Maintaining Quality of PEA BEANS During Shipment Overseas

MARKETING RESEARCH REPORT No. 519

UNITED STATES DEPARTMENT OF AGRICULTURE
AGRICULTURAL MARKETING SERVICE • MARKET QUALITY RESEARCH DIVISION

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PREFACE

For a number of years, foreign importers of United States beans have complained that quality of shipments was not up to expectations. Shippers and exporters, on the other hand, have maintained that quality of beans has been high. In January 1960, the National Dry Bean Council discussed these problems with the personnel of the Market Quality Research Division, Agricultural Marketing Service. The problem was further discussed with the Vegetable Research and Marketing Advisory Committee, which assigned a high priority to work on this problem. Plans for tests were started immediately.

ACKNOWLEDGMENTS

We appreciate the cooperation of the National Dry Bean Council in the initiation of the study.

Particular credit is due Maurice A. Doan, Secretary of the Michigan Bean Shippers Association; Albert L. Riedel, division president and general manager, Michigan Bean Company of the Wickes Corporation; and Edward Crawford, Manager of the Wallace and Morley Company.

The cooperation of the H. J. Heinz Company, Limited, London, through John Eccles and his staff, and of Hamburg Chicago Line, through H. Kielin, Master M/S Suderholm, was of primary importance in the success of the study.

Walter Redit, Market Quality Research Division, helped select appropriate temperature-measuring equipment; many others in the Agricultural Marketing Service made valuable suggestions.

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Washington, D.C. February 1962

MAINTAINING QUALITY OF PEA BEANS

During Shipment Overseas

By Judson A. Thompson, Methodius S. Sefcovic, and C. H. Kingsolver[1]
Market Quality Research Division

SUMMARY

We must deliver beans of higher quality if we are to retain and expand our European market for dry beans. The ways of loading and unloading the beans shipped overseas and conditions in the holds of the ships must be improved for higher quality and less container breakage.

Aeration or ventilation should be used to lower the humidity in the holds of the ships when the moisture content of the beans becomes high enough to cause the growth of funguses and bacteria. Over-aeration, however, could be harmful, since excessively dry beans (10 percent moisture content) are sensitive to physical damage in handling. Humidity in the holds should range between 60 and 70 percent.

A study of loading and unloading methods, shipping conditions, and storage conditions in Europe was made in the summer of 1960.

Three ships were loaded with dry Pea (Navy) beans and other cargo at Detroit, Mich., in June. Each ship was equipped with electrical devices located among the bags of beans in the holds to make continuous recordings of moisture and temperature changes throughout the voyage to western Europe.

One of the authors accompanied one of the ships and checked conditions in the hold daily. He met each of the other ships as it arrived in Europe and observed unloading and storage of the beans in Europe.

This report is a compilation of the data and findings in the ships during their 22-25 days of ocean voyage and of observations concerning storage in Europe. Findings in this study indicate that:

(1) Moisture increased as much as 3 or 4 percent in the surface bags under the deck and in bags near or in contact with bulkheads.

(2) The beans in the center two-thirds of the hold remained almost constant in temperature, moisture, and quality throughout the voyage.

(3) Humidity of the air over the beans increased to 100 percent and moisture condensed on the cold beans when the ships moved from the cold Labrador Current into the Gulf Stream where the water and air temperatures were 10 to 15 degrees F. warmer.[2]

(4) When the humidity was below 60 percent and aeration was used during most of the midday for more than 4 or 5 consecutive days, the moisture content of some of the

[1] Mr. Thompson is a marketing specialist; Mr. Sefcovic is a food technologist; and Dr. Kingsolver is a plant pathologist.

[2] A hygrothermograph can be used by the ship's engineer to obtain a continuous record of temperature and humidity so that the holds can be properly aerated.

beans fell below 14 percent. Handling beans at this moisture level may cause an increase in splits and in cracked seedcoats.

(5) Mold developed most frequently in bags at the bottom of the hold and in those next to the outside bulkheads. More mold was found in the lower tiers of bags aboard one ship than on the other two ships, probably because of insufficient aeration.

(6) Mold developed at temperatures as low as 60° F. if humidity remained above 80 percent.

(7) Beans in bags wet by condensate drip or rain were not damaged by mold if only one bag in an area was soaked, since the excess moisture moved to adjacent bags.

(8) At destination, beans in bags from the areas in the hold in which the humidity remained high for several days contained too much moisture for safe storage on the floor, next to the wall, or in any place where air circulation would be poor.

(9) Upon arrival of the beans at destination, moisture content should be checked by a representative of the importer so that beans containing over 16 percent moisture can be segregated for preferential storage or immediate processing.

BACKGROUND OF THE STUDY

Expansion of the export market for Pea (Navy) beans is very important to the Michigan growers and shippers since over 99 percent of these beans grown for export are produced in Michigan. The final (December) estimate of production of all beans in Michigan in 1961 is 7,290,000 bags (100-pound bags). Of these, it is estimated that 6,720,000 bags were Pea beans, an all time high production. A crop of 5,811,000 bags of cleaned Pea beans was harvested in 1960, and the previous high record was 6,006,000 bags in 1959. Michigan growers produced 4,949,000 bags in 1958 and 3,272,000 bags in 1957. More Pea beans are produced in and exported by the United States than any other class of beans.

The United States was the world's largest bean importer in the 1920's. For several years, we imported more than a million bags each year, primarily from Japan. We imported more than two million bags in 1928, mostly small white beans for canning. By the 1930's, we exported about 100,000 bags annually. In the1940's, our exports increased to an average of 1.7 million bags. In the 1950's, exports increased to a yearly average of 2.6 million bags with an all time record in 1959 of 4.5 million bags. Having changed from importer to the world's largest dry bean exporter, we need to improve methods of handling and shipping this commodity in order to retain, if not expand, this export market.

New processing plants are being opened in northern Europe. The demand for beans by these plants and throughout the world will increase the export of all beans but especially Pea beans since they are the most desirable type for canning.

Quality of Beans Exported

The quality of beans exported from Michigan during the 1960 season was better than in previous years. The largest European importer of Michigan Navy beans advised the Michigan shippers that the quality shipped was good, and the percentage of foreign material (stones) was substantially less than in previous years.

In their efforts to maintain the quality of the beans, Michigan growers strive to limit their harvesting operations to one day. Bean plants are pulled or cut early in the morning, windrowed by side-delivery rake after 2 or 3 hours, and by afternoon the vines are dry enough to combine. Harvesting in one day prevents discoloration of beans from

heavy dew or rain and from the pods lying on the ground for long periods. If the vines do not settle onto the ground, small stones are less likely to be picked up with the vines.

Exporters and country shippers now have efficient cleaning and handling equipment, including destoners and electronic sorting machines, which help to maintain the quality of the beans.

Importers find top quality beans most economical for their use. It is not profitable to pay water freight and handling charges on defective beans which must be removed before the good beans are canned. In addition, since the St. Lawrence Seaway is closed during winter months, some of the imported beans are stored in England for several months before processing. The high humidity there during much of the year, makes it difficult to store beans without deterioration.

Inspection and Certification of Quality

The Michigan Bean Shippers Association employs inspectors who certify the quality of all lots of beans shipped out of Michigan. These inspectors are supervised by the State Department of Agriculture. They sample and inspect the beans offered for export at point of origin. The lots then move to terminal storage (fig. 1). Because there may be some delay before shipment, some certificates of quality may not reflect the correct grade at time of export. The larger, more important export shipments may be checked by a buyer's representative to see if the lots meet his quality requirements. This procedure has resulted in deliveries more acceptable to canners, though the importers dislike the added expense.

BN-14710

Figure 1. --This method of interlocking bags of dry beans stored in a terminal warehouse keeps the bags from slipping and allows better aeration of the beans than if the bags are laid flat.

When beans are moved out of the State on Government contract, or when dry beans owned by the Commodity Credit Corporation are inspected for grade, the official United States standards for beans are used. The table of grade requirements applicable for Pea beans, as revised effective September 1, 1956, is used for beans owned by the Commodity Credit Corporation (appendix, p. 40). An example of a certificate covering a lot of United States Choice Handpicked beans is shown in figure 2.

Commercial exports from Michigan are usually inspected under the Michigan standards. Some of the European importers are not familiar with the difference between the quality of "Choice Handpicked" grade under standards of the Michigan Department of Agriculture and comparable grades under the United States standards. This has led to confusion in some export shipments. (See standards, appendix, pp. 40-41).

In spite of special inspection and handling precautions, however, some lots or bags in the test shipments were not up to quality or grade when opened by the buyers at foreign destinations.

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(1-12-61)

UNITED STATES DEPARTMENT OF AGRICULTURE
AGRICULTURAL MARKETING SERVICE
MICHIGAN DEPARTMENT OF AGRICULTURE
AND
MICHIGAN BEAN SHIPPERS ASSOCIATION

ORIGINAL

A 011

INSPECTION CERTIFICATE

Saginaw, Michigan, January 12, 1961
(Place and date)

I CERTIFY that I inspected, on the above date, the following-described LOT OF BEANS with the results stated below:

Location Lowell, Michigan Quantity 800/100 lb. bags

Identification C&O 290597

Grade and class U.S. Choice Handpicked Pea Beans

Moisture: 17.0%

Seals Applied: MDA 13392-93

Remarks: Single burlap bags, good condition.

A. A. Bean Company
Applicant.

Fee $ 16.00 Charges $ Total $

John Doe
Inspector.

This certificate is issued under the authority of the Agricultural Marketing Act of 1946, as amended (7 U.S.C. 1621 et seq.), and the regulations thereunder (7 CFR 68.1 et seq.), and certain provisions of the statutes of the State of Michigan, and is receivable in all courts of the United States as prima facie evidence of the truth of the statements therein contained. This certificate does not excuse failure to comply with the provisions of the Federal Food, Drug, and Cosmetic Act, or other Federal laws.

Figure 2. --An inspection certificate must be issued for each carlot of beans exported.

HOW THE STUDY WAS MADE

Equipment and Procedures

Equipment and special samples were placed in one hold of Ship A and additional instruments and samples were placed aboard Ship B and Ship C. The most detailed study was made of the 33,679 bags of Pea beans (about 1,600 metric tons) loaded on Ship A. She is a typical Great Lakes ocean freighter of about 3,500 tons used as a lake and ocean transport for dry beans and mixed cargo.

Sixty thermistors (electrical devices for measuring temperature) were installed in one hold of the ship so that the effect of fluctuating air and water temperatures on bean temperatures could be measured and the relationship of temperature to moisture and quality changes in the beans could be studied (fig. 3). At each point indicated in figure 3 by the symbols, a small fiberglass-screen bag, 5 inches x 9 inches,[3] containing about 1 pound of beans of uniform quality, was attached. Figure 3 illustrates this arrangement in detail. These sample bags were made up before loading from a sample having the quality and moisture characteristics of the shipment. Air and moisture pass freely through the fiberglass screen, but it does not absorb moisture. An example of how the fiberglass container was used is illustrated in figure 4.

