period for what really amounted to low-valued screenings. On the other hand, if dockage had been reported in tenths of a percent, with weight reduction imposed for any reported dockage, then total barley exports would have been reduced by only 0.046 percent (4,069 metric tons). That is, the difference between reporting dockage in truncated whole percentage points and truncated tenths of a percentage point amounted to 44,711 metric tons during 1988-92, or $4.1 million.

The NDSU study reported that when U.S. and Canadian grain inspectors measured dockage in 25 paired samples according to the official testing procedures used in each country, the Canadian tests averaged about 0.45 of a percentage point higher than the U.S. tests. FGIS measurements of dockage in the 25 samples averaged about 0.7 percent, and the Canadian measurements about 1.1 percent. Canadian dockage is certified to the nearest tenth. Any importer, including U.S. importers, would prefer to purchase Canadian barley (price and reported dockage being equal) because Canadian barley would actually be cleaner (due to less rounding down).

Reporting dockage in tenths of a percentage point would benefit barley end-users, primarily feed manufacturers and importers, with costs passed back through the marketing channel to producers and intermediate handlers. Accurate measurement and recording of dockage may help U.S. barley compete with foreign barley exporters and against competing feed grains by providing buyers with information on what portion of the nongrain material would be easily removable by simple screen cleaners (dockage) and what portion is not (foreign material). An accurate accounting can only help enhance the reputation of U.S. grain standards as being objective and fair.

In June 1997, a new procedure will report dockage in U.S. barley in half and whole percents with a fraction less than one-half percent disregarded. This change will reduce the undisclosed dockage by 50 percent. The new procedure provides a more accurate description of non-barley material, and it will enable handlers and end-users to better evaluate quality, storability, and end-product yields. Also, actual dockage (to tenths of a percent) will be provided in the remarks section of the grade certificate upon request.

Opposition to reporting dockage in tenths of a percent exists because of the increase in weight reduction penalties and because a new variable would be introduced into barley marketing. Blending would have little effect on weight discounts (except in the hundredths-percent column). Because of this, and because costs would be borne solely by suppliers, some may prefer to see dockage included as a grade-determining factor.

Add Dockage as a Grade-Determining Factor

Grade-determining factors establish the numerical grade according to established factor limits. The United States Grain Standards Act (USGSA) states that the primary objective for grain standards is to certify grain quality as accurately as possible. The basic objectives for grain standards are: (1) to define uniform and accepted descriptive terms to facilitate trade, (2) to provide information to aid in determining grain storability, (3) to offer users of the standards the best possible information from which to determine end-product yield and quality, and (4) to provide the framework necessary for markets to establish grain quality improvement incentives.

In deciding whether a factor can be used for grade determination, the 1989 study by the Office of Technology Assessment developed the following guidelines:

> "...standards should serve the needs of a majority of users and should reflect value for those uses. This suggests that grade determining factors should be those that relate to sanitary quality, purity, and soundness (absence of imperfections). Using this guideline, the grade would be based on factors such as impurities, foreign material, total damage, and heat damage. The lower the values of any of these defects, the greater is the value of the product. Non-grade determining factors would be those related to properties such as broken kernels, moisture, oil and protein content, and other intrinsic characteristics or physical properties that influence value for the major processing uses. Higher or lower percentages for these do not necessarily mean higher end-use value over the entire range." [8, p. 210]

Dockage is clearly an impurity that is not related to the end-use value of barley. It is distinct from foreign material in that it has a different size than barley kernels and can be removed by cleaning the grain. The amount of dockage recorded on an inspection certificate informs the buyer not only how much nongrain material must be removed but (implicitly) how much was paid to transport a lower-valued material. Currently, if importers desire to limit cleaning and freight costs through lower dockage levels, they must specify this in the purchase contract. Many sophisticated buyers already understand this system. However, some buyers may not understand that dockage can vary independent of the grade and thus feel that they are not getting the same consistency of cleanliness when they pay for a superior grade. Without specifying a contractual maximum for dockage, there is no guarantee that grade U.S. No. 1 barley will have less dockage than grade U.S. No. 2. Certainly, contracts can and do satisfy importers' cleanliness requirements, but there is no formal procedure to transmit this information back to producers, first handlers, and the Commodity Credit Corporation (CCC).

