1972

Analysis of quality factors in soybean grading as related to production, processor's needs and product value

Duane Milton Murken
Iowa State University

Analysis of quality factors in soybean grading as related to production, processors' needs and product value

by

Duane Milton Murken

13

A Thesis Submitted to the
Graduate Faculty in Partial Fulfillment of
The Requirements for the Degree of
MASTER OF SCIENCE

Department: Economics
Major: Agricultural Economics

Iowa State University
Ames, Iowa

1972

TABLE OF CONTENTS

INTRODUCTION

An efficient marketing system seeks to deliver adequate quantities of products from producers to consumers subject to reasonable marketing cost. Grading and standardization serves as a facilitating function in this marketing process.

The principle of consumers' sovereignty implies that the consumer is king and that all production and marketing practices should be constructed to meet the wants and desires of the consumer. Unfortunately, technological, institutional, and resource restrictions sometimes limit the extent to which this goal can be achieved. Performance and efficiency of the marketing system must therefore be analyzed relative to the optimal performance and efficiency possible under the given physical and institutional restraints.

The particular problem under investigation here is the grading and standardization of U. S. soybeans. The tremendous growth in soybean production and processing over the past 25 years gives impetus to such research. A vast amount of research has been undertaken to improve yield per acre, quality, and processing techniques for soybeans. Unfortunately, the grading system has been frequently overlooked.

Purpose

The purpose of this research is to determine the relevancy and efficiency of the present soybean grading system. This provides a basis for evaluating alternative grading systems and their relative efficiency.

The first numerical grades for soybeans were established over forty-five years ago with only slight modifications since then. Since the original promulgation of soybean standards, great strides have been made in our knowledge of processing, marketing and distribution of soybeans. The basic purpose of this research is to determine if these changes have brought about a need for revision in the present soybean standards.

The soybean seed is composed of two principal products, soybean oil and soybean meal. The present system of grading does not, however, take into account either oil or meal content of soybeans. If we assume that consumer wants and desires are reflected by the prices they are willing to pay for particular products, the pricing mechanism will serve as a means of communication between consumer demands and production decisions. For optimal communication between producers and consumers in the soybean market, demand for the two principal products, oil and meal, should be reflected in the price of soybeans.

If we assume that "true product value" is reflected by the quantity and quality of oil and meal in soybeans, we can then determine if present grading standards adequately portray this "true product value". Since value of the product is reflected by market price, a grading and pricing scheme which accurately describes true product value is instrumental in the expedient and precise transfer of consumer wants back to the producer. An attempt will be made to determine if the present pricing and grading system does in fact reflect "true product value".

An attempt will be made to estimate the costs involved in soybean quality determination for both the present grading system and for the analysis of oil and protein content.

The present grade factors--test weight, moisture, splits, damage and foreign material--will be evaluated to determine the importance of these factors upon quality and/or quantity of oil and meal output.

Method of Analysis

The method of analysis is first to develop the distributions of quality measurements for soybeans at various stages in the marketing channel. The second is to determine which of these quality characteristics processors desire and their relative importance. The third is to develop (a) the interrelationships among quality factors, (b) the relationships between quality factors and market prices, (c) the relationships between quality factors and actual product value, (d) the relationship between market prices and actual product value, and (e) the relationship between numerical grades and prices. The fourth and final method of analysis will involve determining the efficiency, cost and workability of the present and alternative grading systems for soybeans.

Twelve cooperating country elevators in a ten county area in North-Central Iowa provided 199 samples of farmer delivered soybeans during the 1971 fall harvest period. All 199 soybean samples were submitted to an official grain inspector for grading. These results were used to establish quality characteristic distributions for moisture, test weight, damage, grade, splits and foreign material. A subset of the 199 samples (47 samples) was sent to an official oil and meal chemist for oil and protein determination. The ten county fall harvest sample area is shown in Figure 1.

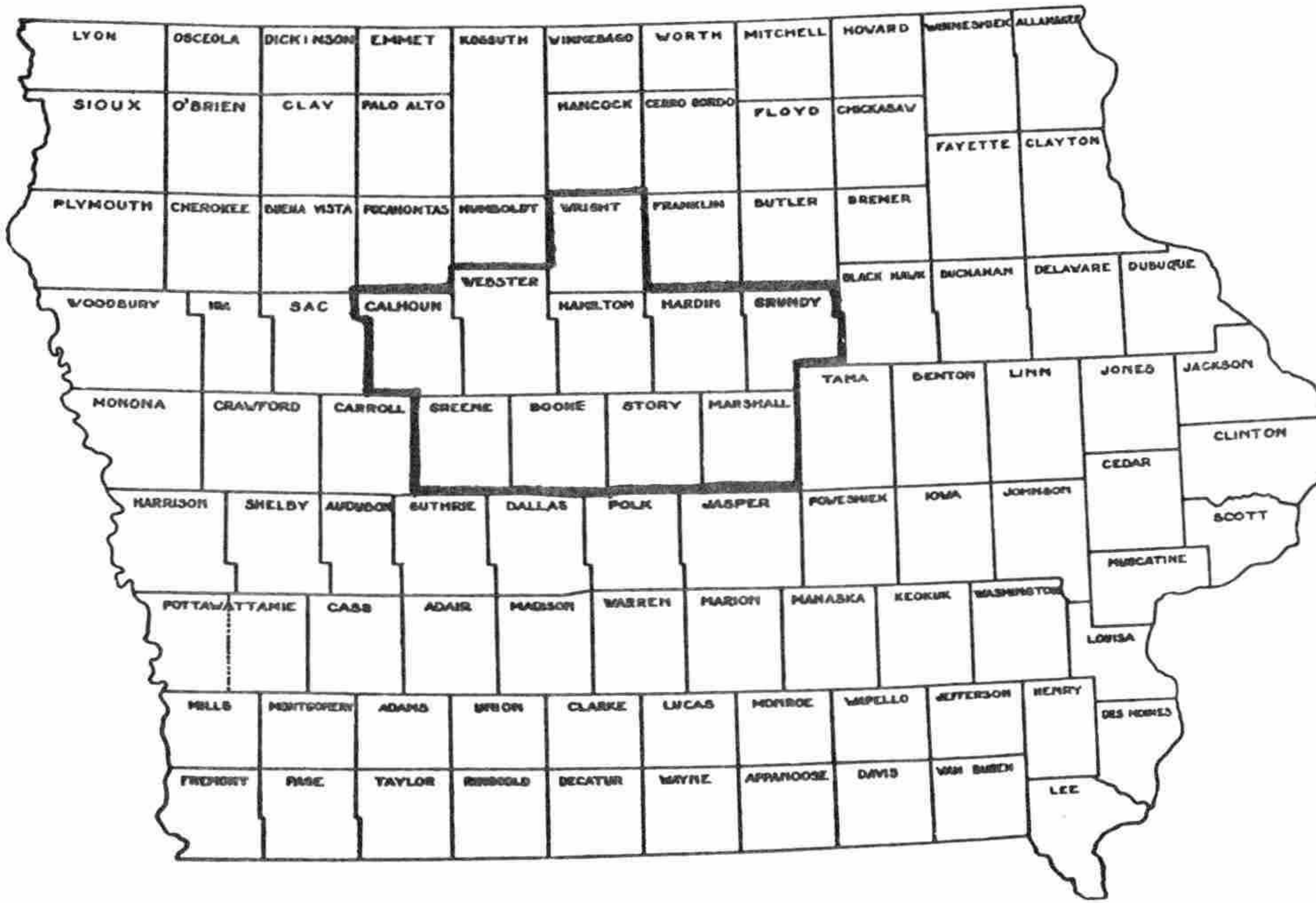

Figure 1. Fall harvest sample area

A total of 124 official grade certificates were collected from two local soybean processors and from a local terminal elevator to determine what, if any, changes in quality occur during transit and storage.

Fifty-two soybean processors in nine states were surveyed. The questionnaire objectives were to (a) determine what quality characteristics processors determine important, and their relative ranking, (b) establish cost estimates for quality determination at the processing point, and (c) evaluate processor opinions on present and alternative grading systems. Of the 52 processors contacted, 32 replied to the questionnaire in one form or another. Of the 32 replies, 21 involved actual completion of the questionnaire.

Two hundred and ninety-three elevator managers in Iowa were also surveyed. The country elevator questionnaire objectives were similar to the ones outlined above for the processor questionnaire.

In order to arrive at a dollar estimate for "actual product value" two total-value-product models were developed. These two models define total product value as a function of oil and protein content.

SOYBEANS AND THE SOYBEAN INDUSTRY

The soybean has been cultivated in Eastern Europe since ancient times. The first cultivated soybeans were derived from a wild species. The United States first experimented with soybeans as a crop in the early 1800's. The primary usage of soybeans during this period was as a forage or pasture crop. Early production of soybeans in the U. S. was concentrated in the southeastern states. In 1915 approximately 10,000 bushels of soybean seed were crushed at a cottonseed oil mill in North Carolina. This operation resulted in a grain production and marketing revolution that continues even today (10).

Production

The soybeans principle growing areas are in the temperate growing regions of the world, notably North America and Asia. The United States, the world's largest producer, supplies approximately 1,134 million bushels of the total world production of 1,526 million bushels. The second largest producer is mainland China with an approximate annual production of 255 million bushels. Brazil and the Soviet Union follow with 47 and 22 million bushels, respectively. The remaining soybean producing nations supply approximately 35 million bushels annually. These soybeans are produced on

71 million acres of the world's cropland. The United States leads in total area harvested with 41.6 million acres. Mainland China harvests approximately 19.7 million acres compared with slightly less than 2 million acres for both the Soviet Union and Brazil (27).

The United States does not lead, however, in yield per acre. Canada's average of 31.2 bushels per acre for its 1970 crop is a current world record. The United States and Columbia rank second and third in yield per acre with 27.3 and 26.5 bushels per acre, respectively. The average soybean yield for the world is 21.5 bushels per acre (27).

The United States, Mainland China, and Brazil account for almost 95 per cent of the world's production of soybeans. The United States, which accounts for 75 per cent of world production, is of particular importance. The U. S. dominance in world production is exemplified by the fact that the two leading soybean production states in the U. S., Illinois and Iowa, produce more soybeans than all foreign countries combined (27).

The corn belt states of Ohio, Indiana, Illinois, Iowa, Missouri, and Minnesota accounted for approximately 65 per cent of 1971 U. S. production. See tables 1, 2, and 3. Iowa accounted for approximately 15 per cent of total U. S. production. Illinois was the only state to exceed Iowa with approximately 20 per cent of total production.

Table 1. Soybean acreage by states[1] [2]

	1968	1969	1970	1971[3]
North Carolina	972	885	867	936
South Carolina	931	959	988	1,047
Georgia	472	467	528	635
Alabama	557	641	609	662
Total South East	2,932	2,952	2,992	3,280
Kentucky	466	485	558	742
Tennessee	1,193	1,193	1,217	1,302
Mississippi	2,120	2,290	2,313	2,359
Arkansas	3,989	4,228	4,313	4,266
Louisiana	1,436	1,608	1,688	1,644
Total South Central	9,204	9,804	10,089	10,313
Ohio	2,276	2,344	2,414	2,494
Indiana	3,246	3,311	3,278	3,377
Illinois	6,663	6,730	6,800	7,150
Iowa	5,561	5,450	5,680	5,440
Missouri	3,663	3,150	3,465	3,605
Minnesota	3,232	3,068	3,099	2,851
Total Eastern Corn Belt	24,641	24,053	24,736	24,917
North Dakota	215	185	181	208
South Dakota	300	243	247	240
Nebraska	782	766	812	640
Kansas	957	852	1,005	871
Total Western Corn Belt	2,254	2,046	2,245	1,959
Other[4]	2,073	2,127	1,994	1,940
Total U.S.	41,104	40,982	42,056	42,409

[1]Source: Fats and Oils Situation, February, 1971, April, 1971 (35).

[2]All amounts are in thousand acres.

[3]Preliminary reports.

[4]New York, New Jersey, Pennsylvania, Michigan, Wisconsin, Delaware, Maryland, Virginia, Florida, Oklahoma and Texas.

Table 2. Yield per acre by states[1]

	1969	1970	1971[2]
North Carolina	26.5	24.0	24.0
South Carolina	22.5	20.5	21.5
Georgia	24.0	22.5	25.5
Alabama	23.0	23.5	26.5
	----	----	----
Total South East	24.0	22.6	24.4
Kentucky	28.0	27.0	29.5
Tennessee	24.0	23.0	26.0
Mississippi	22.0	24.0	23.0
Arkansas	20.5	22.5	21.5
Louisiana	19.0	22.5	23.0
	----	----	----
Total South Central	22.7	23.8	24.6
Ohio	29.0	28.5	30.5
Indiana	32.5	31.0	33.5
Illinois	33.5	31.0	33.0
Iowa	33.0	32.5	32.0
Missouri	26.0	25.5	27.0
Minnesota	24.5	26.5	23.0
	----	----	----
Total Eastern Corn Belt	29.8	29.2	29.8
North Dakota	16.0	15.0	14.0
South Dakota	24.5	17.5	21.0
Nebraska	33.5	22.0	25.0
Kansas	23.0	15.0	20.5
	----	----	----
Total Western Corn Belt	24.2	17.4	20.1
All others[3]	25.5	23.6	25.3
	----	----	----
Total United States	27.5	26.7	27.6

[1]Source: Fats and Oils Situation, February, 1972 (35).

[2]Preliminary reports.

[3]New York, New Jersey, Pennsylvania, Michigan, Wisconsin, Delaware, Maryland, Virginia, Florida, Oklahoma and Texas.

Table 3. Soybean production by states[1]

	1969	1970	1971[2]
	Thousand bushels		
North Carolina	23,453	20,808	22,464
South Carolina	21,578	20,254	22,511
Georgia	11,208	11,880	16,193
Alabama	14,743	14,312	17,543
Total South East	70,982	67,254	78,711
Kentucky	13,580	15,066	21,889
Tennessee	28,632	27,991	33,852
Mississippi	50,380	55,512	54,257
Arkansas	86,674	97,043	91,719
Louisiana	30,552	37,980	37,812
Total South Central	209,818	233,592	239,529
Ohio	67,976	68,799	76,067
Indiana	107,608	101,618	113,130
Illinois	225,455	210,800	235,950
Iowa	179,850	184,600	174,080
Missouri	81,900	88,358	97,335
Minnesota	75,166	82,124	65,573
Total Eastern Corn Belt	737,955	736,299	762,135
North Dakota	2,960	2,715	2,912
South Dakota	5,954	4,323	5,040
Nebraska	25,661	17,864	16,000
Kansas	19,596	15,075	17,856
Total Western Corn Belt	54,171	39,977	41,808
All others[3]	53,388	46,618	47,178
Total U. S.	1,126,314	1,123,740	1,169,361

[1]Source: Fats and Oils Situation, February, 1972 (35).

[2]Preliminary reports.

[3]New York, New Jersey, Pennsylvania, Michigan, Wisconsin, Delaware, Maryland, Virginia, Florida, Oklahoma and Texas.

Soybean Exports

The United States dominance in world soybean production is exceeded by its dominance in world trade of soybeans and soybean products. More than 75 per cent of world soybean exports have originated in the United States for all but a few years following World War II. Since 1962, the United States has accounted for nearly 90 per cent of total world soybean trade. Tables 4, 5, and 6 show soybean, soybean oil, and soybean meal exports for selected years since World War II by area of destination. Table 7 shows the relative importance of the major soybean exporting nations for the years 1965-67.

Soybean oil faces a highly competitive international fats and oils market. The principal competing fats and oils are butter, lard, groundnut (peanut) oil, cottonseed oil, coconut oil, sunflower oil, palm oil, olive oil, rapeseed oil, and marine oils. In 1955 soybean oil ranked third in world fats and oils production and third in international trade of fats and oils. By 1967 soybean oil was the leading source of fats and oils production in the world. Further, in 1967 soybean oil was the leading fat and oil in international trade, with almost double the trade of its nearest competitor, coconut oil (15).

Table 4. U. S. soybean exports by area of destination[1]

	1949	1954	1959	1964	1969[2]
			1000 bushels		
North America	2,831	7,865	16,585	35,128	66,000
South America	-	3	37	1,234	3,000
Western Europe	7,388	22,668	69,797	105,545	220,000
Eastern Europe	-	-	22	4,857	6,000
Africa	-	122	588	419	-
Asia and Oceania	4,907	26,650	52,898	64,992	120,000
Total	15,127	57,307	139,931[3]	212,175	415,000

[1]Source: Fats and Oils Situation, June, 1970 (35).

[2]Estimate based on June indications.

[3]Includes three million bushels not designated.

Table 5. U. S. soybean meal exports by area of destination[1]

	1949	1954	1959	1964	1969[2]
			1000 tons		
North America	24.7	91.8	242.3	305.8	300.0
South America	.7	1.2	8.7	3.1	-
Western Europe	21.9	158.4	362.0	1501.1	3025.0
Eastern Europe	-	-	20.4	165.9	500.0
Africa	-	-	-	-	5.0
Asia and Oceania	.1	20.3	15.3	59.9	170.0
Total	47.4	271.7	648.7	2036.0	4000.0

[1]Source: Fats and Oils Situation, June, 1970 (35).

[2]Estimate based on June indications.

Table 6. U. S. soybean oil exports by area of destination[1]

	1949	1954	1959	1964	1969[2]
			Million pounds		
North America	25	29	62	72	150
South America	2	2	107	151	100
Western Europe	255	14	509	348	15
Eastern Europe	-	-	80	56	10
Africa	2	6	90	145	175
Asia and Oceania	6	-	105	576	750
Total	291	50	953	1339	1220

[1]Source: Fats and Oils Situation, June, 1970 (35).

[2]Estimate based on June indications.

Table 7. Soybean production and exports by major producing nations[1] [2]

Country	Production		Exports	
	amt.[3]	%	amt.[3]	%
U. S.	917	72	246	89
China	252	20	21	7
Brazil	22	2	6	2
Others	78	6	5	2
	----	---	---	---
Total	1269	100	278	100

[1]Source: Houck, Ryan, and Subotnik (15).

[2]Years 1965-1967.

[3]All amounts are in million bushels.

Soybean meal, on the other hand, does not face as competitive an international market as does soybean oil. Soybeans are the most important and one of the fastest growing sources of high-protein meal. Soybean meal exports of over 9.8 million metric tons in 1967 were over three times the volume of exports of its nearest competitor, fish meal, at 3.0 million metric tons (15).

One of the major reasons for the dominance of soybeans in the world meal market is their high percentage of crude protein. Unlike the oils, high-protein meals are not close substitutes since they differ in quality and quantity of protein. Although fish meal contains a higher content of protein then does soybean meal, its use in livestock feed is limited due to the residual oil remaining in the meal after processing. Table 8 shows the crude protein content of the major high-protein meals.

Another major reason for the dominance of soybeans in the international oil-seeds markets is the high meal-to-oil ratio of soybeans. The increased importance of high-protein meals in world agriculture gives soybeans a comparative advantage over the other oilseeds. Table 9 shows the percentage oil and meal composition of the major oilseeds.

Table 8. Approximate crude protein of the major meals[1]

Meal	Per cent crude protein by weight
Soybean	42-50
Cottonseed	36-43
Groundnut	45-56
Sunflowerseed	37-38
Linseed	32-39
Copra	22
Palm kernel	23
Fish	60-73

[1]Source; Houck, Ryan, and Subotnik (15).

Table 9. Average percentage yield by weight of the major oilseeds[1]

Item	Per cent meal	Per cent oil
Groundnuts	58	42
Cottonseed	46	18
Linseed	64	35
Sunflowerseed	68	31
Copra	35	64
Palm kernel	52	46
Rapeseed	58	40
Soybeans	80	17

[1]Source; Houck, Ryan, and Subotnik (15).

The leading import countries for U. S. soybeans, soybean oil, and soybean meal are listed in tables 10, 11, and 12. These tables indicate that the more developed countries tend to import the greatest proportion of soybeans and soybean meal, while the less developed countries tend to import larger quantities of U. S. soybean oil.

The total value of U. S. soybean exports as soybeans was 1,325 million dollars in 1970. This figure represents an average price of $3.06 per bushel of soybeans exported. The value of 1970 soybean meal and soybean oil exports were 405 million dollars and 250 million dollars, respectively. These figures imply the value of exports for soybeans and soybean products approached two billion dollars in 1970 (35).

Soybeans are an important source of protein in the diet of the people in Asia and Oceania. However, this "protein" market is a highly competitive one. Some of the countries in this area produce their own soybeans, but most countries rely on imports to fill their soybean demand. Mainland China has been the traditional supplier of soybeans for food usage in this area of the world.

U. S. soybeans have faced criticism in Asia and Oceania because of low quality for use in soybean foods. U. S. soybeans for food use have been limited to those foods which can utilize broken or split soybeans, namely curd and sauce.

Table 10. Ten leading importers of U. S. soybeans during 1970[1]

Country	1000 bushels[2]
Japan	102,791
Netherlands	57,381
West Germany	52,980
Canada	42,162
Spain	38,691
Italy	25,978
Denmark	21,442
Taiwan	19,582
France	13,223
Belgium-Luxembourg	13,222

[1]Source: Fats and Oils Situation, November, 1971 (35).

[2]Preliminary reports.

Table 11. Ten leading importers of U. S. soybean meal during 1970[1]

Country	1000 tons[2]
West Germany	994.4
France	712.1
Netherlands	675.4
Italy	330.8
Belgium-Luxembourg	308.8
Canada	242.1
Yugoslavia	186.8
Hungary	156.0
Mexico	116.3
Poland	112.3

[1]Source: Fats and Oils Situation, November, 1971 (35).

[2]Preliminary reports.

Table 12. Ten leading importers of U. S. soybean oil during 1970[1]

Country	Million lbs.[2]
India	284
Pakistan	278
Yugoslavia	271
Iran	134
Peru	111
Morocco	90
Tunisia	76
Chile	58
Canada	50
Israel	41

[1]Source: Fats and Oils Situation, November, 1971 (35).

[2]Preliminary reports.

The substantial increase in poultry meat, hogs, and egg production in Asia and Oceania has created a substantial new demand for soybean meal for feed use. This demand is expected to increase in the future as farmers realize the advantages of feeding high-protein rations. As the countries in this region develop their own continuous solvent extraction plants, the United States and other soybean exporting nations can expect to export more soybean meal in the form of whole soybeans (33).

The European countries all have important livestock industries. Livestock producers in this area recognize the importance of feeding high-protein rations to their animals. Because of low soybean production in this area and because of the competitive price of soybean meal as a protein source, soybeans and soybean meal are important import commodities in this region.

Because of the high income elasticity of meat, soybean meal exports to this region are expected to increase as per capita disposable income increases. The form of U. S. soybean exports, whole beans or meal, will depend upon the number, size, and efficiency of solvent extraction plants being operated in this area.

P. L. 480 has had a substantial impact on U. S. exports of soybean oil. Concessional exports of soybean oil have exceeded commercial exports of soybean oil in every year since the program began. In 1967-68 concessional exports accounted for 87 per cent of all U. S. soybean oil exports (15).

The Soybean Processing Industry

As mentioned previously, the first soybeans processed for oil and meal were processed at cottonseed oil mills. The first soybean processing mills were developed in the World War I time period due to shortages of cottonseed in the South. By 1935 the amount of soybeans being processed for oil and meal exceeded 50 per cent of the total soybean supply.

Soybean oil is a member of the semi-drying class of oils. The oil product of soybean processing, crude soybean oil, is yellow to dark brown in color. Crude soybean oil is refined for use in food and industrial products. The refining process involves deacidifying, bleaching, and deodorizing the crude soybean oil. This hydrogenation process has increased the extent to which fats and oils can be substituted in food manufacturing. Refined soybean oil contains primarily oleic, linoleic, and un-saturated acids (26).

The hydraulic-press method of soybean oil extraction was the first method used in processing soybeans. This process involved flaking and heating the soybean seed and then submitting the "conditioned" soybeans to a hydraulic pressing operation at elevated temperatures.

The hydraulic press was replaced in the 1930's by the more efficient screw press method. The screw press method involves grinding and conditioning the soybeans before submitting them to a continuous pressing process at elevated temperatures. The screw press method utilizes a rotating worm shaft to extract the oil from the soybeans.

During the 1948-49 processing season, the solvent method of extraction became the leading method of soybean oil extraction. Solvent extraction is a chemical process that involves washing or leaching the oil from flaked soybeans by the use of a hexane solvent (26).

The solvent extraction type process lends itself to large economies of scale. This has resulted in the enlargement of individual processing plants. Although the number of soybeans crushed has increased tremendously since 1950, the number of processing plants has decreased due to the economies of scale in solvent extraction. The solvent extraction process is more efficient than the screw press method in relationship to the amount of oil recovered per sixty-pound bushel (26).

Soybean processing plants have usually been located in areas of concentrated production. Illinois is the leading soybean state in the union and also has the largest soybean processing crushing capacity. Iowa has the largest number of processing plants with 16 in 1970 followed by Mississippi and

Illinois with 15 and 12, respectively (35).