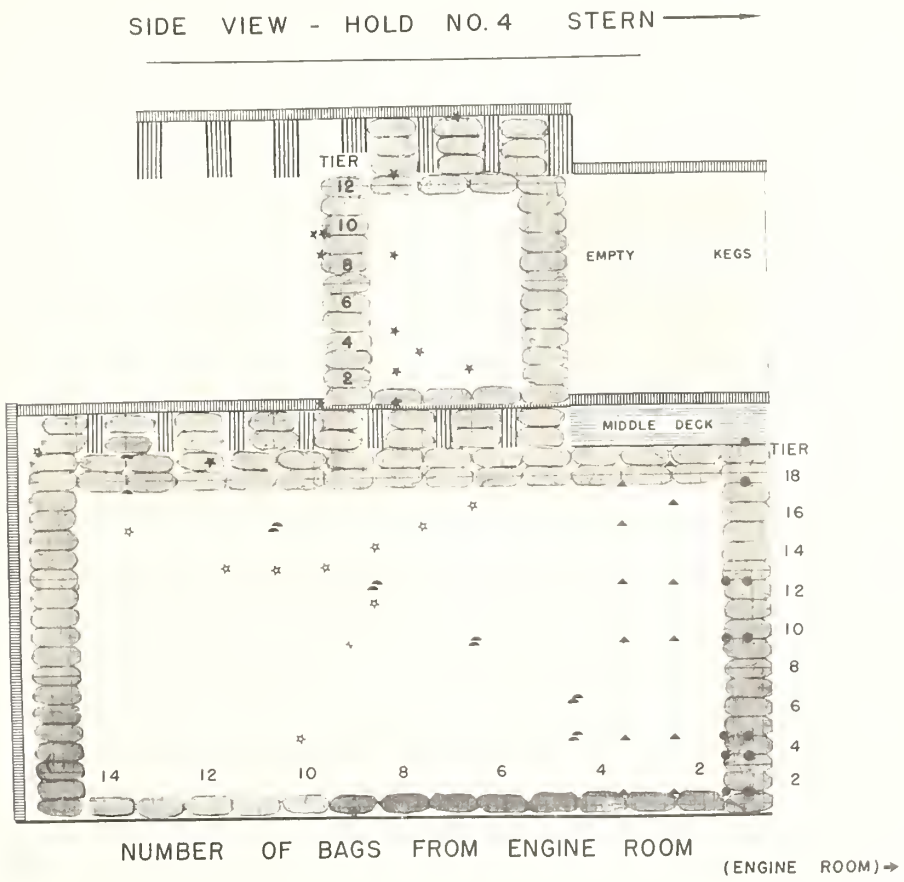

Figure 3. --Electrical thermometers were placed in 1-pound bags of beans in Ship A at the 60 locations indicated in this diagram. Changes in the moisture, temperature, and color of these beans showed the effects of location, in relation to the engine room and sides of the ship and upper or lower holds, on the beans. Each symbol indicates one thermistor cable.

The fiberglass bags are exceptionally strong and, although 20 or more 100-pound bags were resting on some of the sample bags, none were broken. To assure recovery of the many samples during unloading, they were all tied to a heavy nylon cord.

It was necessary to install the 12-thermistor cables and leads in the hold of Ship A while the bags of beans were being put in place. The cables and leads had to be installed

[3] 14 by 18 mesh (threads per inch).

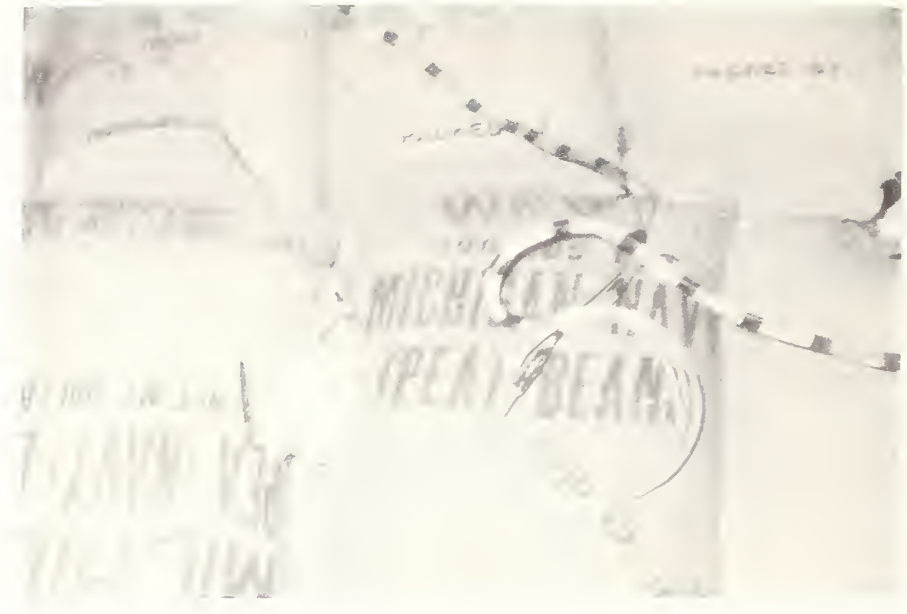

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Figure 4. --A fiberglass bag containing a pound of beans of known quality and moisture content was placed adjacent to a 100-pound bag of beans in which a thermistor probe had been inserted. Thermistor probe with coiled lead attached to a cable is shown at right.

carefully so that the weight of the bags on the cables would not break the wires (fig. 5). All main leads were run to one central point where all thermistors could be read with the instrument shown in figure 6.

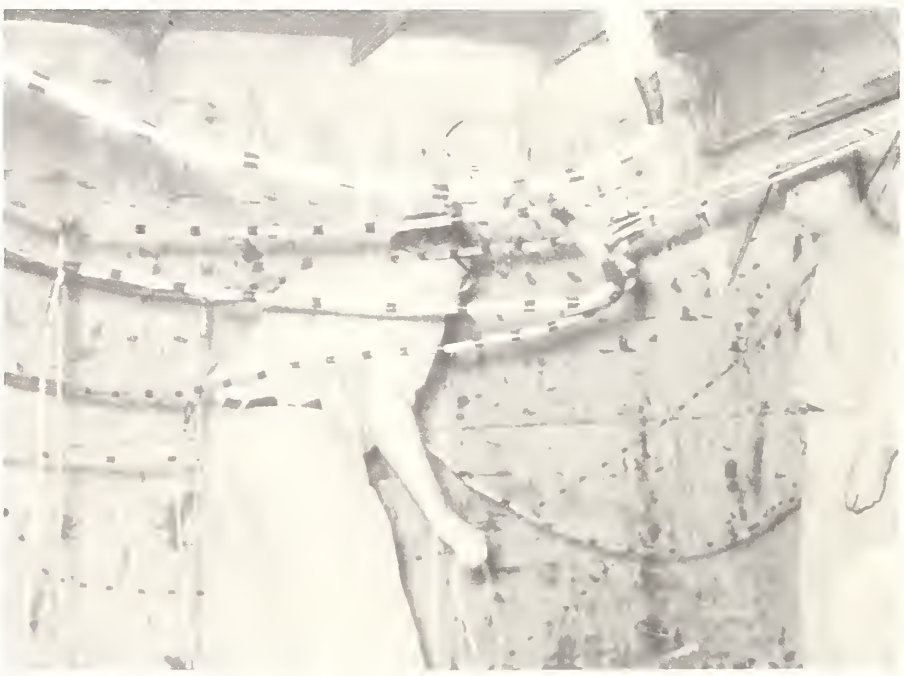

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Figure 5. --Installing thermistor cables in ship's hold. Cable and thermistor leads are shown.

BN-14690

Figure 6. --The leads for the 5 cables were arranged so that temperatures from all 60 points could be read from this one instrument.

Since it was not possible to use thermistor equipment for determining temperatures on Ships B and C, recording thermometers were used for this purpose. These thermometers record temperatures continuously for 30 days on special charts. The instrument is about the size of a quart jar (fig. 7). Each instrument was sewed into the top of a bag of beans (fig. 8), and these bags were distributed throughout the load. Eight such instruments were used in Ship C and 10 in Ship B.

In addition to the 1-pound samples in fiberglass containers, eighteen 100-pound bags were marked with white bands for quick identification (fig. 8). These bags were sampled with a grain "trier" as they were loaded, and the area of the bag from which the sample was drawn was marked "X" so that this same location could be sampled at destination. Some of the marked bags contained recording thermometers.

Color Change

The special samples that were used to study moisture content were analyzed for color at shipping point and at destination. An automatic color difference meter (fig. 9) was used to measure the color (table 8, appendix).

The color difference meter has been used in previous studies to measure yellowing and darkening of beans in storage; samples were compared after storage with the original readings to determine how much the color of the beans had changed. The three measurable attributes of color--hue, saturation, and lightness--may be indicated on the meter by its Rd, a, and b scales. The "a" scale indicates redness when plus, grayness when zero, and greenness when minus; "b" indicates yellowness when plus, grayness

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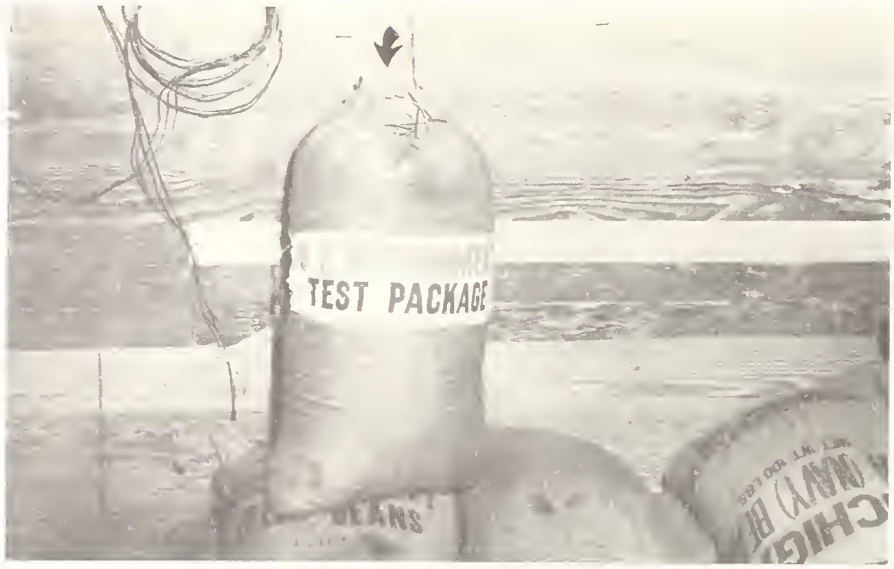
Figure 7. --Recording thermometers were used in two of the shipments. These thermometers are used extensively in test shipments of fruits, vegetables, and other produce.



BN-14708

Figure 8. --Marked bags were placed throughout the hold and were sampled for changes in the quality of the beans. Note recording thermometer sewed in top of test bag.

when zero, and blueness when minus; the Rd readings represent a measure of luminous reflectance or lightness.

All color measurements in these overseas shipping tests were made in reference to a white tile standard with the machine set at Rd = 83.9, a = -1.9, b = 2.0, and with 2 1/4-inch-diameter aperture and large spot illuminator. Little difference was detectable in the color of the beans in such a short period as indicated in table 8.

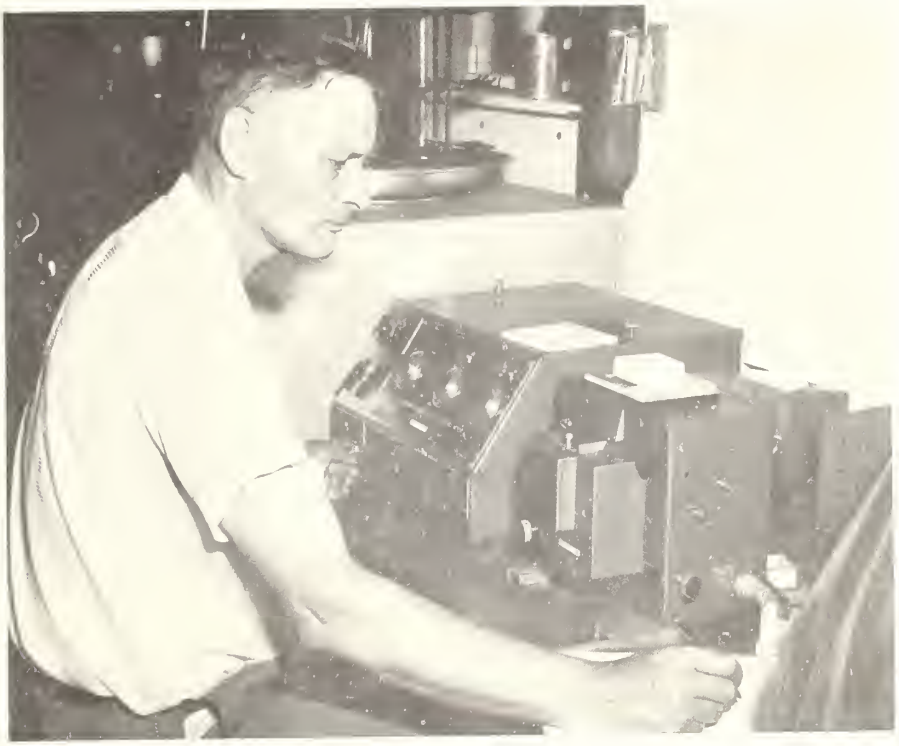


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Figure 9. --A color difference meter was used in determining the amount of color change in overseas shipment of beans.