Adding dockage as a grade-determining factor in barley may slightly facilitate marketing and price-discovery. For example, buyers would know that the amount of dockage in U.S. No. 1 barley would always be in a range that was less than the average for grade U.S. No. 2 barley. This is not necessarily true under the current system although it is usually true that smaller-numbered grades have less dockage. This consistency between crop years may help some buyers as they would learn that specifying a particular grade would result in proportionate transportation and cleaning costs. Thus, this change may improve communication about the total amount of non-barley material that would be received in a particular grade of barley in any given year.

If the grade limits for dockage are set too low, importers who did not wish to pay a premium for cleaner grain could still specify a higher-numbered grade of barley (with contract maximums on other factors). Importers would buy a grade that has limits closest to what they previously received at a lower cost. However, they would likely continue to demand the factor limits of the lower-numbered grade that they previously received. This change could also cause exporters to rewrite some contracts and could lower the market's base grade. Setting limits that have all export barley grading out as U.S. No. 1 on dockage does not serve any useful purpose; limits should be binding. On the other hand, limits need to be sensitive to the impact on barley producers and merchants. Thus, standards should not be so tight that all export barley would go out as grade U.S. No. 3 if it were not cleaned. Because dockage is already recorded on official inspection forms (but reported to the importer only if requested), making it a grade-determining factor would not increase FGIS administrative costs.

Reasonable limits for dockage can be inferred from other barley grade-determining factors. Non-binding limits currently exist for three factors: heat-damaged kernels, broken kernels, and foreign material. During 1988-92, all U.S. export barley graded out as U.S. No. 1 on each of these factors. Similarly, 97.4 percent of all U.S. export barley graded U.S. No. 1 on test weight, with the rest grading U.S. No. 2. The three remaining factors were more binding. Damaged kernels was the least restrictive of these three factors, with 80 percent going out as U.S. No. 1, 19.8 percent as U.S. No. 2, and 0.2 percent as U.S. No. 3. Sound barley had 56.1 percent as U.S. No. 1, 43.7 percent as U.S. No. 2, and 0.2 percent as U.S. No. 3. Thin barley was the most restrictive factor, with 54.2 percent as U.S. No. 1, 44.7 percent as U.S. No. 2, and 1.1 percent as U.S. No. 3.

Similarly, limits for dockage could be set at 1.5 percent, 2.5 percent, and 3.5 percent for U.S. No. 1, No. 2, and No. 3. If these limits were applied to 1988-92 U.S. export barley, 62.1 percent would have graded U.S. No. 1, 36.0 percent would have graded U.S. No. 2, and the remaining 1.9 percent would have graded U.S. No. 3.

Consider other possible dockage limits for barley, of say 0.5 percent for U.S. No. 1, 1.0 percent for U.S. No. 2, and 2.0 percent for U.S. No. 3 and above. The top U.S. grade would then match the cleanest barley available from Canada and Australia and compete for the same dockage-conscious import markets. Few buyers purchase U.S. No. 1 now but domestic and foreign millers that want very clean barley could find it. Other importers could still purchase higher-numbered grades (with the higher dockage limits) as this would be closer to what they are now purchasing.

Another meaningful signal to the barley producer would be to establish a sample grade limit for dockage. For instance, heavily discounting barley with dockage over 2.5 percent would discourage that small amount from ever leaving the farm uncleaned and eventually becoming blended with cleaner barley. Many elevators already reject high-dockage barley, but requiring it to be designated as "sample" grade would encourage greater conformity. This may help reduce dockage to all buyers, not just the premium markets. Currently, there is no limit on maximum amount of dockage delivered to the market, although the Grain Quality Title effectively requires a cleanliness minimum allowed for government storage programs and discounts for nonrecourse loans. Some producers may object to penalizing sound grain that meets a U.S. grade on all other factors except dockage, which could be removed easily at an elevator and then sold for a higher grade than the grade purchase. However, under that scenario, the barley would be cleaned only if the enhanced value was greater than the costs of cleaning.

