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THE STORAGE OF SHELLED PECANS

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Shelled pecans may change in flavor, texture, and color, while in storage. They may also change as a result of insect or disease damage. Kernels change in flavor by becoming progressively rancid and by absorbing odors from other products. Rancidity may be largely prevented by proper storage at low temperature. Changes in texture are caused by absorption of moisture, which causes the kernels to be spongy; or loss of moisture from excessive drying which causes them to be brittle. Changes in color are caused by rancidity and by exposure to ammonia fumes. Blue mold is likely to develop if pecan kernels are stored under conditions where the relative humidity is high, even where the prevailing temperature is about 32°F.

Pecan kernels are best stored in containers that are moisture-proof or nearly so. Sealed tin cans of varying sizes, moisture-proof cellophane and glass jars sealed under vacuum, provide satisfactory conditions for storage.

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THE STORAGE OF SHELLED PECANS

By

FRED R. BRISON*

The pecan is the most important nut crop of the Southern States. The 1944 crop was about 143 million pounds. Pecans are harvested during a period of about 8 weeks in the late fall and early winter. During some years, insect pests and diseases materially reduce the size of the crop; spring frost may cause a crop failure. Records show that alternately pecan crops tend to be heavy and light. For these and other reasons production usually fluctuates widely from year to year. The 1935 crop in the United States amounted to 106 million pounds; that in 1936 was only 40 million pounds. The 1943 crop in Texas amounted to only 19 million pounds; that in 1944 was over 43 million.

The quantity which can be consumed during the entire year is greater than that which could be consumed during the harvest period only. When the crop is heavy, it may be profitable to hold a part of it until the following year when the crop is likely to be light and better prices prevail. These conditions make it desirable to hold the crop in storage from harvest time until it can be distributed into marketing channels during the months that follow.

Pecans may be stored before the kernels are removed from the shell, or the extracted kernels may be stored. In recent years the trend has been to store the kernels. Less space is required for them than for the unshelled nuts. The kernels of fully-matured and newly-harvested pecans are fresh, crisp, and appetizing in taste. Those that are commonly available on the markets during the summer and early fall—after having been stored several months—are often dry, strong in flavor and dark in color. This is evidence that the methods of storage and handling now being generally employed are not entirely satisfactory. The result is that customers are not pleased. The results presented herein show that it is possible to preserve pecan kernels for a year or longer with very little deterioration.

Materials and Methods

Tests were begun in 1936 and have continued until the present time to study causes of deterioration of pecans in storage, and to determine conditions suitable for storage. For these tests, selected native seedling pecans and those of one standard variety, the Schley, have been used. The pecans were harvested when mature in November of each year and held temporarily in common storage. They were shelled during different years from 6 to 14 weeks after harvest, and the kernels were used immediately in the storage tests. In shelling, the half-kernels were separated from the pieces, and only the halves were used in the tests.

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Kernels were packed in bulk, in cellophane bags, in paper cartons, in small glass jars under partial vacuum, in cloth bags, and sealed in cans of various sizes. Differences in humidity were created by sealing kernels in cans separately with calcium chloride, and water. Liquid ammonium hydroxide was sealed in cans with kernels in order to note its influence.

Kernels packed in these various ways were stored at the following approximate temperatures: room, 40°F, 32°F, and minus 10°F. In general the kernels remained in storage from a few weeks after harvest until the following October or November. This period included the warm season of the year when kernels deteriorate most rapidly.

Results and observations show that pecans in storage change in the important qualities of flavor, texture, and color; they may change also as a result of insect or disease damage.

Flavor

The varieties of pecans differ in flavor or taste. Some are rich and oily and have a nut-like flavor. These qualities are not so pronounced in kernels of other varieties. Growing conditions and maturity affect the flavor of the kernels.

Chemical analyses were made of the pecan kernels used in this investigation. Results are presented in Table 1. These results correspond closely with those published by Fraps (3) and by Hutt (4). The fat, or oil, content was 71.43 per cent for one of the seedlings, and 73.08 per cent for the other. This oil is reported (1) to be a mixture of varying proportions of the triglyceride esters of oleic and linoleic acids, principally, and also of stearic and palmitic acids. When the oils of the pecan kernel are broken down, glycerol and free fatty acids are formed. It is known that rancidity results, in part at least, from the formation of these free fatty acids. Pecan kernels stored under different conditions from February to October developed different degrees of rancidity as measured by taste or flavor.