Moisture Determination

As soon as the special fiberglass bags, each holding about 1 pound of beans, were available during unloading operations, the beans were transferred to moistureproof polyethylene bags (fig. 3).

Arrangements had been made for the Agricultural Marketing Service to make moisture determinations on the samples obtained from the three shiploads of beans at a processing plant in Harlesden, England. All moisture analyses from the three shipments were made at this plant. Duplicate samples of 20 to 25 grams were dried in an air oven for 72 hours at 103° C.

To measure the relative humidity in the hold of Ship A, a standard hygrothermograph with a 24-hour chart was operated during the entire voyage. This instrument records the temperature and relative humidity continuously (fig. 10).

BN-14706

Figure 10. --A hygrothermograph with 24-hour chart was placed over the commodity and under the ship's deck to measure temperature and humidity at this point.

Loading

Beans were moved from the warehouse by trucks, each carrying two pallets with 30 bags (1 1/2 tons) per pallet (fig. 11). Tow trucks handle these 3-ton loads (two pallets) rapidly. All of the beans in the terminal were stacked as shown in figure 11.

BN-14691

Figure 11. --Method of moving bagged beans to shipside on wooden pallets in the United States. Note how bags are interlocked to hold 30 containers on each pallet.

Each pallet load was sampled just before it was moved into the hold (fig. 12). A 12-inch standard seed ("thief") probe was used and the samples were composited for average moisture and quality analysis.

BN-14692

Figure 12. --Sampling procedure carried out at shipside from each pallet of 30 bags. A sample was taken from each pallet of 30 bags at shipside with a seed probe before beans were loaded onto the ship.

Steel plate was laid in the bottom of the holds of Ship A to bring up load weight. Dunnage was placed over the steel, and an attempt was made to cover the steel and the sides of the hold with paper (fig. 13).

Much of the rough lumber used in bridging the spaces between the pieces of steel or crates was so warped that it was difficult to do a good job. Many of the bags settled down in the remaining cracks and were broken.

The hold is usually loaded hurriedly as the ship's owner is under pressure to load and unload as rapidly as possible. While the bags are usually interlocked on the pallets in the warehouse, they may become loosened during loading. Several accidents happened during the tests, causing bags to fall from the pallet or an entire pallet load to fall (fig. 14). Many bags were broken in one way or another, and although an effort was made to sew up the broken bags, it was not possible to mend all of them. The loose beans were lost in the bottom of the hold and a large part of them were not reclaimable.

Voyage

Loading was completed about 5:30 p. m. , June 14, after several interruptions by rain (3 days' delay), and Ship A sailed at 6:30 p. m. The shipping was heavy at this time of year, and 3 days elapsed before the ship reached Montreal. Two days were required at Montreal to take on additional cargo to complete the licensed cargo weight. Two more days were required to reach the Atlantic. The ship left Montreal on June 19, and on July 3 it reached Belgium, where part of the Montreal cargo was discharged. Beans were unloaded in London, July 4-6 (fig. 15).

(a)
BN-14705

(b)
BN-14704

(c)

BN-14703

Figure 13. --(a) Steel plate is used in bottom of hold as ballast. Open areas between plates must be bridged with dunnage to protect bags from rough corners. (b) Paper is being attached to side of hold and over steel plates to protect bags and keep beans from absorbing condensation from the cold steel. (c) Rough corners and irregular levels must be covered before beans are loaded. Numbered parcels are steel sheets covered with paper held fast by steel straps.

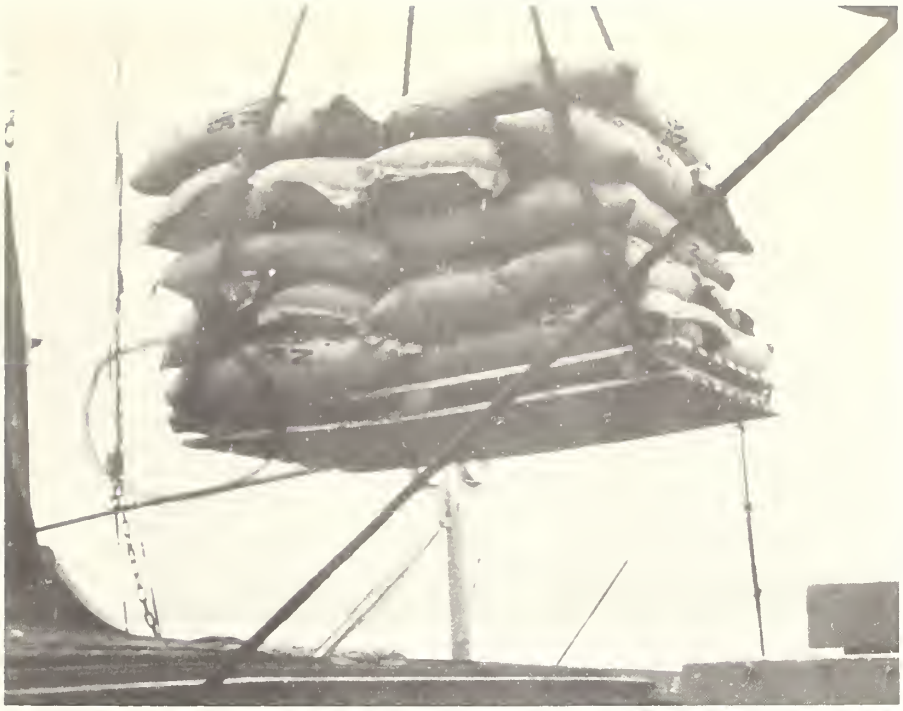

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Figure 14. --This loaded pallet is being lowered into the hold. Two bags on upper left and the line at lower left (circled) have begun to slip. Often, several bags are broken when a rope slips off a pallet.

DETROIT-LONDON, JUNE 12-JULY 6

JUNE		JUNE	
12-14	Installed equipment	22-24	Labrador Current
14	Sailed at 6:30 p. m.	25	Entered Gulf Stream
14-17	Detroit-Montreal	25-29	Humidity near 100%
18	Added cargo, Montreal	29-JULY 3	Aeration
19	Sailed at 3:30 p. m.	3	Hatch opened, Belgium
20-21	Montreal to Atlantic	4-6	Unloading

Figure 15. --Log of Great Lakes freighter, Ship A, carrying cargo of dry beans.

Storms at sea completely saturated all the tarpaulin hatch covers (fig. 16). The cold Labrador water cooled the ship. Then as the ship encountered the warm Gulf Stream, gallons of condensate dripped like rain from the exposed steel beams in the hatch. Beads of moisture, which formed on the surface of the beans, entered the cold beans and raised their moisture content above acceptable levels.

Unloading

Rope slings were used in England for unloading. Fifteen to twenty bags were piled on two parallel ropes and the load was lifted by a crane into a warehouse or onto a lighter (fig. 17).

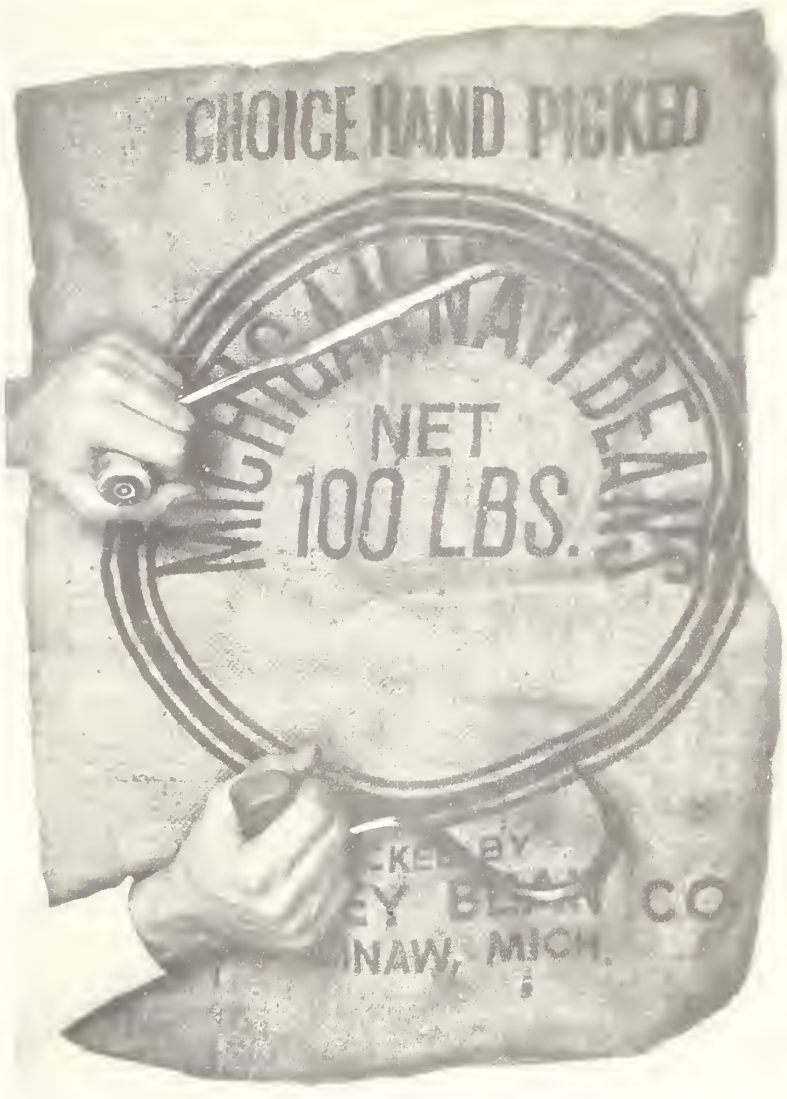
This method of unloading was very destructive to lightweight bags, especially when large crates and protruding dunnage were placed so that the sling load might be thrown against the sharp corners as the beans were removed from the hold. The cargo hooks shown in figure 18 tore many bags.

BN-14702

Figure 16. --Storms in the cold north seas thoroughly cooled the entire ship.

BN-14694

Figure 17. --Rope slings are used for unloading in Europe, whereas wooden pallets are used in the United States.



BN-14701

Figure 18. --Two kinds of cargo hooks used by dock workers in Europe for handling bags.

A 250-ton lighter was used for moving beans from the ship to storage in London. The lighter was anchored alongside the ship, and the sling loads were lifted over the side of the hold and into the barge where the bags were covered as quickly as each area was filled (fig. 19). Unloading beans by lighter necessitates additional handling. After they are loaded onto the lighter, it delivers them to the warehouse, where they are lifted to the desired floor by crane. If the freighter can dock at the warehouse, beans may be lifted by sling directly to the desired floor for storage.

BN-14700

Figure 19. --Lighter being loaded direct from hold of ship by use of rope slings.

FINDINGS

Moisture Content of Beans

The moisture content of the beans loaded on Ship A was 15.5 percent at Detroit. The moisture of the sixty 1-pound test samples varied at destination from 14.8 to 17.8 percent. In the final analysis, nineteen 100-pound bags, selected because of higher moisture at Detroit or because of special location in the ship, were found to have changed more than the 1-pound samples studied (table 1). Note that sample 19, with 17.3 percent moisture just before aeration, lost 3.0 percent in 4 days. Samples 7 and 9 were dampened by rain during loading and lost moisture to adjacent bags.

Temperature

Table 2, appendix, shows daily thermistor readings in the upper hold of Ship A; tables 3 and 4 show the temperatures recorded daily at various locations on Ships B and C. The most complete temperature records were obtained on Ship A.

On Ship A, the temperature was almost constant at distances of more than three bag widths from the outside wall (48-52 inches) and at the different vertical levels (floor, 2d, 4th, 8th, and 12th layers). There was a difference of only 2 degrees F. between temperatures at the different layers on the same day, and a maximum of 4 degrees over the 20 days studied. The last two columns in table 2 show the effect of cooling in a position three bags from the sidewall. The beans closer to the water and cold outside air were 1 to 4 degrees cooler than those in the center of the load.

