Technical

Raw Materials Handling and Controls

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ABSTRACT

This presentation discusses some of the commonly used methods for handling raw materials prior to processing and the controls necessary to limit deterioration of raw materials in storage. Reference is made to properties of major oil-bearing raw materials and specific care needed in both storage and handling. Examples of typical handling and storage facilities are given.

INTRODUCTION

It is appropriate that these AOCS Short Course lectures start with a discussion of the origination of the seed and what can or does happen to it before the processor actually removes oil from the seed. Since each seed is different, let's consider some of the major seeds individually, starting with the condition of seed at harvest time, plus storage and handling prior to actual processing.

A few general commments are in order: first, that oil seed quality is very dependent on weather conditions at harvest time; second, that trading rules may not adequately consider in discounts or premiums what it means to oil processors that seeds have been damaged, or that deliveries from the farmer are high in moisture or green weed seed, etc., or that the oil content is higher in some seed than others; third, that governmental policies and regulations are factors to consider. For example, stiffer export controls may mean that more of the poor quality seeds and screenings stay in the U.S.A. for processing, or that regulatory agencies or EPA and OSHA will change the normal way in which we have handled or stored. There is a question as to what extent governments will intercede to replace the free market system.

Since soybeans are the dominant source of vegetable oil, both in this country and in the world, and since I am personally more familiar with soybeans, most of this discussion will deal with that oilseed.

SOYBEANS

Nature plays a big part in soybean quality and resultant oil quality. Processors' experience confirms that processing normal soybeans soon after harvesting yields oil higher in green color than the same soybeans do after being in storage for approximately a month (1). Producers have the problem of deciding when to harvest their beans. That is, should they risk the harvest before moisture content is low enough for safe storage and some green remains in the foliage, or should they wait for more drying and maturing of the beans? There is some evidence to show that oil yields also increase slightly after storage. Likewise, stored soybeans tend to process better than soybeans soon after harvesting. As refiners know, green color is hard to remove from the oil. It is fair to say, therefore, that it is desirable from a processor's viewpoint that soybeans are not harvested too early, but that the beans are permitted to mature and dry in the field. However, the processor shares another risk with the producer: namely that the soybean cannot be harvested because of wet conditions, or frost occurs before the soybeans mature. Both conditions can result in severely damaged soybeans.

Of interest is the experience in the fall of 1971 when the Southeastern states had a very wet fall which resulted in much field damage to soybeans before they could be harvested. Extensive studies were made by Northern Regional Research Center scientists who have linked poor flavor to oxidation and the higher iron content of oil from the damaged soybeans. Oil from damaged soybeans is extremely difficult to refine to acceptable standards. I refer you to an article by the Northern Regional Research Center in the January, 1977 issue of the Journal of American Oil Chemists, in which they present the results of their studies as to special treatment necessary for refining oil from damaged soybeans (2). These comments apply to oil from soybeans damaged by heating in storage as well as field damage.

Of great importance also is how the soybean is handled after harvesting and before processing. There is an increasing amount of storage by farmers on their own premises. Of the 15.1 billion bushels of total storage capacity in the U.S., 8.5 billion is on the farm, and 6.6 billion is in commercial storage off the farm. This means to the processors that farmers are controlling a large share of our soybean quality from harvest until they market their soybeans. We saw a great reluctance on the part of farmers to sell their soybeans during the fall of 1977. As a result, many processors' plant storage facilities were not filled as is traditional during the harvest season. Of concern to us as processors is that it is particularly important that in a wet crop year farmers adequately watch the temperatures and conditions of their soybeans. Moisture levels which are generally considered safe for longer term storage (13) are 13% for soybeans, 9.5% for sunflowers, 10% for cottonseed, 7.0% for rapeseed and copra. Allowable safe storage times for wet soybeans are plotted against grain temperatures in Figure 1. These are only guidelines, and they do not take into consideration such things as foreign material and spout lines.