Because of these facts it was hoped that a chemical test for rancidity of pecan kernels could be developed. Chemical tests of certain lots were made for free fatty acids, and for rancidity by the Division of Chemistry. The determination of free fatty acids was made by titration of the extracted oil dissolved in alcohol with standard sodium hydroxide, using phenolphthalein as indicator, and expressed as oleic acid. The test for rancidity was made by shaking the extracted oil with strong hydrochloric acid, then adding a 0.1% solution of phloroglucinol. A pink to red color was taken to indicate rancidity. Results of these tests are included in Table 2. It is evident that these tests do not give an accurate indication of the strong flavor which characterized some of the pecan kernels. For instance, sample 208 stored in bulk at room temperature was rancid in flavor at the end of the storage period, yet the above chemical test did not show it to be rancid, and it was not so high in free fatty acids as some samples which were not rancid in flavor. Further chemical tests for ran-

Table 1. Chemical Analysis of Two Varieties of Pecan Kernels*

Variety	Protein (%)	Fat (%)	Crude fiber (%)	Nitrogen-free extract (%)	Water (%)	Ash (%)	Lime (CaO) (%)	Phosphoric (P_2O_5) (%)	Magnesia (MgO) (%)	Insoluble ash (%)	Iron (p.p.m.)	Free fatty acids (%)	Rancidity
185	12.05	71.43	1.71	9.59	3.59	1.63	.12	.68	.23	.12	38.2	.23	none
208	11.26	73.08	1.70	9.04	3.37	1.55	.12	.73	.22	.05	42.2	.20	none

*Analyses made by The Division of Chemistry.

cidity were not made. Since the tests used were not found to be an accurate index, rancidity in this report refers to strong flavors and odors that render the kernels unappetizing.

Knight (5) states (1) that the enzyme catalase is somewhat effective in keeping oil-bearing foods from becoming rancid, (2) that catalase-bearing products such as . . . nuts remained free from rancidity so long as the catalase is potent, (3) that catalase is destroyed by high temperatures, (4) that oil-bearing foods containing catalase should not be heated to a temerature exceeding 60° C. (140°F.), and (5) that the chlorophyll present in vegetable oils when exposed to light, liberates free hydrogen which reacts with oil to form a rancid compound.

Shelled pecans when stored improperly become progressively more rancid until they finally are not edible and are not suitable for usual culinary purposes. Knight (5) recognized this and defined the "rancidity induction period . . . as the time required . . . for the reactive substance to develop . . . to a point where rancidity is recognized by taste and odor."

Influence of Temperature. It is generally known that pecan kernels become rancid if stored at a high temperature; and, on the contrary, do not soon become noticeably rancid if stored at a low temperature. Tests were conducted to determine definite temperatures and treatments which are effective in preventing rancidity. Separate lots of kernels were stored at (a) room temperature, (b) 40°F, (c) 32°F, and (d) minus 10°F. All kernels stored at room temperature regardless of package were unmistakably rancid after having been stored from harvest time through the following summer. Those stored in certain containers at 40°F were edible and acceptable, though their taste had somewhat changed. Those stored in sealed containers at 32°F and at minus 10°F did not develop any taste or odor that even suggested rancidity. Relatively small containers holding about half a pound were used in these early tests. Another year kernels were stored in sealed containers of sizes that ranged from a No. 3 tin can holding about 1 pound to those that hold approximately 100 pounds of kernels. The storage temperature was 32°F. After eleven months, the kernels were considered as good as those from freshly harvested nuts. They had retained the characteristic taste and flavor of fresh pecans. They had no qualities or peculiarities which would readily identify them as having been in cold ctorage. When kept at room temperature for a month after being removed from the low temperature, the kernels did not become rancid any more readily than fresh kernels.

For the past 3 years pecans have been stored in sealed containers in a commercial frozen locker vault where the temperature is about 5°F. The kernels keep perfectly for as long as two years without any perceptible changes in taste or odor. They are no more susceptible to becoming rancid upon removal than pecans which have not been stored.

A method has been recommended (2,7) whereby the kernels are placed in glass jars and steamed for a few minutes, after which they are sealed.