TABLE 1.--Moisture changes in 100-lb. bags of dry beans, by location in hold of Ship A during voyage from Detroit to London, June 15 to July 4, 1960

Sample	No. of bags from sidewall	Tier	Moisture content		Gain or loss ±
			Detroit	London	
			Percent	Percent	Percent
1.....	8	2	15.5	15.6	+0.1
2.....	13	4	14.4	14.9	+0.5
3.....	12	6	16.2	16.7	+0.5
4.....	14	4	15.1	15.8	+0.7
5.....	12	7	14.5	16.1	+1.5
6.....	13	9	16.0	16.2	+0.2
7.....	22	3	[1] 17.0	16.5	-0.5
8.....	8	9	16.4	[2] 16.8	+0.4
9.....	8	9	[1] 17.7	17.1	-1.6
10.....	5	11	15.8	15.8	±0.0
11.....	10	Top	16.8	16.2	-0.6
12.....	9	16	15.2	16.1	+0.9
13.....	12	12	16.1	16.7	[3] +0.6
14.....	11	4	16.1	15.5	-0.6
15.....	13	9	16.3	14.7	-1.6
16.....	3	6	14.1	14.8	+0.7
17.....	Edge	Top	15.9	15.7	-0.2
18.....	4	Top	15.7	15.2	-0.5
19.....	Top	Top	[4] 17.3	[5] 14.3	-3.0

[1] Rain wet--lost water to adjacent bags.
[2] Adjacent to rain-wet bags; therefore increased in moisture.
[3] Next to wooden cases--increased moisture.
[4] Sample from humidity soaked bags before aeration.
[5] Sample from same bags as [4] after 4 days' aeration.

On 7 days, the temperature in the top layers of beans under the deck of Ship C exceeded 90° F. If the humidity is high, this temperature is conducive to mold development and discoloration of the beans.

A comparison of the average temperature range of dry beans on the three freighters is shown in figure 20.

Only about one-third of the total load of beans was substantially affected by the air and water. These beans were located near the top and around the edge of the hold. The average temperature change of the center two-thirds of the test hold on Ship A was only 3 degrees F. (fig. 21).

The weather during the voyage of Ship A was about average for a shipment in the early summer via the North Atlantic. The average temperature of beans at loading was 67° to 69° F. with maximum of 73° and minimum of 50°. The highest temperature was in the top tier of bags just under the deck, and the lowest at the bottom adjoining the side of the ship.

Load temperatures recorded by the recording thermometers on Ship B and Ship C are given in figures 22 and 23. The effect of ambient conditions on average transit temperatures of beans are indicated in figure 24.

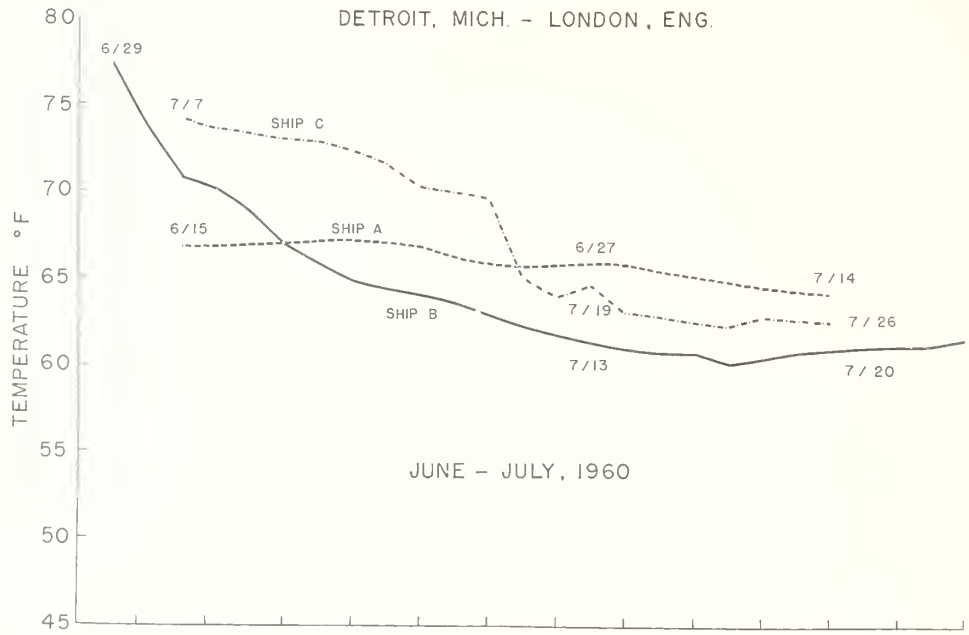


Figure 20. --Average daily transit temperatures of dry beans on three ships.

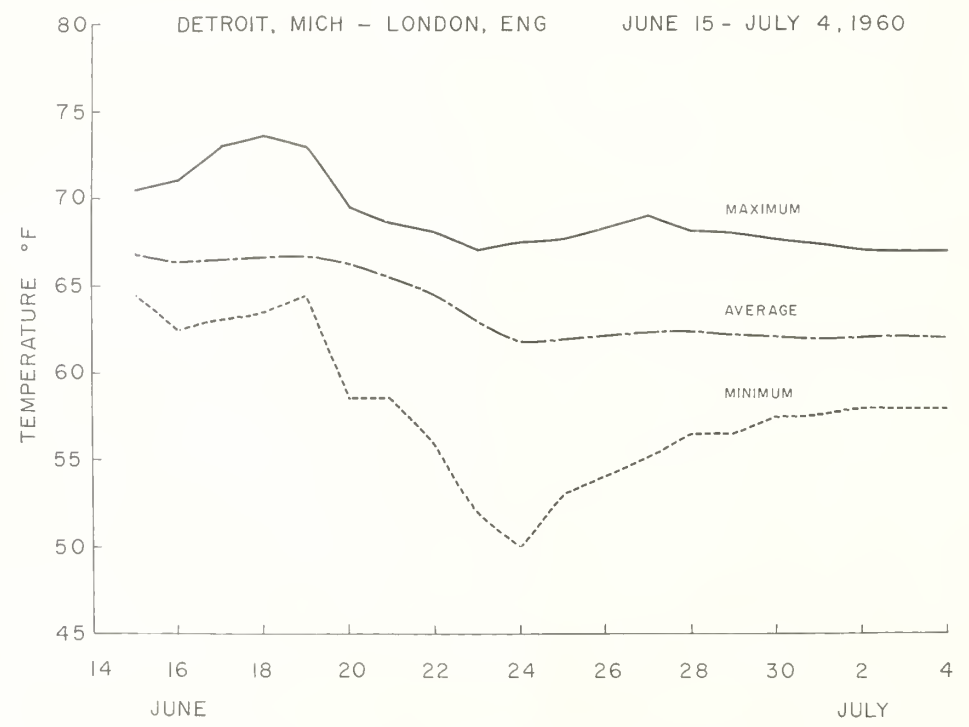


Figure 21. --Daily transit temperatures of dry beans on Ship A.

Figure 22. --Daily transit temperatures of dry beans on Ship B.

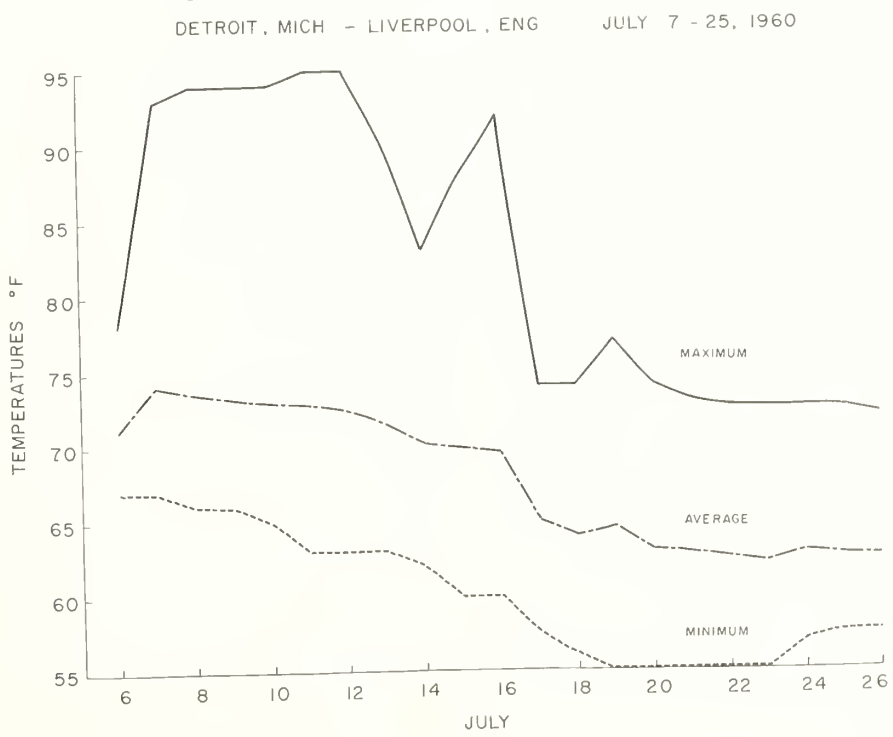


Figure 23. --Daily transit temperatures of dry beans on Ship C.

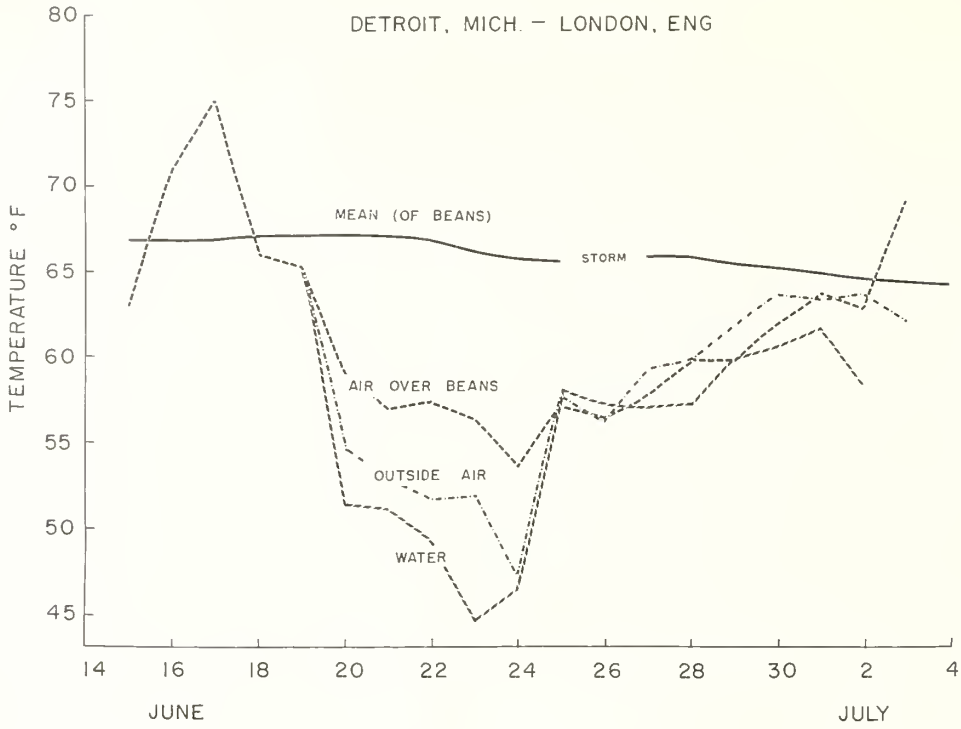


Figure 24. --Effect of ambient conditions on average transit temperatures of dry beans on Ship A.

Daily temperatures of outside air and water are tabulated in table 5. The temperature of the air and water during the time the freighter was moving was recorded each 4 hours from midnight on. For simplicity, only three readings are included in the table.