As suggested earlier, there are economies of scale involved in large scale soybean solvent extraction operations. However, there are increasing costs involved in procuring soybeans over a wide geographical area. Theoretically, there exists a point where internal economies of scale are just offset by external diseconomies in soybean procurement and product sales. Tables 13 and 14 show that the economies of scale in production have been greater than the diseconomies in procurement and product dispersion due to the decreasing number and increasing average size of processing plants.

The soybean processing industry has been a highly competitive industry in recent years. The amount of profit or loss accruing to an individual processor is highly dependent upon processing or crushing margin. This margin is defined as the difference between the value of the soybean products, oil and meal, and the price the processor pays for his soybeans.

An important factor influencing processing margin is the quantity and quality of products the processor obtains from his soybean inputs. Since soybean oil is more valuable per pound than soybean meal, processing soybeans with higher oil content will result in a larger crushing margin, ceteris paribus. In a later chapter we hope to explain how oil and protein, as well as other quality factors, affect total value product and processing margins.

Table 13. Estimated number of soybean oil mills in U. S.[1] [2]

State	1951	1955	1961	1965	1970
Illinois	31	31	19	16	12
Iowa	30	26	22	19	16
Indiana	10	10	5	5	5
Ohio	14	8	7	5	4
Missouri	9	6	4	3	3
Minnesota	7	8	8	7	7
Kansas	6	3	3	4	4
Nebraska	3	3	3	3	3
Arkansas	10	7	7	8	11
Mississippi	13	9	11	11	15
Louisiana	3	3	1	2	4
North Carolina	13	7	6	6	7
South Carolina	7	3	5	7	7
Virginia	3	1	1	1	1
Maryland	-	-	1	1	1
Delaware	1	1	1	1	1
Georgia	6	2	3	2	5
Florida	1	2	2	1	-
Alabama	2	3	3	3	4
Tennessee	6	3	7	7	8
Kentucky	4	2	3	2	2
Oklahoma	5	5	3	4	2
Texas	5	4	2	3	5
California	4	5	4	4	3
Total	193	152	131	125	130

[1]Source: Fats and Oils Situation, June, 1970 (35).

[2]Estimates based mainly from Census data and trade directories.

Table 14. Estimated number of mills and processing capacity[1]

Year	Number of mills[2]	Capacity[3]	Crush[4]	Ratio[5]
		mil. bu.	mil. bu.	%
1951	193	310	244	79
1952	174	(315)	234	74
1953	159	(320)	218	68
1954	162	(340)	241	71
1955	152	(355)	282	79
1956	145	370	314	85
1957	141	450	351	78
1958	131	450	399	89
1959	123	500	394	79
1960	125	525	406	77
1961	131	(535)	431	81
1962	130	550	473	86
1963	132	570	437	76
1964	125	585	479	82
1965	125	600	537	89
1966	129	650	551	85
1967	135	750	576	77
1968	134	750	606	81
1969[6]	132	770	725	

[1]Source: Fats and Oils Situation, June, 1970 (35).

[2]Estimates based mainly from Census data and trade directories.

[3]Trade estimates. Data in brackets are USDA interpolations.

[4]Soybeans actually crushed.

[5]Ratio of utilized capacity to total capacity.

[6]Preliminary reports.

Soybean Utilization

Soybeans are the "miracle crop of the 20th Century". The tremendous growth in production, world trade and processing, outlined in previous sections, has been made possible by the vast and diversified usage made of soybeans and soybean products. Soybeans are used in the production of such things as candy and antibiotics, soap and textiles, sandwich spreads and muffins.

Soybean oil is used primarily in cooking oils and salad dressings. The rapid growth in popularity of unsaturated fats has accelerated soybean oil consumption. Soybean meal has been used primarily as a protein supplement in livestock feed. The introduction and development of soy protein for human consumption is probably the most dynamic use for soybeans at the present time. The urgent world demand for high-protein foods will probably increase the importance of soybeans as a high-protein human food. The reason for this is simple. Soybeans can produce a large amount of protein per acre at a relatively low cost. Tables 15 and 16.

The domestic disappearance of soybeans in the United States for 1969 was 27.0 pounds per capita. This figure compares with 4.7 pounds per capita for cottonseed oil and 2.0 pounds per capita for corn oil. Coupled with the domestic disappearance is the 428.7 million bushels we exported (35).

Table 15. Cost per pound for various protein sources[1]

Source	Protein cost per pound
Beef (retail)	4.44
Chicken (dressed)	1.50
Wheat flour	.60
Bulgar flour	.47
Peanut meal (defatted)	.43
Dry skim milk	.40
Wheat (whole)	.30
Cottonseed flour	.17
Fish meal (feed)	.14
Soy flour (food)	.11

[1]Source: Martin (24, p. 45).

Table 16. Acre yield and protein yield for various commodities[1]

Commodity	Yield per acre	Protein per acre
Soybean	24.2 bu.	508
Other legumes	20.7 bu.	293
Corn	64.1 bu.	323
Wheat	25.1 bu.	180
Milk	2,780.0 lbs.	97
Beef	342.0 lbs.	58

[1]Source: Martin (24, p. 45).

A graphical presentation of soybean disposition and utilization for 1969 is presented in figure 2.

Soybean oil constituted over 50 per cent of all fat ingredients in shortening in 1968, almost 67 per cent of the ingredients in salad and cooking oils, and greater than 67 per cent of all vegetable oils consumed. Table 17 shows soybean oil food utilization by products for various years since 1958. Table 18 shows soybean oil utilization for nonfood uses. Soybean oil food usage in 1969 accounted for well over 90 per cent of total domestic soybean oil disappearance. Shortening accounted for the largest percentage of soybean oil usage for food in 1969, with 38 per cent of total edible usage going for shortening production. Margarine accounted for 37 per cent of food usage, and cooking and salad oils accounted for 24 per cent.

An aggregate picture of U. S. soybean oil utilization is given in table 19. This table shows total soybean oil supply for 1970 to be 8,808 million pounds. Of this total supply, 71 per cent was used for domestic purposes, 20 per cent for export or shipment to U. S. territories, and 9 per cent was carryover stock.

An aggregate picture of U. S. soybean meal utilization is given in table 20. Total soybean meal supply in 1970 was 18,172 tons. Seventy-three per cent of this total supply was used for domestic purposes, while soybean meal exports accounted for one-fourth of the total U. S. supply.

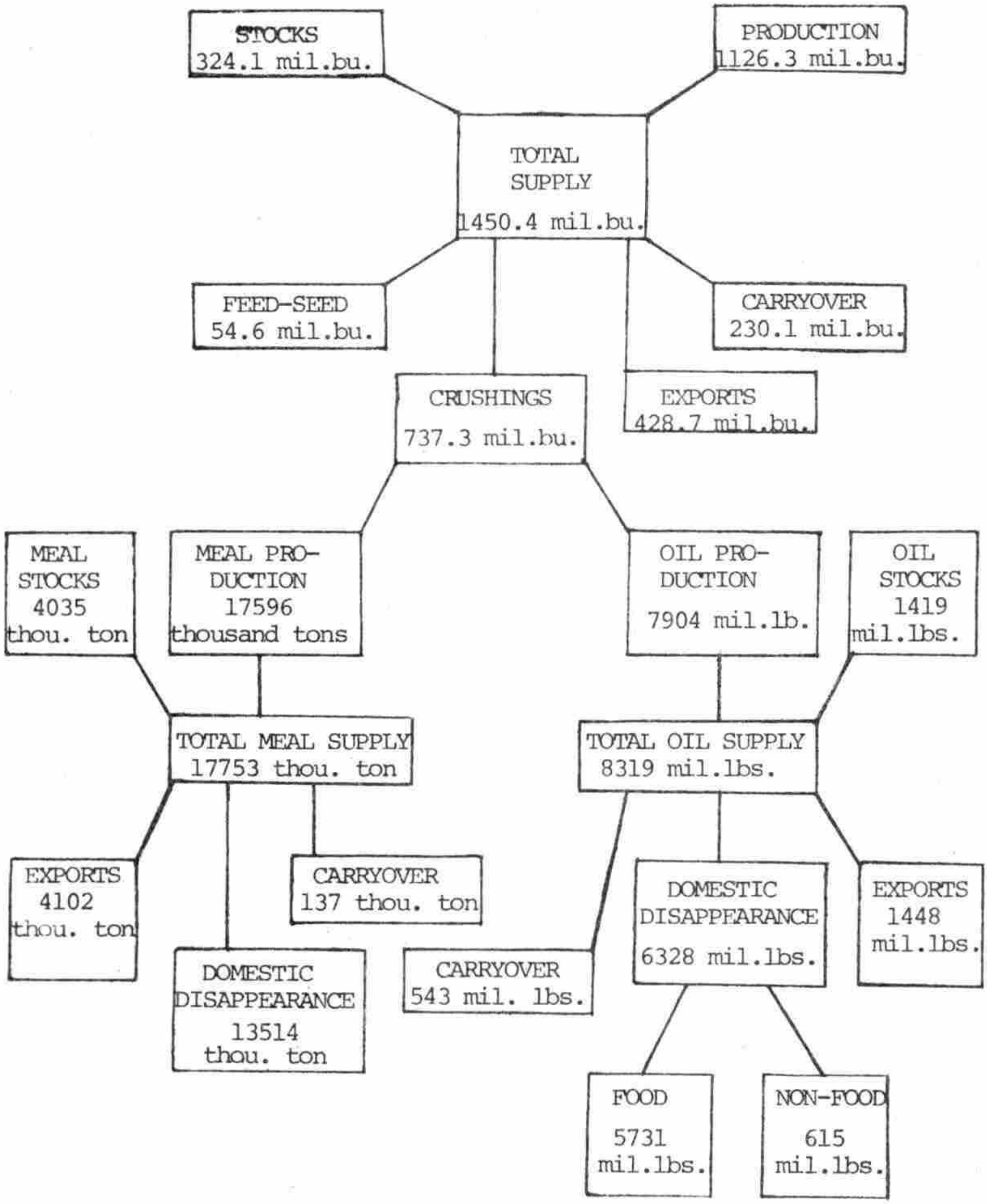

Figure 2. Disposition of soybeans for 1969

Table 17. Soybean oil, food utilization, by products[1]

Year[2]	Shortening	Margarine	Cooking & salad oil[3]	Other	Total
			Million pounds		
1958	1136	1082	665	77	2960
1959	1183	1114	680	23	3000
1960	1097	1072	793	26	2989
1961	1353	1036	771	20	3180
1962	1222	1069	933	15	3239
1963	1391	1126	1146	21	3684
1964	1404	1107	1100	32	3643
1965	1739	1241	1200	38	4218
1966	1691	1273	1353	58	4375
1967	1816	1234	1494	44	4588
1968	1978	1290	1967	36	5271
1969[4]	2240	1416	2163	37	5856

[1]Source: Fats and Oils Situation, November, 1970 (35).

[2]Year beginning October 1.

[3]Adjusted for exports of refined and further processed salad oil. Prior to 1965 no adjustment was made for exports of undeodorized hydrogenated oil.

[4]Preliminary reports.

Table 18. Soybean oil: non-food utilization, by products[1]

Year[2]	Paint and resin	Plastic and resin	Other drying oil	Linoleum and oilcloth	Other non-food	Foots and losses	Total non-food
				Million pounds			
1949	112	-	-	30	97	78	317
1950	91	62	11	7	50	87	308
1951	109	68	11	19	60	97	364
1952	155	61	9	12	42	106	386
1953	138	56	7	7	32	84	324
1954	138	71	11	2	15	107	344
1955	115	71	9	3	39	107	344
1956	117	72	9	1	31	107	337
1957	103	54	9	-	28	132	325
1958	102	66	6	-	37	133	343
1959	101	74	4	-	48	147	375
1960	96	64	4	1	36	139	340
1961	88	74	4	-	43	151	359
1962	90	78	6	-	48	163	385
1963	97	84	6	-	42	146	374
1964	94	105	5	-	57	165	426
1965	100	104	6	-	53	206	469
1966	96	97	7	-	61	201	462
1967	86	97	7	-	59	259	508
1968	87	94	7	-	61	236	485
1969[3]	87	79	7	-	56	243	472

[1]Source: Fats and Oils Situation, November, 1970 (35).

[2]Year beginning October 1.

[3]Preliminary reports.

Table 19. U. S. soybean oil utilization[1]

Year[2]	Prod,n	Stocks	Total supply	Exports[3]	Domestic disappearance
			Million pounds		
1950	2,454	113	2,567	490	1,906
1951	2,444	171	2,615	271	2,150
1952	2,536	194	2,730	93	2,462
1953	2,350	174	2,525	71	2,326
1954	2,711	127	2,838	50	2,609
1955	3,143	179	3,322	556	2,539
1956	3,431	227	3,658	807	2,565
1957	3,800	286	4,085	804	3,051
1958	4,251	281	4,532	930	3,304
1959	4,338	298	4,636	953	3,376
1960	4,420	308	4,728	721	3,329
1961	4,790	677	5,476	1,308	3,540
1962	5,091	618	5,709	1,165	3,624
1963	4,822	920	5,742	1,106	4,058
1964	5,146	578	5,724	1,357	4,069
1965	5,800	297	6,097	948	4,687
1966	6,076	462	6,538	1,105	4,837
1967	6,032	596	6,628	993	5,096
1968	6,531	540	7,071	899	5,756
1969	7,904	415	8,319	1,448	6,328
1970[4]	8,265	543	8,808	1,782	6,253
1971[5]	7,825	773	8,600	1,250	6,450

[1]Source: Fats and Oils Situation, February, 1972 (35).

[2]Year beginning October 1.

[3]Includes shipments to U.S. territories.

[4]Preliminary reports.

[5]Forecast.

Table 20. U. S. soybean meal utilization[1]

Year[2]	Prod'n	Imports	Stocks[3]	Total supply	Exports[4]	Domestic disappearance
			1,000 tons			
1950	5,897	33	35	5,965	181	5,748
1951	5,704	24	36	5,764	42	5,670
1952	5,551	41	52	5,644	47	5,540
1953	5,051	16	57	5,124	67	4,995
1954	5,705	-	62	5,767	272	5,458
1955	6,546	-	37	6,583	400	6,072
1956	7,510	-	111	7,621	443	7,123
1957	8,284	1	55	8,340	300	7,992
1958	9,490	-	48	9,538	512	8,968
1959	9,152	-	58	9,210	649	8,479
1960	9,452	-	83	9,535	590	8,867
1961	10,342	-	78	10,420	1,064	9,262
1962	11,127	-	94	11,221	1,476	9,586
1963	10,609	-	159	10,769	1,478	9,168
1964	11,286	-	122	11,408	2,059	9,243
1965	12,901	-	106	13,007	2,656	10,219
1966	13,483	-	132	13,615	2,706	10,772
1967	13,660	-	138	13,798	2,959	10,693
1968	14,581	-	145	14,726	3,100	11,469
1969	17,596	-	157	17,753	4,102	13,514
1970[5]	18,035	-	137	18,172	4,620	13,406
1971[6]	17,150	-	146	17,300	3,960	13,200

[1]Source: Fats and Oils Situation, February, 1972 (35).

[2]Year beginning October 1.

[3]Stocks at processors plants, October 1.

[4]Includes shipments to U. S. territories.

[5]Preliminary reports.

[6]Forecast.

QUALITY IN THE MARKETING OF GRAIN

History

The development of grades and standards has paralleled the development of industrialization and communication. The need for grades and standards in a simple barter economy is not as great as in an industrial society. Early attempts to establish grades in the U. S. brought about as much confusion and abuse as the initiators had hoped to eliminate. Trade groups, dealers, and government all established their own grades and standards. Confusion between and among grades reached a peak in the early 1900's. In 1906 there were no less than 308 grading names or titles being used in grain grading alone (21). The existence of this type of grading system failed to bring about a simplified common language for buyers and sellers. Progress toward a systemized nomenclature was achieved only after intervention by the federal government. Passage of the Cotton Futures Act in 1914 and the Grain Standards Act of 1916 laid the ground work for present day grading and standardization.

The history of the establishment of grades and standards is indeed interesting. The efficiency we enjoy today in our marketing system owes much to their establishment. The establishment of grades and standards must not, however, result in a complacent attitude toward their existence. If we are to avoid the rule of "caveat emptor", we must continuously appraise and evaluate grading schemes and standards.

Advantages of Grading and Standardization

Before proceeding further, it is imperative that we define terms as they are to be used in this research. Quality factors are those attributes or characteristics of the commodity which influence the market price of that commodity. Standards are yardsticks of measurement. They refer to the criteria used as a test of quality. A grading scheme is a set of quality criteria defining a mutually exclusive and exhaustive set of categories referred to as grades. Grading refers to the placement of products or commodities into the categories established by the grading scheme.

Grading and standardization in agricultural commodities is necessitated by the existence of a wide range of quality characteristics in biologically produced products. The development of standards and the placement of products into grades in many situations is advantageous to the marketing of an ungraded or unsorted product. The following is a list of some of the advantages that accrue when the grading function is properly performed (8,21,25,30,34).

(1) Grading makes possible more meaningful price quotations. Buyers and sellers in distant markets can trade more easily, permitting bargaining over price relative to supply and demand rather than quality conditions.

(2) Since everyone is talking the same language, market information and market news reports are more meaningful.

(3) Grading enables the market to be more perfect with respect to time and distance.

(4) Grading makes meaningful the sale of goods for future delivery.

(5) Once the product has been graded, it enables the handler of the product to "pool" products of like quality or grades.

(6) Grading reduces the risk of fraudulent practices.

(7) Grading facilitates the settlement of claims.

(8) Grading facilitates financing. Loans are easier to obtain if product quality is known.

(9) Grading enables the producer and buyer to know the relative worth of the product.

(10) Grading enables buyers to obtain goods or commodities to meet their particular needs or requirements.

(11) Grading may enable the processor to specialize in production.

(12) Grading may increase the quality of the product placed on the market.

(13) Grading results in greater uniformity of products within each grade.

(14) Grading may, at least in the short-run, increase the demand for certain qualities or products.

(15) Grading should result in higher profits for producers.

(16) Grading helps to increase the size of the market area. This brings a larger number of buyers and sellers into the market, thus encouraging a more efficient movement of goods to ultimate outlets.

(17) Grading reduces marketing costs.

(18) Grading, with a large number of buyers and sellers in the market, enables small producers to compete with large producers.

(19) Grading reduces the expense of competitive brand advertising and high-pressure salesmanship.

(20) Grading may reduce the chance of spoilage, especially in highly perishable products, since products which deteriorate quickly can be sorted out and utilized more rapidly.

(21) Grading may reduce relative transportation costs, since higher quality products can be shipped to distant markets and lower quality products can be utilized closer to the point of production.

(22) Grading may reduce the middleman's risk in handling the product.

This extensive list gives unimpaired coverage to the advantages of grading, all of which are important, many of which are often overlooked. In summary, grading develops a common language in the market whereby both buyers and sellers know the relative value and quality of each product and each grade. It should be noted that the advantages outlined above are dependent upon a competent and efficient grading scheme and that grading, no matter how efficient, may not ensure that each individual advantage will be achieved for every product we wish to grade.

Grading Criteria and Objectives

The basic problem in assigning grades arises from the fact that agricultural products vary over a large range of quality, while at the other end of the marketing channel these products or qualities face heterogeneous demand functions. The objective of grading is to arrange the wide range of quality characteristics into homogeneous lots that meet the needs and demands of processors and final consumers.

Kohls (21) established two primary objectives of grading. The first objective states that a grading system should differentiate the products in such a way that each consumer pays as much as he is willing to pay for the particular commodity. Or simply, that consumer surplus is minimized. The second objective states that the grading system should move as large a quantity as possible into consumption and obtain the greatest total price possible for that quantity. These two objectives simply state that a grading system should be established in such a way that the consumer gets what he wants and that total revenue to the producer is maximized.

It is possible that one of the primary deficiencies of the present day systems is that consumers' wants are not adequately translated back to the producer. The problem associated with oil and meal content in soybean grading is a primary example. Similarly, standards for other grains do not take into account the total digestible nutrients or the protein content of these grains.

One of the major reasons why standards have not been adopted to "measure" these important quality characteristics is that adequate objective means of measurement have not been developed. The development of such "tests" would enhance the relationship between the price of the product and the grade given that product. This relationship is necessary for efficient and meaningful marketing.

The fact that no two consumers' wants are identical should be kept in mind. This concept would imply that an infinite number of grades for each product should exist so that every consumer could voice his opinion on product quality. However, the development of an infinite number of grades would destroy the very purpose for which they were developed. On the other end of the spectrum, there should be enough grades so that the differences in grade qualities and the tolerance for certain defects are not so large as to discredit the grade designation.

Where should the boundaries between grades be set? How many grades should there be? According to Kohls, there should be "enough of the normal production falling in each grade to make it a meaningful market category (21)." Given a continuous, normal distribution of product quality, it is apparent that grade boundaries will tend to be "zones" rather than precise lines. It may be very difficult to determine between high grade "B" and low grade "A". It is this area or zone of indecision that presents problems in grade determination. If objective tests are used, the area of indecision should be reduced. Changes in environmental and production variables may result in an adjusted frequency distribution within the assigned grades. Likewise, if we were to change the specifications for each grade, there would follow a change in the proportion of the products placed in each grade. According to Erdman, the boundaries for each grade should be placed where they will be "dependent upon the degree to which the various users will pay premiums for certain qualities rather than substitute adjacent qualities within the range available" (11).

The idea that producer's profits should be maximized with regard to boundary classifications is illustrated by the following example. First assume a product with the following characteristics:

	% of Lot	Price in Market	Return to Producer
Grade A	25	$3.00	$ 75.00
Grade B	50	2.50	125.00
Grade C	25	2.00	50.00

			$250.00

Let us now redefine the boundaries for the top two grades to obtain the following:

	% of Lot	Price in Market	Return to Producer
Grade A	20	$3.50	$ 70.00
Grade B	55	2.50	137.50
Grade C	25	2.00	50.00

			$257.50

This change in boundaries will have two effects on market price and demand. First, the demand for both Grade A and B should be increased since the quality of each grade has been increased. Secondly, the difference in quality should result in a higher price for A since the quantity has been reduced, and in a lower price for B since the quantity has been increased.

Taking each grade separately, it is apparent that the price of A in the second case will be greater since demand is increased and quantity supplied is decreased. The price of B will have increased due to the increase in demand, but will have decreased due to the increase in quantity supplied. The extent to which these prices vary will depend upon the elasticity of demand and cross-elasticity of demand for each grade for the particular time period in question.

In this example the elasticity and cross-elasticity of demand were such that total revenue to producers was increased by changing the boundaries of the grades.

Unfortunately, the problem is not as easy as presented here. As mentioned earlier, the range in product quality varies from year to year. In addition, demand elasticity is not constant over time.

In the above example we assumed that an increase in quality resulted in an increase in demand. As was stated earlier in the list of the advantages of grading, this situation does not always exist. As Kohls has stated:

> The purpose of grading is not to assure the marketing of only top quality products. Those who conceive a grading system as a vehicle for the elimination of variation in quality are ignoring the wide range of consumer preferences and uses which exist (2).

Also to be noted is the fact that producers face diminishing returns to scale with respect to quality production. The extra return from producing a high-quality product may not cover the additional cost. In developing the quality of the products to be placed on the market, the production of each grade should be at the point where the expected price in the market equals the marginal cost of production.

Another major question in grading is, "Where should the product be graded?" This problem is made more complex by the fact that most agricultural products are perishable. Darrah described the place where grading should take place very accurately.

> Grade determination, to be meaningful must be performed at a point in the market system where a minimum of change occurs in the product prior to the time of purchase by the final customer yet far enough back in the system to reflect to the producer the full value of his output (8).

This usually implies that grading should be done when the farmer first sells his product, thus telling him immediately what consumers desire. If the product undergoes deterioration in the marketing process, it may be necessary to grade the product again to assure an accurate grade to the consumer.

A not-to-be-overlooked problem in grading is whether or not the grading system is workable. The easiest and perhaps even the best test for workability of a grading system is its acceptability and use by the marketing interests concerned. All of the preceding considerations for an efficient grading system have been for naught if the grading system is unworkable.

It should be noted here that the cost of grading and standardization is a diminishing returns concept. No grading system should be adopted in which the cost of grading exceeds the benefits to consumers, producers, and processors.

SOYBEAN GRADING AND PRICING

History

Early attempts at establishing official grades and standards for soybeans were manifested by the American Soybean Association. The demands of the American Soybean Association were met in 1924 when the Bureau of Agricultural Economics issued tentative standards for soybeans. J. E. Barr has given a complete background concerning the development and origin of the original standards (3). It is interesting to note that the quality factors included in the 1925 standards are the same factors recognized in 1972. This fact is somewhat frightening when one considers the uncertainty that developed concerning which quality factors to include in the original soybean standards. This uncertainty is exemplified in Barr's statement:

> ...at first manufacturers, themselves, were in doubt regarding what seemed to be important quality factors. During the past two years some of these factors have been eliminated as irrelevant and the relative importance of others has declined in the minds of those in close touch with the industry.