Samples of high quality fresh kernels were placed in glass jars in the early spring of 1944. The lids were placed but not tightened. The packed jars were put in a pressure cooker and heated under ten pounds pressure for ten minutes. They were then removed, the lids were clamped down tightly and the jars stored in a dark cabinet in the Agricultural Building throughout the summer. For comparison, kernels were also sealed in two jars without being heated. One was kept in the cabinet with the jar of kernels which had been heated, and one was stored in a frozen locker vault at 5°F. All samples were examined in late September. The untreated kernels stored at room temperature were unmistakably rancid and stale. The ones kept at 5°F were as good as fresh kernels. The heated kernels, stored at room temperature, were intermediate. Though not definitely rancid, the flavor was slightly strong, and was definitely different and inferior to that of fresh kernels that are kept in proper cold storage. Cameron (2) noted the same change in taste and referred to it as a "cooked" flavor.

Influence of Humidity. Tests were conducted to determine primarily the influence of humidity on the texture of shelled pecans. Kernels were stored under conditions of (a) high, (b) uncontrolled and (c) low humidities. These tests will be discussed fully under the section on texture. It was observed incidentally that humidity does have an influence on rancidity. Those stored under high humidity had poor texture when examined later, but did not develop rancidity that was seriously objectionable at either minus 10°F, 40°F, or room temperature. In contrast to this the lots that were stored under a low humidity at minus 10°F and at 40°F, developed off flavors which tended to be strong and those at room temperature became definitely rancid and inedible. Objections to high humidity are that it causes poor texture and encourages fungus growth unless methods of sterilization are employed. For these reasons it is of doubtful value as a means of preventing rancidity.

The treatment whereby the unsealed jars are heated in steam and sealed immediately while hot doubtless results in considerable moisture being included in the jar. It seems reasonable that the kernels so treated do not become rancid so readily when stored at high temperature as untreated kernels because of this high humidity.

Influence of Other Factors. Frequently "foreign" odors are present in storage vaults. It is known that some foods absorb such odors and the taste is influenced accordingly. One pound of shelled kernels was placed in a domestic cloth bag, and stored with pecans in other types of containers. The temperature of the storage room was 32°F. Smoked meat was also stored in the vault and strong odors of it were present. The kernels remained in storage eleven months. The judges who tasted the kernels without knowing the identity of the samples said the ones from the cloth bags were "strong", "rancid", and "stale"; whereas those that were stored in sealed containers in the same vault were regarded as "excellent" in taste. The evidence was convincing that shelled pecans do absorb odors, and that the quality is lowered accordingly.

Some varieties have better inherent flavor than others. Hutt (4) found that Teche contained only 68.41 percent oil, while the oil content of Schley was 80.55 percent. When disease or insects attack pecan trees or growing conditions are unfavorable, the pecans fail to develop and mature properly. The kernels of such pecans tend to be dry and without distinctive taste. They are inferior in quality when fresh, but do not become rancid as readily as high quality kernels.

Texture

Pecan kernels have a characteristic crispness and brittleness when they have ripened normally and are properly cured. Conditions in storage may cause this texture to change, and render the kernels less desirable.

Influence of Humidity. Pecan kernels contain about 3.5% moisture when properly cured to give a good texture. It was observed in certain early tests that pecan kernels, stored in bulk, became spongy and moist and lost some of the original crispness. Analysis showed that the kernels had absorbed moisture. Kernels stored in bulk in storage rooms where the relative humidity was high, ranging up to 85 per cent, increased in moisture from 3.59 to 4.56 per cent in one case: and from 3.37 to 4.80 per cent in another (Table 5). This relatively small increase made a pronounced difference in texture and resulted in an inferior product. On the contrary, kernels that were sealed in cans in the same storage rooms increased only from 3.59 to 3.76 per cent in one instance and from 3.37 to 3.77 per cent in another. These kernels were still crisp in texture and appetizing.

Further tests were made in succeeding years. High humidity was provided by sealing quarter-pound samples of kernels with 2 ml. of water in plain No. 2 tin cans. Low humidity was provided by sealing quarter pound samples with 3 grams of calcium chloride in plain No. 2 tin cans. Calcium chloride absorbs moisture from the air, which in turn absorbs it from the kernels. Kernels in the cans to which water was added, those to which calcium chloride was added, and some that were sealed in cans without treatment were stored from February until November at room temperature, at 40°F, and at minus 10°F. All kernels to which water had been added were spongy, and gum-like at the end of the storage period. The texture was poor. This was true for those stored at all temperatures. Liquid ammonium hydroxide, used as described later in this report, had the same effect on texture as water. The kernels stored with calcium chloride were too dry and brittle. The texture was poor, and the kernels were slightly strong. Those that were sealed in tin cans without treatment remained normally crisp throughout storage, and the texture was considered good.