Currently, dockage is simply deducted from the weight of barley. This implicit discount suggests that the difference in value between dockage levels is a constant proportion of the grain's price. Whether this is an accurate valuation of dockage or a convention that understates the worth of low-dockage grain to certain markets is uncertain. It is difficult to foresee an impact on premiums (if any) large enough to induce additional cleaning. We may expect that the dockage premium between U.S. No. 1 and No. 2 would not exceed the discount for an equivalent percentage of foreign material, which is harder to remove. But market forces would determine the dockage premium, not government policy. The grade limits do not create value, they merely describe it. The premium would adjust to market conditions; it would increase when a particular crop is unusually high in dockage, when screenings prices are high relative to barley prices, when transportation rates are high, or when a particularly dockage-sensitive importer's demand expands. As with foreign material, there is no guarantee that the dockage premium would be large enough to induce farmers to alter their production and harvesting practices although there could be sufficient incentive to do additional cleaning at inland elevators.

Blending high-dockage lots with low-dockage lots would help circumvent the grade discounts. Thus, making dockage a grade determining factor would not necessarily result in a significant overall improvement in barley cleanliness or higher prices except for the export markets that bought the top grade exclusively. Only the importers that seek low-dockage barley would pay the higher price for cleaner grain. Cleanliness would improve only to the extent that the new standard facilitated the exchange of information between those better able to supply clean barley and the importers more willing to pay for it.

There would naturally be some adjustments in the domestic market. Cash markets use U.S. No. 2 grade for feed barley and the U.S. No. 3 grade for malting barley as their benchmark for pricing. Most U.S. cash market participants do not purchase solely on the grade but discount for each factor differing from the base grade. Thus, dockage as a grade-determining factor would not affect the barley quality that processors would want or get, but including it as a grade-determining factor would affect the price determination process. The long lead time for public comment required prior to the implementation of Federal rules would allow the market ample time to adjust, and the disruption in market pricing would be minimal. However, a majority of producer groups, handlers, and exporters commenting on previous FGIS proposals for rule changes indicated that they preferred dockage to remain as a non-grade determining factor.

Barley Cleanliness in the Export Enhancement Program

The major objective of the Export Enhancement Program (EEP) is to counter export subsidies offered by some U.S. competitors in the world grain market. A secondary goal for EEP initiatives is to demonstrate a potential to develop, expand, or maintain export markets for U.S. agricultural commodities. Barley exports under the EEP have accounted for about 84 percent of total export volume since the inception of the program in 1985/86. Promoting cleanliness through this program has the potential to affect the U.S. competitive position in some, but not all, major barley import markets.

A relatively simple administrative adjustment for barley dockage is possible: making the export bonus payable on the basis of the grain weight net of dockage rather than the gross weight. Currently, the higher the prevailing EEP bonus, the greater the return from exporting the maximum allowable dockage. A net-weight policy would remove any incentive for allowing dockage to reach its maximum contract limit and would encourage more cleaning. This policy could affect the bidding process for bonuses by causing exporters to compete not only on the basis of price but also cleanliness. However, not all foreign countries targeted for EEP would be concerned about receiving lower dockage in the grain they purchase. Other countries that are sensitive to dockage may not qualify for an EEP allocation. Again, the likely trade benefit would be negligible and could be countered with higher subsidies by other exporting countries.

Conclusions

The costs of cleaning barley above and beyond the current level would outweigh any potential benefits. Cleaner barley is incidental to both the domestic malting and feed markets. That leaves only the export market, which is mostly feed. Dockage is not a major concern for most foreign feed barley users, either. As long as buyers know how much dockage they are receiving in U.S. barley, they can properly evaluate the relative value of U.S. grain. Therefore, enhancing cleanliness is based on changing the way that information about barley's dockage content is communicated in the market.