Humidity

There is a continuous exchange of moisture between the cargo and the atmosphere. Part of this activity may be visible, such as the condensation of moisture on cold beans and on the cold metal surfaces of the ship's hold when the saturation or dew point is reached.[4] As already mentioned, a recording hygrothermograph (fig. 10) was used in the tests to obtain a continuous record of the temperature and humidity of the air above the beans and under the deck.

[4] The amount of water vapor carried in the atmosphere, though invisible, is always considerable. As an illustration, an empty cargo hold of 100,000 cubic-foot capacity, that is, approximately 7,000 pounds of air, contains about 20 pounds of water vapor in freezing weather and as much as 200 pounds in humid tropical weather. Air can carry a certain amount of moisture at a given temperature. This maximum moisture content, "saturation," is different for each temperature. The amount of water vapor in the air at a given time is expressed as a percentage of the amount required to saturate the air at the same temperature and is referred to as "relative humidity." If air is heated, its relative humidity is reduced because the air can carry more moisture at higher temperatures. On the other hand, if air is cooled, its relative humidity is increased (even though no more actual moisture is added to the air).

When a mixture of air and water vapor is cooled without removal of any moisture, it will ultimately become saturated. The temperature at which this occurs is called the "dew point." Any further cooling will cause condensation.

In previous studies, it was found that beans stored under controlled conditions at 80 percent relative humidity or more and a temperature of 70° F. or above will mold although the equilibrium moisture[5] of the beans may be as low as 16.5 percent.[6] The colder the commodity, the more moisture it can contain without molding.

While some beans on board Ship C near the bottom and water side of the hold had been at 60° F. for a major part of the trip, some of the burlap bags molded during the voyage. The mold had not apparently invaded the beans themselves by the time of arrival as samples from these bags did not appear to be moldy at that time. Although these beans appear to be sound on arrival, they will quickly deteriorate if placed under poor storage conditions. When the ship is being unloaded, moldy bags and bags of beans high in moisture should be segregated for immediate processing or special handling and storage. Musty spots on the side of a bag will spoil not only the beans in that bag, but those in adjacent bags as well.

An increase of 1 percent in the moisture content of the beans does not appear to be important. However, in terms of the quantity of water (3,500 gallons or 70 barrels) in a shipment of beans, it is more impressive. We found that the moisture content of about one-third of the beans could be changed by ventilation or aeration and that some of the bags could take up or give off as much as 3 percent in as little as 4 days' time. Therefore, careful management of ship ventilators is essential for delivery of high quality beans to European ports.

Dry Bean Quality Related to Temperature and Humidity

Details on the moisture content of beans and related commodities at different temperature and humidity conditions are given in table 7. Beans stored at 80 percent humidity or above can be expected to deteriorate at any temperature. Equilibrium moisture of beans stored at 40° F. and 80 percent relative humidity is only 17 percent, but beans stored under these conditions molded, as did other samples stored at 50°, 77°, 100°, and 130° at this high relative humidity. Samples of Small Red, Great Northern, Light Red Kidney, Dark Red Kidney, Small White, and Pinto beans were stored at 77° under various relative humidity conditions, and at 80 percent the equilibrium moisture varied from 18 percent for Great Northern to 18.6 percent for Small Red and Dark Red Kidney. All samples held at room temperature (77° F.) and 80 percent humidity were moldy.

Figure 25 indicates the danger areas for humidity-temperature and gives the equilibrium moisture content of beans. This chart may be helpful to ship personnel responsible for control of humidity in the holds carrying dry beans. For example, although moisture content of the beans at 80 percent relative humidity and 90° F. would be only 16.5 percent, their condition would be doubtful after a few weeks' storage.

The normal relation of temperature and humidity to percent of moisture in beans at 40°, 70°, and 90° F. at 55 to 85 percent relative humidity is indicated in figure 25. At 80 percent relative humidity, mold occurred at both 70° and 90°.

Data from a study to determine how maximum storage life of Pea beans could be extended indicates that beans subjected to climatic conditions in England would be damaged after 4 months.[7] Beans were stored in relative humidities of 52, 75, and 90 percent at 40° and 55° F. At these temperatures, beans with about 12, 16.5, and 20 percent moisture are in equilibrium with 52, 75, and 90 percent relative humidities, respectively.

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[5] When the moisture content of a commodity is in balance with that of air at a given relative humidity, the commodity is said to be at equilibrium moisture content.

[6] Thompson, Judson A., and Perry, John S. Storage of Pea beans in Michigan and Indiana. U. S. Dept. Agr., AMS-123, 78 pp., illus. Washington, D. C. May 1956.

[7] Perry, J. S., and Hall, Carl W. Storing and Handling Pea Beans. Reprint from Quart. Bul. Mich. Agr. Expt. Sta., Mich. State Univ., vol. 43, No. 2, pp. 444-445. 1960.

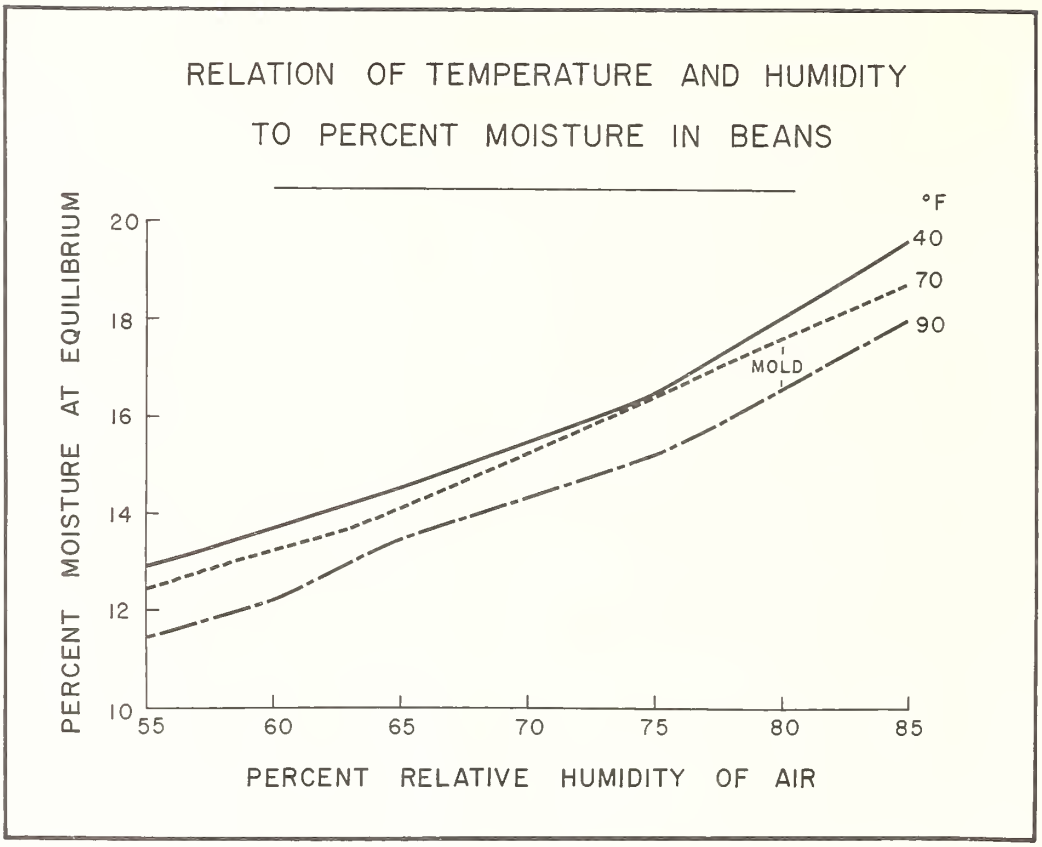


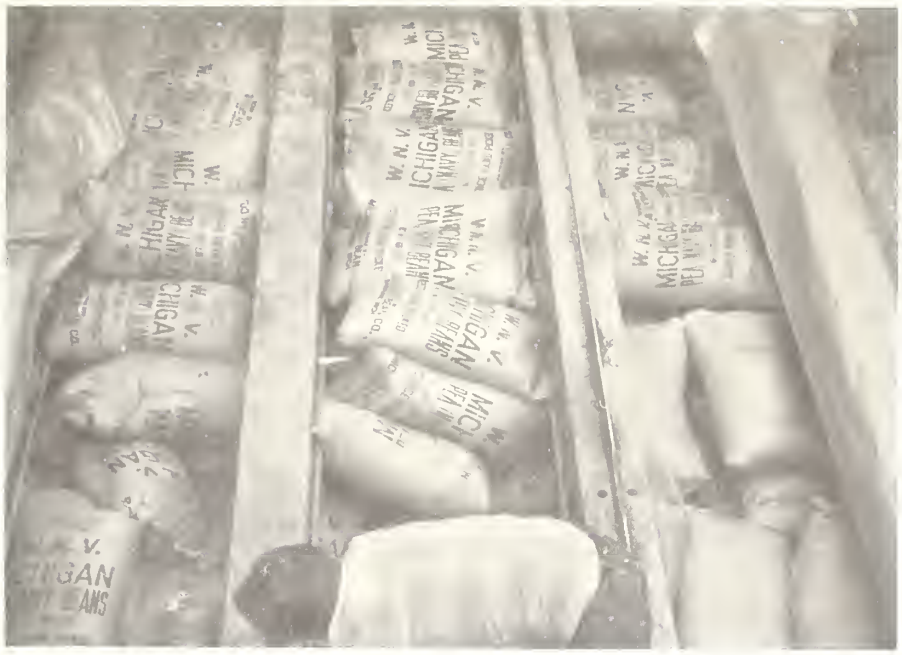
Figure 25. --At relative humidity of 80 percent, mold developed at both 70° and 90° F.

At 40°, no increase in mold growth was observed under any of the storage conditions. Results of storage at 55° showed comparatively rapid increase in the percentage of beans having mold after 4 to 4 1/2 months in 90 percent relative humidity. A smaller increase was noted after 7 to 8 months for beans stored at 55° and 75 percent relative humidity. No increases in mold were noted in beans stored at 55° and 52 percent relative humidity. Many factors probably influence the mold-free storage life of Pea beans. Temperature and humidity may determine the types of mold growth. The previous history of the beans influences storage condition.

Methods of Protecting Beans from Condensation

Beans are protected from moisture condensation by lining the holds and beams of the ship with paper. Several kinds of paper are used to line the holds and cover any steel beams or other parts of the ship from which condensation is likely to drip on the bags. Unless this paper is moistureproof, it is of no value; building paper or other nonmoistureproof paper absorbs water and causes damage to cargo. Lining the hold appears to be unnecessary if aeration is used. Wrapping the steel beams before the wooden planks are arranged in place is helpful (fig. 26).

Moisture content of beans in bags placed directly against the beams, as in the illustration, increased to dangerous levels after several days in humidities of 95 to 100 percent, because the workers that arranged the moistureproof paper in place failed to cover the beams completely.



BN-14695

Figure 26. --An attempt is made to wrap the steel beams with moistureproof paper to avoid direct contact of the condensing water with the containers.

Ventilation of Ships at Sea

Moisture is the main source of trouble in cargoes of beans. The moisture in the cargo can be controlled by circulating air of proper temperature and humidity through the hold. On most ocean shipments during dry weather, the temperature and relative humidity of the outside air are satisfactory for at least short periods of aeration on most days. An ample supply of such air should be distributed through the holds so that the areas of excessive moisture, heat, and cold are well aired. The term "ample supply" means at least two complete changes of air per hour for the empty cargo hold. When the outside atmosphere is unsatisfactory for aeration because of high relative humidity, it is best to keep the holds sealed.

Control of atmospheric conditions in the hold of a ship over and around the commodity is of utmost importance. For example, during the voyage of Ship A, beans directly under the deck and unprotected from the atmosphere increased in moisture from 15.5 to 17.5 percent in 2 to 3 days. The Labrador Current cooled the ship and its contents. When the ship entered the warmer Gulf Stream (12° to 15° F. warmer), large quantities of moisture condensed from the warm air onto the ship and its contents. From June 24 through June 29, daily mean humidity was above 90 percent. The mean humidity for 4 of those 6 days was more than 95 percent, and on 2 days the mean was above 98 percent (table 6).

