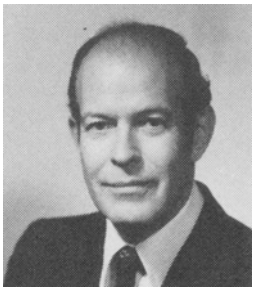
Effect of Shipping on Quality of Seeds, Meals, Fats, and Oils



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ABSTRACT

Although few studies have been conducted relative to quality preservation of oilseeds and their products while in transportation containers, there are known causative factors of quality degradation which are applicable from long experience of storage in ordinary land-based containers. Often the success of quality retention is a function of the basic level of quality negotiated by the buyer and seller and the inherent idiosyncrasies of the commodity when handled and when exposed to the ambient conditions of the air and container.

GENERAL CONSIDERATIONS

Few studies have been done, and even fewer published, on the quality preservation or degradation of oilseeds and their products while being transported. This is a subject of current interest in many quarters and has been programmed as an imminent research project by both the USDA and the Agricultural Economics Department of the University of Illinois.

Many earlier studies have, however, been related to the quality problems in static land-based storage situations which can be applied to or extrapolated to transportation containers. Industry has been confronted with these problems for many years and has developed for itself many rules of thumb or guidelines. Whether or not these problems can or will be solved is not the subject of this paper.

In the international marketing of oilseeds and their products, the greatest concern for quality preservation during shipment has been for the seed itself—particularly soybeans. Worldwide trade of this oilseed during the calendar year 1975 (1) exceeded 15.8 million metric tons, mostly from the U.S. and Brazil. The equivalency of its end products (oil, meal, and millfeed) added to this total makes it one of the most essential food and feed oriented commodities moving by bulk transportation methods.

Contributing to the quality preservation problems of the soybean during shipment in international commerce have been the changing patterns of transportation modes and handling techniques in the past 15 years. Cargoes are loaded at much faster rates of up to 2,500 M tons per hr; vessels have increased in size from 15,000-18,000 ton capacities to 45,000 and 60,000 tons or larger. The concurrent harvest of increased soybean acreage with field shelled corn in some areas has brought both entire crops to market in a very short time span requiring storage conditioning and preservation demands of enormous proportions.

QUALITY FACTORS

Foremost in the eyes of the soybean processor have been the quality factors of moisture, splits, foreign material, and damage. All of these contribute to his ability not only to store the crop for up to 10 months but to obtain commercially optimum yields, operating costs, and quality end products. The processing yield of oil (aside from the inherent content) and its refining and bleaching properties, the protein of the derived meal, and the amount and quality of so-called millfeed are basically derived from the above factors.

The U.S. grading standards (2) define the maximum limits for each of these factors at time of loading into the transport container to facilitate the orderly marketing of the crop on a basis easily understood by any buyer or seller. The contractual terms of the marketing agreement are a result of the price/quality relationship mutually attractive to the customer and merchant. It is axiomatic that #1 quality soybeans do not move in normal international commerce, and this is to say that the price/quality rationale has generally determined that #2 or lower quality is a more economically sound commodity for the buyer's use.

How, then, does this affect the quality preservation during transportation in a container such as a ship for up to 30-45 days? Obviously, with higher limits of moisture, foreign material, etc., permitted by U.S. standards during loading of these lesser grades, the known potential problems of storage for relatively short periods are accentuated. Such quality related phenomena as broken beans, particle separation, spontaneous heating, mold growth, and other damage are closely related to the grade factors negotiated by the parties to the transaction. These phenomena may be well known to the buyer and are considered in his economically oriented decision. Some of the specific conditions affecting quality during an ocean voyage, to which the thrust of this paper is directed, are expanded below.

Moisture

The moisture content of soybeans in equilibrium with air at a given temperature and percent relative humidity is well known. The family of curves is shown in Figure 1 (3). While moistures of 13.5% or below have been thought to assure storage stability over reasonably long periods, it must be emphasized that this is true only when temperatures are kept below the level at which storage fungi cannot grow rapidly. More precisely, Christensen and Kaufmann (4) have reported that fungi generally cannot grow at moisture levels below those in equilibrium with a relative humidity of approximately 65%.