Research opportunities include controlled experiments at grain elevators to determine the grain loss from additional cleaning at varying beginning and ending dockage levels. Grain harvesters could also be evaluated to determine the operator adjustments necessary (under varying conditions) to maximize yield, minimize damage, and enhance cleanliness. Field studies could address whether different farm production practices could lower dockage levels without significantly altering yields, costs, or resource use.

Glossary

Aspirator cleaner—A device that draws a column of high-velocity air across a flowing grain stream to separate low-density materials (foreign material, chaff, insects) from grain. The air pressure is based on the weight of the grain. An aspirator can operate at a higher throughput capacity than screen cleaners but may result in a higher grain loss.

Broken kernels—Barley with more than 1/4 of the kernel removed.

Damaged kernels—Kernels and pieces of barley kernels, other grains, and wild oats that are badly ground-damaged, badly weather-damaged, diseased, frost-damaged, germ-damaged, heat-damaged, insect-bored, mold-damaged, sprout-damaged, or otherwise materially damaged.

Disc-cylinder cleaner—Removes dockage on the basis of particle shape and length. Grain passes through the middle of a horizontal revolving cylinder, which has small indentations in the metal. Smaller materials fall into the indentations and are lifted as the cylinder revolves. As the material approaches the top of the cylinder, depending on its length, it falls either into the dockage compartment or the grains compartment of the cleaner. Disc-cylinder cleaners are generally the most effective means to attain a low dockage level. However, their throughput capacity is generally less than other types of cleaners.

Discount—Reductions from the base price offered for grain. Generally calculated for factors that lower the value of the grain. May be expressed as percentages of the price or as fixed cents per bushel. Serve as a disincentive for selling grain below the quality of the base market grade.

Dockage—All matter other than barley (e.g., chaff, stems, stones, etc.) that can be removed by the Carter dockage machine using procedures prescribed by FGIS. It also may contain underdeveloped, shriveled, and small pieces of barley kernels removed with the nongrain material, which cannot be recovered by proper rescreening. Dockage is all coarse material that remains on the top sieve and all material that passes through the bottom sieve. Dockage does not determine the grade but must be measured and reported on the grade certificate.

Foreign material (FM)—A grading factor in barley, is defined as all matter other than barley, other grains, and wild oats found in a sample after the removal of dockage. It is the most difficult material to remove from barley.

Germination level—A measure of the percentage of kernels that have live germs capable of germinating during the malting process.

Grade-determining factor—Factors selected as indicators of value and quality that help set the numerical grade of grain.

Grade—A number designation assigned to grain based on a pre-established set of criteria.

Grain grades and standards—Specific standards of grain quality established to maintain the uniformity of grain of a specific grade and facilitate the purchase of grain without the need for visual inspection and testing by the buyer.

Intrinsic value—Characteristics critical to the end-use of grain. These are nonvisual and can only be determined by analytical tests. For example, the intrinsic quality of wheat is determined by characteristics such as protein, ash, and gluten content.

Malt—Produced by germinating moistened barley under controlled conditions for 5-7 days, depending on barley type and intended use. Germination brings about changes in the barley, including development and activation of enzyme systems important in producing the desired color and flavor characteristics. The germination process is ended by kilning (drying with heat). Rootlets that formed during germination are removed and the resulting product is malt, a major ingredient for beer production.

Non-grade determining factors—Factors that influence the quality of grain, but which are not taken into account in the grading of grain, and which must be reported as information whenever an official inspection is made.

Plump barley—A non-grade determining factor. Barley that remains on top of a 6/64-inch x 3/4-inch slotted hole sieve after sieving according to procedures prescribed in FGIS instructions.

Premium—Increases from the base price offered for grain of higher quality characteristics than specified. Generally calculated for factors that increase the value of the grain.