It thus appears that the pecan kernel readily absorbs or loses moisture from the air. Relatively slight increases or losses of moisture from the optimum of about 3.5 per cent result in inferior texture. Sealing the cured kernels in moisture-proof containers is an easy way of preventing wide fluctuations in the moisture content. Tin cans of various sizes, 5 and 40 gallon cans with screw top lid, and moisture-proof cellophane bags were found effective for this purpose.

If pecan kernels are exposed to warm air as soon as they are removed from cold storage, moisture precipitates on the surface of exposed kernels. The absorption of this by the kernel causes poor texture. It may be avoided by allowing the package to attain room temperature before it is opened, or by keeping the kernels under an electric fan until the temperature has become that of the surrounding air.

Color

Color is one factor by which the quality of pecan kernels is measured. There are differences in the characteristic color of kernels of different varieties; those of the Jersey and Burkett varieties, for example, are normally darker than those of the Schley, Success and San Saba Improved.

Age. Color change can be used as a criterion of the degree of rancidity, where the characteristic color of the variety is known. This is true since a progressive darkening of color indicates an increasing degree of rancidity. As this occurs only at higher temperatures the storage of kernels at a temperature that prevents rancidity, thus preserve the original natural color.

Ammonia. Medlock (6) found that ammonium hydroxide caused kernels of unshelled pecans to turn dark. In some of the earlier tests of this investigation, kernels packed in bulk, in ice cream cartons, and in plain cellophane bags turned black. Subsequently quarter-pound samples of the Schley variety and of a good seedling pecan were sealed in pint glass jars with 1 ml. of 10 per cent ammonium hydroxide. Both seedling and Schley kernels turned dark almost immediately and the Schley ultimately became definitely black. Only the outside covering known as the testa was affected; the meat of the kernel remained normal in color. The taste was not influenced adversely by the change in color though most of the kernels were rendered unmarketable by their unattractive appearance. This type of damage is fairly common when shelled kernels are stored where ammonia is used as the refrigerant. In one case a large quantity of shelled pecans was stored in wooden barrels. The surface layers of kernels in many barrels were found to be black after a storage period which lasted from March until October. They were identical in appearance to those that had been caused to turn black by the addition of ammonium hydroxide. Whenever ammonia leaks from the cooling system it creates a hazard, since the evidence indicates that small amounts cause kernels to turn dark or black in storage.

Insect and Disease Damage

Pecan kernels are frequently rendered unmarketable by becoming infested with insects. The larvae of the Indian meal moth are particularly troublesome. Adult moths lay the eggs on the kernels. Larvae hatch from the eggs and infest the kernels. Kernels should be protected at all times to prevent the moths from laying eggs on them. In this investigation, meal moth damage was encountered in certain samples stored at room temperature, but none at temperatures of 40°F or lower.

Blue mold is likely to develop on kernels if they are not dried sufficiently before being stored, or if the humidity about the kernels becomes too great. In some of the earlier tests of this investigation, kernels stored in bulk, and in plain cellophane bags molded severely (Table 2), even where the prevailing temperature was about 32°F. Analysis of the molded samples showed that the moisture percentage of the kernels had increased appreciably (Table 2). It is evident that a storage humidity sufficient to cause a relatively small increase in moisture content of the kernels is enough to encourage blue mold.

Table 2. Analysis of Pecan Kernels Stored from March 11, to October 1, 1936

Container	Temp. F.	Per cent water content		Texture	Flavor	Free fatty acids (%)	Rancidity (Chemical test)
		Mar. 11	Oct. 1				
Variety 185							
Bulk	—10	3.59	4.56	spongy	good	.15	none
Bulk	32	3.59	....	....	....	....	....
Bulk	40	3.59	4.44	spongy	fair	.22	none
Bulk	room	3.59	3.87	crisp	rancid	.48	trace
Sealed can	32	3.59	3.76	crisp	good	.16	none
Plain Cellophane	32	3.59	4.64	spongy	molded	.93	trace
Variety 208							
Bulk	—10	3.37	4.59	spongy	good	.24	none
Bulk	32	3.37	4.80	spongy	good	.76	none
Bulk	40	3.37	4.15	spongy	fair	.29	none
Bulk	room	3.37	3.73	crisp	rancid	.30	none
Sealed can	32	3.37	3.77	crisp	good	.14	none
Plain Cellophane	....	3.37	4.49	spongy	molded	7.20	none