Once these fungi have begun to grow, the respiratory rate and resultant exothermic reaction comprise a self-regenerative destruction process which accelerates the heating and damage degradation.

It must also be recognized that sudden changes in ambient conditions during handling are a distinct separate phenomenon. For example, barges are often loaded in the

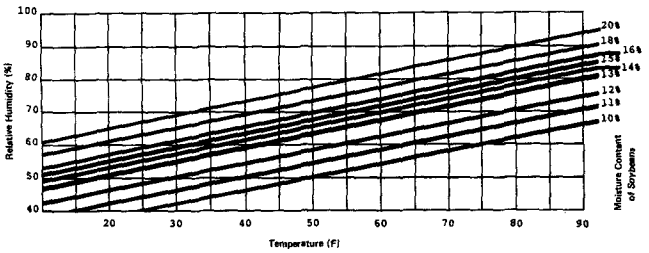

FIG. 1. Equilibrium level of soybeans with the temperature and relative humidity of the surrounding air. For example, an air temperature of 63 F and a relative humidity of 70% is in equilibrium with 14% soybeans. With the temperature remaining constant, the moisture content of the soybeans could be reduced only with a decrease in the relative humidity from 70%. There are other equilibrium levels for 14% soybeans, such as 50 F and 65% relative humidity.

northern climates of the U.S. in winter and early spring with soybeans which are at 13.5% moisture and which have been cooled through aeration to a 2 C (35 F) temperature for winter storage. These travel in reasonably tight containers to the Gulf Coast ports where they are discharged, handled, and loaded aboard ocean vessels in ambient temperatures of 85-90 F and a relative humidity of 90%. This sudden exposure of the cold soybean to such a humid, hot climate is an ideal vapor condensing mechanism. The surface of the soybean, which has a temperature well below the dew point, is suddenly near saturation; this represents a serious threat to its preservation during a particularly long ocean voyage through warm climates. Fungi can grow rapidly since the temperature/humidity relationship has been radically disturbed, and spontaneous heating can be destructive in 30-45 days.

Should the vessel carrying the soybeans employ deck scoop ventilators turned into the wind during the voyage through warm humid climates, the surface and adjacent layers of the cargo will surely come to equilibrium with the air having a relative humidity of 85-90% in a very short time. Figure 2 (3) shows the "moisture-storage time" instability of the cargo under such conditions.

Splits

Unlike other oilseeds and grains, soybeans have two structurally strong halves held together by a relatively weak bond. This bond weakens nearly in direct linear relationship to the reduction of moisture content. Hence, the desire to preserve quality by lowering moisture produces a disadvantageous higher percentage of "splits."

Tests conducted by the USDA Agricultural Research Service (5) relating to the breakage of soybeans by commercial handling have shown some interesting comparative results. Nearly 95% of soybean breakage occurring after falling to a surface or impacting on bulkheads was splits, and 5% was broken pieces of beans which would be categorized as "foreign material" by U.S. grading standards. In free fall tests on concrete and on other soybeans at various heights, the comparison was found to be:

	Breakage of soybeans on	
Drop ht (ft)	Concrete (%)	Soybeans (%)
100	4.5	3.2
70	2.1	1.4
40	1.1	.7

In today's modern cargo vessels with deep holds, it is not surprising, therefore, to find that the percentages of splits and broken bean pieces are greater at the discharge port than when loaded. The combined height of the loading spout and free fall into the hold of the vessel can approach a 100-ft average for the entire cargo. The splits are conducive to mold proliferation and increased respiration rates if the temperature and humidity are high. This results in increased fatty acids and other biochemical changes.

The advent of large capacity "self-trimming" bulk carriers and OBO's in recent years has further increased the so-called spout-line natural separation of splits and foreign material. Some single holds of such vessels now carry nearly as much tonnage as the entire cargo of the "Victory" or "Liberty" ships prevalent in the 1950s and early 1960s. A loading spout can be (and often is) left in one position above such a hold pouring at full capacity for several hours; and, although the uniformity of splits and foreign material determined by accurate sampling during loading may be well within the allowable limits, the spout-line separation can result in concentrations of up to 20% or more of these components. This highly concentrated area of broken bean particles, splits, and true foreign material is prone to deteriorate quite rapidly.