Moving on to storage of soybeans off the farm in warehousemen's facilities or processors' storage, we find many varied type facilities. Soybeans are stored in concrete silos, large and small steel bins and flat storage. By flat storage, we basically mean any large volume, low depth storage space like a conventional warehouse. It is considered good practice, though not always possible, to clean soybeans before going to storage to remove weed seed, stems, pods or trash which may contribute to heating in storage. Likewise, it is not desirable to store soybeans for any length of time at over 13% moisture. Of utmost importance is a bin temperature monitoring system for any long term storage. Temperatures should be taken weekly or more often if there is any rise in temperature. Any rise in temperature is cause for concern. Certainly there are many variables to consider, such as (a) temperature at which soybeans go into storage; (b) whether the soybeans were harvested before or after a killing frost; (c) amount of weed seed and foreign material mixed with the soybeans to give spout line or segregation in storage; (d) moisture level of the beans; (e) type storage (that is, concrete or steel silos which are easy

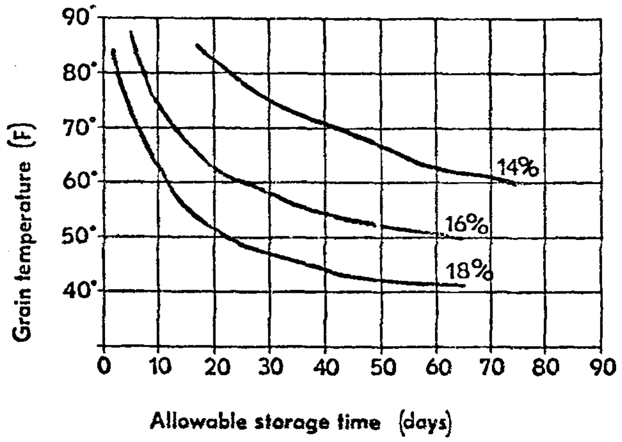

FIG. 1. Allowable storage time for soybeans.

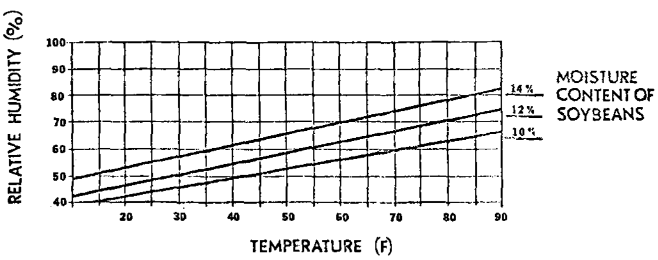

FIG. 2. Equilibrium level of soybeans w/temp. and relative humidity.

TABLE I

Drop Height	Breakage of soybeans on Concrete %	Breakage of soybeans on Soybeans %
100	4.5	3.2
70	2.1	1.4
40	1.1	0.7

TABLE II

Typical Rise in FFA, Cottonseed 10% Moisture, Average Seed 50 F.

Initial FFA	Rise in FFA per month storage
1.0%	Less Than 0.1%
2.5%	About 0.2%
5.0%	About 0.5%

to empty, very large bin storage or low depth flat storage); (f) relative humidity and ambient temperature of external air and (g) availability of areation. Aeration can be a great help to remove heat if the air can be directed to the heating area. There are many types of areation systems, such as perforated ducts on the floors of large steel tanks, wall areation on tall concrete or steel storage, center column areation or temporarily installed ducts to specific points usually possible only in flat or low depth storage. Quantities of air are usually designed for 0 05 to 0 1 cubic feet of air per bushel of grain per minute. Normal practice would be to operate aeration fans only when outside air temperatures are below grain temperatures, and relative humidity is equal to or less than the grain equilibrium relative humidity. See Figure 2.

Of concern also can be sweating when cold grain is removed from storage and exposed to air more than 15 to 20 F warmer and with high relative humidity. Under these conditions, moisture from the air actually condenses on the soybean, and when again put into storage, the cumulative effect of this sweat or moisture can cause heating problems in storage.