The writer observed another instance of severe damage by blue mold. Pecan kernels were stored in cardboard containers of 50 lb. capacity. Some of the boxes were stacked with one side only a few inches from the coils of refrigeration pipes. The kernels of each box were molded badly on the side that was next to the refrigeration pipes. Those in other parts of the box were not damaged. It was learned that the pipes were defrosted at intervals by running hot water through them. This warmed the air and possibly caused a precipitation of moisture on the kernels inside the container next to the pipes, which was a condition favorable for blue mold. The mold developed despite the low temperature of 32°F which was maintained, except when defrosting.

Types of Package for Successful Storage

It was early observed that successful storage depends upon proper packaging. Tests were included in this investigation to show the relative value of several different packages for storing pecans.

Quarter-pound samples of kernels of a good seedling, and of the Schley variety were used in the storage tests. The pecans were harvested in late November and kept in common storage until early in February. Kernels of each of the two varieties were packed in the five ways outlined below

Table 3. Storage of Pecans in Different Types of Packages at Four Different Temperatures (Feb. 11 to Oct. 11)

Storage Container	Variety	Results		
		Color	Texture	Flavor
Minus 10° Fahrenheit				
Tin Can	159	bright	good	good
Tin Can	Schley	bright	good	good
Glass Jar, Vacuum	159	bright	good	good
Glass Jar, Vacuum	Schley	bright	good	good
Moisture-Proof Cellophane	159	bright	good	good
Moisture-Proof Cellophane	Schley	bright	good	good
Tin Can + H_2O	159	bright	spongy	fair
Tin Can + H_2O	Schley	bright	spongy	fair
Glass Jar + NH_4OH	159	dark	spongy	fair
Glass Jar + NH_4OH	Schley	black	spongy	fair
Paper Carton	159	dark	spomgy	fair
Paper Carton	Schley	dark	spongy	fair
Tin Can + CA CL_2	159	dark	brittle	sl. strong
Tin Can + CA CL_2	Schley	dark	brittle	sl. strong
Plain Cellophane	159	amber	spongy	sl. strong
Plain Cellophane	Schley	black	spongy	sl. strong
40° Fahrenheit				
Glass Jar, Vacuum	159	bright	good	good
Glass Jar, Vacuum	Schley	bright	good	good
Tun Can	159	bright	good	fair
Tin Can	Schley	bright	good	fair
Glass Jar, Vacuum	159	bright	good	good
Glass Jar, Vacuum	Schley	bright	good	good
Tin Can	159	bright	good	fair
Tin Can	Schley	bright	good	fair
Tin Can + H_2O	159	bright	spongy	fair
Tin Can + H_2O	Schley	bright	spongy	fair
Glass Jar + NH_4OH	159	amber	spongy	fair
Glass Jar + NH_4OH	Schley	dark	spongy	fair
Moisture-Proof Cellophane	159	bright	good	strong
Moisture-Proof Cellophane	Schley	amber	good	strong
Tin Can + CA CL_2	159	dark	brittle	strong
Tin Can + CA CL_2	Schley	dark	brittle	strong
Paper Carton	159	dark	good	sl. rancid
Paper Carton	Schley	black	good	sl. rancid
Plain Cellophane	159	black	good	sl. rancid
Plain Cellophane	Schley	black	good	sl. rancid
Room Temperature				
Glass Jar, Vacuum	159	bright	good	sl. rancid
Glass Jar, Vacuum	Schley	bright	good	sl. rancid
Tin Can + H_2O	159	sl. dark	spongy	sl. rancid
Tin Can + H_2O	Schley	sl. dark	spongy	sl. rancid
Glass Jar + NH_4OH	159	dark	spongy	sl. rancid
Glass Jar + NH_4OH	Schley	black	spongy	sl. rancid
Tin Can	159	amber	good	rancid
Tin Can	Schley	amber	good	rancid
Tin Can + Ca CL_2	159	dark	brittle	rancid
Tin Can + CA CL_2	Schley	dark	brittle	rancid
Moisture-Proof Cellophane	159	dark	brittle	rancid
Moisture-Proof Cellophane	Schley	dark	brittle	rancid
Plain Cellophane	159	dark	brittle	rancid*
Plain Cellophane	Schley	dark	brittle	rancid*
Paper Carton	159	dark	brittle	rancid
Paper Carton	Schley	dark	brittle	rancid

*Damaged by Indian Meal Moth Larvae.
SL=Slightly

Table 4. Showing Condition of Pecan Kernels Stored in Different Containers for Eleven Months at 32° F.