Table 21 gives a listing of the soybean grades and grade requirements from 1925 to the present time.

Table 21. Official quality standards for soybeans[1]

	Minimum	Maximum limits of			
	Test weight	Moisture	Splits	Damage	F.M.
	lbs.	%	%	%	%
1925					
No. 1	58	15	1.0	2.0	0.5
No. 2	57	16	10.0	3.0	2.0
No. 3	56	17	20.0	5.0	5.0
No. 4	54	18	30.0	8.0	10.0
Sample grade[2]					
1926					
Extra No. 1	56	15	0.5	1.0	0.2
No. 1	56	15	1.0	2.0	0.5
No. 2	54	16	10.0	3.0	2.0
No. 3	52	17	20.0	5.0	5.0
No. 4	50	18	30.0	8.0	10.0
Sample grade					
1948					
No. 1	56	13	10.0	2.0	1.0
No. 2	54	14	15.0	3.0	2.0
No. 3	52	16	20.0	5.0	3.0
No. 4	49	18	30.0	8.0	5.0
Sample grade					
1949					
No. 1	56	13	10.0	2.0	2.0
No. 2	54	14	20.0	3.0	3.0
No. 3	52	16	30.0	5.0	4.0
No. 4	49	18	40.0	8.0	6.0
Sample grade					
1972					
No. 1	56	13	10.0	2.0	1.0
No. 2	54	14	20.0	3.0	2.0
No. 3	52	16	30.0	5.0	3.0
No. 4	49	18	40.0	8.0	5.0
Sample grade					

[1]Source: USDA, BAE (40). USDA, PMA (38). USDA, CMS (39).

[2]Sample grade soybeans are soybeans which do not meet the requirements for any of the grades U. S. number one to four, inclusive.

Although factors included in the grade designations have not changed since 1925, the grade boundaries, the inclusions of special grades, and the treatment of dockage have changed. A "special" grade was introduced into the 1926 standards. This "Extra No. 1" grade classification has since been dropped from the soybean standards. It is interesting to note, that except for 1926, the soybean standards have always consisted of four numerical grades (1 through 4) and sample grade.

The grade factors--test weight, moisture, splits, and foreign material--have undergone changes in grade boundaries. Test weight per bushel was originally promulgated with a range of 58 to 54 pounds per bushel for No. 1 to No. 4 soybeans. This range was changed in 1948 to 56 to 49 pounds per bushel and has remained at that level since. The maximum moisture limit for U. S. No. 4 Soybeans has been 18 per cent since 1925, however, the maximum limit for No. 1 soybeans has dropped from 15 per cent moisture to 13 per cent moisture. The maximum splits limit for U. S. No. 1 soybeans has undergone the most drastic change. In 1925, No. 1 soybeans could have no more than one per cent splits, this boundary for No. 1 was changed to 10 per cent in 1948 and has remained at that level. The amount of foreign material allowed in each grade has undergone the most changes. Grade boundaries for foreign material have changed three times since their original promulgation. The present standards allow a maximum of one per cent foreign material in U. S. No. 1 soybeans. Table 21 fails to point out the fact that prior to 1949 foreign material or dockage greater than one per cent was always neglected. In the early standards, foreign material less than or equal to one per cent was called "dockage" and foreign material greater than one per cent was called "foreign material". The 1949 revisions combined these two factors into a common factor, "foreign material".

Soybean Grading and Grade Factors

For grading and standardization purposes, soybeans

> ...shall be any grain which consists of 50 per cent or more of whole or broken soybeans which will not pass readily through an 8/64 sieve and not more than 10 per cent of other grains for which standards have been established under the United States Grain Standards Act (37, p. 5-6).

Soybeans are divided into five different classes: yellow, green, brown, black, and mixed soybeans. Each of the five classes has four numerical grades plus sample grade. In addition, there are two special grades, garlicky soybeans and weevily soybeans. In order for a lot of soybeans to be graded garlicky, the lot must contain five or more garlic bublets in 1,000 grams of the sample. Soybeans which are graded weevily, are soybeans which are infested with live weevils or any other insect that is injurious to stored soybeans.

The basic grading factors for soybeans are test weight, splits, moisture, foreign material, total damaged kernels, heat damaged kernels and black, brown, and/or bicolored soybeans in yellow or green soybeans. Test weight per bushel for soybeans is recorded in terms of whole and half pounds. All other factors are in percentage terms where percentage refers to per cent of total weight (37).

> Each determination of class, splits, damaged kernels, and heat-damaged kernels, and of black, brown, and/or bicolored soybeans in yellow or green soybeans, shall be upon the basis of the grain when free from foreign material. All other determinations shall be upon the basis of the grain as a whole (37, p. 182).

When determination of the various factors has been completed, a grade is assigned according to the lowest grade permitted by any one of the sample's measured grading factors. There are, however, exceptions to this rule. Sour, musty, or heating soybeans are graded sample grade. Likewise, soybeans with any "commercially objectionable foreign odor" are graded sample grade. Soybeans that contain seven or more stones with weight in excess of 0.2 per cent are graded sample grade. Sample grade is also assigned to lots of soybeans which are otherwise of "distinctly low quality." This term refers to such things as large stones, rodent excreta, castor beans, etc. "Materially weathered" soybeans cannot be graded higher than U. S. No. 4. Soybeans which contain greater than two per cent purple mottled soybeans shall not be graded higher than U. S. No. 3 (37).

The determination of the "true" soybean grade is dependent upon the taking of a representative sample of soybeans.

Test weight per bushel is basically a measure of seed density. When the original standards were developed, test weight was not considered to be an important factor in soybean quality. For this reason grade boundaries were set in such a fashion to avoid down-grading a majority of the crop (3). Despite this original thinking, it is still mandatory that test weight be recorded on the grade certificate whether or not it determines the final grade (37).

The moisture content of every sample of soybeans for cargo shipment must be included on the grade certificate. Moisture content in excess of 13 per cent must be placed on the certificate for all non-cargo shipments of soybeans (37). When moisture content of soybeans is greater than 13 per cent, storage becomes a problem.

Splits, as a grading factor in grains, is unique to soybeans. Splits are defined as pieces of soybeans with more than 1/4 broken off. Splits are recorded on the grade certificate in terms of whole per cents (35). The original reason for including splits in the soybean standards was because splits "can be prevented by the exercise of reasonable care in threshing (3)."

Damage in soybeans is extremely heterogeneous. The present grading standards for soybeans aggregate all types of damage into two general classifications, heat damaged kernels and total damaged kernels. The 1971 Grain Inspection Manual defines damaged kernels as:

> ...soybeans and pieces of soybeans which are heat damaged, sprouted, frosted, badly ground damaged, badly weather damaged, moldy, diseased, stink-bug stung, or otherwise materially damaged (37).

Damage differs not only in the nature of damage but also in the extent of damage. The determination of damage in soybeans involves more subjective measurement than any other soybean grading factor.

Foreign material is defined as:

> All matter, including soybeans and pieces of soybeans, which will pass through an 8/64 inch sieve and all other matter other than soybeans remaining on such sieve after sieving (37, p. 188).

QUALITY CHARACTERISTIC DISTRIBUTIONS

Numerical Grade Distribution

The present section deals with the development of distributions for various soybean quality characteristics. Of the 199 samples we collected during the 1971 fall harvest season, 122 were graded number one. There were 56 number two samples, 16 number three's, three number four's, and two samples which graded sample grade. Table 22 depicts the percentage of total samples falling into each grade classification for various years and from various sources. This particular table shows that Iowa as a whole has a larger percentage of soybeans falling into numerical grades one and two than does the United States as a whole. In 1971, for instance, 78.3 per cent of inspected receipts from Iowa graded number one or number two. This compares with 50.6 per cent of total U. S. inspected receipts.

An interesting aspect of table 22 involves the variation in numerical grade distributions among different crop years. In 1968 only 25.5 per cent of inspected receipts in Iowa graded number one, while in 1967 the top soybean grade accounted for 55.0 per cent of inspected receipts. Unfortunately, we cannot tell by the numerical grade which factor or factors were responsible for the smaller percentage of number one soybeans in 1968. The numerical grade tells us only what the grade was and not what factors were involved in establishing the particular grade.

The comparison of numerical grade distributions between fall harvest samples and processors and terminal elevator certificates is quite interesting. It should be noted here that the processors and terminal elevator data originated from the same sample area as the harvest samples. The processors and terminal elevator data was collected approximately four months following harvest and consisted of only 1971 harvest samples. The comparison between these two sources of grade information should reflect the changes in numerical grade and quality factor levels due to handling, storage, transportation, and blending. The processor and terminal elevator data showed 92.8 per cent of inspected receipts fell into grades number one and two compared with 89.4 per cent for the fall harvest samples. However, 61.3 per cent of the harvest samples graded number one, and only 36.3 per cent of the processor and terminal elevator receipts achieved that grade.

Table 22. Numerical grade distributions

	No.1	No.2	No.3	No.4	Sample
			Per cent		
Harvest samples[1]	61.3	28.1	8.0	1.5	1.0
Iowa-1971[2]	38.4	39.9	12.8	5.3	3.7
Iowa-1970	45.5	38.0	11.5	2.5	2.5
Iowa-1969	38.0	40.0	17.0	3.0	2.0
Iowa-1968	25.5	52.0	16.5	3.5	2.5
Iowa-1967	55.0	32.0	8.0	3.5	1.5
U.S.-1971	12.6	38.0	30.7	11.4	7.2
U.S.-1970	22.6	37.6	24.4	10.0	5.4
U.S.-1969	22.3	44.0	23.2	6.9	3.6
U.S.-1968	17.8	46.9	22.2	8.6	4.5
U.S.-1967	29.9	41.8	19.1	6.8	2.4
Processors & terminal[3]	36.3	56.5	3.2	4.0	0.0
Export-1971[4]	0.2	85.4	10.0	4.2	0.1
Export-1970	0.2	88.3	8.5	3.0	0.0

[1]Harvest samples refer to the 199 producer delivered samples collected during the 1971 soybean harvest at 12 country elevators in North-Central Iowa.

[2]Iowa and U. S. figures refer to inspected receipts two months following harvest. Source: Grain Crop Quality (36).

[3]Official certificates collected from processors and a terminal elevator in central Iowa.

[4]Inspections for export soybeans. 1971 = September 1970 to August 1971. 1970 = September 1969 to August 1970.

Moisture Distribution

Moisture content in the fall harvest samples ranged from 8.7 per cent to 16.8 per cent while attaining an average moisture content of 11.42 per cent. The normal soybean discount schedule discounts soybeans which are greater than 13 per cent moisture. Twenty-two harvest samples exceeded the 13 per cent moisture level. Table 23 shows the moisture distribution for the harvest samples as well as for the U. S. as a whole and for the processor and terminal elevator certificates. Using the grade boundaries for moisture outlined earlier, we see that 177, or 88.9 per cent, of the fall harvest samples meet the requirements for number one soybeans; 17, or 8.5 per cent, meet the requirements for number two soybeans; four samples, or 2.0 per cent, meet the requirements for number three soybeans; and one sample fell into the number four numerical grade classification. One hundred and twenty-two of the 124 inspected receipts from processors and the terminal elevator graded number one on moisture content. The remaining two inspected receipts graded number two. This implies that since only two inspected receipts from processors and the terminal elevator exceeded 13 per cent moisture, only two of the 124 samples of soybeans were discounted because of moisture content.

Table 23. Moisture distributions

Per cent	Harvest samples[1]	1971[2]	1970	1969	P.&T.[3]
10.0 and under	17	4,452	2,198	876	2
10.1-12.0	143	31,514	37,464	28,716	90
12.1-13.0	17	31,990	31,220	48,960	30
13.1-13.5	9	14,294	13,076	19,212	2
13.6-14.0	8	17,108	12,852	18,144	-
14.1-14.5	1	11,788	7,462	9,744	-
14.6-15.0	1	10,234	7,532	8,016	-
15.1-15.5	1	6,482	4,732	3,900	-
15.6-16.0	1	5,684	4,788	2,796	-
16.1-16.5	-	2,646	2,436	900	-
16.6-17.5	1	2,268	2,072	840	-
17.6-18.0	-	966	966	336	-
18.1-20.0	-	686	980	276	-
20.1 and over	-	840	1,036	192	-
Total	199	140,952	128,814	142,908	124

[1]1971 producer delivered harvest samples from central Iowa.

[2]U. S. figures refer to inspected receipts two months following harvest. Source: Grain Crop Quality (36).

[3]Official certificates collected from processors and a terminal elevator in central Iowa.

A somewhat different picture is exhibited in table 24. Although a larger percentage of samples fell into the number one grade classification for the processor and terminal elevator certificates when compared to harvest samples, this particular table shows that the harvest samples were, on the average, lower in moisture content than were the processor and terminal elevator samples, 11.425 per cent versus 11.593 per cent.

The differences that existed in the percentage of each source of data falling into the numerical grade classifications is explained by the differences in dispersion for the two sources of data. Using variance, standard deviation, and range as measures of dispersion, it is quite evident that the producer delivered samples exhibited larger dispersion than did the inspected receipts from processors and the terminal elevator. That is, a larger percentage of individual sample moisture readings were closer to the mean moisture reading for the processors and terminal elevator data than for the producer delivered harvest samples.

It should be noted that although the producer delivered samples were slightly lower in moisture content than were the inspected receipts from the processors and terminal elevator, the difference was not statistically significant. In fact, a test of the hypothesis that there is no difference between the two sample means requires accepting the hypothesis that the two means are in fact the same at the 95 per cent confidence level. Considering that there is no statistical difference in mean moisture levels for the samples that were Producer delivered at country elevators and for the processors and terminal elevator receipts from the same area four months following harvest, it seems safe to assume that moisture content does not change substantially during storage, handling, and transportation. The reduction in variation or dispersion of moisture content levels in these samples implies that blending and pooling of the soybeans at the country elevator level tends to reduce the amount of variation in soybean moisture content as soybeans are moved through the marketing channel.

Further examination of table 24 reveals that on the average, the moisture content of the 1971 harvest sample soybeans was lower than the 1971 moisture content of inspected receipts for the U. S. as a whole. This difference was found to be statistically significant at the 99 per cent confidence level.

An examination of total U. S. inspected receipts for moisture content distribution reveals that in 1971, 55 per cent of the inspected receipts had moisture content that met the requirements for number one soybeans. The remaining 45 per cent were distributed into the lower grades with 26.1 per cent falling into the number two classification, 17.1 per cent into the number three classification, 1.5 per cent into number four, and 0.3 per cent sample grade. Recalling that the maximum limits for number one soybeans is 13 per cent moisture, and that soybeans in excess of 13 per cent moisture are discounted, it follows that 45 per cent of the U. S. inspected receipts in 1971 were subject to moisture discounts.

The differences between mean moisture content for the various years should also be noted. For the five years recorded in table 24, average moisture content for inspected receipts for the entire U. S. ranged from 12.28 per cent to 13.25 per cent.

Using the chi-square test for goodness of fit for the producer delivered harvest samples, it was determined that the distribution of moisture did not approximate the normal distribution. The actual results and computations involved in this test can be found in Appendix C.

Table 24. Moisture content, statistical measures[1]

	No.	$\bar{Y}$	S^2	S	Range	C
Harvest samples	199	11.425	1.541	1.241	8.10	10.864
Processors and terminal elevator	124	11.593	0.576	0.759	3.60	6.547
1971-U.S.[2]	135,660	13.250	2.770	1.660	-	12.564
1970-U.S.	125,580	13.010	3.000	1.730	-	13.305
1969-U.S.	141,840	12.970	1.820	1.350	-	10.414
1968-U.S.	108,132	12.780	2.050	1.430	-	11.203
1967-U.S.	118,140	12.280	1.770	1.330	-	10.834

[1]For a description of the statistical measures used in this table and in other segments of the thesis, see Huntsberger (16, chapter 2).

[2]U. S. figures refer to inspected receipts two months following harvest. Source: Grain Crop Quality (36).

Foreign Material Distribution

Foreign material content in the fall harvest samples ranged from 0.0 per cent to 8.5 per cent while attaining an average foreign material content of 0.786 per cent. Table 25 shows the distribution of foreign material for the various sources of data.

According to processor scale discounts, all foreign material in excess of one per cent is deducted from gross weight and not paid for. Thirty-eight, or 19.1 per cent, of the 199 producer delivered harvest samples were subject to weight discounts because of excess foreign material. This figure compares with 39.5 per cent for the processors and terminal elevator samples. 1971 inspected receipts for the U. S. as a whole showed 54.9 per cent of the samples subject to dockage because of foreign material.

The foreign material distribution depicted in table 25 implies that 80.9 per cent of the 1971 fall harvest samples fell into the number one numerical grade classification, 13.6 per cent fell into the number two classification, 3.5 per cent into the number three classification and 1.0 per cent for both number four and sample grade classifications. The inspected receipts from the processors and the terminal elevator had 60.5 per cent, 33.1 per cent, 3.2 per cent and 3.2 per cent of the total samples falling into the numerical grades one, two, three and four, respectively. Although these two sources of data had about the same percentage of samples falling into the three lower grades, the producer delivered samples had over 20 per cent more samples falling into the number one classification. Inspected receipts for the U. S. in 1971 had even a smaller percentage of samples grading number one, 45.1 per cent. The remaining 54.9 per cent were distributed into the lower grades with 31.4 per cent classified number two, 11.7 per cent number three, 7.9 per cent number four, and 3.9 per cent sample grade.

A comparison between the means for the harvest samples and the processors and terminal elevator samples shows that the harvest samples were substantially lower in foreign material content, on the average, 0.786 per cent as compared with 1.185 per cent. Assuming that the two population variances are the same, the t-test for the comparison of the means of the two independent samples shows that the mean for the producer delivered samples is 0.168 per cent lower than the mean for the processors and terminal elevator data at the 95 per cent confidence level. Because of the large difference in sample variances for the two independent random samples, 0.997 versus 0.482, an F-test for examining the hypothesis that the two variances were equal, versus the alternative that they were not equal, was developed. The calculated F value was found to be 2.068. The tabular value for the twosided 5 per cent significance level of F was 1.31. Since the calculated F exceeds the tabular F, the null hypothesis that the two variances are the same is rejected.

The above result partially invalidates the original test of significance for the difference between the means of the two samples since that test assumed that the two populations' variances were the same. In order to test for significance, a method explained by Snedecor and Cochran (32, p. 114-115) was used. Since the calculated value for t, 4.227, exceeds the significance level of t', 1.969, the difference is significant at the 95 per cent level.

The statistical tests employed above are important for two reasons. First, the fact that the means for the producer delivered samples and processors and terminal elevator samples are statistically different implies that soybeans undergo changes in foreign material content as they flow through the marketing channels. Second, the fact that the sample variances are statistically different implies different dispersions of foreign material content from the two sources of data. Handling, storage and transportation probably explain the reason for the increase in foreign material content. It is hypothesized here that the increase in foreign material content is partially explained by an increase in small particles of soybeans that are too small to be classified as splits. These particles result from breakage of the soybean seed during handling. The relative decrease in the amount of dispersion about the mean as the samples move from the farmers to the processors and terminal elevators can be explained by the blending or pooling function.

On the average, the 1971 U. S. inspected receipts contained almost twice as much foreign material as did the 1971 harvest samples, 1.563 versus 0.786. Part of this difference can be explained by the increase in foreign material content due to handling, storage and transportation. However, the U. S. average still exceeded the average for the Iowa processors and terminal elevator samples by a statistically significant amount, implying that soybeans from the harvest sample area were lower in foreign material content than were samples from the U. S. as a whole.

Examination of the mean foreign material content for the five years recorded in table 26 shows that average foreign material content for the U. S. ranged from a low of 1.30 per cent in 1970 to a high of 1.563 per cent in 1971.

Using the chi-square test for goodness of fit for the 1971 producer delivered harvest samples, it was found that the distribution of foreign material content did not approximate the normal distribution.

Table 25. Foreign material distributions

Per cent	H.S.[1]	P.&T.[2]	U.S.-1971[3]	U.S.-1970	U.S.-1969
0.0	6	-	70	28	12
0.1-0.2	52	-	1,302	2,702	5,220
0.3-0.4	33	9	5,768	10,864	12,324
0.5-0.6	21	12	10,556	13,174	15,132
0.7-0.8	22	21	16,828	18,522	18,492
0.9-1.0	27	33	29,036	28,756	28,200
1.1-1.2	6	4	2,646	3,010	3,228
1.3-1.4	7	11	13,118	10,318	10,992
1.5-1.6	4	9	9,296	7,490	7,824
1.7-1.8	4	10	8,190	6,160	6,300
1.9-2.0	6	7	11,032	7,812	8,436
2.1-2.5	3	3	7,770	5,586	6,756
2.6-3.0	4	1	8,736	5,488	6,972
3.1-3.5	-	2	3,136	1,932	2,556
3.6-4.0	1	1	3,920	2,366	2,640
4.1-4.5	1	1	1,680	882	1,224
4.6-5.0	-	-	2,324	1,232	1,536
5.1-6.0	-	-	1,610	882	1,368
6.1 & over	2	-	3,878	1,722	2,760
Total	199	124	140,896	128,926	141,972

[1]1971 producer delivered harvest samples from central Iowa.

[2]Official certificates collected from processors and a terminal elevator in central Iowa.

[3]U. S. figures refer to inspected receipts two months following harvest. Source: Grain Crop Quality (36).

Table 26. Foreign material, statistical measures[1]

	No.	$\bar{Y}$	S^2	S	Range	C
Harvest samples	199	0.786	0.997	0.998	8.50	126.936
Processors and terminal elevator	124	1.185	0.482	0.694	4.20	58.601
1971-U.S.[2]	137,018	1.563	1.141	1.068	-	68.346
1970-U.S.	127,204	1.300	0.900	0.949	-	72.760
1969-U.S.	139,212	1.340	1.038	1.019	-	76.280
1968-U.S.	107,004	1.430	1.042	1.021	-	71.300
1967-U.S.	120,790	1.410	0.902	0.950	-	67.560

[1]For a description of the statistical measures used in this table and in other segments of the thesis, see Huntsberger (16, chapter 2).

[2]U. S. figures refer to inspected receipts two months following harvest. Source: Grain Crop Quality (36).

Splits Distribution

The distribution of splits depicted in table 27 implies that 83.92 per cent of the 1971 fall harvest samples fell into the number one numerical grade classification, 13.57 per cent fell into the number two classification and 2.51 per cent into the number three classification. The fall harvest receipts produced no samples in the lower two grade classifications. The inspected receipts from the processors and terminal elevator samples had 48.35 per cent number one soybeans and 51.65 per cent number two soybeans. There were no samples which graded number three, number four or sample grade. Although these two sources of data had the majority of their samples grading number one and number two on splits content, the producer delivered samples had a much larger percentage falling into the number one grade classification. Inspected receipts in 1971 for the U. S. as a whole had 78.98 per cent grading number one on splits content, 19.03 per cent number two, 1.83 per cent number three, 0.14 per cent number four and only 0.01 per cent sample grade.

Table 27. Splits distributions

Per cent	H.S.[1]	P.&T.[2]	U.S.-1971[3]	U.S.-1970	U.S.-1969
0.0	-	-	-	266	12
0.1-2.0	25	-	3,598	6,538	14,988
2.1-4.0	38	1	17,472	28,210	31,416
4.1-6.0	40	7	25,662	26,572	25,392
6.1-8.0	42	18	26,992	21,266	19,140
8.1-10.0	22	18	18,186	13,916	14,676
10.1-12.0	7	18	8,568	6,104	5,652
12.1-14.0	9	14	5,404	5,208	4,920
14.1-16.0	4	8	3,458	3,374	2,856
16.1-18.0	4	7	2,716	1,904	1,728
18.1-20.0	3	-	2,002	1,274	1,488
20.1-25.0	5	-	1,414	686	816
25.1-30.0	-	-	714	266	264
30.1-35.0	-	-	126	112	72
35.1-40.0	-	-	42	14	-
40.1 & over	-	-	14	42	36
Total	199	91	116,368	115,752	123,456

[1]1971 producer delivered harvest samples.

[2]Official certificates collected from two processors and a terminal elevator in central Iowa. 124 certificates were collected, however, only 91 contained information on splits content.

[3]U. S. figures refer to inspected receipts two months following harvest. Source: Grain Crop Quality (36).

According to processor scale discounts, all soybeans in excess of 20 per cent splits are subject to price discounts. Following this discount scale, only five of the 199 harvest samples, or 2.5 per cent, were theoretically discounted because of excess splits content. None of the inspected receipts from the processors and the terminal elevator exceeded 20 per cent splits, therefore, none of the samples were subject to price discounts because of splits. Approximately two per cent of the 1971 U. S. inspected receipts were discounted for excess splits content. This figure compares with slightly less than one per cent in both 1970 and 1969.