The top bags, wooden crates, and other cargo were wet from the condensate drip. For a 4-day period, aeration was possible from about 9 a. m. to about 7 p. m. (fig. 27).

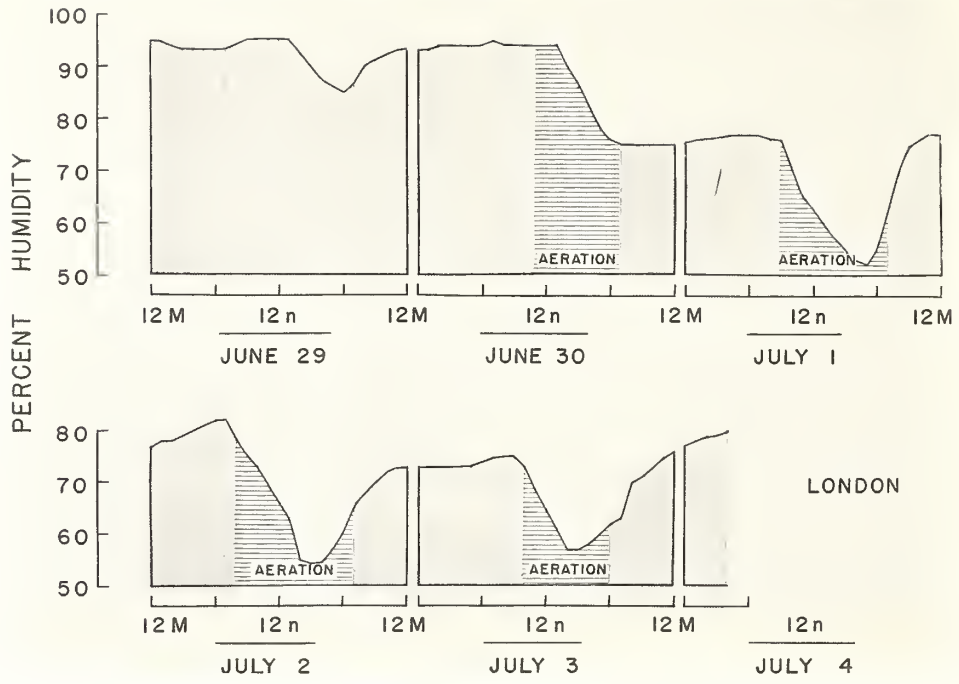


Figure 27. --Humidity of air above beans in Ship A.

Four days of aeration dried the bags and cargo that were wet to the point that the cargo appeared normal. The humidity of the air over the beans (fig. 27) was generally lowest at 4 or 5 p. m. , and highest at 5 to 7 a. m. , based on the means of all readings. The minimum daily mean humidity was 77. 3 percent, and the highest daily mean was 86. 9 percent. At the beginning of the trip, the humidity ranged from 57 to 70 percent, and it increased rapidly after the ship entered the Gulf Stream to 94 to 100 percent. After aeration, the humidity ranged from 55 percent at 3 to 4 p. m. to 79 percent at 6 to 7 a. m. The humidity was below 70 percent from about 10:30 a. m. until about 8:30 p. m. , below 65 percent from 12 noon until 7:30 p. m. , and below 60 percent from 1 p. m. until 6 p. m. Samples of beans were obtained from the top bags just before aeration, and these same bags were sampled again upon arrival in London. The moisture of the beans had been lowered from 17. 5 to 14. 5 percent. Recommendations for the control of humidity in the hold of the ship are given in the appendix, page 42.

In practically any shipment abroad, condensation could be expected on metal surfaces inside the hold unless the warm, moist air in the hold is carried away. The cargo officer of the ship should obtain the moisture content of sensitive goods such as beans, peas, grain, seed, nuts, and comparable commodities at the time of loading. This information will help him determine the storage treatment and amount of care required during the voyage. By knowing the moisture content of the commodity for safe storage and the humidity equilibrium ratio, the hold can be aerated to attain a relative humidity favorable to the commodity.

Quality and Weight of Export Bags

The 10.4-ounce burlap bags used in the shipping tests were not satisfactory because of excessive breakage in handling. The tensile strength of the 10-ounce burlap used in domestic handling and that of the 10.4- and 12-ounce burlap used for export are shown in the following tabulation.[8] The data are not specific as such, but are the average strengths derived by testing many samples of burlap.

Weight of burlap 1 yd. long, 40 in. wide	Thread count	1960 Break strength Warp	Weft
10-oz. Common	11 X 12	85.6	87.8
10.4-oz. Common[1]	12 X 13	97.7	99.6
10.4-oz. Special[2]	12 X 13	105.0	105.0
12.0-oz. Common[3]	11 X 12	94.6	112.5

[1] 10-oz. yarns used in warp and weft.
[2] One extra yarn in both directions gives added strength.
[3] Heavier yarns used in 12-oz. material.

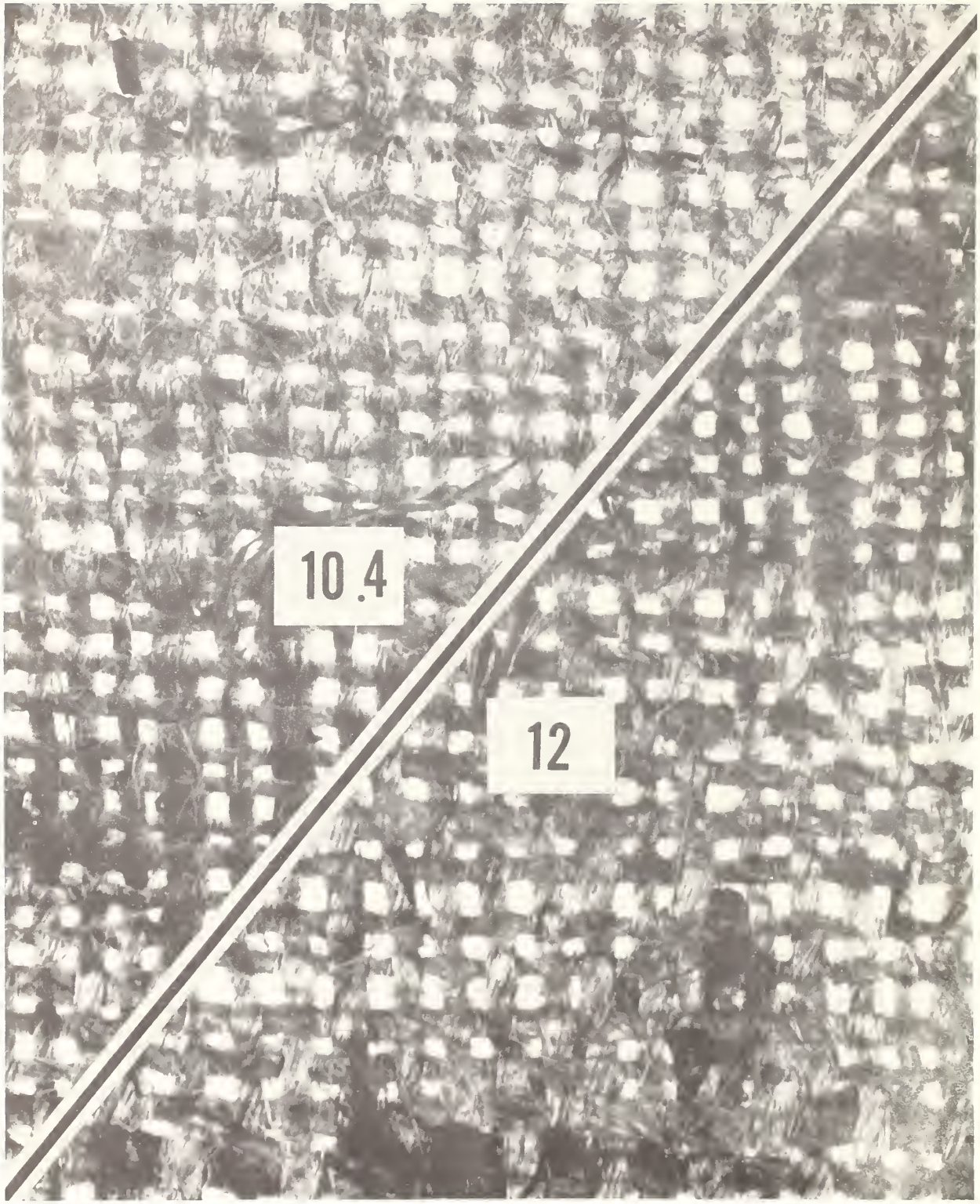
The weight of burlap is computed on the basis of a 40-inch width 1 yard in length. Break strength of the weft (yarn running lengthwise of the finished bag) is most important. Thread in the 12-ounce material is stronger than the other burlap, and although it is less tightly rolled, making a closer weave, there is less air space between threads (fig. 28). This combination of stronger thread and closer weave withstands the use of cargo hooks much better. Export shipments of beans over the last 2 years have resulted in so many broken 10.4-ounce bags that the dry bean industry is insisting that only new 12-ounce bags be used in the overseas shipments, or "special" 10.4-oz. bags.

A bag company annually tests the burlap used by the bean industry for export shipments, and the results it releases are considered the standard for the industry. The following statement is in the results of the 1960 tests: "Stories that reach us from the field indicate cases where the use of 36 in., 10.4-oz. common resulted in very unsatisfactory performance." They point out that one factor of the 10.4-ounce common is the marked fluctuation in the strength of the lots which go to make up the averages. The 10.4-ounce common is supplied by many mills, some of which are known to produce "high grade goods," but others produce "low grade goods".[9] The extensive breakage of 10.4-ounce burlap bags encountered in the three shipments studied, plus the recommendations of bag manufacturers and exporters, is conclusive evidence that the 36 in., 10.4-ounce common burlap bag should not be used for export of beans and peas.

Dry beans and peas imported from other countries by the northern European countries are usually in 100-kilo bags (220 pounds) made of heavy sacking and weighing about 1 kilo (2.2 pounds) each when empty. These are desirable containers and their high initial cost is absorbed by reuse. These bags are not subject to ripping and may make several trips across the ocean.

Since bag breakage in bean exports was excessive at the time of this study, with weight shortages of 3 percent of the commodity not unusual, either stronger burlap must be used or more efficient methods of loading and unloading ships should be arranged.

[8] Correspondence with Textile Bag Manufacturers Association, 518 Davis and Evanston Streets, Chicago, Ill.
[9] Unpublished letter from K. W. Koechig, Bemis Brothers Bag Company, to Judson Thompson, dated March 24, 1961.



BN-14698 and BN-14699

Figure 28. --Burlap weighing 10.4 ounces or 12 ounces per yard of material 40 inches wide is used in bags for export. The 12-oz. material is stronger, and because it is less tightly rolled, the weave is closer than the weave in the 10.4-oz. burlap.

In loading the hold of a ship, care should always be taken to lower each palletload directly onto an empty pallet in the hold (fig. 29). A common practice is to build the stack of empty pallets up to about eight, and then move all except the bottom pallet, which is left on the bags for a landing platform. When the palletload of beans is lowered, it usually swings from side to side, and if lowered directly onto the jute bags, one or more of the top bags may be damaged by a rough corner or projection of the pallet. One pallet landing on the bags in the hold is not so bad, but when no landing pallet at all is used, the bags in this area are soon torn. These torn or weakened bags are likely to be broken open during unloading when rope slings are used to hoist the beans. Also, the damaged bags are more likely to be broken open with cargo hooks.

BN-14696

Figure 29. --An empty pallet should always be left in the hold of the ship as a landing platform for the next load.

As pointed out, the sharp corners of the loaded wooden pallets being lowered into a hold of the ship often will break open a bag of beans on impact by swinging into bags already in place (fig. 30). Already one storage and dock facility has removed the sharp corners from wooden pallets; the company reports that this has reduced the number of bags of beans broken open during loading.

A "needleman" should be available to repair torn bags.

BN-14697

Figure 30. --Rough dunnage, corners of large crates, and cargo hooks cause many broken bags during unloading. Loose beans are scattered over load.