If vessels are of the tanker class, where deck openings are extremely small and the falling oilseeds are subjected to structural protuberances within the holds, additional breakage can occur.

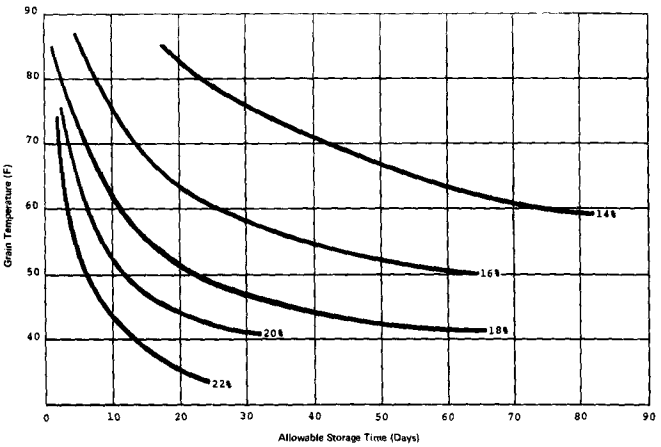

FIG. 2. Allowable storage time for soybeans (seeds).

Foreign Material

This quality factor is defined by U.S. grading standards as any particles which pass through an 8/64-in. round sieve opening and all other non-soybean matter remaining on the sieve. While a large percentage of this factor may consist of broken pieces of soybeans, the "true" foreign material consists of dirt and sand particles, weed seeds, and other small grains harvested with the crop. These are the components of the spout-line natural separation phenomenon which contributes to rapid degradation of localized areas within a transport container.

In addition, the weed seeds prevalent in some crop years when weed control by the producer is made extremely difficult by climatic conditions accentuate this problem. The spout-line separation in a vessel, for example, may then contain a higher concentration of weed seeds than normal. These foreign seeds may be of a higher moisture content than the soybeans and can accelerate the spontaneous heating in those areas. Cargoes which are traded in international commerce on the basis of 3% or 4% maximum foreign material in years of ineffectual weed control have been known to show concentrations of up to 50% of the foreign material as weed seeds in the center of spout-line separation areas.

The resultant effects of the foreign material problems encountered or accentuated are as described above for the moisture and splits factors. All of these quality factors are closely related in their cause/effect relationship, as is the remaining U.S. grading factor-damage.

Damage

This quality term is connoted to mean essentially chemical damage caused by heat, frost, growing conditions, insect sting, or disease. This is one of the most important factors in determining processing yields and product quality. Heat damage is particularly important in quality of the oil and its ultimate refining and bleaching. Many of these causes of damage are results of external conditions to which the soybean has been subjected prior to its loading into a transport container.

This is not to say that the damage factor after loading and while in the transport carrier is to be disregarded. With the other factors of splits, foreign material, and moisture in an interrelated cause/effect relationship, the final result of these factors working in concert during transportation results in increased damage. The growth of storage fungi, spontaneous heating, and respiration moisture all contribute to degradation of the soybean through damage of the sound bean during its relatively short period in containers.

OILSEED PRODUCTS

With the greatest concern currently being voiced over

the preservation of the oilseed itself during transportation, few studies have been done or little concern has been voiced over the transport of the fats and oils in bulk containers. The meal derivatives, however, have received much attention from the producers, handlers, and users.

The caking tendencies of soybean meal have long been known, and factors contributing to this phenomenon have been studied by processors, handlers, and research groups. Contributory to this costly problem are moisture, temperature, particle size and configuration, time, fiber content, additives, and the depth of the stored mass. Many devices have been developed to minimize the handling problem in storage bins and in transportation containers. Discharge of the oceangoing vessel has been greatly improved with these newer techniques.

Preservation of quality of the meals during transportation, as opposed to the handling characteristics, seems to be of lesser importance if one assumes that the quality at time of loading the container was within acceptable norms and follows the trading rules. Certainly, it is imperative to ensure water tightness of the container and provide other physical precautions relative to the admission of external degrading factors.

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