A comparison between the means for the harvest samples and the processors and terminal elevator samples shows the harvest samples with 7.141 per cent splits, somewhat less than the 10.945 per cent splits for the processors and terminal elevator. The F-test for examining the null hypothesis that the two sample variances are equal, versus the alternative that they are not equal, required rejecting the null hypothesis. Therefore, the Snedecor and Cochran test of significance for the difference between two sample means was used (32, p. 114-115). Since the calculated value for t, 8.379, exceeds the significance level of t', 1.972, the difference between the means is significant at the 95 per cent level, even after allowance for the differences in sample variances is made.

The statistically significant difference between the means of the producer delivered samples and the processors and terminal elevator samples implies that soybeans increase in splits as they are stored, handled and transported from the producers, through the country elevators, to the processors and terminal elevators. This increase in split or broken soybeans probably results from breakage involved in the handling and elevating of the soybean seed. The relative decrease in the amount of dispersion about the mean as the sample moves from the producers to the processors and terminal elevators can be explained by the blending or pooling of the soybean seeds.

Examination of table 28 shows that mean splits content for the five years 1967 through 1971 for the U. S. ranged in value from 6.18 per cent to 7.44 per cent. This exemplifies the fact that not only does the distribution vary within a year, but also between years.

Using the chi-square test for goodness of fit for the 1971 producer delivered harvest samples, it was found that the distribution of splits as they arrive at the country elevator, did not approximate the normal distribution.

Table 28. Splits content, statistical measures[1]

	No.	$\bar{Y}$	S^2	S	Range	C
Harvest samples	199	7.141	22.152	4.71	22.00	65.912
Processors and terminal elevators[2]	91	10.945	11.764	3.43	14.00	31.337
1971-U.S.[3]	116,444	7.758	21.110	4.59	-	59.224
1970-U.S.	115,710	6.680	18.005	4.24	-	63.530
1969-U.S.	123,420	6.180	18.647	4.32	-	69.849
1968-U.S.	98,628	7.440	21.959	4.69	-	62.951
1967-U.S.	107,120	6.930	13.562	3.68	-	53.160

[1]For a description of the statistical measures used in this table and in other segments of the thesis, see Huntsberger (16, chapter 2).

[2]Official certificates collected from two processors and a terminal elevator in central Iowa. 124 certificates were collected, however, only 91 contained information on splits content.

[3]U. S. figures refer to inspected receipts two months following harvest. Source: Grain Crop Quality (36).

Test Weight Distribution

The average test weight for the 1971 fall harvest samples was 57.108 pounds per bushel. Test weight in these samples ranged from 52.5 pounds to 59.5 pounds. Table 29 shows the distribution of test weight for the various sources of data.

The processor scale discount schedule implies that soybeans less than 54 pounds per bushel are discounted. Only two fall harvest samples were less then 54 pounds and therefore subject to test weight discount. None of the inspected receipts from processors and terminal elevators were less than 54 pounds, implying none were subject to discount. The percentage of U. S. total receipts subject to discount for 1971, 1970, and 1969 were 9.90 per cent, 6.82 per cent, and 1.17 per cent, respectively.

Using grade boundaries and the distributions depicted in table 29, it follows that 93.47 per cent of the fall harvest samples graded number one for test weight, 5.53 per cent graded number two, and 1.00 per cent graded number three. There were no samples from the fall harvest samples grading number four or sample grade, due to test weight. The inspected receipts from the processors and the terminal elevator had 98.39 per cent number one soybeans and 1.61 per cent number two soybeans according to the test weight boundaries. There were no samples which graded number three, number four, or sample grade. Inspected receipts for the U. S. as a whole had a greater dispersion of samples throughout the grades. These inspected receipts showed 42.16 per cent of the samples falling into numerical grade number one, 47.94 per cent grading number two, 7.95 per cent grading number three, 1.88 per cent grading number four, and only 0.08 per cent grading sample grade.

A comparison between the means for the producer delivered samples and the processors and terminal elevator samples shows the harvest samples averaging 57.108 pounds per bushel, somewhat higher than the 56.786 pounds per bushel for the processors and terminal elevator data. The sample variances for the producer delivered data and the processors and terminal elevator data were 1.048 and 0.326, respectively.

The F-test for equality of the two sample variances showed the calculated F, 3.215, exceeding the tabular F, 1.31, implying the null hypothesis of equal sample variances is rejected at the five per cent significance level. Since the sample variances were determined to be statistically different, the Snedecor and Cochran method for testing the significance between the difference of two sample means was again used (32). This method yielded a calculated value for t of 3.628 exceeding the significance level of t' of 1.967, therefore implying the difference between the two means is statistically significant at the 95 per cent confidence level.

Table 29. Test weight distributions

Pounds	H.S.[1]	P.&T.[2]	U.S.-1971[3]	U.S.-1970	U.S.-1969
60.0 & over	-	-	28	14	60
59.0-59.9	8	-	238	210	348
58.0-58.9	45	4	2,268	4,368	4,788
57.0-57.9	88	60	14,336	21,938	27,852
56.0-56.9	45	58	38,024	41,986	57,804
55.0-55.9	8	2	42,252	35,322	33,912
54.0-54.9	3	-	20,160	16,282	8,292
53.0-53.9	1	-	7,434	5,376	1,200
52.0-52.9	1	-	2,912	2,254	204
51.0-51.9	-	-	1,540	714	60
50.0-50.9	-	-	756	294	48
49.0-49.9	-	-	154	112	48
48.9 & under	-	-	98	42	12
Total	199	124	130,200	128,912	134,628

[1]1971 producer delivered harvest samples.

[2]Official certificates collected from processors and a terminal elevator in central Iowa.

[3]U. S. figures refer to inspected receipts two months following harvest. Source: Grain Crop Quality (36).

The relative decrease in the amount of dispersion about the test weight mean as the samples move from the producers to the processors and terminal elevator can be explained by the blending or pooling function performed at the country elevator. The relative decrease in dispersion is further exemplified by the decrease in the range of values for test weight. The harvest samples had a range of 7.00 pounds per bushel, while the processors and terminal elevator samples had a range of 2.50 pounds per bushel.

Table 30 shows the variation in mean test weight values for the years 1967 through 1971, inclusive. Average test weight for the U. S. during these five years ranged from 55.602 pounds per bushel to 56.786 pounds per bushel. This implies that mean test weight for the U. S. as a whole may vary by over one pound per bushel between various crop years.

Using the chi-square test for goodness of fit for the 1971 producer delivered harvest samples, it was found that test weight did in fact approximate the normal distribution.

Table 30. Test weight, statistical measures[1]

	No.	$\bar{Y}$	S^2	S	Range	C
Harvest samples	199	57.108	1.048	1.024	7.00	1.792
Processors and terminal elevator	124	56.786	0.326	0.571	2.50	1.005
1971-U.S.[2]	130,074	55.602	1.856	1.362	-	2.450
1970-U.S.	128,856	55.920	1.738	1.318	-	2.358
1969-U.S.	134,556	56.320	0.999	0.999	-	1.774
1968-U.S.	108,972	56.100	1.022	1.011	-	1.802
1967-U.S.	122,310	56.600	0.992	0.996	-	1.760

[1]For a description of the statistical measures used in this table and in other segments of the thesis, see Huntsberger (16, chapter 2).

[2]U. S. figures refer to inspected receipts two months following harvest. Source: Grain Crop Quality (36).

Damage Distribution

Of the 199 soybean samples collected from producers at the country elevators, none of the samples contained enough damaged kernels to be considered for grading purposes. Only 27 of the 124 inspected receipts from processors and the terminal elevator contained damaged soybeans. Seven of these samples contained heat damage. Only three of the samples that contained damaged kernels equaled or exceeded 1.00 per cent damage, and only one sample exceeded 2.0 per cent damage. Recalling that 2.0 per cent is the maximum limit for total damage acceptable in the number one numerical grade classification, only one sample out of the 124 total samples graded lower than number one because of total damaged kernels. That particular sample graded number two on damage and had 2.2 per cent total damaged kernels. The processor discount schedule discounts soybeans with total damage in excess of 2.0 per cent. This implies that only the one sample was discounted. The average value for total damaged kernels for the 27 samples that did in fact contain damaged kernels was 0.481 per cent. It should be noted that this average is based only on the 27 samples and makes no inference about the average of the 124 samples. If, however, we assume that the remaining 97 samples contained 0.0 per cent damaged kernels, we can hypothesize that the mean value for all 124 samples was 0.105 per cent total damaged kernels.

Soybeans with heat damaged kernels in excess of 0.6 per cent are discounted. Of the seven processors and terminal elevator samples which contained heat damaged kernels, only one exceeded 0.6 per cent and was subject to a price discount. The mean value for the seven samples containing heat damaged kernels was 0.557 per cent. If we assume that the remaining 117 samples contained no heat damage, we can hypothesize that the mean value for heat damaged kernels for the 124 processors and terminal elevator samples was 0.03 per cent. The sample that was discounted contained 1.9 per cent heat damaged kernels and was graded number four due to that factor.

Tables 31 and 32 are based on U. S. inspected receipts two months following harvest. The statistical measures and distributions are based only on those inspected receipts that in fact contained damaged kernels. Thus, the mean values may be somewhat biased toward higher values. Table 32 shows the variation in mean values for the five years 1967 through 1971.

In 1971, 60.95 per cent of the U. S. inspected receipts which reported damaged kernels graded number one, 12.32 per cent graded number two, 14.85 per cent graded number three, 4.53 per cent graded number four, and 7.35 per cent were graded sample grade due to damage. These figures compare with the 1970 percentages of 79.34, 8.34, 6.46, 3.74, and 2.13 for grade numbers one, two, three, four and sample grade, respectively.

Table 31. Total damage distributions

Per cent	U.S.-1971[1]	U.S.-1970	U.S.-1969
0.0	8	70	-
0.1-0.5	8,820	8,386	12,804
0.6-1.0	15,022	19,418	23,412
1.1-1.5	3,164	7,546	7,788
1.6-2.0	4,648	8,280	9,996
2.1-2.5	2,758	2,310	2,412
2.6-3.0	3,640	2,282	1,452
3.1-3.5	1,750	518	324
3.6-4.0	2,744	1,274	324
4.1-4.5	1,414	504	240
4.6-5.0	1,806	1,260	96
5.1-6.0	770	574	120
6.1-7.0	1,008	812	24
7.1-8.0	574	672	84
8.1-9.0	420	84	24
9.1-10.0	572	308	96
10.1 & over	2,828	784	120
Total	51,946	55,082	59,316
No information[2]	89,096	74,088	83,664

[1]U. S. figures refer to inspected receipts two months following harvest. Source: Grain Crop Quality (36).

[2]Number of inspected receipts that contained no information on total damaged kernels.

Table 32. Total damage, statistical measures[1] [2]

	No.	$\bar{Y}$	S^2	S	C
1971-U.S.[3]	49,120	2.014	3.745	2.014	96.099
1970-U.S.	54,298	1.590	2.442	1.563	98.134
1969-U.S.	59,196	1.130	0.770	0.878	77.936
1968-U.S.	60,564	1.550	1.728	1.315	84.926
1967-U.S.	79,160	1.390	1.275	1.129	81.408

[1]For a description of the statistical measures used in this table and in other segments of the thesis, see Huntsberger (16, chapter 2).

[2]Statistical measures are based only on those inspected receipts which contained information on total damaged kernels.

[3]U.S. figures refer to inspected receipts two months following harvest. Source: Grain Crop Quality (36).

Grade Distribution by Factors

An average grade level can be computed by assigning a value of "1" for number one soybeans, "2" for grade number two soybeans, etc. The average grade level for the harvest samples was 1.528. This average is based on all grading factors. If we assign the same weights for each grade and apply them to each grade factor separately we can arrive at an "average factor grade." For the fall harvest samples, foreign material had the highest average factor grade, 1.2769. Moisture and splits had very close averages, 1.140 and 1.186 respectively. Test weight had the lowest average factor grade, 1.0759. Table 33 shows the distribution of grade levels for the fall harvest samples considering all factors together as well as each factor separately. Likewise, tables 34 and 35 show the distribution for the processors and terminal elevator samples and the 1971 U. S. inspected receipts.

Tables 33, 34, and 35 can be used to test the criteria developed by Kohls (21), that a large enough percentage of production should fall into each grade to make that grade a meaningful market category. The lower two grades for test weight and splits contained zero per cent for both harvest samples and the processors and terminal elevator samples. Inspected receipts for the U.S. contained only 0.1 per cent in the lower two grades for splits and 2.0 per cent for test weight. Similarly, the lower two grades contained only 1.8 per cent of total samples for moisture from the U. S. inspected receipts, with only 0.3 per cent grading sample grade. Following this criteria, the factor grade distributions for total damaged kernels and foreign material place a larger percentage of production into the lower grade classifications and are therefore more meaningful market categories. It should be noted here, however, that soybeans are not usually priced on the numerical grade basis. Rather, they are priced on a processor scale discount basis. The relationship between grades, factor levels and prices will be examined later.

Using the coefficient of variation as a relative measure of variation in factor levels, it can be shown that test weight exhibits the lowest relative variation of all the grading factors for all the sources of data presented in this research. The relative variation in moisture content is also quite low in comparison to foreign material, splits and damage. Table 36.

Table 33. Grade distributions, by factors, harvest samples[1]

Grade	All factors	Moisture	Foreign material	Splits	Test weight
			Per cent		
Number 1	61.31	88.9	80.9	83.9	93.5
Number 2	28.14	8.5	13.6	13.6	5.5
Number 3	8.04	2.0	3.5	2.5	1.0
Number 4	1.51	0.5	1.0	0.0	0.0
Sample grade	1.00	0.0	1.0	0.0	0.0

[1]Excludes total damaged kernels as a factor since none of the 199 samples contained enough total damaged kernels to be considered for grading purposes.

Table 34. Grade distributions, by factors, processors and terminal[1]

Grade	All factors	Moisture	Foreign material	Splits	Test weight
			Per cent		
Number 1	36.29	98.4	60.5	48.4	98.4
Number 2	56.45	1.6	33.1	51.6	1.6
Number 3	3.23	0.0	3.2	0.0	0.0
Number 4	4.03	0.0	3.2	0.0	0.0
Sample grade	0.00	0.0	0.0	0.0	0.0

[1]Excludes total damaged kernels as a factor since none of the 199 samples contained enough total damaged kernels to be considered for grading purposes.

Table 35. Grade distributions, by factors, 1971 U. S. inspected receipts[1]

Grade	All factors	Moisture	Foreign material	Splits	Test weight	Total damage
			Per cent			
Number 1	12.6	55.0	45.1	79.0	42.2	61.0
Number 2	38.0	26.1	31.4	19.0	47.9	12.3
Number 3	30.7	17.1	11.7	1.8	7.9	14.8
Number 4	11.4	1.5	7.9	0.1	1.9	4.5
Sample grade	7.2	0.3	3.9	0.0	0.1	7.4

[1]Source: Grain Crop Quality (36).

Table 36. Relative variation in grading factors[1]

Factor	Harvest samples	Processors & terminal	U.S.-1971[2]
	Coefficient of variation[3]		
Moisture	10.864	6.547	12.564
Test weight	1.792	1.005	2.450
Foreign material	126.936	58.601	68.346
Splits	65.912	31.337	59.224
Damage	-	100.441	96.099

[1]For a description of the statistical measures used in this table and in other segments of the thesis, see Huntsberger (16, chapter 2).

[2]Source: Grain Crop Quality (36).

[3]Coefficient of variation measured in percentage terms.

Relationships Among Grading Factors

We have now seen the relative distributions for the various quality factors used in the grading of soybeans and how these distributions vary within years due to storage, blending, handling and transportation. Using linear regression analysis, the grading factors test weight, moisture, splits, and foreign material were analyzed to determine what relationships, if any, exist between these grading factors. The data used was the grade factor levels for the 199 producer delivered harvest samples. The stepwise regression procedure and partial F tests were used to determine the best possible regression equations. Each grading factor was alternately treated as the dependent variable with the remaining three grading factors considered as possible independent variables. Only those grading factors which had a significant influence on the regression equation, according to the partial F test criteria, were allowed to enter into the equations. All tests were performed at the 95 per cent confidence level. The least squares method of fitting a straight line produced the following coefficients for the regression equations.

(1) Moisture = 34.14 - 0.39(test weight) - 0.057(splits)

(2) Test weight = 60.10 - 0.26(moisture)

(3) Foreign material = 0.43 + 0.049(splits)

(4) Splits = 15.65 - 0.82(moisture) + 1.13(foreign material)

The coefficient of determination was used to examine the amount of relationship between the factors in each regression. The coefficient of determination, R^2, is the fraction of the total variation in the dependent variable that is accounted for by the relationship between the dependent variable and the independent variable. Values for the coefficient of determination range between zero and one, inclusive. If all the observed data points are close to the fitted least squares regression line, the value of the coefficient of determination will be close to one; as the data points disperse from the regression line the value will become closer to zero. In this manner, the coefficient of determination is a measure of the strength of the linear relationship. The coefficients of determination for the four equations were 14.7, 9.0, 5.4, and 10.1, respectively, expressed in percentage terms. These relatively small values for the coefficients of determination imply that none of the four regression equations adequately explains the variations in the data. Analysis of variance for the four equations can be found in Appendix D.

The relationship between test weight and moisture seems quite reasonable when one realizes that test weight is basically a measure of seed density and that water per se is less dense than the dry material in the soybean seed; therefore, when moisture is removed from a lot of soybeans the remaining material is more dense and will therefore have a higher test weight. The inverse relationship between splits and moisture implies that dry soybeans tend to have a greater number of split soybeans relative to soybeans with higher moisture content. The positive relationship between splits and foreign material is explained by the fact that as soybeans are handled and elevated they tend to split or break. Some of these split or broken pieces will pass through an 8/64 inch sieve and are therefore classified as foreign material even though they are in fact soybeans.

Oil Distribution

Since soybean oil and soybean meal are the primary products of soybean processing, it is essential that we also look at the distribution of these two quality factors. Two sources of data were used to arrive at the relative distribution for both oil content and protein content.

Forty-seven of the original 199 fall harvest samples were submitted to an official oil and meal chemist for oil and protein determination. In addition, oil and protein content data was obtained from the Illinois and Iowa Crop Reporting Service. These particular samples were collected from plots in probability selected soybean fields in Iowa in 1971 by the Statistical Reporting Service, USDA, in connection with their annual objective yield program. The samples were chemically analyzed by the Illinois Division of Feeds, Fertilizers,and Standards. Oil and protein content for both sources of data was converted to a zero moisture or dry matter basis in order to eliminate variations due to moisture content. Table 37 shows the distribution of oil content for the two sources of data, while table 38 shows the values for various statistical measures. It should be noted here that the oil and protein data for the fall harvest samples represents data from a nine-county area in North-Central Iowa, while the Statistical Reporting Service (SRS) data was collected by random sample from the entire state of Iowa. There were 47 fall harvest samples and 72 SRS samples analyzed for oil and protein content and used for quality characteristic distribution analysis.

The mean oil content, on a dry matter basis, for the 1971 fall harvest samples was 22.39 per cent. Values ranged from a high of 23.83 per cent to a low of 20.76 per cent. The mean value for the Statistical Reporting Service samples was 21.49. These samples ranged in value from a high of

23.77 to a low of 19.23. The sample variances for the fall harvest samples and the SRS samples were 0.51 and 0.97, respectively. The F-test of equality of the two sample variances produced a calculated F of 1.902 which exceeded the tabular value of F at the five per cent level, implying that the sample variances are not the same. Therefore, to test the significance for the difference between the two sample means the Snedecor and Cochran procedure for testing significance with unequal variances was used (32). Since the calculated value for t', 5.769, exceeded the 95 per cent significance level of t, 2.003, the difference between the means was statistically significant.

The statistically significant difference between the two sample variances implies that there was a greater variability in oil content throughout the state than there was in the nine-county fall harvest sample area. The statistical difference between the two sample means implies that soybeans from the fall harvest sample area produced values higher in oil content than the state as a whole.

Table 37. Oil distributions, dry basis

	Harvest samples		SRS samples[1]	
Per cent	Number	%	Number	%
<19.5	-	-	2	2.78
19.5-19.75	-	-	3	4.17
19.76-20.00	-	-	1	1.39
20.01-20.25	-	-	1	1.39
20.26-20.50	-	-	4	5.56
20.51-20.75	-	-	4	5.56
20.76-21.00	2	4.26	10	13.89
21.01-21.25	2	4.26	6	8.33
21.26-21.50	3	6.38	4	5.56
21.51-21.75	3	6.38	6	8.33
21.76-22.00	3	6.38	5	6.94
22.01-22.25	3	6.38	11	15.28
22.26-22.50	9	19.15	5	6.94
22.51-22.75	5	10.64	5	6.94
22.76-23.00	7	14.89	2	2.78
23.01-23.25	6	12.77	1	1.39
23.26-23.50	3	6.38	1	1.39
>23.50	1	2.13	1	1.39
Total	47	100.00	72	100.01

[1]Samples collected by Statistical Reporting Service.

Table 38. Oil content, statistical measures[1]

	Harvest samples	SRS samples[2]
Mean	22.39	21.49
Variance	0.51	0.97
Standard deviation	0.71	0.98
Coefficient of variation	3.18	4.58
High	23.83	23.77
Low	20.76	19.23
Range	3.07	4.54
Median	22.44	21.62
Number	47.00	72.00

[1]For a description of the statistical measures used in this table and in other segments of the thesis, see Huntsberger (16, chapter 2).

[2]Samples collected by Statistical Reporting Service.

Table 39 shows various statistical measures for oil content for the SRS samples divided into the nine Iowa crop reporting districts. District number one had the highest average oil content with 22.16 per cent, while District number four had the lowest oil content with 20.67 per cent. The previous conclusion that oil content variation was greater within the state as a whole than within a smaller district of the state is generally supported by the results in table 39. Five of the nine crop reporting districts had sample variances smaller than the state-wide variance, and for the four crop districts that did exceed the state variance none of these were found to be statistically greater than the state-wide variance.

The nine crop reporting districts were grouped into three classifications--north, central, and sourth--to determine if any differences in oil content exist as one moves along a north-south line. The mean oil content values for the north, central and south classifications were 21.15 per cent, 21.78 per cent and 21.64 per cent, respectively. Although the mean average for the southern districts exceeded the mean average for the northern districts, the difference was not significant since the calculated t, 1.752, was less than the tabular t, 2.021, at the two-tailed 95 per cent confidence level. However, the difference between the central and northern districts was significant with the calculated t value of 2.246 exceeding the tabular t, 2.008.

Table 39. Oil content, statistical measures, by Iowa crop reporting districts, SRS samples[1]

District	No.	$\bar{Y}$	S^2	S	Range	C
1	12	21.78	1.09	1.04	3.38	4.78
2	13	20.72	0.56	0.75	2.97	3.61
3	4	20.67	1.43	1.20	2.77	5.79
4	7	21.61	0.77	0.88	2.51	4.07
5	11	22.16	0.55	0.74	2.52	3.34
6	4	21.04	1.03	1.02	2.30	4.83
7	7	21.74	1.04	1.02	3.14	4.69
8	5	21.80	0.74	0.86	2.27	3.95
9	9	21.48	0.64	0.80	2.09	3.71
Total	72	21.49	0.97	0.98	4.54	4.58

[1]Samples collected by Statistical Reporting Service.