Screen cleaner—A series of angled perforated plates or wire screens that separates the grain from particles that are larger than the grain. The screens may be stationary, shaken, or rotated. Removes dockage on the basis of particle size. The screens may differ, but generally coincide with the hole sizes specified in the Official U.S. Standards for Grain. Smaller openings may remove more dockage but also reduce throughput capacity.

Screenings—The material removed from grain by means of mechanical sizing devices. Generally include broken grain as well as nongrain material removed on the basis of density or particle size.

Six-rowed barley—The axis of the barley head has nodes throughout its length, alternating from side to side. For six-rowed barley, three kernels develop at each node, a central kernel and two lateral kernels. In the grain standards, six-rowed barley applies to any of these varieties that contain no more than 10 percent of two-rowed barley.

Skinned and broken kernels—A grading factor in barley. It is measured after dockage is removed. Skinned and broken kernels are barley kernels with one-third or more of the hull removed; with a loose or missing hull over the germ, broken kernels, or whole kernels that have a part or all of the germ missing.

Sound barley—Kernels and pieces of barley kernels that are not damaged. The percentage of sound grain in any sample is 100 percent minus the sum of the percentage (if any) of wild oats, foreign material, all damaged grain, and all grains other than barley.

Suitable malting type—Varieties of malting variety that are recommended by the American Malting Barley Association as being suitable for malting purposes.

Test weight—A measure of grain density determined by weighing the quantity of grain required to fill a 1-quart container and converting this to a bushel (2,150.42 cubic inches) equivalent. This term, used from the beginnings of barley grades, is related to density but is also influenced by many other factors.

Thin barley—Six-rowed barley which passes through a 5/64-inch x 3/4-inch slotted-hole sieve after sieving according to procedures prescribed in FGIS instructions. Two-rowed barley which passes through a 5.5/64-inch x 3/4-inch slotted hole sieve.

Two-rowed barley—Grown primarily in the Northwest and Mountain areas of the United States. It has medium-sized, uniform, plump kernels with a thin hull. It is generally low in protein and high in starch with vigorous germination and intermediate enzymatic activity during malting. It is used by the brewing industry both by itself and for blending with midwestern six-rowed barley. In the grain standards, two-rowed barley applies to any of these varieties that contain no more than 10 percent of six-rowed barley.

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Appendix

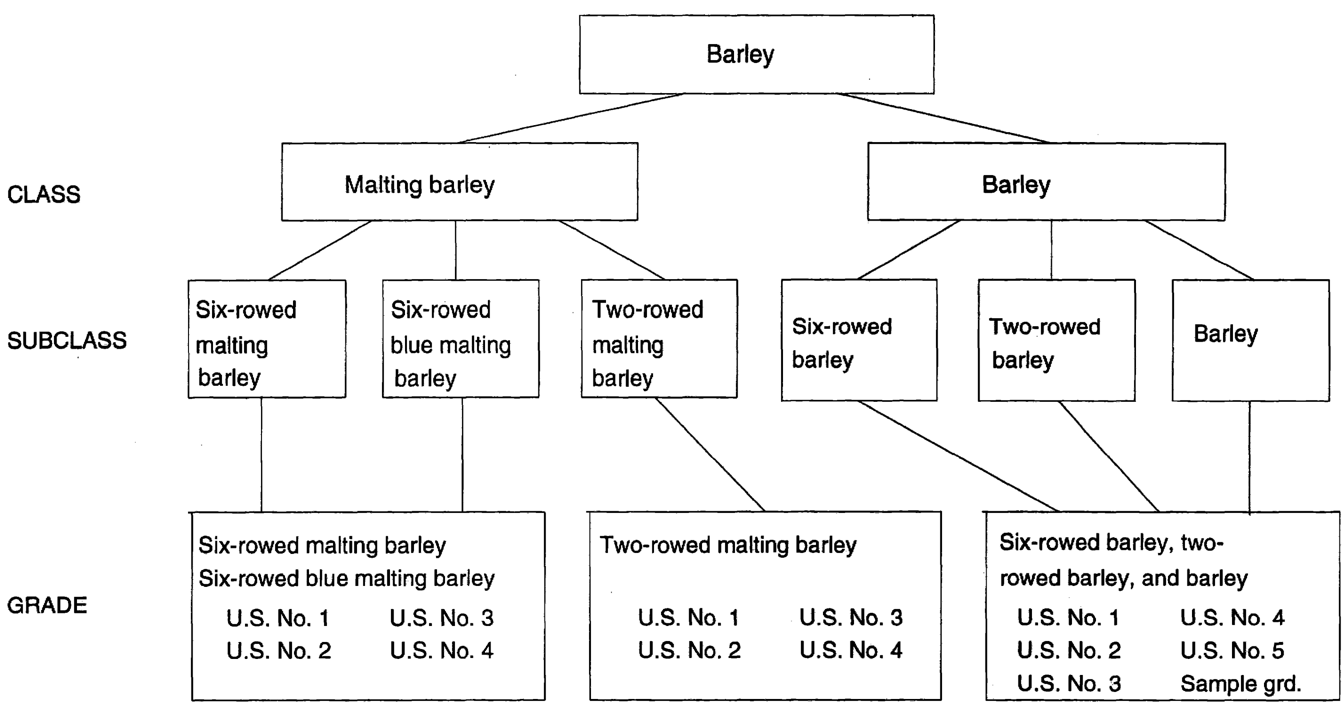
Future U.S Standards for Barley
Effective June 1, 1997
Source: Compiled by ERS, USDA from [11, 12, and 13].