APPENDIX

Statistical Tables

TABLE 2.--Temperature of dry beans in center of top hold of Ship A during voyage from Detroit to London, June 15 to July 4, 1960

Date	Thermistor placed in--						
	11th row of bags[1]					3d row of bags[1]	
	On floor	In 2d layer	In 4th layer	In 8th layer	In 12th layer	In 2d layer	In 3d layer
	°F.	°F.	°F.	°F.	°F.	°F.	°F.
June:							
15	67	66	67	68	66	67	66
16	67	67	67	68	68	68	67
17	67	67	67	68	68	68	67
18	67	67	67	68	68	68	67
19	67	67	67	68	68	67	67
20	67	67	68	68	68	68	67
21	67	67	67	67	67	67	67
22	67	67	68	68	68	67	66
23	66	66	66	67	67	66	65
24	66	66	67	67	67	65	64
25	66	66	67	67	67	65	64
26	STORM (no readings)						
27	66	67	68	68	67	65	64
28	66	67	67	67	67	64	63
29	65	66	66	66	66	63	63
30	65	66	66	66	66	63	63
July:							
1	65	66	66	66	65	63	63
2	64	65	65	65	64	63	62
3	64	65	65	65	64	63	63
4	64	65	65	65	64	63	63

[1] Rows are numbered from side of hold; layers are numbered from floor upward.

TABLE 3.--Temperature of dry beans at nine locations on Ship B during voyage from Detroit to London, June 29 to July 24, 1960

Date	Upper hold[1]				Lower hold[1]				
	On floor in 6th row, 14-16 bags from sidewall	In 2d layer, 6th row, 14 bags from sidewall (on hatch)	In 2d layer, 7th row, next to sidewall	In 1st layer, 1st row, 14 bags from sidewall	In 1st layer, 1st row, 1 bag from sidewall	In 12th layer, 1st row, 10 bags from sidewall	In 13th layer, 3d row, 15-16 bags from sidewall	In 18th layer, 1st row, 1 bag from sidewall	In 20th layer, 1st row, 15-16 bags from sidewall
June:	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.
29	70	82	79	85	75	83	--	73	73
30	60	85	83	75	72	72	77	73	66
July:									
1	57	75	80	73	72	72	70	73	65
2	57	72	78	74	72	72	70	72	64
3	57	72	72	73	71	72	70	68	64
4	55	70	73	67	70	70	69	68	59
5	52	72	72	66	69	69	67	68	58
6	50	72	68	67	68	68	66	66	58
7	50	72	68	66	68	68	66	65	58
8	50	71	67	66	65	68	65	65	58
9	50	73	65	66	64	67	65	64	58
10	50	72	64	65	62	66	65	63	58
11	49	71	63	64	60	66	65	62	58
12	48	72	62	63	60	66	66	61	58
13	48	72	61	63	58	66	66	60	58
14	48	72	60	62	57	65	67	60	58
15	48	73	60	61	57	65	66	60	58
16	48	72	60	61	57	65	66	60	58
17	48	72	60	61	57	65	--	61	58
18	48	72	61	61	57	65	--	62	58
19	48	72	62	61	57	66	--	63	58
20	48	72	63	62	57	66	--	63	57
21	48	71	65	63	57	66	--	63	57
22	48	72	65	63	58	65	--	63	55
23	48	71	66	63	59	65	--	63	55
24	49	70	67	65	60	64	--	63	55
Mean	51	73	67	66	64	68	67	65	59

[1] "Row" indicates the number of bags from engine room, and "from sidewall" indicates the number of bags from side of ship.

TABLE 4.--Temperature of dry beans at eight locations on Ship C during voyage from Detroit to Liverpool, July 6 to July 26, 1960

Date	Upper hold[1]		Lower hold[1]					
	18th (top) layer, rows 8 and 9	8th layer, 18th row, 15 bags from sidewall	13th layer, 13th row, 15 bags from sidewall	9th layer, 3d row, 10 bags from sidewall	18th (top) layer, between 5th & 6th rows	1st layer, 3d row, 15 bags, from sidewall	1st layer, 7th row, 10 bags from sidewall	1st layer, 3d row, 16 bags from sidewall
June:	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.
6	--	--	67	78	70	70	72	70
7	93	75	67	78	70	70	71	70
8	94	72	66	77	70	69	70	70
9	94	72	66	76	70	68	70	70
10	94	72	65	75	70	68	70	70
11	95	73	63	75	70	67	70	70
12	95	73	63	75	70	64	70	70
13	90	73	63	75	70	64	68	70
14	83	73	62	75	69	62	68	70
15	88	72	60	75	68	62	67	68
16	92	70	60	74	68	60	66	67
17	67	67	58	74	68	58	64	65
18	65	66	58	74	68	56	62	64
19	77	63	58	74	68	55	60	63
20	67	63	58	74	68	55	58	63
21	67	62	58	73	68	55	58	63
22	67	60	58	73	68	55	58	63
23	65	60	58	73	67	55	58	63
24	67	60	58	73	67	57	58	63
25	--	60	59	73	68	58	59	63
26	--	--	60	72	--	58	60	63
Mean	81	68	61	75	69	61	65	66

[1] "Row" indicates the distance from engine room, and "from sidewall" is distance from side of ship.

TABLE 5.--Daily temperatures of outside air and water during voyages of Ship A from Montreal to London, June 20 to July 3, Ship B from Toronto to Southampton, July 6 to 19, and Ship C from Montreal to Liverpool, July 13 to 23, 1960

Ship and date	Air temperature			Water temperature		
	8 a.m.	12 noon	8 p.m.	8 a.m.	12 noon	8 p.m.
Ship A:	°F.	°F.	°F.	°F.	°F.	°F.
June:						
20	54	52	57	66	48	50
21	55	55	52	52	50	52
22[1]	50	54	52	50	50	48
23	46	56	51	45	45	45
24	45	46	50	43	46	46
25	59	59	55	61	57	59
26	54	57	55	55	55	54
27	57	61	58	54	55	54
28	59	59	60	57	57	57
29	59	64	61	59	59	61
30	59	72	62	59	61	61
July:						
1	59	68	62	61	61	63
2	59	68	61	61	57	57
3	57	69	59	57	57	57
Mean	55	60	57	56	54	55
	4 a.m.	12 noon	8 p.m.	4 a.m.	12 noon	8 p.m.
Ship B:						
July:						
6	60	61	73	55	46	66
7	63	72	72	--	--	--
8	64	66	57	68	54	48
9	48	61	59	45	55	50
10	57	66	57	54	43	55
11	52	50	50	46	50	50
12	55	57	55	54	54	55
13	54	55	55	54	54	54
14	57	57	55	55	55	55
15	57	54	57	57	57	59
16	61	61	59	59	61	61
17	61	61	61	61	61	61
18	63	64	63	61	63	61
19	63	64	63	66	63	61
Mean	58	61	60	57	55	57

[1] Ship entered Atlantic Ocean.

TABLE 5.--Daily temperatures of outside air and water during voyages of Ship A from Montreal to London, June 20 to July 3, Ship B from Toronto to Southampton, July 6 to 19, and Ship C from Montreal to Liverpool, July 13 to 23, 1960--Continued

Ship and date	Air temperature			Water temperature		
	4 a.m.	12 noon	8 p.m.	4 a.m.	12 noon	8 p.m.
Ship C:	°F.	°F.	°F.	°F.	°F.	°F.
July:						
13	--	--	72	63	63	64
14	63	59	61	63	46	46
15	55	75	54	52	41	50
16	54	82	59	52	55	50
17	50	54	50	45	41	50
18	50	54	50	50	50	50
19	48	82	55	48	50	50
20	52	55	55	50	50	50
21	52	57	57	55	55	55
22	55	59	52	55	57	59
23	54	59	55	57	57	54
Mean	53	64	56	54	51	53

TABLE 6.--Relative humidity of air above dry beans during voyage of Ship A, June 14 to July 3, 1960

Period beginning 9 a.m.	9 a. m.	12 noon	3 p. m.	6 p. m.	9 p. m.	12 p. m.	3 a. m.	6 a. m.	Mean
	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent
June:									
14	65	65	70	67	63	63	64	60	64
15	80	80	85	85	85	85	85	85	84
16	90	81	73	71	75	80	81	83	79
17	70	60	60	70	77	80	82	86	74
18	90	88	80	72	70	81	84	85	81
19	84	77	67	70	75	87	89	90	80
20	92	92	90	88	87	90	91	91	90
21	87	84	80	87	90	92	92	92	88
22	89	86	78	83	90	92	92	93	88
23	80	68	67	73	82	85	--	--	75
24	81	85	85	86	93	95	96	96	90
25	96	90	88	93	98	98	99	100	95
26	100	98	([1])	([1])	([1])	([1])	([1])	([1])	98
27	98	98	98	98	99	99	98	97	98
28	97	100	99	98	97	95	93	93	96
29	95	95	90	85	91	93	94	94	92
30	94	94	87	76	75	75	76	77	80
July:									
1	76	63	55	55	75	77	79	82	70
2	75	66	54	60	70	73	73	74	68
3	75	65	57	62	71	76	79	80	71
Mean	85.7	81.8	77	77.8	82.3	85.1	85.9	86.6	83

[1] Storm. No records made.

TABLE 7.--Equilibrium moisture content of beans and grain[1]

Commodity	Temp.	Relative humidity									
		10	20	30	40	50	60	70	80	90	100
	°F.	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent
Beans:											
Michelite.....	40	--	--	--	--	--	12.8	14.4	[2] 17.0	--	--
...do.....	50	--	--	--	--	--	13.8	15.3	18.0	--	--
...do.....	77	5.6	7.4	8.6	9.8	11.2	12.9	14.9	17.5	--	--
...do.....	100	--	--	--	--	--	12.0	14.2	17.1	--	--
...do.....	130	--	--	--	--	--	12.4	14.3	18.5	--	--
Small Red.....	77	6.0	7.5	8.6	9.8	11.0	12.8	15.2	18.6	--	--
Great Northern..	77	5.9	7.4	8.5	9.6	10.9	12.6	15.0	18.0	--	--
Light Red Kidney	77	6.1	7.5	8.7	9.9	11.1	12.9	15.1	18.5	--	--
Dark Red Kidney.	77	5.4	7.2	8.4	9.6	10.7	12.5	15.0	18.6	--	--
Small White.....	77	6.0	7.1	8.3	9.6	11.0	12.6	15.0	18.1	--	--
Pinto.....	77	6.1	7.4	8.5	9.8	11.0	12.6	15.2	18.2	--	--
Barley.....	77	4.4	7.0	8.5	9.7	10.8	12.1	13.5	15.8	19.5	26.8
Rice (milled).....	77	5.1	7.6	9.0	10.3	11.5	12.6	13.8	15.4	18.1	23.6
Shelled corn.....	50	--	--	--	9.2	10.7	12.1	13.6	15.5	--	--
...do.....	70	--	--	7.1	8.3	9.8	11.4	13.2	--	--	--
...do.....	77	5.1	7.0	8.4	9.8	11.2	12.9	14.0	15.6	19.6	23.8
...do.....	86	4.4	7.4	8.2	9.0	10.2	11.4	12.9	14.8	17.4	--
Wheat:											
Soft Red Winter.	77	4.3	7.2	8.6	9.7	10.9	11.9	13.6	15.7	19.7	25.6
Hard Red Spring.	77	4.4	7.2	8.5	9.8	11.1	12.5	13.9	15.9	19.7	25.0

[1] Hall, Carl W. Drying Farm Crops. 336 pp. Agr. Consult. Assoc., Inc., Reynoldsburg, Ohio 1957.
[2] Because beans were moldy, moisture content shown may not be typical.