Package No.	Container	Appearance	Texture	Flavor	Remarks
1	5 gal. can.....	good	good	excellent	
2	5 gal. can.....	good	good	excellent	
3	No. 10 can...	good	good	excellent	
4	Cloth bag....	somewhat dark	fair	rancid	Odor of rancid fat in storage room
5	In shell......	good	good	excellent	

and held at the four different temperatures of minus 10°F, 32°F, 40°F, and room temperature: (1) Sealed in plain tin can; (2) in a pint ice cream carton; (3) in a plain cellophane bag; (4) in moisture-proof cellophane bag; and (5) sealed in a vacuum equivalent to 16 inches of mercury.

During other years kernels were stored in 5 to 20 lb. lots with no effort to make the packages airtight, in cloth bags, and sealed in No. 10 cans, 5-gallon cans, and 40-gallon cans. Results given in Tables 3 and observations made throughout the test show that:

(a) Pecans stored in bulk are subject to deterioration in texture, apparently caused by varying humidity. They will turn black if, ammonia leaks into the storage vault.

(b) Kernels sealed in tin cans are protected against deterioration that may result from high humidity, free ammonia, and light, if this is a factor.

(c) Pint size ice cream cartons and common cardboard containers do not protect kernels against absorption of odors. Kernels stored in such containers are also subject to deterioration from high humidity and fumes of ammonia.

(d) Kernels stored in plain cellophane bags may deteriorate from high humidity, excessively low humidity, or ammonia fumes.

(e) Moisture-proof Cellophane bags* are apparently about as satisfactory as tin cans in protecting kernels against ammonia fumes, and changes in moisture content caused by high or low humidity.

(f) Kernels under vacuum and held at room temperature were superior to those stored at the same temperature sealed in tin cans without vacuum. Even under vacuum, however, the kernels did deteriorate when stored at this temperature. They were edible, but were not as fresh and desirable as kernels properly stored at low temperature. When stored under vacuum at low temperature from February until October, the kernels were comparable in quality, but not superior to those that were sealed in tin cans without vacuum and stored at the same temperature.

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*Moisture-proof Cellophane bags supplied through courtesy of Doebeckum Co.

Conclusions

1. The development of rancidity is the most important change that influences the flavor of pecans.

2. Rancidity can be retarded and largely prevented for a period of at least 11 months by storing the shelled kernels at a temperature of 32°F, or lower. Kernels stored at 5°F were perfectly good, edible and marketable throughout a period of 2 years.

3. Kernels remain good and edible for at least a month after being removed from storage. It is believed that kernels do not become rancid more rapidly after being removed from storage than fresh pecans would under the same conditions. The rate at which they become rancid is determined by temperature and other factors, and this rate prevails whether the kernels have or have not been in cold storage.

4. Shelled pecans should be stored soon after harvest, while they are fresh, and before time has elapsed to permit initiation of chemical changes which causes rancidity. If this is done the kernels remain fresh longer after being removed from storage than those that are allowed to become perhaps slightly strong, though not positively rancid, before they are put under favorable storage conditions.

5. Pecan kernels that were sealed while hot in cans or jars, and stored at average room temperature were better than kernels which had been sealed without heating, but definitely not as good as fresh pecans, or those that had been stored in sealed cans or moisture-proof cellophane at low temperature.

6. Kernels that lose moisture measurably below that of normally cured kernels become unmistakably strong and rancid at high temperature; at low temperature they tend to become strong, lose the characteristic taste and flavor, and become unduly brittle. Kernels that increase in moisture percentage above that of normally cured kernels do not become rancid readily even at a relatively high storage temperature, but the texture become poorer.

7. Rancidity causes kernels to become progressively darker.

8. Fumes of ammonia cause the outer covering of kernels to turn black.

9. Larvae of the Indian meal moth are likely to infest pecan kernels. This damage can be avoided by protecting the kernels from moths, by proper packaging and by holding the kernels at a low temperature.

10. Blue mold is likely to develop on pecan kernels if their moisture percentage increases from 3.5 or 4.0 to as much as 4.76 per cent for example. The moisture content does increase if pecans are stored at high humidity.

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