The Grain Inspection, Packers and Stockyards Administration (GIPSA) is revising the United States Standards for Barley to: (1) modify the classification system of barley to better reflect current marketing practices by establishing two classes—malting barley and barley; (2) revise procedures to permit applicants the option of requesting either the malting standards or barley standards for malting types; (3) revise the standards for two-rowed malting barley by removing the "U.S. No. 1 Choice" grade designation; (4) amend the definition for suitable malting type to include other malting varieties used by private malting and brewing companies; (5) revise the dockage certification procedure by reporting results in half and whole percents with a fraction less than one-half percent being disregarded; (6) amend the definition of thins to require the use of a single sieve (5/64 x 3/4 slotted-hole) only in the class barley; and (7) eliminate the numerical grade restriction for barley badly stained and materially weathered from the standards. In addition, GIPSA is amending the breakpoint for dockage and establishing new break-points for malting barley to conform with standard changes.

The objective of these revisions is to ensure that the barley standards facilitate the marketing of barley. The new grade requirements are summarized in appendix figure 1 and appendix tables 1-3.

Appendix figure 1

Barley classes, subclasses, and special grades, effective June 1, 1977



SPECIAL SUPPLEMENTAL GRADE DESIGNATIONS: Blighted, Ergoty, Garlicky, Smutty, and Weevily

Source: Compiled by ERS, USDA from Federal Register.

Appendix table 1--U.S. grades and grade requirements for six-rowed malting barley and six-rowed blue malting barley (effective June 1, 1997)

Grade-determing factor	Grade				
	U.S. No. 1	U.S. No. 2	U.S. No. 3	U.S. No. 4	U.S. No. 5
MINIMUM LIMITS OF:			*Pounds*		
Test weight per bushel	47.0	45.0	43.0	43.0	n.a.
			Percent		
Suitable malting types	95.0	95.0	95.0	95.0	n.a.
Sound barley[1]	97.0	94.0	90.0	87.0	n.a.
MAXIMUM LIMITS OF:			*Percent*		
Damaged kernels[1]	2.0	3.0	4.0	5.0	n.a.
Foreign material	0.5	1.0	2.0	3.0	n.a.
Other grains	2.0	3.0	5.0	5.0	n.a.
Skinned and broken kernels	4.0	6.0	8.0	10.0	n.a.
Thin barley	7.0	10.0	15.0	15.0	n.a.