As stated earlier, there are few grain elevators or processors who have capability to clean soybeans as received. It is, however, quite common to have cleaning facilities ahead of grain driers. The overs from the top screen would be pods, sticks and foreign material like cockel burrs. This material may be thrown away, but in some cases is ground and added to hulls or mill feed. The throughs of the second screen would be weed seeds, cracked beans and dirt. The overs or clean soybeans will then, in some cases, be aspirated to remove loose hulls and dirt. The throughs from the second screen would then go over a screen of relatively fine mesh to remove sand and dirt. This dirt is normally thrown away, but can in some cases be added to the mill feed. Weed seeds and soybean screenings are usually added to soybeans going to process, while making 44%, or low protein soybean meal.

Soybeans above 13.0% would normally be dried before going to longer term storage, if drying capacity permits. Soybeans are also usually dried to plus or minus 10.5% to loosen hulls prior to dehulling when making 50%, or hi pro meal. In these days of high energy costs, processors are attempting to control and reduce the amount of drying of soybeans ahead of processing. Drier manufacturers also have designed energy conservation recirculation features into their driers.

Another quality concern in the handling and storage of soybeans is that of breaking up of the soybean into splits or half sections or even smaller pieces. Table I gives some idea of what dropping soybeans from various heights into a bin can do. Without the protection of the hull, the meat of the bean with its oil content is exposed to air, and the free fatty acid of the oil goes up. The rapidity of this reaction increases with the higher the temperatures and the more exposure to air.

COTTONSEED

As with soybeans, nature plays an important part in the ultimate quality of the oil the refiners obtain. Bailey's book, "Industrail Fats and Oils," states that the critical period in the maturation of cottonseed appears to be within 10-15 days after opening of the balls when, under ideal weather conditions, the moisture content of the seed will drop from 50% to 10% (5). If weather conditions are wet and harvest is delayed, the free fatty acids will rise. As previously shown, cottonseed for safe storage should be below 10%. Cottonseed is usually stored in flat, metal type warehouses with roofs that slope close to the angle of repose of the cottonseed. The trade name of Muckagee typifies this type of warehouse. Cottonseed warehouses will normally be equipped with aeration systems and temperature pipes. The protection of cottonseed quality in storage is both an art and science. It requires diligent monitoring of temperatures and rapid action if seed temperatures start to rise. Cottonseed entering storage with an FFA content above 2.5% can be expected to deteriorate much more rapidly than seed with 1% free fatty acids. Figure 3 gives a general indication as to importance moisture plays in length of time cottonseed can be stored before the FFA rise is excessive. Likewise, the rate of deterioration increases greatly with higher temperatures. Ideally, if cottonseed is to be stored for several months, its temperature should be no more than 50-60 F. If possible, a processor should process the highest FFA seed first.

Since cottonseed handling is well known to most of you, I will not go into this, but will go on to other not as well known oil seeds.

SUNFLOWERS

Sunflowers as an oil seed crop are just now gaining momentum in the U.S.A., whereas it has been a significant source of vegetable oil in East European countries, Russia and Argentina for many years. Presently the growing of sunflowers is expanding in Texas and in the Red River Valley area bordering Northwestern Minnesota, North and South Dakota. Nature again plays a big part. First, as you all know, sunflower seeds are produced in the face of the large flower, or head as it is called. Harvesting is by conventional grain combines with some modifications. Before this harvesting can take place, the head must be relatively dry so it can be broken apart in the threshing operation. With farmers eager to harvest their seed and with frequent fall rains in the Red River Valley, it is hard to prevent delivery of wet seed including a liberal share of broken pieces of pods. For proper protection of sunflower seed quality in storage, the seed should be cleaned as received and segregated according to moisture. Previously we noted that 9.5% is a safe storage moisture. As in all cases of oil seed storage, so many factors are involved; however, I would suggest only short term storage at 9.5% or above and moisture of 7% or below for longer term storage without areation. Temperature detection systems are a must.