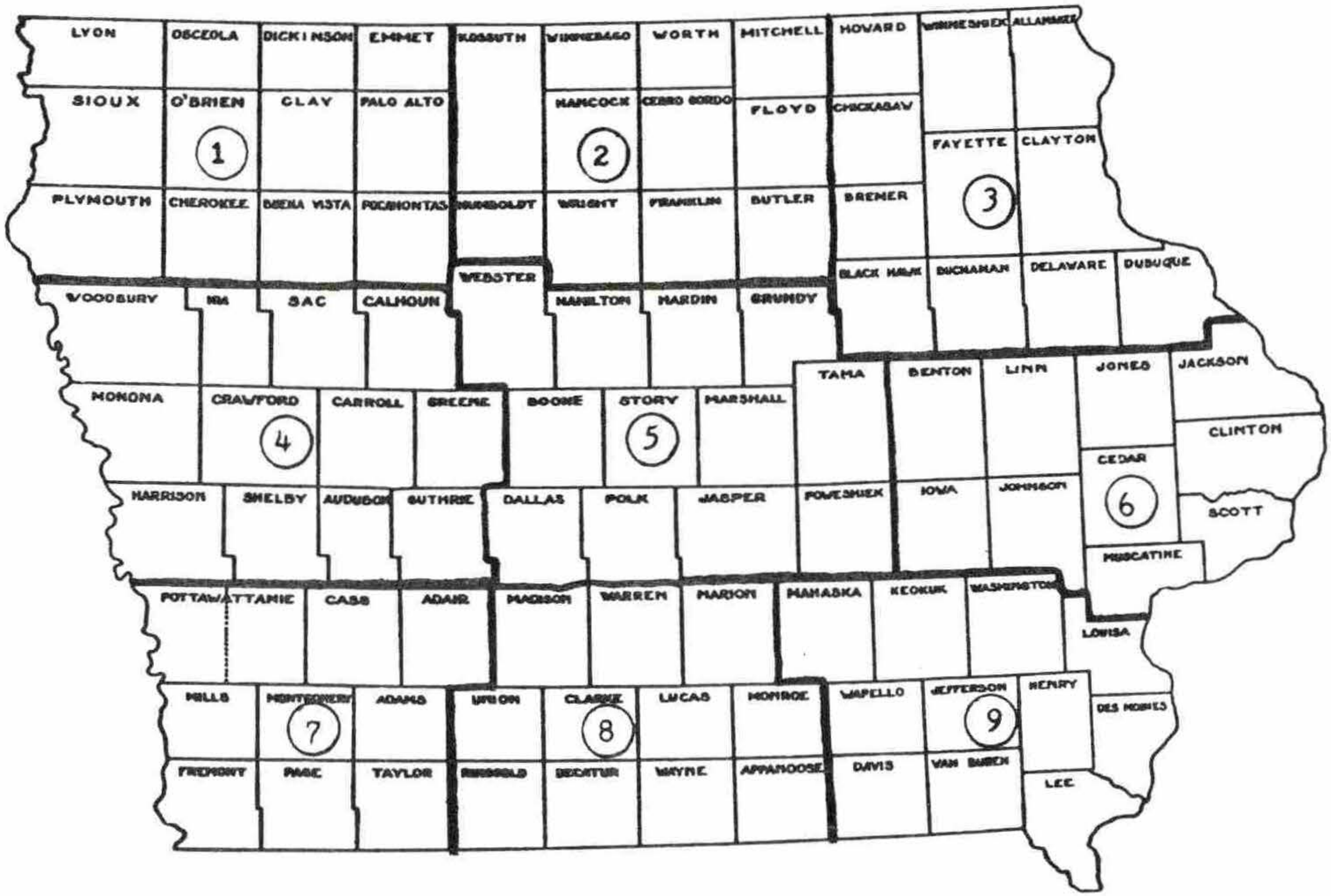

Figure 3. Map of Iowa crop reporting districts

The nine crop reporting districts were also grouped into the classifications east, central, and west. The mean oil content values for the east, central, and west classifications were 21.19 per cent, 21.45 per cent, and 21.72 per cent. Although the mean value for the western classification was greater then the mean value for the eastern classification, the difference was not statistically significant at the 95 per cent confidence level.

Using the chi-square test for goodness of fit for the producer delivered harvest samples and for the SRS samples, it was found that the distribution of oil content for both samples did approximate the normal distribution.

Protein Distribution

The mean protein content for the 47 chemically analyzed fall harvest samples was 41.46 per cent. Values ranged from a high of 43.68 per cent to a low of 39.30 per cent. The mean value for the SRS samples was 41.33. These samples ranged in value from a high of 45.36 per cent to a low of 37.80 per cent. The sample variances for the fall harvest samples and the SRS samples were 0.82 and 2.70, respectively. Use of the F-test to examine the difference between the two sample variances required rejecting the null hypothesis that the two sample variances were the same since the calculated

F, 3.293, exceeded the five per cent significance level of F, 1.80. The T' test for significance between the two mean values required accepting the null hypothesis that the two means were in fact equal at the 95 per cent confidence level. The statistically significant difference between the two sample variances implies that there was a greater variability in protein content throughout the entire state of Iowa than there was in the nine-county fall harvest sample area. Although there did exist a difference in variability or dispersion, the mean values were statistically equivalent. See tables 40 and 41.

Using the SRS samples, table 42 shows various statistical measures for protein content for the nine Iowa crop reporting districts. District number three had the highest average protein content with 43.72 per cent, while District number seven had the lowest mean protein content with 40.21 per cent. Six of the nine crop reporting districts had sample variances smaller in value than the state-wide variance. Sample variances from Districts three, six, and seven exceeded the state-wide variance; however, use of the F test for determining the equality of the sample variances required accepting the null hypothesis that the variance were equal in all three cases.

Table 40. Protein distributions, dry basis

	Harvest samples		SRS samples[1]	
Per cent	Number	%	Number	%
<38.5	-	-	3	4.17
38.50-39.00	-	-	1	1.39
39.01-39.50	1	2.13	6	8.33
39.51-40.00	1	2.13	5	6.94
40.01-40.50	6	12.77	6	8.33
40.51-41.00	5	10.64	10	13.89
41.01-41.50	10	21.28	9	12.50
41.51-42.00	12	25.53	9	12.50
42.01-42.50	6	12.77	7	9.72
42.51-43.00	4	8.51	5	6.94
43.01-43.50	1	2.13	4	5.56
43.51-44.00	1	2.13	2	2.78
44.01-44.50	-	-	3	4.17
>44.50	-	-	2	2.78
	--	------	--	------
Total	47	100.02	72	100.00

[1]Samples collected by Statistical Reporting Service.

Table 41. Protein content, statistical measures[1]

	Harvest samples	SRS samples[2]
Mean	41.46	41.33
Variance	0.82	2.70
Standard deviation	0.90	1.64
Coefficient of variation	2.18	3.96
High	43.68	45.36
Low	39.30	37.80
Range	4.38	7.56
Median	41.56	41.23
Number	47.00	72.00

[1]For a description of the statistical measures used in this table and in other segments of the thesis, see Huntsberger (16, chapter 2).

[2]Samples collected by Statistical Reporting Service.

Table 42. Protein content, statistical measures by Iowa crop reporting districts[1] [2]

District	No.	$\bar{Y}$	S^2	S	Range	C
1	12	41.17	1.33	1.15	3.64	2.81
2	13	42.40	1.53	1.24	3.84	2.92
3	4	43.72	3.07	1.75	3.36	4.01
4	7	41.25	1.89	1.38	3.97	3.33
5	11	40.75	2.58	1.61	5.69	3.94
6	4	42.13	3.59	1.89	4.20	4.50
7	7	40.21	3.23	1.80	4.55	4.47
8	5	40.90	0.55	0.74	1.92	1.82
9	9	40.49	2.26	1.50	5.11	3.71
	--	-----	----	----	----	----
total	72	41.33	2.70	1.64	7.56	3.96

[1]For a description of the statistical measures used in this table and in other segments of the thesis, see Huntsberger (16, chapter 2).

[2]Samples collected by Statistical Reporting Service.

To test for differences in mean values for various sections of the state, the nine crop reporting districts were again classified into three groups--north, central and south. The mean protein content values for the north, central and south classifications were 42.07 per cent, 41.16 per cent, and 40.50 per cent, respectively. Unlike the results obtained for oil content, there was a statistical difference between the mean protein values for the northern and southern classifications of crop reporting districts.

We again divided the nine crop reporting districts into three classifications--east, central and west. The mean protein content for the east, central and west classifications was 41.64 per cent, 41.51 per cent, and 40.93 per cent, respectively. Although the mean value for the eastern classification was greater than the mean value for the western classification, the difference was not significant at the 95 per cent confidence level.

Using the chi-square test for goodness of fit for the 47 producer delivered samples and for the 72 SRS samples, it was found that the distribution of protein content did approximate the normal distribution in both cases.

Relationships Between Oil and Protein Content

The results of linear regression analysis indicate an inverse relationship between oil and protein content--as the oil content increases, the protein content decreases. The sample correlation coefficient between oil and protein content for the 47 harvest samples was -0.580. The sample correlation coefficient for the 72 SRS samples was somewhat higher in absolute value, -0.723. Use of simple linear regression analysis yielded the following four equations:

(5) Oil = 41.371 - 0.458 (protein)

(6) Protein = 57.217- 0.737 (oil)

(7) Oil = 39.465 - 0.435 (protein)

(8) Protein = 67.238 - 1.206 (oil)

Equations seven and eight resulted from the fall harvest samples, and equations nine and ten resulted from the SRS samples. Equations seven and eight had a coefficient of determination equal to 38.585 in percentage terms. The coefficient of determination for equations nine and ten was 52.265 in percentage terms.

Relationships Among Grade Factors and Oil and Protein Content

Since grade factor information was available only on the fall harvest samples, these samples were used to determine what relationships, if any, exist between oil and protein and the present soybean grading factors. Simple linear regressions were run for the following equations: oil = f(test weight), protein = f(test weight), oil = f(foreign material), protein = f(foreign material), oil = f(splits), protein = f(splits), oil = f(numerical grade), protein = f(numerical grade). The only significant relationship was the relationship between oil content and foreign material content. This relationship produced the following regression equation:

(9) Oil = 22.558 - 0.218 (foreign material)

This equation produced a coefficient of determination equal to 10.73 per cent. The sample correlation coefficient of -0.328 implied a negative or inverse linear relationship between foreign material content and oil content.

It is interesting to note that the grade factors test weight, splits and foreign material had no significant relationship with protein content; and test weight and splits had no significant relationship with oil content. Although these factors have no significant linear relationship with the two primary products of the soybean seed, oil and protein-meal, they are still included in the soybean grade factors.

QUALITY DETERMINATION--METHODS AND COSTS

Oil and Protein Determination Methods

Several different methods and kinds of machines and testing procedures have been developed to determine the amount of oil and protein present in a sample of soybeans. These machines and procedures are based on several different methods of determination.

The most accurate method, and the most widely used method, for the determination of protein content is the kjeldahl extraction method. This is the official chemical procedure used by official meal chemists for the National Soybean Processors Association. Total nitrogen content, as ammonia, is determined from a ground sample of soybeans. Per cent protein is equated with (per cent ammonia) x (5.14 or per cent nitrogen) x (6.25).

Solvent extraction is the official chemical method used by official oil chemists. Ground soybean seed is extracted with petroleum ether for several hours with the resultant substances considered part of the oil fraction. These two chemical methods have a high degree of accuracy but require analytical ability, special equipment, considerable time, and are somewhat expensive.

Nuclear Magnetic Resonance (NMR) is an alternative way to accurately determine oil content. Conway and Earle (7) found Nuclear Magnetic Resonance to be as accurate as the extraction procedure. One advantage of NMR is the relatively small amount of time required to analyze a sample, usually less than three minutes. The greatest disadvantage of NMR is the high cost of equipment, somewhere between $25,000 and $40,000 (12).

The United States Department of Agriculture in conjunction with the Illinois Department of Agriculture and two private companies have developed prototype instruments to determine oil, protein, and moisture content of soybeans by the use of infrared light. The United States Department of Agriculture, Instrumentation Laboratory - Agriculture Research Service in Beltsville, Maryland, has been engaged in research on this program for several years and has successfully demonstrated that an optical electronic instrument can be used to determine oil, protein, and moisture content in soybeans. The instrument utilizes the differences in reflectance of narrow bands of infrared light. The reflected energy from the soybean sample is then detected by a sensitive photocell. Moisture, protein and oil content can be determined in less than 5 minutes by anyone capable of following a few simple instructions.[1]

---

[1]Private communication with Hugh Shown, DICKEY-john Corporation, Auburn, Illinois, and with Lynn Kessinger, Illinois Department of Agriculture.

Estimated Cost for Oil and Protein Determination

In order to determine if oil and protein content should be incorporated into the soybean grading and pricing systems, it is necessary that we develop cost estimates for such determination. The method developed by the USDA explained in the preceding paragraph will serve as the basis for oil and protein determination cost analysis. This method was selected because of the small amount of testing time needed, because of the relatively simple operational procedures involved, and because of the expected accuracy of determination. Since the machine is still in the prototype stage, an accurate estimate of initial cost is still lacking. Early estimates place the cost of procurement somewhere between $5,000 and $15,000. Based on labor costs of $2.50 per hour and testing time of three minutes the variable cost per sample analyzed was estimated at 12.5 cents. Labor cost was the only variable cost considered since the determination requires no additional equipment and electricity cost and maintanence cost are insignificant at the single sample level. If the sample being analyzed represented a 3,000 bushel lot of soybeans, the variable cost per bushel would be 0.004167 cents per bushel. If the lot represented only 200 bushels of soybeans, the variable cost per bushel would be 0.3625 cents per bushel.

Quality Determination Costs of Processors

Twenty soybean processors provided information necessary to estimate the actual costs involved in quality determination. These 20 processors represented a total annual crush of 173,550,000 bushels, or an average crush of 8,677,500 bushels per processor. Total quality determination cost was made up of four separate costs--equipment cost, labor cost, licensed inspector cost and chemical analysis cost. These four cost factors represent the costs involved in grading inbound samples of soybeans in order to arrive at the numerical grades. In addition, all chemical tests performed by the processors on inbound samples of raw soybeans are included in total quality determination cost.

To arrive at cost estimates, labor costs were set at $2.50 an hour. The cost for inspection and grading by licensed grain inspectors was provided by the processors used in the estimates. Equipment cost represented depreciation allowances only. Table 43 shows the yearly depreciation allowances used for each type of grading equipment. Chemical analysis costs were set at $6.00 per sample. This was the average price quoted by four midwestern chemical analysis firms. The 20 processors reported using 23,022 man hours of labor for grading purposes. Table 44 shows total quality determination cost. Total cost was estimated to be $396,551, or 0.2285 cents per bushel crushed.

Table 43. Grain grading equipment, number owned and soybean processors annual depreciation allowances[1]

Equipment type	Depreciation[2]	Total number owned	Average number owned
Mechanical sampler	100	17	0.85
Moisture meter	75	35	1.75
Test weight scale	3	19	0.95
Grain sieve	6	40	2.00
Gram scale	10	28	1.40
Grain divider	12	23	1.15
Probe	50	37	1.85
Pelican sampler	6	2	0.10

[1]Figures based on mail survey of soybean processors in nine North-Central states.

[2]Cost in dollars per year.

Table 44. Estimated quality determination cost for processors[1]

	Cost in dollars	Per cent of total
Equipment	7,040	1.8
Labor	57,555	14.5
Inspection	310,604	78.3
Chemical analysis	21,352	5.4
	-------	-----
Total	396,551	100.0

[1]Figures based on mail survey of soybean processors in nine North-Central states.

Quality Determination Costs of Iowa Elevators

Ninety-five elevators reported receiving 121,096,236 bushels of corn and soybeans combined per year. To arrive at cost estimates, labor costs were again set at $2.50 an hour. The 95 elevators reported using 58,024 man hours per year for grading purposes. Equipment cost represented depreciation allowances only. These expenses totaled to $177,151 for the 95 elevators which was approximately 0.146 cents per bushel of grain received.

The elevators surveyed were divided into categories A, B, and C according to bushels of storage capacity. Group A was made up of elevators with storage capacity of greater than 800,000 bushels; group B had storage capacity between 400,000 and 800,000; and group C had storage capacities of less than 400,000 bushels.

In summary, the estimated cost for grading a bushel of soybeans at the average Iowa country elevator was 0.146 cents per bushel and the estimated cost of quality determination at the processor level was 0.228 cents per bushel. Assuming the most elementary movement of soybeans through the marketing channel, producer to country elevator to soybean processor, the estimated cost for soybean quality determination would be 0.374 cents per bushel.

Table 45. Estimated grading costs for Iowa country elevators[1]

	A[2]	B[3]	C[4]
Equipment cost	13,424	10,943	7,724
Labor cost	57,820	48,275	38,965
	------	------	------
Total cost	71,244	59,218	46,689
Bushels received	61,944,994	39,508,515	19,642,727
Cost per bushel[5]	.115	.150	.238
Number of elevators	34	32	29

[1]Figures based on mail survey of Iowa country elevators.

[2]Elevators with greater than 800,000 bushels storage capacity.

[3]Elevators with between 400,00 and 800,000 bushels storage capacity.

[4]Elevators with less than 400,000 bushels storage capacity.

[5]Cost in cents per bushel.

Table 46. Grain grading equipment, number owned, Iowa grain elevators[1]

	A[2]	B[3]	C[4]	Total number owned	Average number owned
Mechanical sampler	24	11	2	37	0.389
Moisture meter	65	59	45	169	1.779
Test weight scale	57	52	41	150	1.579
Grain sieve	76	83	47	206	2.168
Gram scale	62	51	41	154	1.621
Grain divider	46	42	32	120	1.263
Probe	87	75	59	221	2.326

[1]Figures based on mail survey of Iowa country elevators.

[2]Elevators with greater than 800,000 bushels storage capacity.

[3]Elevators with between 400,00 and 800,000 bushels storage capacity.

[4]Elevators with less than 400,000 bushels storage capacity.

Quality Determination Cost Comparisons

How do the preceding cost estimates compare with the costs involved for the infrared light machine? Since no actual cost figures have been developed for the use of the infrared light machine, all figures and estimates presented will be dependent upon the accuracy of the assumptions used in determining such costs. The amount and type of equipment used was assumed to be the same as that used by soybean processors in conventional grading to the extent that such equipment was required in conjunction with the infrared light machine. Also, the size load represented by each sample tested was assumed to be the same size as the average load size sampled by the processors. As stated in the previous section this load size was 542.24 bushels. The variable cost for operating the machine was 12.5 cents per sample analyzed, therefore, if the time required to operate the machine were five minutes the operating cost would be 0.0231 cents per bushel. If we assume it took five minutes to collect the sample, the labor cost would be 0.0384 cents per bushel. Depreciation allowances for sample collecting equipment would also have to be considered. Table 43 shows that the average processor owns 0.85 mechanical samplers and 1.85 probes. Depreciation allowances for these two kinds of sample collection equipment would be $177.50 per year. Since the average size of the reporting processors was 8,677,500 bushels crushed per year, this figure would amount to 0.0020 cents per bushel. The total cost for sampling equipment, sample collecting labor and machine operating labor would be 0.0635 cents per bushel.

The only costs yet to be considered are depreciation allowances and repairs for the infrared light machine. As stated earlier, the estimated procurement cost for the machine is between \$5,000 and \$15,000. Setting procurement cost at \$10,000 and using five years as the lifetime of the machine, we could arrive at a depreciation cost \$2,000 per year using straight-line depreciation. If we assume that the average processor does not want the cost of quality determination to exceed 0.228 cents per bushel (the average cost per bushel for all processors), we can then determine how many bushels the processor must handle in order to keep costs equal to or below 0.228 cents per bushel. Solving the equation $0.228X = 200{,}000 + 0.635X$ produces an X equal to 1,215,805.4. This result implies that if a processor handles more than 1,215,805.4 bushels of soybeans, his cost of quality determination will be less than 0.228 cents per bushel.

The figure of slightly over one million bushels is directly related to the amount of depreciation allowed for the infrared light machine. If this figure was reduced to \$1000 per year, the resulting equation to be solved would be 0.228X

= 100,000 + 0.0635X. This implies the soybean processor would have to handle 607,902.7 bushels of soybeans in order to achieve the 0.228 cents per bushel quality determination cost. The form of the above equations implies there would be economies of scale in soybean quality determination with the infrared light machine. Such economies of scale were shown to exist presently with Iowa grain elevators.

We are assuming in these estimates that the processor will choose one or the other method of quality determination. That is, if he chooses to use the infrared light machine, he will not perform the usual grading procedures. We are indirectly assuming that the processor is indifferent toward which type of quality information he is supplied with. That is, he does not prefer knowing oil, protein and moisture content over knowing the factor levels for the present soybean grading factors, and vice versa.

SOYBEAN QUESTIONNAIRE RESULTS

The figures and calculations presented in the preceding chapter, although entirely dependent upon the assumptions used, tend to indicate that quality determination by use of an infrared light machine could be as economical as present quality determination practices. The basic question arises as to whether or not the information supplied by the infrared light machine determination is as worthwhile and significant to the members of the marketing system as the present practice of soybean grading. In order to ascertain the answer to this question, various members of the soybean marketing system were surveyed. Several references have already been made to these surveys. An example of the questionnaires sent to processors and to Iowa country elevators can be found in Appendix E.

Soybean Processor Questionnaire

One of the soybean processor questionnaire objectives was to determine what quality characteristics the processors consider important and their relative ranking. It was also used to determine processors' opinions on various quality factors and their reception to possible changes in the soybean grading and pricing system.

Fifty-two soybean processors in the nine North-Central states of Indiana, Illinois, Iowa, Kansas, Kentucky, Minnesota, Missouri, Nebraska and Ohio were surveyed. Of the 52 processors contacted, 32 replied to the questionnaire in one form or another. Of the 32 replies, 21 involved actual completion of the questionnaire.

Twenty-one processors responded to the question, "Do you feel that test weight is an important determinant in quantity or quality of product output?" Fourteen of the 21 responding processors, or 67 per cent, answered "Yes." Only 47.6 per cent responded "Yes" to a similar question, "Do you feel that splits are an important determinant in quantity or quality of product output?"

In order to arrive at the relative ranking of soybean quality characteristics, the processors were asked to consider the following quality characteristics--foreign material, oil content, splits, protein content, test weight, total damage, heat damage, moisture and black, brown and/or bicolored soybeans and then rank these characteristics in order of importance to them as soybean processors (one being the highest rank and nine being the lowest rank). Twenty processors responded to the ranking question and produced the results presented in table 47.

These results indicated that processors place the highest relative importance on oil content and the lowest relative importance on splits. The three quality characteristics determined by the infrared machine--oil, protein, and moisture--were also the highest three characteristics in the relative rankings. Of the nine characteristics included in the rankings, only oil and protein were not part of the present soybean grading system. This fact is quite disturbing when you consider that these two quality factors had the highest average rank. Although the average rank for protein, 3.30, was greater than the average rank for moisture, 3.35, the difference was not significant at the 95 per cent confidence level. Table 48 gives a complete listing of those quality characteristics which had mean values statistically greater than the other quality characteristics. The results presented in tables 47 and 48 indicate that oil, protein, moisture and foreign material are the most important quality factors to the processors, while test weight, color and splits are the least important.

Since processors ranked oil and protein content as the two most important quality factors, the question now arises as to whether or not processors would be willing to buy soybeans on an oil and protein content basis. To answer this question the processors were asked, "Would you be willing to buy soybeans on an oil and protein basis if a fast, economical, and reliable method of oil and protein determination was available?" Thirteen of the 19 processors who responded to this question, or 68.4 per cent, answered "Yes."

Table 47. Statistical measures resulting from soybean processor response to ranking question[1] [2]

Characteristic	Average rank	Variance	Standard deviation	Coefficient of variation
Oil	2.50	3.526	1.878	75.12
Protein	3.30	3.379	1.838	55.69
Moisture	3.35	3.082	1.756	52.41
Foreign material	3.85	4.450	2.109	54.77
Heat damage	4.15	2.134	1.461	35.20
Total damage	5.15	3.082	1.756	34.09
Test weight	6.78	3.184	1.784	26.33
Color	7.90	1.990	1.411	17.86
Splits	8.02	1.131	1.063	13.24

[1]Figures based on mail survey of soybean processors in nine North-Central states.

[2]For a description of the statistical measures used in this table and in other segments of the thesis, see Huntsberger (16, chapter 2).

Table 48. Listing of statistically greater mean rankings[1] [2]

Test characteristic	Quality characteristics with means statistically greater than test characteristic
Oil	Foreign material, heat damage, total damage, test weight, color, splits
Protein	Total damage, test weight, color, splits
Moisture	Total damage, test weight, color, splits
Foreign material	Total damage, test weight, color, splits
Heat damage	Test weight, color, splits
Total damage	Test weight, color, splits
Test weight	Color, splits
Color[3]	None
Splits	None

[1]Figures based on mail survey of soybean processors in nine North-Central states.

[2]All tests performed at 95 per cent confidence level.

[3]Refers to black, brown, or bicolored soybeans.

Country Elevator Questionnaire

Iowa elevator managers were asked the same question regarding the ranking of soybean quality characteristics. The results from the 172 elevators who responded to this question are given in tables 49 and 50. Foreign material and moisture were by far the most important quality factors, with oil and protein content ranked last.

The relative placement of the quality factors is quite different for the Iowa country elevators when compared to the average rankings reported by the soybean processors. The most significant difference is the relative placement of oil and protein content in the rankings. The reason for the difference in relative placement of these two quality factors is best explained by the economic conditions that prevail in the present marketing system. Although soybean processors prefer soybeans with high oil and protein content, no premium is paid for soybeans which possess these quality characteristics. Likewise, no discounts are applied to lots of soybeans with lower than average oil and protein content. On the other hand, processors do have discount schedules for test weight, moisture, splits, heat damage, total damage, and color. In addition, all foreign material in excess of one per cent is deducted from gross weight and not paid for. Since the country elevator is subjected to these discounts by the processor, the elevator must place a greater emphasis on those quality factors which are discounted. In later sections we will see that foreign material and moisture constitute the highest dollar figures for discounts and dockage. Because of the highly competitive nature of the country elevator business, these elevators place a relatively greater emphasis on moisture and foreign material content simply because of the economics involved. Since soybeans that they sell to processors, terminal elevators, and exporters are subject to discount, they reflect this discount schedule to the producers.