TABLE 8.--Color difference meter readings of samples of beans during voyage of Ship A from Detroit to London, June 14 to July 3, 1960

Sample	Location in hold			Moisture content	Color difference		
	Layer	Distance from shipside	Distance from engine room partition		Rd[1]	a[2]	b[3]
		Bags	Bags	Percent			
Composite	--	--	--	15.5	34.2	-2.9	10.6
A-1	17	1	--	16.4	34.0	-3.2	11.1
A-2	15	1	--	15.3	34.1	-3.3	10.4
A-3	12	1	--	15.9	34.1	-3.1	10.7
A-4	9	1	--	15.5	33.9	-2.6	10.8
A-5	6	1	--	16.1	34.8	-2.3	10.8
A-7	4	1	--	15.8	34.7	-2.9	10.6
A-12	19 (top)	1	--	15.7	34.3	-3.5	10.7
Average				15.8	34.3	-3.0	10.7
A-6	4	--	2	15.3	34.2	-2.5	10.7
A-8	6	---	2	15.1	34.2	-3.5	11.1
A-9	9	--	2	15.6	34.5	-3.0	10.5
A-10	12	--	2	16.1	33.9	-2.4	10.9
A-11	15	--	2	15.6	34.7	-2.2	10.7
Average				15.5	34.3	-2.7	10.8
B-7	1	2	--	15.3	34.7	-2.3	10.9
B-8	4	2	--	16.7	34.9	-2.8	10.7
B-9	9	2	--	16.8	34.3	-2.6	10.9
B-10	12	2	--	17.8	34.0	-2.5	10.8
B-11	16	2	--	16.5	34.4	-2.6	10.7
B-12	18	2	--	16.8	33.7	-2.7	10.8
Average				16.7	34.3	-2.6	10.8
B-1	17	--	3	17.4	34.1	-2.5	11.2
B-2	15	--	3	16.9	34.7	-1.8	11.0
B-3	12	--	3	16.3	34.7	-1.9	10.8
B-4	9	--	3	16.0	34.7	-2.5	11.2
B-5	4	--	3	16.7	34.3	-2.2	11.1
B-6	1	--	3	17.4	33.9	-2.3	10.8
Average				16.8	34.4	-2.2	11.0
C-1	floor	--	14	15.3	33.9	-2.7	11.1
C-2	4	--	16	15.5	34.0	-2.2	10.8
C-3	9	--	15	15.2	34.2	-2.3	10.8
C-4	11	--	15	15.6	33.8	-2.3	10.9
C-5	14	--	15	15.8	33.9	-2.1	11.1
C-6	17	--	16	16.1	33.7	-2.9	10.9
Average				15.6	33.9	-2.4	10.9

TABLE 8.--Color difference meter readings of samples of beans during voyage of Ship A from Detroit to London, June 14 to July 3, 1960--Continued

Sample	Location in hold			Moisture content	Color difference		
	Layer	Distance from shipside	Distance from engine room partition		Rd[1]	a[2]	b[3]
		Bags	Bags	Percent			
C-7	--	8	--	15.7	33.3	-2.5	10.7
C-8	--	9	--	15.7	34.5	-2.4	10.4
C-9	--	10	--	15.4	34.5	-2.4	10.6
C-10	--	11	--	16.0	33.9	-2.3	10.5
C-11	--	13	--	15.6	34.1	-2.5	10.6
Average				15.7	34.1	-2.4	10.6
D-1	8	[4] top	--	16.7	33.5	-1.7	10.7
D-2	9	[4] 5	--	15.6	33.4	-1.7	10.8
D-3	8	[4] 7	--	15.4	32.4	-1.6	10.8
D-4	floor	[4] 5	--	15.5	33.7	-2.9	10.1
Average				15.8	33.3	-2.0	10.6
D-5	3	3	--	17.3	33.3	-2.5	10.4
D-6	2	3	--	17.5	34.3	-2.3	10.4
D-7	floor	4	--	15.9	34.5	-2.4	10.2
D-8	2	44	--	16.7	33.6	-3.3	10.4
D-9	4	44	--	15.8	33.6	-2.8	10.8
D-10	8	4	--	16.3	33.4	-2.7	10.6
D-11	12	4	--	16.7	33.0	-2.8	10.6
D-12	top	4	--	16.5	32.1	-2.7	10.3
Average				16.6	33.5	-2.7	10.5

[1] Rd--luminous reflectance or lightness.
[2] a--redness when plus, grayness when zero, and greenness when minus (-).
[3] b--yellowness when plus, grayness when zero, and blueness when minus (-).
[4] Next to wooden crates of ammunition.

Michigan Standards for Dry Edible Beans [10]

Grade Requirements for Handpicked Beans

Grade	Maximum limits of defects consisting of splits, damaged beans, contrasting classes, and foreign material				Other classes that blend	Average color of crop year
	Total defects	Badly damaged	Contrasting classes	Foreign material		
	Percent	Percent	Percent	Percent	Percent	
Michigan Choice Handpicked.....	1.5	0.3	0.01	0.01	5.0	Good
Michigan Prime Handpicked.....	3.0	.3	.01	.01	5.0	Fair

All graded beans shall be dry and well screened, show evidence of being well processed and graded, and shall possess a clean natural odor, and shall be free from highly objectionable foreign material.

United States Standards for Dry Edible Beans [11]

Grades, Grade Requirements, and Grade Designations

The following grades, grade requirements, and grade designations are applicable under these standards:

Grades and grade requirements for the classes Pea (Navy), Marrow, Great Northern, Small White, Flat Small White, Large White, White Kidney, Light Red Kidney, Dark Red Kidney, Western Red Kidney, Small Red, and Pink beans and the classes of Miscellaneous beans (see also special grades).

Grade[1]	Maximum limits of--				
	Defects consisting of splits, damaged beans, contrasting classes, and foreign material				Classes that blend
	Total	Contrasting classes	Foreign material		
			Total	Stones	
	Percent	Percent	Percent	Percent	Percent
U. S. No. 1.....	2.0	0.5	0.5	0.2	5.0
U. S. No. 2.....	4.0	1.0	1.0	.4	10.0
U. S. No. 3.....	6.0	2.0	1.5	.6	15.0
U. S. Substandard	U. S. Substandard shall include beans of any one of these classes which are not well screened or which otherwise do not come within the requirements of the specifications for the grade U. S. No. 1, U. S. No. 2, or U. S. No. 3, or for the grade of U. S. Sample grade.				

See footnote at end of table.

[10] Standards for Pea beans effective May 15, 1959, superseding standards effective October 1, 1953. Mich. Dept. Agr., Foods and Standards Div., Regulation No. 523 as amended.

[11] Complete copies of these instructions may be obtained from the Agricultural Marketing Service, United States Department of Agriculture, Washington 25, D. C.

U. S. Sample Grade	U. S. Sample grade shall include beans of any one of these classes which are musty, or sour, or heating, or materially weathered, or which are weevily, or which have any commercially objectionable odor or which are otherwise of distinctly low quality.

[1] The beans in grades U. S. No. 1, U. S. No. 2, and U. S. No. 3 of any one of these classes shall be well screened.

Special Grades, Special Grade Requirements, and Special Grade Designations for All Classes of Beans

(1) Handpicked beans

(i) Requirements. --Handpicked beans shall be beans of any one of the classes, except Blackeye, Cranberry, Large Lima, Baby Lima, Miscellaneous Limas, and Mixed beans, which meet the grade requirements of any of the grades U. S. No. 1, U. S. No. 2, or U. S. No. 3, which have been handpicked or otherwise processed so that they contain not more than 0.3 percent badly damaged beans, not more than 0.01 percent contrasting classes, and not more than 0.01 percent foreign material. Handpicked beans shall not include "off-color" beans.

(ii) Grade designation. --Handpicked beans shall be graded and designated as provided in either subdivision (a) or subdivision (b) of this subdivision.

(a) Choice handpicked. --Handpicked beans of all classes to which the special grade "Handpicked" applies, except the class "Pinto beans," which meet the grade requirements of grade U. S. No. 1, and which do not contain more than 1.5 percent "total defects," and Pinto beans which meet the grade requirements of grade U. S. No. 1, and which do not contain more than 2.0 percent "total defects," shall be graded and designated as "U. S. Choice Handpicked." Such designation shall precede the name of the class.

(b) Handpicked. --Handpicked beans which do not meet the grade requirements for the grade U. S. Choice Handpicked shall be graded and designated according to the grade requirements of the standards applicable to such beans, if they were not handpicked, and there shall be added to, and made a part of, the grade designation, following the number of the grade, the word "Handpicked."

(2) High moisture beans

(i) Requirements. --High moisture beans shall be beans of any class which contain more than 18 percent of moisture.

(ii) Grade designation. --High moisture beans shall be graded and designated according to the grade requirements of the standards otherwise applicable to such beans and there shall be added to, and made a part of, the grade designation, following the name of the class, the words "high moisture," followed by a statement of the percentage of moisture in the beans.

(3) Off-color beans

(i) Requirements. --Off-color beans shall be beans of any class that, en masse, are distinctly off-color due to age or to any other natural cause but which are not materially weathered.

(ii) Grade designation. --Off-color beans shall be graded and designated according to the grade requirements of the standards applicable to such beans if they were not off-color, and there shall be added to, and made a part of, the grade designation, following the name of the class, the words "off-color."

RECOMMENDATIONS

Shipping tests of Michigan Pea beans (Navy) during June and July 1960 indicated that precautions are necessary to assure deliveries of higher quality. Receivers of beans in European ports have reported that the quality received was not the same grade as the quality purchased. Information leading to the cause of the deterioration or changes in quality is necessary for mutually satisfactory business operations.

To reduce losses from breakage of bags during loading and unloading, bags of 12-ounce burlap, or its equivalent, should be used. The closeness of weave resists tearing more than open-weave bags and results in less breakage.

For better quality beans for the European market, high moisture beans found in bags on top of the hold or along the sides, at destination, should be checked with a moisture tester suitable for making quick tests.[12] The following procedures are recommended for use by ship operators in loading and unloading the beans and in controlling atmospheric conditions in the holds of ships during voyages.

1. Plan the loading of dry beans so that the entire area assigned for the commodity will be free of crates, protruding dunnage, or other sharp articles that could rip bags during loading and unloading.

2. Store all dry crates and other items with similar moisture and temperature requirements under the deck or out of the way of the loading and unloading operations. (When beans are being lowered into the hold of the ship on wooden pallets or lifted out onto the docks with slings, sharp corners on crates protruding into the hold break many bags.)

3. Lower loaded pallets into the hold onto an empty pallet resting on the bags in the hold. This will prevent tearing bags already in place.

4. Place bags flat and close together to avoid their shifting during the voyage and to conserve space. Keep tiers as level as possible.

5. Load no material of a different moisture and temperature requirement than beans in the hold, since this would hinder proper aeration.

6. Install a hygrothermograph under the deck of the ship and read it daily. This instrument will provide a continuous record of humidity and temperature.

7. Aerate the hold to lower the humidity and protect the quality of the beans. Operate fans on clear days from 10 a.m. to 6 p.m.

   (a) Aerate when the temperature is above 24° C. (75° F.) or the humidity above 80 percent, to protect the quality of the beans.

   (b) Aerate when the freighter, thoroughly chilled by the Labrador Current, enters the Gulf Stream. Regulated aeration will lower the humidity and prevent the condensation of moisture under the deck.

8. In loading during rainy weather, see that water dripping from the tarpaulin is not saturating several bags of beans. Cover the hatch during showers.

9. Do not allow large numbers of palletloads to stand by the ship's side when weather is threatening.

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[12] A partial list of the manufacturers of rapid moisture-testing devices for grain and related commodities in the United States can be obtained from the Grain Division, Agricultural Marketing Service, U. S. Department of Agriculture, Beltsville, Md.

10. Use good dunnage. Dunnage that is rough and warped is likely to puncture bean bags.

11. When loading, see that the "needleman" is available to sew all torn bags. Torn or broken bags result in a messy cargo that is difficult to unload.

12. Do not use cargo hooks on bags of beans. The hobnail type of hook with 12 short points is less destructive to bags than the large, long single hook. Both are destructive.

13. Insist that a quality control representative of the receiver be present at destination to segregate bags of high-moisture beans. (These beans can likely be processed immediately without loss, but if stored they will mold and cause bags in contact with them to mold.)

14. Do not store dry beans in holds with commodities that (1) contain more moisture than the beans, (2) have strong odors, or (3) are very dry. Dry beans are semiperishable and may deteriorate if stored with such commodities.

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