Notes: Malting barley shall not be infested in accordance with Section 810.107(b) and shall not contain any special grades as defined in Section 810.206 of the standards. Six-rowed malting barley and six-rowed blue malting barley varieties not meeting these grade requirements shall be graded in accordance with standards established for the class barley (app. table 3).

[1] Injured-by-frost kernels and injured-by-mold kernels are not considered damaged kernels or considered against sound barley.

n.a.—Grade not applicable for subclasses.

Source: Compiled by ERS, USDA from USDA, Federal Grain Inspection Service [12].

Appendix table 2--U.S. grades and grade requirements for two-rowed malting barley (effective June 1, 1997)[1]

Grade-determing factor	Grade				
	U.S. No. 1	U.S. No. 2	U.S. No. 3	U.S. No. 4	U.S. No. 5
MINIMUM LIMITS OF:			*Pounds*		
Test weight per bushel	50.0	48.0	48.0	48.0	n.a.
			Percent		
Suitable malting types	97.0	97.0	95.0	95.0	n.a.
Sound barley[1]	98.0	98.0	96.0	93.0	n.a.
MAXIMUM LIMITS OF:			*Percent*		
Wild oats	1.0	1.0	2.0	3.0	n.a.
Foreign material	0.5	1.0	2.0	3.0	n.a.
Skinned and broken kernels	5.0	7.0	10.0	10.0	n.a.
Thin barley	5.0	7.0	10.0	10.0	n.a.

Notes: Malting barley shall not be infested in accordance with Section 810.107(b) and shall not contain any special grades as defined in Section 810.206 of the standards. Two-rowed malting barley varieties not meeting these grade requirements shall be graded in accordance with standards established for the class barley (app. table 3).

[1] Injured-by-frost kernels and injured-by-mold kernels are not considered damaged kernels or considered against sound barley.

n.a.—Grade not applicable for subclass.

Source: Compiled by ERS, USDA from USDA, Federal Grain Inspection Service [12].

Appendix table 3--U.S. grades and grade requirements for barley (effective June 1, 1997)

Grade-determining factor	Grade[1] U.S. No. 1	U.S. No. 2	U.S. No. 3	U.S. No. 4	U.S. No. 5
MINIMUM LIMITS OF:			*Pounds*		
Test weight per bushel	47.0	45.0	43.0	40.0	36.0
			Percent		
Sound barley	97.0	94.0	90.0	85.0	75.0
MAXIMUM LIMITS OF:			*Percent*		
Damaged kernels[2]	2.0	4.0	6.0	8.0	10.0
Heat damaged kernels	0.2	0.3	0.5	1.0	3.0
Foreign material	1.0	2.0	3.0	4.0	5.0
Broken kernels	4.0	8.0	12.0	18.0	28.0
Thin barley	10.0	15.0	25.0	35.0	75.0

1 U.S. Sample grade shall be barley that: (a) Does not meet the requirements for the grades 1, 2, 3, 4, or 5; or (b) Contains 8 or more stones or any number os stones which have an aggregate weight in excess of 0.2 percent of the sample weight, 2 or more pieces of glass, 3 or more crotalaria seeds (Crotalaria spp.), 2 or more castor beans (Ricinus communis L.), 4 or more particles of an unknown foreign substance(s) or a commonly recognized harmful or toxic substance(s), 8 or more cocklebur (Xanthium spp.) or similar seeds singly or in combination, 10 or more rodent pellets, bird dropping, or equivalent quantity of other animal filth per 1-1/8 to 1-1/4 quarts of barley; or (c) Has a musty, sour, or commercially objectionable foreign odor (except smut or garlic odor); or (d) Is heating or otherwise of distinctly low quality.

2 Includes heat-damaged kernels. Injured-by-frost kernels and injured-by-mold kernels are not considered damaged kernels.

Source: Compiled by ERS, USDA from USDA, Federal Grain Inspection Service [12].