In essence, the producer receives his price signal from the country elevator, who receives his signal from the processor. So indirectly, the processor is telling the farmer to produce soybeans low in splits, damage, moisture and foreign material and high in test weight. The producer receives no signal about oil and protein content, therefore, in an economic context should place no importance on producing soybeans high in oil and protein content. This is in direct conflict with the significance processors placed on oil and protein content according to the ranking question. This deficiency in the present soybean pricing and grading system can only be averted by pricing soybeans on an oil and protein content basis. Only in this way can the processors' quality desires be adequately translated back to the producer.

Table 49. Statistical measures resulting from Iowa grain elevator response to ranking question[1] [2]

Characteristic	Average rank	Variance	Standard deviation	Coef. of variation
Foreign material	1.890	1.654	1.286	68.07
Moisture	1.895	1.638	1.280	67.53
Total damage	4.064	1.943	1.394	34.30
Test weight	4.677	2.949	1.717	36.72
Heat damage	4.785	2.860	1.691	35.34
Splits	5.724	3.077	1.754	30.64
Color	6.459	3.911	1.978	30.61
Protein	7.721	1.851	1.361	17.62
Oil	7.779	2.091	1.446	18.59

[1]Figures based on mail survey of Iowa country elevators.

[2]For a description of the statistical measures used in this table and in other segments of the thesis, see Huntsberger (16, chapter 2).

table 50. Listing of statistically greater mean rankings[1]

Test characteristic	Quality characteristics with means statistically greater than test characteristic
Foreign material	Total damage, test weight, heat damage, splits, color, protein, oil
Moisture	Total damage, test weight, heat damage, splits, color, protein, oil
Total damage	Test weight, heat damage, splits, color, protein, oil
Test weight	Splits, color, protein, oil
Heat damage	Splits, color, protein, oil
Splits	Color, protein, oil
Color	Protein, oil
Protein	None
Oil	None

[1]Figures based on mail survey of Iowa country elevators.

Before we can recommend soybean grading and pricing on oil and protein content, we must be sure that the introduction of such a change meets with the approval of the members of the marketing system. An elementary test of this workability criteria was presented in the form of a survey question on both the country elevator and the soybean processor questionnaires. One hundred and sixty-nine elevators responded to the question, "Would you be willing to buy soybeans on an oil and protein basis if a fast, economical, and reliable method of oil and protein determination was available?" One hundred and three, or approximately 61 per cent of the elevators, answered the question "Yes." This figure compares with the 68.4 per cent "Yes" response from the soybean processors.

ANALYSIS OF SOYBEAN PRICES AND DISCOUNTS

The results presented in the preceding chapter relied on the questionnaire method to determine demand for the various quality factors. This method of demand analysis is somewhat limited, however, in that it fails to provide a quantitative measure of the various quality factors as they relate to price. The following section deals with the statistical analysis of prices and discounts for soybeans.

Gross Price Minus Discounts

Since grade factor levels for the 199 fall harvest samples were known, we can develop gross price minus discount values by following the standard processor discount scale.

There are at least two sets of economic forces operating in the establishment of soybean prices. The basic supply-and-demand forces determine the average or general level of prices, and the demand and supply of the various quality factors determine whether the particular lot in question will have a selling price above or below this general level of prices.

In arriving at a gross price minus discount value, the general price level for soybeans was assumed to be three dollars per bushel. By assigning the same general price level to all sample lots of soybeans, exogenous and endogenous variations in the basic supply-and-demand forces are eliminated and full attention can be placed on prices relative to quality factor levels. The gross price level of three dollars per bushel was a realistic level that made for easy calculations and comparisons. Any other realistic gross price could have been used. Discounts were based on the processor discount schedule. All grading or quality factors present on the discount schedule, with the exception of foreign material, are stated in terms of cents or fractions of cents per bushel according to the factor levels. Foreign material is treated on strictly a percentage basis, with all foreign material in excess of one per cent deducted from gross weight and not paid for.

Using the three dollars per bushel gross price and the processor discount schedule, the average value for the 199 producer delivered harvest samples was $2.9866. Values ranged from $3.00 per bushel to a low of $2.75 per bushel. Sixty of the 199 samples were subject to price discount or weight dockage. Seven samples were discounted for two quality factors. Of the total 199 samples, 22 were subject to moisture discounts, two to test weight discounts, five for splits discounts, and 38 were subject to dockage due to foreign material. The average discount for all 199 samples was 1.34 cents per bushel. Of the 60 samples actually discounted, the average discount was 4.43 cents per bushel. Foreign material accounted for 51.01 per cent of total discounts, with moisture accounting for 47.96 per cent. These two factors together accounted for 98.97 per cent of discounted value. Test weight and splits discounts made up the remaining 1.03 per cent.

Again using processor scale discounts and three dollar soybeans, gross price minus discount values were developed for the 124 processor and terminal elevator samples. These samples had an average value of $2.9895. Fifty-one of the 124 samples, or 41.1 per cent, were subject to price discounts or weight dockage. Only two of the samples were subject to discount on more than one quality factor. In aggregate, two samples were subject to moisture discounts, one sample was subject to discount because of heat damaged kernels, one sample was discounted due to total damaged kernels, and 49 samples were subject to weight dockage because of excess foreign material. None of the 124 samples were discounted for splits or for test weight. The average discount for all 124 samples was 1.05 cents per bushel. Of the 51 samples actually discounted, the average discount was 2.55 cents per bushel. Foreign material accounted for 93.09 per cent of total discounts. Moisture, heat damaged kernels and total damaged kernels accounted for 3.84 per cent, 2.30 per cent, and 0.77 per cent of total discounts, respectively.

These results indicate that foreign material was the most important quality factor influencing price at both the country elevator level and the processor and terminal elevator level. It is interesting to note that moisture content is also an important determinant of price at the country elevator level, but is not nearly as important at the processor and terminal elevator level of the marketing channel.

Since none of the producer delivered samples contained either heat damaged kernels or total damaged kernels, their importance in quality price determination at the country elevator level is insignificant. However, these two quality factors did account for 3.07 per cent of total discounted value from the processors and terminal elevator data. In contrast, splits and test weight accounted for 1.03 per cent of total discounted value from the producer delivered samples but were not discounted at the processor and terminal elevator level. These results could be expected when one examines the quality characteristic distributions presented earlier. The blending or pooling effect on distribution for splits and test weight tends to eliminate both the extreme high and low values. The samples variances presented earlier explain why a certain percentage of samples will be discounted at the country elevator level; but after pooling and blending, these discounts are avoided at the processor and terminal elevator level. The discount schedules for splits and test weight are such that only a small percentage of production will actually be discounted. After pooling and blending the per cent discounted for these two factors would be expected to decrease due to the smaller sample distribution variance. The same type of reasoning applies to the decreased importance of moisture discounts as one moves from one level of the marketing channel to another. The reason for the more drastic reduction in value of discounts for moisture is explained by the fact that the moisture discount schedule is more severe in cents discounted per bushel relative to the splits and test weight scales.

The most important quality factor in determining soybean price, foreign material, presents an interesting comparison between country elevator pricing and processor and terminal elevator pricing. Only 19.10 per cent of all producer delivered samples were discounted for excess foreign material. This compares with the 39.52 per cent discounted for the processors and terminal elevator samples. Of the samples discounted for excess foreign material, the average discount per sample was 2.47 cents per bushel for the processors and terminal elevator samples and 3.57 cents per bushel for the producer delivered samples. This implies that a larger percentage of samples were discounted but the average discount per sample was smaller as one moves from the country elevator to the processors and terminal elevator. The increase in the percentage of samples discounted for foreign material at the processor and terminal elevator level can be explained by the statistically significant increase in mean foreign material content as one moves from country elevator to processors and terminal elevators. On the other hand, the blending and pooling functions decrease the amount of variation thereby reducing the number of extreme values in foreign material content and therefore decreasing the average or mean value of foreign material discount. It is also interesting to note that foreign material comprised 51.01 per cent of total discounts at the country elevator level and 93.09 per cent of the discounted value at the processor and terminal elevator level. This increased percentage was not due to a relative increase in foreign material discounts but rather to a decrease in the magnitude of other factor discounts, notably moisture.

Recalling the relative quality characteristic rankings presented earlier, it is easy to see why local elevators placed such a large emphasis on foreign material content and on moisture content. These two factors constituted by far the largest influence on prices the country elevator paid and received for soybeans.

The numerical grades for soybeans should indicate the relative value of the soybean samples. That is, number 2 soybeans should be more desirable than number 3 soybeans, but should be less desirable than soybeans grading number 1. The market desirability of the soybean grades should be reflected by market prices. That is, soybeans graded number 2 should be priced higher than soybeans graded number 3, but lower than those graded number 1.

One test for the relevancy of numerical grade classifications is how accurately the numerical grades follow rank-ordering with respect to price. Using the 199 fall harvest samples and three dollar soybeans, the mean values for number one, number two, number three, number four and sample grade soybeans were found to be \$3.00, \$2.9827, \$2.9470, \$2.8723 and \$2.7805, respectively. Using mean values as the test criteria, the numerical grades for soybeans do exhibit rank-ordering. However, rank-ordering was not perfect when individual sample prices between grades were examined. All 122 samples that graded number one were priced at \$3.00. The 56 samples graded number two ranged in value from \$3.00 per bushel to \$2.941 per bushel. Likewise, samples graded number three ranged from \$2.9975 to \$2.85. Eleven of the sixteen samples graded number three exceeded the \$2.941 per bushel price of the lowest priced number two sample.

Theoretically it would be possible to have a sample of soybeans grading number two with the following factor levels: test weight equal to 54 pounds per bushel, moisture equal to 14.0 per cent, 20 per cent splits, 3.0 per cent total damaged kernels, 0.5 per cent heat damaged kernels, 2.0 per cent foreign material, and 2.0 per cent brown, black, and/or bicolored soybeans. Such a sample would be subject to a five cents per bushel moisture discount, a one cent per bushel total damaged kernel discount, a one-half cent per bushel other colors discount, and a three cent discount resulting from weight dockage due to excess foreign material. Assuming three-dollar soybeans, the discounted value of this theoretical sample would be $2.905 per bushel. In contrast, a sample containing 30.1 per cent splits and grading number one in all other factors would have a discounted value of $2.9925, but would be graded number four. In this respect, the numerical grades for soybeans are a poor predictor of net price.

With this problem in mind soybean processors were asked, "Would you be willing to buy soybeans on strictly a factor basis, omitting numerical grade classifications?" Twelve of the 19 processors who responded to the question, or 63.2 per cent, answered "Yes."

Total Product Value Pricing

It has been stated previously that oil and meal are the primary products of the soybean seed. In the preceding analysis price was based on the general supply and demand conditions, assumed to result in three dollar soybeans, and on any price discounts. In order to establish a more accurate product value for soybeans, two pricing models were developed. The soybean values in the models are based on oil and protein content. They have been named the simulated processing model and the direct computation model.

The simulated processing model determines the value of a 60 pound bushel of soybeans by first determining the value of oil and meal in each of the 47 samples. The direct computation model on the other hand computes the bushel value of carbohydrates as well as protein and oil. The carbohydrate content in the latter model was derived by subtracting the sum of the oil, protein and ash percentages from 100 per cent. The ash content of the samples was assumed to have no significant value. All calculations were computed on a dry matter basis as reflected by the DM variable in the model. The two models are presented in tables 51 and 52.

The constant values, XLOS, CMOIS, and AOR, in the simulated processing model were based on averages reported by processors in the soybean processor questionnaire. The constant SPMPD was introduced into the model to allow for variations in total value due to variations in per cent protein meal. SBMP is based on 44 per cent protein meal. SBMPD is a premium concept implying that meal over 44 per cent protein will receive an additional .06 cents for each one per cent in excess of 44 per cent protein. This implies that 50 per cent meal is worth .36 cents more per pound than 44 per cent meal.

Table 51. Simulated processing model

Relationships

```
XOR(i)  = TW x CMOIS x AOR x AOIL(i)
XMR(i)  = TW - XLOS - XOR(i)
TPA(i)  = TW x CMOIS x APRO(i)
XPPM(i) = (TPA(i) / XMR(i)) x 100
VM(i)   = (XMR(i) x SBMP) + (((XPPM(i) - 44.) x SBMPD x XMR(i))
VO(i)   = XOR(i) x SBOP
TVP(i)  = VM(i) + VO(i)
```

Identification of variables

XOR(i)	=	Pounds of oil recovered from 60 pounds of soybeans from the ith sample.
AOIL(i)	=	Oil content, dry matter basis, for the ith sample. Expressed as a fraction.
XMR(i)	=	Pounds of meal recovered from 60 pounds of soybeans from the ith sample.
TPA(i)	=	Pounds of protein available in 60 pounds of soybeans from the ith sample.
APRO(i)	=	Protein content, dry matter basis, for the ith sample. Expressed as a fraction.
XPPM(i)	=	Per cent protein meal for the ith sample.
VO(i)	=	Value of oil for the ith sample.
VM(i)	=	Value of meal for the ith sample.
TVP(i)	=	Total value of products for the ith sample.

Identification of constants

XLOS	=	Processing loss.
TW	=	Sixty pounds.
CMOIS	=	One minus average moisture content.
AOR	=	Average oil recovery.
SBMP	=	Price per pound for 44 per cent protein meal.
SBMPD	=	Soybean meal price differential.
SBOP	=	Price per pound for soybean oil.

Table 52. Direct computation model

Relationships

```
POA(i)  = AOIL(i) x DM
PPA(i)  = APRO(i) x DM
PCA(i)  = DM - POA(i) - PPA(i) - ASH
VO(i)   = POA(i) x SBOP
VP(i)   = PPA(i) x SBPP
VC(i)   = PCA(i) x SBCP
TVP(i)  = VO(i) + VP(i) + VC(i)
```

Identification of variables

POA(i) = Pounds of oil available from 60 pounds of soybeans from the ith sample.
AOIL(i) = Oil content, dry matter basis, for the ith sample. Expressed as a fraction.
PPA(i) = Pounds of protein available from 60 pounds of soybeans from the ith sample.
APRO(i) = Protein content, dry matter basis, for the ith sample. expressed as a fraction.
PCA(i) = Pounds of carbohydrate available from 60 pounds of soybeans from the ith sample.
VO(i) = Value of oil for the ith sample.
VP(i) = Value of protein for the ith sample.
VC(i) = Value of carbohydrate for the ith sample.
TVP(i) = Total value of products for the ith sample.

Identification of constants

DM = Dry matter, in pounds per 60 pound bushel.
SBCP = Soybean carbohydrate price per pound.
SBPP = Soybean protein price per pound.
SBOP = Soybean oil price per pound.
ASH = Ash content in pounds per 60 pound bushel.

The results presented in table 53 indicate that the simulated processing model gives a total value figure approximately five cents per bushel higher than the direct computation model. The mean total value of the 47 producer delivered samples was \$3.346 using the simulated processing model. Values for these 47 samples ranged from a high of \$3.472 per bushel to a low of \$3.271 per bushel. The mean value for the 72 SRS samples was \$3.290 using the simulated processing model. Values ranged from \$3.383 to \$3.160 per bushel. The difference between the two total value means using the simulated processing model was found to be statistically significant at the 95 per cent confidence level since the calculated t of 7.887 exceeded the tabular t value of 1.98. The total value sample variances were not found to be statistically different. The meal values for the two samples were almost identical, with the harvest samples having a mean meal value of \$1.929 and the SRS samples having a mean meal value of \$1.930. The difference between the two total value means was caused by the difference between the mean oil values for the two samples. The producer delivered samples had a mean oil value of \$1.417, while the SRS samples had a mean value of \$1.360. Recalling the comparison between oil and protein content values for the two sources of data presented earlier, the above results are not surprising. The earlier comparisons showed protein content for the two sources of data to be statistically equivalent, while mean oil content from the producer delivered samples was found to be statistically greater than mean oil content from the SRS samples. With these comparisons in mind, it is not surprising that mean oil value for the producer delivered samples exceeded mean oil value for the SRS samples. These differences in total product values emphasize the need for an equitable soybean grading and pricing system whereby producers and handlers of soybeans receive prices that reflect actual product values.

Recalling that the SRS samples were collected from the entire state while the producer delivered samples were collected from a much smaller area in North-Central Iowa, it is not surprising that the SRS samples exhibited a larger variance and larger range values.

The mean total value for the 47 producer delivered samples using the direct computation model was $3.299 per bushel. Values ranged from $3.413 to $3.215. The mean total value for the 72 SRS samples was $3.241. Values ranged from $3.363 to $3.123. The difference between the two total value means was found to be statistically significant for this model as well. Once again the SRS samples had larger variances and larger range values then did the producer delivered samples.

Table 53. Total value of products for producer delivered and SRS samples

	Producer delivered		SRS	
	Simulated processing	Direct computation	Simulated processing	Direct computation
Meal or protein value				
Mean	1.9290	1.2260	1.9300	1.2220
Variance	.0010	.0007	.0032	.0023
Range	.1480	.1300	.2560	.2230
% of total value	57.6500	37.1600	58.6600	37.7000
Oil value				
Mean	1.4170	1.6790	1.3600	1.6110
Variance	.0020	.0029	.0039	.0054
Range	.1940	.2300	.2870	.3400
% of total value	42.3500	50.8900	41.3400	49.7100
Carbohydrate value				
Mean	-	.3950	-	.4080
Variance	-	.0001	-	.0002
Range	-	.0580	-	.0720
% of total value	-	11.9700	-	12.5900
Total value				
Mean	3.3460	3.2990	3.2900	3.2410
Variance	.0011	.0014	.0016	.0021
Range	.2010	.1980	.2230	.2400
Coef. of Deter.	1.0010	1.1440	1.2290	1.4020

A comparison between the two models shows the simulated processing model producing higher mean total values. However, the direct computation model had larger variances, larger range values and larger coefficients of variation.

These two models were developed not as pilot systems for oil and protein pricing, but rather to establish a "more accurate" product value for a sample of soybeans. The values developed from these two models enable us to compare oil and protein pricing with the standard soybean pricing system. The sample correlation coefficient between net discounted value (using three dollars as the gross soybean price) and oil and protein value from the simulated processing model was +0.366. The sample correlation coefficient between net discounted value and oil, protein and carbohydrate value from the direct computation model was +0.303. The relatively low values for the correlation coefficients imply that the present soybean pricing system is poorly correlated to the actual oil and meal value of the soybeans.

Using the chi-square test for goodness of fit it was found that total value for the producer delivered samples and the SRS samples followed a normal distribution for both the simulated processing model and the direct computation model.

Sensitivity Analysis For Total Product Models

The two models were used to develop total product values for both the producer delivered harvest samples and the Statistical Reporting Service samples. Table 54 shows the effect of changes in the "constant" parameters upon mean, variance, and range for oil value, meal value, and total value, using the simulated processing model on the 47 chemically analyzed producer delivered samples. Similarly, table 55 shows the changes in values using the direct computation model on the same producer delivered samples. For the sake of simplicity only one set of values for the constants was used for each model in the preceding analysis. Tables 54 and 55 will give some insight into the effects of changes on the constants as they relate to oil value, meal value, protein value, carbohydrate value, and total value in the two models. The particular values used were based on realistic present-day prices and processing procedures. The values used in the preceding simulated processing analysis of total product value are presented in column six of table 54. The set of values used in the direct computation model are those presented in column one of table 55.

Table 54. Value of products for producer delivered samples using simulated processing model

	1	2	3	4	5	6
Constants						
CMOIS	.8858	.8858	.8858	.8858	.8858	.8858
AOR	.9160	.9160	.9160	.9160	.9160	.9160
XLOS	1.7000	1.7000	1.7000	1.7000	1.7000	1.7000
SBMP	.0392	.0366	.0410	.0392	.0392	.0392
SBMPD	.0007	.0006	.0006	.0006	.0006	.0006
SBOP	.1300	.1300	.1300	.1100	.1400	.1300
Meal value						
Mean	1.9410	1.8060	2.0140	1.9290	1.9290	1.9290
Variance	.0012	.0010	.0010	.0010	.0010	.0010
Range	.1680	.1460	.1490	.1480	.1480	.1480
Oil value						
Mean	1.4170	1.4170	1.4170	1.1990	1.5260	1.4170
Variance	.0020	.0020	.0020	.0015	.0024	.0020
Range	.1940	.1940	.1940	.1640	.2090	.1940
Total value						
Mean	3.3580	3.2230	3.4310	3.1280	3.4550	3.3460
Variance	.0013	.0012	.0011	.0008	.0013	.0011
Range	.2150	.2050	.1990	.1740	.2150	.2010

Table 54. (continued)

	7	8	9	10	11	12
Constants						
CMOIS	.8858	.9000	.8858	.8858	.8858	.8858
AOR	.9160	.9160	.8960	.9360	.9160	.9160
XLOS	1.7000	1.7000	1.7000	1.7000	1.5000	1.9000
SBMP	.0392	.0392	.0392	.0392	.0392	.0392
SBMPD	.0006	.0006	.0006	.0006	.0006	.0006
SBOP	.1500	.1300	.1300	.1300	.1300	.1300
Meal value						
Mean	1.9290	1.9480	1.9320	1.9260	1.9310	1.9260
Variance	.0010	.0011	.0010	.0010	.0010	.0010
Range	.1480	.1510	.1480	.1480	.1480	.1480
Oil value						
Mean	1.6350	1.4400	1.3860	1.4480	1.4170	1.4170
Variance	.0027	.0021	.0019	.0021	.0020	.0020
Range	.2240	.1970	.1900	.1980	.1940	.1940
Total value						
Mean	3.5640	3.3880	3.3180	3.3740	3.3480	3.3430
Variance	.0015	.0012	.0011	.0012	.0011	.0011
Range	.2280	.2050	.1980	.2050	.2010	.2020

Table 55. Value of products for producer delivered samples using direct computation model

	1	2	3	4	5
Constants					
Ash	2.6400	2.6700	2.7000	2.6400	2.6400
DM	52.8000	53.4000	54.0000	52.8000	52.8000
SBCP	.0240	.0240	.0240	.0270	.0210
SBPP	.0560	.0560	.0560	.0560	.0560
SBOP	.1420	.1420	.1420	.1420	.1420
Oil value					
Mean	1.6790	1.6980	1.7170	1.6790	1.6790
Variance	.0029	.0029	.0030	.0029	.0029
Range	.2300	.2330	.2350	.2300	.2300
Protein value					
Mean	1.2260	1.2400	1.2540	1.2260	1.2260
Variance	.0007	.0007	.0007	.0007	.0007
Range	.1300	.1310	.1330	.1300	.1300
Carbohydrate value					
Mean	.3950	.3990	.4040	.4440	.3450
Variance	.0001	.0001	.0001	.0001	.0001
Range	.0580	.0590	.0600	.0660	.0510
Total value					
Mean	3.2990	3.3370	3.3740	3.3490	3.2500
Variance	.0014	.0014	.0015	.0014	.0015
Range	.1980	.1990	.2020	.1900	.2040

Table 55. (continued)

	6	7	8	9
Constants				
ASH	2.6400	2.6400	2.6400	2.6400
DM	52.8000	52.8000	52.8000	52.8000
SBCP	.0240	.0240	.0240	.0240
SBPP	.0520	.0600	.0560	.0560
SBOP	.1420	.1420	.1320	.1520
Oil value				
Mean	1.6790	1.6790	1.5600	1.7970
Variance	.0029	.0029	.0025	.0033
Range	.2300	.2300	.2140	.2460
Protein value				
Mean	1.1380	1.3130	1.2260	1.2260
Variance	.0006	.0008	.0008	.0008
Range	.1200	.1390	.1300	.1300
Carbohydrate value				
Mean	.3950	.3950	.3950	.3950
Variance	.0001	.0001	.0001	.0001
Range	.0580	.0580	.0580	.0580
Total value				
Mean	3.2120	3.3870	3.1810	3.4180
Variance	.0015	.0014	.0017	.0017
Range	.1960	.2000	.1830	.2120

Adjusted Total Value Analysis

The two models presented earlier defined total value product as a function of oil and protein content. The values developed from these two models were a more realistic approximation of total value of the soybean samples than were the values developed from gross price minus discounts. However, these two models failed to include the two most important pricing factors in the present soybean grading system, namely moisture and foreign material. The simulated processing model and the direct computation model calculated per cent oil and per cent protein on a dry matter basis, thus eliminating individual sample variation in moisture content. Individual sample variation can be quite important in total product value as illustrated by the following example. Recalling that soybeans in excess of 13 per cent moisture are discounted, it would be possible to have two non-discounted soybean samples, one containing 13 per cent moisture and the other 8 per cent moisture. If we assume that all other quality factors are identical for the two samples, it can be illustrated that the sample containing 8 per cent moisture is more valuable than the sample containing 13 per cent moisture. The sample that contains 8 per cent moisture has 55.2 pounds of dry matter per sixty-pound bushel of soybeans. The sample that contains 13 per cent moisture has only 52.2 pounds of dry matter per sixty-pound bushel. Although the sample that contains 8 per cent moisture has more dry matter per bushel this difference is not recognized in either the present soybean pricing system or in the total value product models. If the two samples were not discounted for any other factors and if we set the gross price of soybeans at $3.00 per bushel, the sample containing 8 per cent moisture would be priced at 5.4348 cents per pound of dry matter. The 13 per cent moisture sample would be priced at 5.7471 cents per pound of dry matter. This example implies that the sample that contains less moisture is in fact underpriced and would be a better buy for the processor relative to the sample that contained more moisture. This example is dependent upon the assumption that moisture content does not appreciably affect processing efficiency or output.