Sunflower seeds with hulls are bulky, weighing only 25 lbs. per cu ft. The outer surface of the hull has a waxy coating that partially comes off during handling. Sunflower seeds can be handled in normal conveyors, bucket elevators and spouting. However, angles of spouting need to be steeper than for soybeans. Also, the waxy material coming off the hull will stick to surfaces in spouts and buckets, and they need to be periodically cleaned. Conventional grain dryers can be used to dry sunflowers, but considerable care must be taken to prevent fires because of the waxy fuzz. One can generalize that the comments made regarding soybean and cottonseed deterioration due to high moisture and temperature apply also to sunflowers. Unless the seed is stored as dehulled, the FFA buildup is slow as in soybeans, rather than potentially rapid as in cotton seed.

COPRA

Copra, or the white meat from a coconut, is an interesting oil seed produced in a large quantity only in the Philippines, Indonesia and other South Sea Islands. I will not spend much time, but I thought it would be interesting for you to hear just a few comments regarding this industry.

Coconuts are grown on trees and are harvested year around. One acre of land will have ca. 60 trees. Each tree will produce ca. 30 to 50 coconuts per year, and it takes ca. 4400 coconuts to make one ton of copra. Each coconut is cut from the tree by a man climbing up and cutting it loose. Then also by hand, each coconut is husked on a saber looking knife anchored in the ground. Next, the shell is broken with a machette and teh coconut milk thrown away. The coconut is now 30 to 40% moisture and is dried either in the sun or over a smudge fire using the husks and shells as fuel. When dried, the meats removed from the shell change from the name coconut to the name copra. With more hand work, plus help from a donkey or water buffalo, the copra is transferred in bags from the farm to the road side to be sold

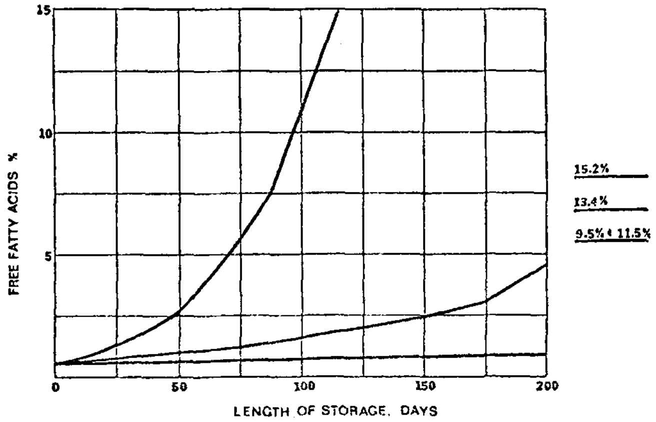

FIG. 3. Free fatty acid content of oil in cottonseed of various moisture contents vs. storage time of the seed.

to dealers who in turn sell to crushers. Crushing plants range from very small up to 1,000 MT of copra per day. Copra is ca. 2/3 oil.

PALM OIL

With the increasing of production of palm oil, largely in Malyaisa, a few comments regarding this oil may be of interest. As perhaps most of you know, palm oil is the oil from the flesh of the palm tree fruit. The fruit is actually a cluster of small sections or kernels all growing out from a central fibrous ball. Each of these kernels resembles a plum with a fleshy mass surrounding a pit or stone. Oil from the flesh is called palm oil. The pit or stone also contains oil and it is called palm kernel oil. At one plant the cluster or whole fruit yielded ca.20% of oil. At the same time, ca.2½% of the cluster was pits or stones which were in turn ca.50% oil.

It takes ca.7 years to grow a palm tree before it becomes a producer. Trees are low so that harvest can be done from ground level. It takes ca. 6 months for a cluster of fruit to mature. Fruit must be watched very carefully for proper maturity for harvesting, which is done by hand from carts pulled past the tree. One acre yields ca. 8 tons of clusters of fruit per year.

The clusters of palm fruits are very fragile, and it is difficult to handle without breaking the skin of the kernels. When the flesh of the kernel is exposed, enzymes cause a very rapid rise in FFA. Hence, fruit must be processed almost immediately after harvesting. The first step is a 1½ hr steaming in a pressure chamber at 15 psi so as to destroy this enzyme activity.

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