A similar type of reasoning also applies to foreign material. Over 94.4 per cent of the processors that responded to the soybean processor questionnaire reported screening excess foreign material from the soybeans before processing. Since most foreign material is removed before processing the samples that contain little or no foreign material are underpriced relative to the samples that contain more foreign material but are not yet discounted.

In order to alleviate these possible total value variations due to individual sample variations in moisture and foreign material content, a premium and discount schedule was developed for both grading factors.

The average moisture content for the 47 chemically analyzed fall harvest samples was 11.157 per cent. This implies that there was an average of 53.3058 pounds of dry matter in a sixty-pound bushel of soybeans. The average total value of the 47 samples using the simulated processing model was $3.346 per bushel. Dividing average total value by average pounds of dry matter yields an average price per pound of dry matter of 6.277 cents. A moisture premium or discount for each sample was then computed using the formula: moisture premiun or discount = (11.157 - per cent moisture) x 60 x .06277, where 11.157 is average moisture content, 60 is pounds per bushel and .06277 is price per pound of dry matter.

A premium and discount schedule for foreign material was computed in a similar fashion. Moisture premium or discount was equated with average foreign material minus sample foreign material times 60 pounds times the average price per pound of dry matter in the following equation: (.77 - per cent foreign material) x 60 x 0.0562 = foreign material premium or discount.

The moisture premium or discount and the foreign material premium or discount was added to the total value of products from the simulated processing model for the 47 producer delivered harvest samples. The adjusted mean total value for the 47 samples was $3.3458 per bushel. This figure is identical to the original total value for the simulated processing model. The equality of these two distinct mean total values is not surprising when one realizes that the moisture and foreign material premiums and discounts were constructed in such a manner that total premiums equalled total discounts.

The significance of the adjusted total value products is not in the mean value but rather in the variance or dispersion of the individual sample net values. The variance, standard deviation and coefficient of variation in percentage terms for the adjusted total values for the 47 producer delivered samples were 0.00562, 0.07497 and 2.2406, respectively. These values were significantly higher than the values for the total products--simulated processing--values, 0.00112, 0.03350 and 1.0013. These measures of dispersion imply a greater variability in total value for samples that are priced on oil, protein, moisture and foreign material when compared to the same samples priced only on oil and protein content. It should be noted however, that oil and protein pricing exhibits a larger dispersion than does pricing on gross price minus discounts.

Using the chi-square test for goodness of fit it was found that adjusted total value for the 47 chemically analyzed producer delivered harvest samples approximated the normal distribution.

SUMMARY AND RECOMMENDATIONS

The tremendous increase in the disposition and production of soybeans in recent years has necessitated a critical evaluation of the soybean marketing system. Grading and standardization serves as a facilitating function in the marketing operation. The purpose of this research is to determine the relevancy and efficiency of the present soybean grading system.

The quality factors included in the original 1925 standards are the same factors recognized in 1972. These factors--moisture, test weight, foreign material, total damaged kernels, heat damaged kernels and splits--were evaluated at various points in the marketing channel to determine quality characteristic distributions. A comparison between producer delivered samples collected at country elevators and quality information collected from processors and a terminal elevator in the same area enabled us to compare changes in quality that result from transportation, storage, blending and handling of the soybeans. These comparisons implied that foreign material, splits, heat damaged kernels and total damaged kernels increased in mean value as the soybeans moved from the country elevator to the processors and terminal elevator. These comparisons also implied that the producer delivered samples had greater variability than the processors and terminal elevator samples for all grading factors. This decrease in variability as soybeans move through the marketing channel can be explained by the blending or pooling function performed by elevators.

Oil and protein quality characteristic distributions were also developed from the producer delivered samples. In addition, oil and protein distributions were developed for the entire state of Iowa. These distributions implied a greater variability in both oil and protein content for the larger state-wide sample area. implied that none of the present grade factors were substantially correlated to protein content, and only foreign material was linearly associated with oil content. Since oil and protein-meal are the primary products of soybeans, any grading factor that does not reflect oil and/or protein content should have value or merit in itself or should not be included in the soybean grading system. Since market prices and discounts should reflect the market value of the product and the quality characteristic, the present pricing system and discount schedule was used to determine the merit or value of each quality factor in arriving at a final product value. This analysis showed that test weight and splits in aggregate accounted for only 2.03 per cent of discounts for the producer delivered samples and zero per cent of discounts for the processors and terminal elevator samples. Since these two factors had no reflection on oil or protein content and had relatively little impact on final product value, their importance as factors in soybean grading is questioned.

A survey of soybean processors in the North-Central states showed that they placed a greater emphasis on oil and meal content as desirable quality characteristics relative to all the present factors included in the soybean grading system. These processors also placed the least amount of importance on splits and test weight, further questioning the importance of these two factors as grading requirements. A survey of Iowa country elevators showed a somewhat different relative ranking of the desirability of the various quality factors. The difference between the processor and the country elevator rankings has been necessitated due to the grading and pricing system that now exists. Although processors place a greater relative importance on oil and protein content, their desires are not translated back to the country elevator or to the producer due to the fact that soybeans are not priced, either directly or indirectly, on oil and protein content. An evaluation of the costs involved in quality determination showed that oil, protein and moisture determination can be as economical to the processor as the present soybean grading procedures.

Two total value product models were developed to arrive at a more realistic approximation of true product value.

These models implied that there was a poor correlation between the actual value of a sample of soybeans and the net discounted price for the soybeans according to the present pricing system. Using the various assumptions of the models, it was also shown that soybeans vary in oil and protein value by as much as 20 cents in a ten-county area in North-Central Iowa and by as much as 24 cents for the entire state of Iowa. Since soybeans are not priced on quantity or quality of oil or protein, these figures imply that those soybeans with high-quality, high-quantity oil and/or protein content are underpriced and those with less desirable oil and protein content are overpriced. In addition, an adjusted total value model showed that some producers are overpaid and some underpaid for soybean moisture and foreign material depending on the amount of each factor in the lot of soybeans in question.

LITERATURE CITED

1. American Soybean Association. Inspections for export. Soybean Digest 32(6): 76. March, 1972.

2. Barr, Jason E. Development of U.S. standards for soybeans Soybean Digest 11(11): 48-50.

3. __________. Proceedings of the American Soybean Association. Volume I.

4. Bowring, James R.; Southworth, H. M.; and Waugh, F. V. Marketing policies for agriculture. Englewood Cliffs, New Jersey, Prentice Hall, Inc. 1960.

5. Brunk, Max E. and Darrah, L. B. Marketing of agricultural products. New York, N. Y., Ronald Press Company. 1955.

6. Cartter, J. G. and Hopper, T. H. Influence of variety, environment, and fertility level on the chemical composition of soybean seed. USDA Technical Bulletin 787. May, 1942.

7. Conway, T. F. and Earle, F. R. Nuclear magnetic resonance for determining oil content of seeds. American Oil Chemist,s Society Journal 40: 263-268. 1963.

8. Darrah, L. B. Food marketing. New York, N. Y., Ronald Press Company. 1967.

9. Draper, N. R. and Smith, H. Applied regression analysis. New York, N. Y., John Wiley and Sons, Inc. 1966.

10. Eckey, E. W. Vegetable fats and oils. New York, N. Y., Reinhold Publishing. 1954.

11. Erdman, H. E. Problems in establishing grades for farm products. Journal of Farm Economics 32: 15-29. February, 1950.

12. Fehr, R. W. Methods for evaluating protein and oil in soybeans and mass selection by seed size and specific gravity in soybean population. Unpublished Ph. D. thesis. Ames, Iowa, Library, Iowa State University. 1967.

13. Henderson, J. M. and Quandt, R. E. Microeconomic theory. New York, N. Y., McGraw-Hill Book Company. 1958.

14. Houck, J. P. and Mann, J. S. Domestic and foreign demand for U. S. soybeans and soybean products. Minnesota Agricultural Experiment Station Technical Bulletin 256. 1968.

15. __________, Ryan, M. and Subotnik, A. Soybeans and their products. Unpublished manuscript.

16. Huntsberger, D. V. Elements of statistical inference. Boston, Mass., Allyn and Bacon, Inc. 1967.

17. Hyslop, J. D. Price/quality relationships in spring wheat. Minnesota Agricultural Experiment Station Technical Bulletin 267. 1970.

18. Jessnes, O. B. The economic basis of market grades. Journal of Farm Economics 15: 708-717. October, 1933.

19. Jordan, G. L. What determines soybean prices. Illinois Agricultural Experiment Station Bulletin 700. August, 1960.

20. Keirstead, C. H. Marketing study of factors affecting the quality and value of products obtained from soybeans. USDA Production and Marketing Administration, Fats and Oils Branch. June, 1952.

21. Kohls, R. L. Marketing of agricultural products. New York, N. Y., The Macmillan Company. 1961.

22. Mackie, A. B. World trade in selected agricultural commodities; 1951-65: Volume V - Oilseeds, oilnuts, and animal and vegetable oils. USDA Economic Research Service, Foreign Agricultural Economic Report No. 47. 1968.

23. Markley, K. S. Soybeans and their products. Vol. I and II. New York, N. Y., Interscience Publishers. 1950-1951.

24. Martin, R. E. Edible soy proteins. Soybean Digest Blue Book 31(6): 44-50. March, 1971.

25. Mehren, G. L. The function of grades in an affluent, standardized quality economy. Journal of Farm Economics 43: 1377-1383. December, 1961.

26. Nakamura, H. and Heironymus, T. A. Structure of the soybean processing industry. Illinois Experiment Station Bulletin 706. February, 1965.

27. National Soybean Processors Association. Soybean statistics. Washington, D. C., author. 1971.

28. Pahigian, N. Marketing study of the oil content of soybeans as related to production area and climate. USDA Production and Marketing Administration, Fats and Oils Branch. September, 1950.

29. Pitcher, S. Soybean production in Brazil. USDA Foreign Agricultural Service FAS M-225. January, 1971.

30. Sheppard, G. S. and Futrell, G. A. Marketing farm products. Ames, Iowa, Iowa State University Press. 1969.

31. Smith, T. B. Soybean and cottonseed oils used in shortening and salad and cooking oils. USDA Economic Research Service, Marketing Research Report No. 898. 1970.

32. Snedecor, G. W. and Cochran, W. G. Statistical methods. 6th ed. Ames, Iowa, Iowa State University Press. 1967.

33. Spilsbury, C. C. Markets for U. S. soybeans and their products in Asia and Oceania. USDA Foreign Agricultural Service, FAS-M 227. February, 1971.

34. Thomsen, F. L. Agricultural marketing. New York, N. Y., McGraw-Hill Book Company. 1951.

35. U. S. Department of Agriculture. Fats and oils situation. Economic Research Service. Various issues.

36. __________. Grain crop quality. Consumer and Marketing Service- Grain Division. 1967, 1968, 1969, 1970, and 1971.

37. __________. Grain Inspection Manual. Instruction No. 918(6r)-6. Consumer and Marketing Service - Grain Division. Washington, D.C., author. May, 1971.

38. __________. Handbook of official grain standards of the United States. Production and Marketing Administration - Grain Branch. Washington, D.C., author. 1947.

39. __________. Official grain standards of the United States. Consumer and Marketing Service - Grain Division. Washington, D.C., author. Revised February, 1970.

40. __________. Official handbook of United States standards for soybeans. Washington, D.C., author. 1925, 1926.

41. Waugh, F. V. Quality as a determinant of vegetable prices. New York, N. Y., Columbia University Press. 1929.

42. West, V. I. Evaluation of certain systems for differentiating market qualities of soybeans. Unpublished Ph. D. thesis. Urbana, Illinois, Library, University of Illinois. 1951.

43. Zusman, P. A theoretical basis for determination of grading and sorting schemes. Journal of Farm Economics 49: 89-106. February, 1967.

ACKNOWLEDGEMENTS

The guidance of Dr. J. T. Scott throughout this study is gratefully acknowledged. Appreciation is also extended to the elevator managers, soybean processors and university representatives who contributed to the study.

A special thank you to Sharon and Dwight for their encouragement and assistance in manuscript reading and keypunching.

APPENDIX A. DISCOUNT SCHEDULES FOR SOYBEAN GRADING FACTORS

Table 56. Test weight discounts[1]

Pounds per bushel	Discount per bushel
>54.0	0.0¢
53.0-53.9	0.5¢
52.0-52.9	1.0¢
51.0-51.9	1.5¢
50.0-50.9	2.0¢
49.0-49.9	2.5¢
<49.0[2]	

[1]Discount schedules provided by Swift and Company, Des Moines, Iowa, and by Boone Valley Cooperative Processing Association, Eagle Grove, Iowa.

[2]All amounts under 49 pounds are subject to rejection or discount on merit.

Table 57. Moisture discounts[1]

Per cent moisture	Discount per bushel
<13.1	0.0¢
13.1-13.5	2.5¢
13.6-14.0	5.0¢
14.1-14.5	7.5¢
14.6-15.0	10.0¢
15.1-15.5	12.5¢
15.6-16.0	15.0¢
16.1-16.5	17.5¢
16.6-17.0	20.0¢
17.1-17.5	22.5¢
17.6-18.0	25.0¢
>18.0[2]	

[1]Discount schedules provided by Swift and Company, Des Moines, Iowa, and by Boone Valley Cooperative Processing Association, Eagle Grove, Iowa.

[2]All amounts over 18 per cent moisture are subject to rejection or discount on merit.

Table 58. Splits discounts[1]

Per cent splits	Discount per bushel
<20.1	0.00¢
20.1-25.0	0.25¢
25.1-30.0	0.50¢
30.1-35.0	0.75¢
35.1-40.0	1.00¢
>40.0[2]	

[1]Discount schedules provided by Swift and Company, Des Moines, Iowa, and by Boone Valley Cooperative Processing Association, Eagle Grove, Iowa.

[2]All amounts over 40 per cent splits are subject to rejection or discount on merit.

Table 59. Total damage discounts[1]

Per cent damage	Discount per bushel
0.0-2.0	0.0¢
2.1-3.0	1.0¢
3.1-4.0	2.0¢
4.1-5.0	3.0¢
5.1-6.0	4.0¢
6.1-7.0	5.0¢
7.1-8.0	6.0¢
>8.0[2]	

[1]Discount schedules provided by Swift and Company, Des Moines, Iowa, and by Boone Valley Cooperative Processing Association, Eagle Grove, Iowa.

[2]All amounts exceeding 8.0 per cent total damage are subject to rejection.

Table 60. Heat damage discounts[1]

Per cent heat damage	Discount per bushel
0.0-0.5	0.0¢
0.6-1.0	1.0¢
1.1-1.5	2.0¢
1.6-2.0	3.0¢
2.1-2.5	4.0¢
2.6-3.0	5.0¢
3.1-3.5	6.0¢
3.6-4.0	7.0¢
4.1-4.5	8.0¢
4.6-5.0	9.0¢
>5.0[2]	

[1]Discount schedules provided by Swift and Company, Des Moines, Iowa, and by Boone Valley Cooperative Processing Association, Eagle Grove, Iowa.

[2]All amounts exceeding 5.0 per cent heat damaged kernels are subject to rejection.

APPENDIX B. QUALITY FACTOR LEVELS FOR HARVEST SAMPLES AND STATISTICAL REPORTING SERVICE SAMPLES

Table 61. Factor levels for the 199 producer delivered harvest samples

Sample number	Numerical grade	Moisture	Test weight	Foreign material	Splits
1	2	12.4	57.0	1.4	12.0
2	1	11.5	57.0	0.6	8.0
3	1	10.6	56.0	1.0	7.0
4	1	10.0	57.0	1.0	10.0
5	2	13.7	56.0	1.3	5.0
6	1	11.0	56.5	0.2	3.0
7	1	11.0	58.0	0.4	6.0
8	1	9.9	58.0	0.1	2.0
9	1	10.9	57.5	0.2	3.0
10	2	10.6	57.0	0.7	14.0
11	1	10.3	56.0	0.7	5.0
12	1	10.4	57.0	0.2	4.0
13	1	11.3	56.5	0.1	2.0
14	2	11.9	56.5	2.0	4.0
15	1	10.5	58.0	0.9	8.0
16	1	11.2	58.0	1.0	10.0
17	1	9.3	58.5	0.7	10.0
18	2	11.7	58.0	1.2	7.0
19	1	11.2	57.5	0.7	8.0
20	5	11.7	57.0	7.3	7.0
21	1	8.9	58.0	0.3	5.0
22	1	12.0	59.0	0.1	1.0
23	1	11.5	58.5	0.4	5.0
24	1	10.8	59.0	0.0	3.0
25	1	12.3	58.0	0.6	4.0
26	1	11.8	58.0	0.2	8.0
27	1	11.0	59.0	0.3	3.0
28	1	11.6	57.5	0.9	7.0
29	1	11.8	57.5	0.8	8.0
30	1	11.9	56.5	0.7	5.0
31	1	10.6	58.0	1.0	6.0
32	1	11.0	57.0	1.0	8.0
33	2	11.6	57.5	1.0	12.0
34	1	11.3	56.0	0.3	8.0
35	2	11.6	57.0	0.6	17.0
36	2	13.7	56.0	0.3	5.0
37	2	11.6	57.0	0.1	13.0
38	3	9.9	57.0	1.0	23.0
39	1	10.2	57.5	0.1	2.0
40	2	13.7	56.0	0.4	3.0

Table 61. (Continued)

Sample number	Numerical grade	Moisture	Test weight	Foreign material	Splits
41	2	10.4	57.5	1.0	18.0
42	2	9.8	55.5	1.7	20.0
43	1	10.5	57.0	0.7	7.0
44	1	10.2	56.0	0.3	6.0
45	1	11.6	57.0	0.1	2.0
46	1	10.5	56.5	0.2	10.0
47	1	11.5	56.0	0.4	2.0
48	2	9.3	57.0	1.4	5.0
49	1	11.3	56.0	0.7	9.0
50	1	10.5	57.0	0.2	4.0
51	1	11.0	56.0	0.2	1.0
52	1	10.8	58.0	1.0	8.0
53	1	12.5	57.0	0.0	3.0
54	1	10.2	56.5	0.8	5.0
55	1	10.0	57.0	0.7	4.0
56	2	12.9	55.5	0.1	1.0
57	2	11.9	55.0	0.5	6.0
58	1	10.8	58.5	0.1	3.0
59	2	11.0	54.0	0.1	1.0
60	1	12.3	56.0	0.2	3.0
61	1	10.2	57.0	0.1	2.0
62	3	12.0	53.5	2.9	5.0
63	1	11.5	56.0	0.2	5.0
64	2	11.9	55.5	0.4	8.0
65	2	11.3	55.5	0.3	11.0
66	1	12.7	57.5	0.2	4.0
67	2	10.6	57.5	1.3	13.0
68	1	10.7	57.5	0.1	3.0
69	1	9.6	57.5	0.5	8.0
70	1	12.2	57.5	0.0	2.0
71	3	10.8	57.0	2.8	22.0
72	2	13.3	57.5	0.1	2.0
73	1	10.4	57.0	0.7	9.0
74	2	10.2	58.0	1.2	15.0
75	1	11.8	57.5	0.4	8.0
76	1	11.5	57.0	0.1	4.0
77	1	9.9	56.5	0.2	5.0
78	3	13.3	52.5	1.0	7.0
79	3	14.5	54.0	0.7	5.0
80	2	13.5	54.5	0.8	7.0

Table 61. (Continued)

Sample number	Numerical grade	Moisture	Test weight	Foreign material	Splits
81	2	11.3	55.5	1.0	6.0
82	1	12.0	57.5	0.1	1.0
83	1	11.0	57.0	0.2	2.0
84	1	11.0	57.5	0.2	4.0
85	1	10.9	57.0	0.1	3.0
86	3	12.0	58.0	2.7	18.0
87	2	11.9	57.5	1.5	4.0
88	1	11.5	57.0	0.2	5.0
89	1	10.4	57.5	0.8	7.0
90	2	11.3	57.0	1.9	14.0
91	1	10.5	57.0	0.2	3.0
92	1	10.2	58.0	0.3	3.0
93	3	10.6	57.0	2.2	14.0
94	1	11.5	57.5	1.0	7.0
95	3	10.7	56.5	2.4	7.0
96	2	10.4	58.5	1.3	13.0
97	1	11.4	57.0	0.4	5.0
98	1	11.9	57.5	0.1	6.0
99	1	12.0	59.0	0.2	3.0
100	1	11.5	58.0	0.4	6.0
101	1	12.4	56.5	0.6	8.0
102	2	11.5	57.0	1.3	10.0
103	1	11.7	57.0	1.0	8.0
104	4	11.0	56.0	3.7	19.0
105	2	10.8	57.5	1.5	10.0
106	1	12.5	58.5	1.0	6.0
107	1	11.4	58.0	1.0	6.0
108	2	11.3	57.5	1.7	8.0
109	1	11.9	57.0	1.0	7.0
110	1	11.4	57.0	1.0	1.0
111	4	11.5	56.0	4.4	1.0
112	1	12.3	56.0	0.5	5.0
113	1	11.2	59.0	0.0	2.0
114	2	10.7	57.0	0.1	12.0
115	1	11.0	58.5	0.1	5.0
116	1	11.3	56.0	0.5	8.0
117	1	11.5	58.5	0.1	3.0
118	1	10.8	59.5	0.0	2.0
119	1	11.0	57.5	0.0	6.0
120	3	11.5	58.5	2.2	6.0

Table 61. (Continued)

Sample number	Numerical grade	Moisture	Test weight	Foreign material	Splits
121	1	10.4	57.0	0.3	7.0
122	2	13.7	56.5	0.6	6.0
123	1	11.2	57.0	0.9	7.0
124	1	11.4	58.0	0.5	9.0
125	1	11.9	58.5	0.1	7.0
126	1	11.9	59.0	0.2	3.0
127	1	10.8	57.0	0.4	6.0
128	1	10.5	56.5	0.7	4.0
129	1	10.9	58.0	0.2	4.0
130	1	10.2	59.0	0.3	3.0
131	1	9.6	57.0	0.6	3.0
132	1	10.5	58.0	0.3	10.0
133	2	11.3	58.5	0.3	13.0
134	1	11.7	56.5	0.4	6.0
135	2	13.9	57.0	0.6	4.0
136	3	11.5	57.5	2.9	16.0
137	1	10.5	56.5	0.3	7.0
138	1	11.5	57.5	0.2	6.0
139	1	11.5	57.0	0.3	5.0
140	1	10.8	58.0	0.5	9.0
141	1	10.8	58.5	1.0	10.0
142	2	11.5	58.0	1.2	8.0
143	1	11.2	57.0	0.6	9.0
144	2	11.0	57.0	1.2	9.0
145	2	13.3	57.0	0.4	1.0
146	3	16.0	56.5	1.0	5.0
147	1	12.7	56.0	0.4	8.0
148	1	12.0	57.5	0.7	10.0
149	2	9.9	57.0	1.9	11.0
150	2	13.4	58.5	0.5	4.0
151	4	16.8	55.5	0.2	1.0
152	2	14.0	57.0	0.2	4.0
153	3	11.4	57.5	0.4	21.0
154	2	11.6	56.0	1.2	17.0
155	1	11.2	58.0	0.2	7.0
156	1	12.5	58.0	0.5	7.0
157	1	11.8	57.0	0.1	2.0
158	1	11.2	57.0	0.2	8.0
159	5	13.5	56.5	8.5	1.0
160	2	8.7	57.0	1.5	3.0

Table 61. (Continued)

Sample number	Numerical grade	Moisture	Test weight	Foreign material	Splits
161	1	9.8	58.0	0.7	7.0
162	2	11.4	57.0	1.7	12.0
163	2	13.5	57.0	0.5	5.0
164	1	11.0	58.0	0.7	4.0
165	2	10.9	56.5	1.7	5.0
166	2	13.5	57.0	0.2	4.0
167	2	13.6	56.0	0.4	8.0
168	2	10.7	56.5	0.2	14.0
169	2	11.5	58.0	1.0	19.0
170	1	11.6	56.5	0.1	3.0
171	3	10.2	56.5	0.5	23.0
172	1	10.3	57.0	0.8	4.0
173	1	10.2	58.5	0.2	6.0
174	1	11.3	57.0	0.6	7.0
175	1	9.4	57.0	1.0	9.0
176	1	12.8	57.0	0.4	6.0
177	3	11.0	56.5	1.4	22.0
178	2	12.2	57.0	2.0	7.0
179	2	12.7	56.5	1.6	9.0
180	1	12.5	58.0	0.1	4.0
181	2	10.6	57.5	0.1	16.0
182	1	10.2	58.5	0.3	10.0
183	1	10.2	58.5	0.2	1.0
184	1	11.0	57.0	0.7	8.0
185	1	12.0	57.0	0.9	4.0
186	2	10.2	57.5	1.9	10.0
187	1	12.8	57.0	0.1	1.0
188	2	13.8	56.5	2.0	12.0
189	1	12.0	56.0	0.5	6.0
190	1	11.7	57.5	0.7	9.0
191	3	15.4	55.5	0.3	2.0
192	2	13.5	56.0	0.7	13.0
193	3	14.7	56.0	0.4	10.0
194	1	10.4	56.5	0.3	10.0
195	1	10.4	58.0	0.3	5.0
196	1	11.5	58.0	1.0	8.0
197	2	11.0	58.0	1.2	6.0
198	1	9.0	57.0	0.5	8.0
199	2	9.3	58.0	1.0	15.0

Table 62. Oil and protein content for producer delivered harvest samples

Sample Number	Per cent oil	Per cent protein
1	22.59	41.46
2	22.90	41.92
3	22.89	40.90
4	23.32	41.08
5	22.76	39.30
6	23.29	40.15
7	23.00	39.68
8	22.43	41.45
9	22.44	41.07
10	23.05	40.36
11	21.41	43.68
12	21.85	41.75
13	22.37	41.00
14	21.49	42.35
15	23.83	42.85
16	23.15	40.36
17	20.76	42.56
18	21.67	42.09
19	21.70	41.85
20	21.01	41.58
21	22.61	41.29
22	22.68	40.70
23	22.43	41.03

Table 62. (Continued)

Sample Number	Per cent oil	Per cent protein
24	22.47	40.68
25	21.25	42.18
26	21.80	42.53
27	21.92	41.80
28	22.05	41.84
29	20.96	42.26
30	21.51	41.41
31	22.33	42.27
32	22.27	41.71
33	22.22	42.09
34	22.15	42.62
35	23.04	41.03
36	23.13	40.69
37	22.78	41.63
38	22.32	41.32
39	21.45	43.21
40	22.86	40.03
41	22.70	41.11
42	22.28	41.79
43	22.65	41.88
44	23.40	40.47
45	22.78	41.56
46	23.25	41.71
47	23.15	40.32

Table 63. Oil and protein content for Statistical Reporting Service samples

Sample number	Crop district	Per cent oil	Per cent protein
1	1	21.27	41.92
2	1	22.46	40.78
3	1	22.64	40.03
4	1	22.09	40.09
5	1	20.39	41.63
6	1	23.77	40.14
7	1	22.96	39.26
8	1	21.43	40.86
9	1	20.94	42.39
10	1	20.81	42.55
11	1	21.97	41.47
12	1	20.64	42.90
13	2	20.60	43.21
14	2	20.85	41.15
15	2	20.87	40.56
16	2	19.53	44.14
17	2	22.26	41.96
18	2	19.29	44.40
19	2	20.94	41.90
20	2	21.31	41.58
21	2	20.82	41.10
22	2	20.46	43.30
23	2	21.10	42.22
24	2	20.98	41.90
25	2	20.35	43.76
26	3	20.25	45.36
27	3	21.19	42.00
28	3	22.00	42.43
29	3	19.23	45.10
30	4	22.05	42.31
31	4	19.74	43.07
32	4	21.63	39.10
33	4	21.42	42.21
34	4	21.95	40.83
35	4	22.23	41.09
36	4	22.25	40.17

Table 63. (Continued)

Sample number	Crop district	Per cent oil	Per cent protein
37	5	22.41	40.01
38	5	21.75	41.21
39	5	22.12	41.33
40	5	22.72	39.23
41	5	22.96	37.90
42	5	23.45	39.20
43	5	22.02	42.10
44	5	20.93	43.59
45	5	22.19	40.75
46	5	21.11	42.16
47	5	22.11	40.72
48	6	21.62	41.15
49	6	19.65	44.23
50	6	21.95	40.03
51	6	20.95	43.12
52	7	20.95	42.59
53	7	19.96	39.98
54	7	22.01	42.82
55	7	22.37	39.77
56	7	21.68	39.28
57	7	23.10	38.79
58	7	22.08	38.27
59	8	22.72	40.71
60	8	22.34	40.56
61	8	20.45	41.36
62	8	21.71	39.98
63	8	21.78	41.90
64	9	21.64	41.90
65	9	22.62	37.80
66	9	22.62	39.45
67	9	20.53	40.88
68	9	21.02	42.91
69	9	20.59	40.67
70	9	22.05	39.55
71	9	21.18	39.98
72	9	21.11	41.26

APPENDIX C. CHI-SQUARE TESTS FOR NORMALITY

Table 64. Chi-square test of normality for moisture content in the producer delivered harvest samples[1]

Range	Expected	Observed	Chi-square
<10.05	26.65	17	3.49
10.05-10.55	21.19	30	3.66
10.56-11.05	28.04	39	4.28
11.06-11.55	31.62	41	2.78
11.56-12.05	30.37	33	0.23
12.06-12.55	24.86	11	7.73
12.56-13.05	17.34	6	7.42
>13.05	18.92	22	0.50
	------	---	-----
Total	198.99	199	30.09

[1]The null hypothesis that the distribution is normal is rejected since the calculated value of chi-square, 30.09, exceeds the tabular value, 11.07.

Table 65. Chi-square test of normality for foreign material content in the producer delivered harvest samples[1]

Range	Expected	Observed	Chi-square
<0.1	48.96	31	6.59
0.1-0.3	13.35	44	70.37
0.3-0.5	14.71	28	12.01
0.5-0.7	15.58	26	6.97
0.7-0.9	15.93	9	3.01
0.9-1.1	15.57	23	3.55
1.1-1.3	14.56	10	1.43
1.3-1.5	13.13	6	3.87
>1.5	47.22	22	13.47
	------	---	------
Total	199.01	199	121.27

[1]The null hypothesis that the distribution is normal is rejected since the calculated value of chi-square, 121.27, exceeds the tabular value, 12.59.

Table 66. Chi-square test of normality for splits in the producer delivered harvest samples[1]

Range	Expected	Observed	Chi-square
<1.5	22.98	12	5.25
1.5-2.5	9.28	13	1.49
2.5-3.5	11.42	19	5.03
3.5-4.5	13.52	19	2.22
4.5-5.5	15.15	21	2.26
5.5-6.5	16.39	19	0.42
6.5-7.5	16.79	20	0.61
7.5-8.5	16.60	22	1.76
8.5-9.5	15.54	9	2.75
9.5-10.5	14.04	13	0.08
10.5-12.5	21.90	7	10.14
12.5-14.5	13.64	9	1.58
>14.5	11.75	16	1.54
	------	---	-----
Total	199.00	199	35.13

[1]The null hypothesis that the distribution is normal is rejected since the calculated value of chi-square, 35.13, exceeds the tabular value, 18.31.

Table 67. Chi-square test of normality for test weight content in the producer delivered harvest samples[1]

Range	Expected	Observed	Chi-square
<55.25	6.93	6	0.12
55.26-56.25	33.07	29	0.50
56.26-57.25	70.50	81	1.88
57.26-58.25	62.15	60	0.07
>58.25	26.36	23	0.43
	------	---	----
Total	199.01	199	3.00

[1]The null hypothesis that the distribution is normal is accepted since the calculated value of chi-square, 3.00, is less than the tabular value, 5.59.

Table 68. Chi-square test of normality for oil content in the producer delivered harvest samples[1]

Range	Expected	Observed	Chi-square
<20.80	0.60	1	0.27
20.80-21.20	1.63	2	0.08
21.21-21.60	4.06	5	0.22
21.61-22.00	7.44	5	0.80
22.01-22.20	4.84	2	1.67
22.21-22.40	5.19	6	0.13
22.41-22.60	5.19	5	0.01
22.61-23.00	8.84	11	0.53
23.01-23.20	3.20	5	1.01
>23.20	6.02	5	0.17
	-----	--	----
Total	47.01	47	4.89

[1]The null hypothesis that the distribution is normal is accepted since the calculated value of chi-square, 4.89, is less than the tabular value, 14.89.

Table 69. Chi-square test of normality for oil content in the Statistical Reporting Service samples[1]

Range	Expected	Observed	Chi-square
<20.20	6.77	6	0.09
20.20-20.60	6.33	7	0.07
20.61-21.00	9.12	12	0.91
21.01-21.20	5.41	6	0.06
21.21-21.40	5.74	2	2.44
21.41-21.60	5.85	2	2.53
21.61-21.80	5.72	7	0.29
21.81-22.20	10.19	13	0.77
22.21-22.60	7.63	7	0.05
22.61-23.00	4.82	7	0.99
>23.00	4.44	3	0.47
	-----	--	----
Total	72.02	72	8.67

[1]The null hypothesis that the distribution is normal is accepted since the calculated value of chi-square, 8.67, is less than the tabular value, 15.51.

Table 70. Chi-square test of normality for protein content in the producer delivered harvest samples[1]

Range	Expected	Observed	Chi-square
<40.00	2.50	2	0.10
40.00-40.40	3.16	4	0.22
40.41-40.80	5.27	4	0.31
40.81-41.20	7.25	7	0.01
41.21-41.40	4.07	3	0.28
41.41-41.40	4.13	5	0.18
41.61-41.80	3.99	5	0.26
41.81-42.00	3.68	5	0.47
42.01-42.40	5.91	6	0.02
42.41-42.80	3.76	3	0.15
>42.80	3.26	3	0.02
	-----	--	----
Total	46.98	47	2.02

[1]The null hypothesis that the distribution is normal is accepted since the calculated value of chi-square, 2.02, is less than the tabular value, 15.51.

Table 71. Chi-square test of normality for protein content in the Statistical Reporting Service samples[1]

Range	Expected	Observed	Chi-square
<39.20	6.98	5	0.56
39.20-39.60	3.51	6	1.77
39.61-40.00	4.53	4	0.06
40.01-40.40	5.52	6	0.04
40.41-40.80	6.33	7	0.07
40.81-41.20	6.85	7	0.00
41.21-41.60	6.98	6	0.14
41.61-42.00	6.71	7	0.01
42.01-42.40	6.05	7	0.15
42.41-42.80	5.19	3	0.92
42.81-43.20	4.18	5	0.16
43.21-43.80	4.40	4	0.04
>43.80	4.75	5	0.01
	-----	--	----
Total	71.98	72	3.93

[1]The null hypothesis that the distribution is normal is accepted since the calculated value of chi-square, 3.93, is less than the tabular value, 18.31.

Table 72. Chi-square test of normality for total value of products--simulated processing model--producer delivered harvest samples[1]

Range	Expected	Observed	Chi-square
<3.300	4.01	5	0.24
3.300-3.320	6.22	2	2.63
3.321-3.340	9.91	13	0.96
3.341-3.360	11.00	14	0.82
3.361-3.380	8.62	9	0.02
3.381-3.400	4.70	2	1.55
3.401-3.420	1.89	1	0.42
>3.420	0.64	1	0.20
	-----	--	----
Total	46.99	47	6.84

[1]The null hypothesis that the distribution is normal is accepted since the calculated value of chi-square, 6.84, is less than the tabular value, 11.07.

Table 73. Chi-square test of normality for total value of products--direct computation model--producer delivered harvest samples[1]

Range	Expected	Observed	Chi-square
<3.220	0.82	2	1.70
3.221-3.240	1.92	2	0.00
3.241-3.260	3.05	2	0.36
3.261-3.280	8.55	6	2.13
3.281-3.300	9.54	11	0.22
3.301-3.320	9.44	9	0.02
3.321-3.340	7.10	11	2.14
3.341-3.360	4.06	3	0.28
>3.361	2.52	1	0.92
	-----	--	----
Total	47.00	47	7.77

[1]The null hypothesis that the distribution is normal is accepted since the calculated value of chi-square, 7.77, is less than the tabular value, 12.59.

Table 74. Chi-square test of normality for total value of products--simulated processing model--Statistical Reporting Service samples[1]

Range	Expected	Observed	Chi-square
<3.220	2.94	2	0.30
3.221-3.240	4.79	8	2.15
3.241-3.260	8.58	5	1.49
3.261-3.280	12.44	10	0.48
3.281-3.300	14.07	18	1.09
3.301-3.320	12.63	14	0.15
3.321-3.340	8.66	7	0.32
3.341-3.360	4.86	6	0.27
3.361-3.380	2.08	1	0.56
>3.380	0.92	1	0.00
	-----	--	----
Total	71.97	72	6.81

[1]The null hypothesis that the distribution is normal is accepted since the calculated value of chi-square, 6.81, is less than the tabular value, 14.07.

Table 75. Chi-square test of normality for total value of products--direct computation model--Statistical Reporting Service samples[1]

Range	Expected	Observed	Chi-square
<3.160	2.70	2	0.18
3.161-3.180	3.79	8	4.68
3.181-3.200	6.76	4	1.13
3.201-3.220	9.99	10	0.00
3.221-3.240	12.19	13	0.05
3.241-3.260	12.29	9	0.88
3.261-3.280	10.25	11	0.05
3.281-3.300	7.06	12	3.46
3.301-3.320	4.02	1	2.27
>3.320	2.95	2	0.31
	-----	--	-----
Total	72.00	72	13.01

[1]The null hypothesis that the distribution is normal is accepted since the calculated value of chi-square, 13.01, is less than the tabular value, 14.07.

APPENDIX D: ANALYSIS OF VARIANCE FOR REGRESSION EQUATIONS

Table 76. Analysis of variance for regression equation 1, moisture = f(test weight, splits)

Source	Degrees of freedom	Sum of squares	Mean square	F-value
Total (uncorrected)	199	26278.68	-	-
Mean	1	25973.40	-	-
Total (corrected)	198	305.28	-	-
Regression	2	45.00	22.50	16.92
Residual	196	260.28	1.33	-

Table 77. Analysis of variance for regression equation 2, test weight = f(moisture)

Source	Degrees of freedom	Sum of squares	Mean square	F-value
Total (uncorrected)	199	649211.75	-	-
Mean	1	648979.31	-	-
Total (corrected)	198	232.44	-	-
Regression	1	20.99	20.99	19.56
Residual	197	211.45	1.07	-

Table 78. Analysis of variance for regression equation 3, foreign material = f(splits)

Source	Degrees of freedom	Sum of squares	Mean square	F-value
Total (uncorrected)	199	320.38	-	-
Mean	1	123.07	-	-
Total (corrected)	198	197.31	-	-
Regression	1	10.73	10.73	11.33
Residual	197	186.57	0.95	-

Table 79. Analysis of variance for regression equation 4, splits = f(moisture, foreign material)

Source	Degrees of freedom	Sum of squares	Mean square	F-value
Total (uncorrected)	199	14533.00	-	-
Mean	1	10146.69	-	-
Total (corrected)	198	4386.31	-	-
Regression	2	444.86	222.43	11.06
Residual	196	3941.45	20.11	-

Table 80. Analysis of variance for regression equation 5, oil = f(protein)

Source	Degrees of freedom	Sum of squares	Mean square	F-value
Total (uncorrected)	47	23585.87	-	-
Mean	1	23562.44	-	-
Total (corrected)	46	23.43	-	-
Regression	1	7.89	7.89	22.84
Residual	45	15.54	0.34	-

Table 81. Analysis of variance for regression equation 6, protein = f(oil)

Source	Degrees of freedom	Sum of squares	Mean square	F-value
Total (uncorrected)	47	80825.38	-	-
Mean	1	80787.50	-	-
Total (corrected)	46	37.88	-	-
Regression	1	12.69	12.69	22.68
Residual	45	25.18	0.56	-

Table 82. Analysis of variance for regression equation 7, oil = f(protein)

Source	Degrees of freedom	Sum of squares	Mean square	F-value
Total (uncorrected)	72	33312.68	-	-
Mean	1	33243.92	-	-
Total (corrected)	71	68.76	-	-
Regression	1	35.99	35.99	76.89
Residual	70	32.77	0.47	-

Table 83. Analysis of variance for regression equation 8, protein = f(oil)

Source	Degrees of freedom	Sum of squares	Mean square	F-value
Total (uncorrected)	72	123197.81	-	-
Mean	1	123006.69	-	-
Total (corrected)	71	191.12	-	-
Regression	1	99.77	99.77	76.44
Residual	70	91.36	1.30	-

Table 84. Analysis of variance for regression equation 9, oil = f(foreign material)

Source	Degrees of freedom	Sum of squares	Mean square	F-value
Total (uncorrected)	47	23585.87	-	-
Mean	1	23562.44	-	-
Total (corrected)	46	23.43	-	-
Regression	1	2.52	2.52	5.41
Residual	45	20.91	0.46	-

APPENDIX E: SOYBEAN PROCESSOR AND IOWA ELEVATOR QUESTIONNAIRES

CONFIDENTIAL

USDA North-Central Regional Project

Iowa State University

Soybean Processing Questionnaire

Date ______________________________

Name of Company ______________________________

Address of Company ______________________________

Name of person completing questionnaire ______________________________

Title ______________________________

(1) What is your soybean crushing capacity?

_____________ bu. per year

(2) Approximately how many soybeans did you crush last year?

_____________ bu.

(3) Which of the following soybean protein products does your firm produce?

Soybean meal _____________ Soybean flour _____________

Other _____________
(specify)

(4) What is your average soybean meal (or flour) yield per sixty-pound bushel?

_____________ lbs.

(5) What is your average soybean oil yield per sixty-pound bushel?

_____________ lbs.

(6) Approximately what per cent of the soybeans you receive are artifically dried by you?

_____________%

(a) At what average moisture level do you process soybeans?

_____________%

(b) Are all soybeans processed at or near the same moisture level?

Yes _____ No _____

(7) Do you differentiate in soybean bids by area or locality of procurement?

Yes_____ No_____

If yes, for what reasons?____

____

(8) Approximately what percent of the soybeans you buy are on a contract-future delivery basis?

__________%

(a) Is the numerical grade for these soybeans specified in the contractual agreement?

Yes_____ No_____

(9) Do you consider the value of the numerical grade of soybeans sufficient information for procurement and/or pricing purposes?

Yes_____ No_____

(a) If no, do you feel that the inclusion of the test results for the various grade factors is sufficient information?

Yes_____ No_____

(10) What percent of the soybeans you receive are from:

(a) Farmers ____________%

(b) Country elevators ____________%

(c) Terminal elevators ____________%

(d) Other____________ (specify) ____________%

100%

(11) Consider the following modes of arrival for soybeans, then complete the relevant parts of the table.

	Loads Per Week	% Graded by Your Company	% Graded by Licensed Inspector	Cost Per Sample for Grading by Licensed Inspector
Tractor-wagon				
100-300 bu. truck				
Over 300 bu. truck				
Box car				
Hopper car				
Barge				

(12) If you do your own grading, approximately how many man-hours per year are devoted to such activities?

______________ hrs.

(13) Check the following types of grain grading equipment your firm has and uses.

	Number Owned	Number Used	Brand Name
(a) Mechanical sampler	____________	____________	______________
(b) Moisture tester	____________	____________	______________
(c) Test weight scale	____________	____________	
(d) Grain sieve	____________	____________	
(e) Gram scale	____________	____________	
(f) Grain divider	____________	____________	
(g) Proble	____________	____________	
(h) Pelican sampler	____________	____________	

(14) Do you buy origin grade soybeans?

Yes ________ No _________

(a) If yes, what percent of these origin grades do you re-grade at the receiving area?

______________%

(b) If no, are you in favor of origin grading?

Yes ________ No _________

(15) Are all, or any, of your soybeans "screened" to remove excess foreign material before processing?

Yes ________ No _________

(a) If yes, please indicate the approximate percent screened.

______________%

(16) Would you be willing to buy soybeans on strickly a factor basis, omitting numerical grade classification?

Yes _______ No ________

(17) Would you be willing to buy soybeans on both a premium and discount basis?

Yes _______ No ________

(a) If yes, what criteria would you use? _____________________________________

____

(18) Do you distinguish between green damage and damage other than green when procuring soybeans?

Yes ________ No _________

(a) If yes, what distinction is made? ____

____

(19) Do you feel that test weight is an important determinant in quantity or quality of product output?

Yes_____ No_____

If yes, in what way?____

____

(20) Do you feel that splits are an important determinant in quantity or quality of product output?

Yes_____ No_____

If yes, in what way?____

____

(21) What quality factors, others than those included in the present grading system, do you feel affect the final quantity or quality of your soybean meal or oil output? Please list.

	Do you test for these? Yes	No

(22) What type of processing does your firm perform?

Solvent extraction ____________ Screw-press______________

(23) Do you take oil and protein tests on your raw soybeans?

Yes_____ No_____

(a) If yes, how many such tests are performed per month?

____

(b) Does an outside chemical lab do the testing for you?

Yes_____ No_____

(24) Would you be willing to buy soybeans on an oil and protein basis if a fast, economical, and reliable method of oil and protein determination was available?

Yes_____ No_____

(25) Do you experience a seasonality in soybean quality characteristics other than moisture?

Yes_____ No_____

(a) Elaborate____

____

(26) On the average, approximately what percent of your total soybean receipts have the following characteristics?

(a) Sour, musty, or heating soybeans ____________%

(b) Black, brown, or bi-colored soybeans ____________%

(c) Garlicky soybeans ____________%

(d) Weevily soybeans ____________%

(e) Purple mottled soybeans ____________%

(27) Do you consider purple mottled soybeans a serious problem if present in a shipment of soybeans?

Yes_____ No_____

(a) If yes, in what way?____

____

(28) There are several important quality characteristics to consider when buying and processing soybeans. Consider the following list of quality characteristics and then rank them in the order of importance to you, as a processor. (1 being the highest rank and 9 being the lowest rank)

Foreign material ____________

Oil content ____________

Splits ____________

Protein content ____________

Test weight ____________

Total damage ____________

Heat damage ____________

Moisture ____________

Black, brown, or bi-colored ____________

(29) What changes, if any, would you like to see made in the present soybean grading system?____

____

____

____

____

____

CONFIDENTIAL April 1972

IOWA STATE UNIVERSITY
206

IOWA GRAIN ELEVATOR CORN AND SOYBEAN QUALITY AND GRADING QUESTIONNAIRE

I. QUALITY FACTORS

(1) Consider the following lists of corn and soybean quality characteristics and then rank them from 1 through 9 in order of importance to you, as an elevator manager. (1 being of most importance and 9 of least importance)

Corn	Soybeans
_______ Foreign material	_______ Foreign material
_______ Rodent excreta	_______ Oil content
_______ Stress cracks	_______ Splits
_______ Weevily corn	_______ Protein content
_______ Test weight	_______ Test weight
_______ Total damage	_______ Total damage
_______ Heat damage	_______ Heat damage
_______ Moisture	_______ Moisture
_______ Musty, sour, or heating	_______ Black, brown, or bi-colored

(2) The present standards for corn include the factors "broken corn and foreign materials." Broken corn is defined as pieces of kernels that will pass through a 12/64-inch round-hole sieve. It has been suggested that large broken pieces of kernels which will remain on top of an 8/64-inch round-hole sieve should <u>not</u> be included in the factor "broken corn and foreign material" but should be included in a new factor, "large broken corn."

Do you believe that the standards should be revised to include a new factor, "large broken corn"?

Yes _______ No _______

II. SAMPLING AND GRADING

(3) How many of each of the following types of grain grading equipment does your firm own?

	Number Owned	Brand Name
(a) Mechanical sampler	__________	____________________
(b) Moisture tester	__________	____________________
(c) Test weight scale	__________	
(d) Grain sieve	__________	
(e) Gram scale	__________	
(f) Grain divider	__________	
(g) Probe	__________	

(4) Do you have a mechanical sampler for sampling outbound grain?

207

Yes _______ No _______

(a) If YES, what percent of your rail corn and rail soybeans do you sell on origin grade?

Corn ______% Soybeans ______%

(b) If NO, do you plan to acquire a mechanical sampler within 5 years?

Yes _______ No _______

(5) Approximately how many man-hours per year are devoted to sampling and grading grain at your elevator?

Inbound grain _______ hr/yr Outbound grain _______ hr/yr

(6) What percent of the total inbound samples of corn and soybeans are evaluated for each of the following factors?

	Corn	Soybeans
Moisture	________%	________%
Test weight	________%	________%
Foreign material	________%	________%
Total damage	________%	________%
Splits	XXX %	________%

III. PRICING AND DISCOUNTS

(7) What is your discount schedule for corn and soybeans? [Feel free to insert a printed copy if you have one available.]

	Corn	Soybeans
Moisture		
Test weight		
Foreign material		
Total damage		
Splits	XXX	
Other (specify)		