Some Factors Pertaining to the Packaging of Shortening in Glass

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In the past, the major portion of all-vegetable shortenings for the household trade has been marketed in tin cans. These containers were ideally suited for this purpose, the more popular style having such advantages as being practically nonbreakable, completely greaseproof, tamperproof, airtight, light in weight, convenient to open, easy to handle during filling, and moderate in cost.

The national marketing of these shortenings had become completely dependent on metal containers, and a few years ago, it would have been almost impossible to imagine getting along without tin cans.

About a year ago, however, the War Production Board issued an order prohibiting the use of either tin plate or sheet steel for household shortening cans. Fortunately, this first order did not restrict the use of metal caps for glass shortening containers, but their diameter was limited, which explains the comparatively small-sized opening adopted on these jars.

Even the use of metal for caps has now been prohibited, so the manufacturers of household all-vegetable shortenings have had to adopt and assist in the development of a number of new-type packages during the past year.

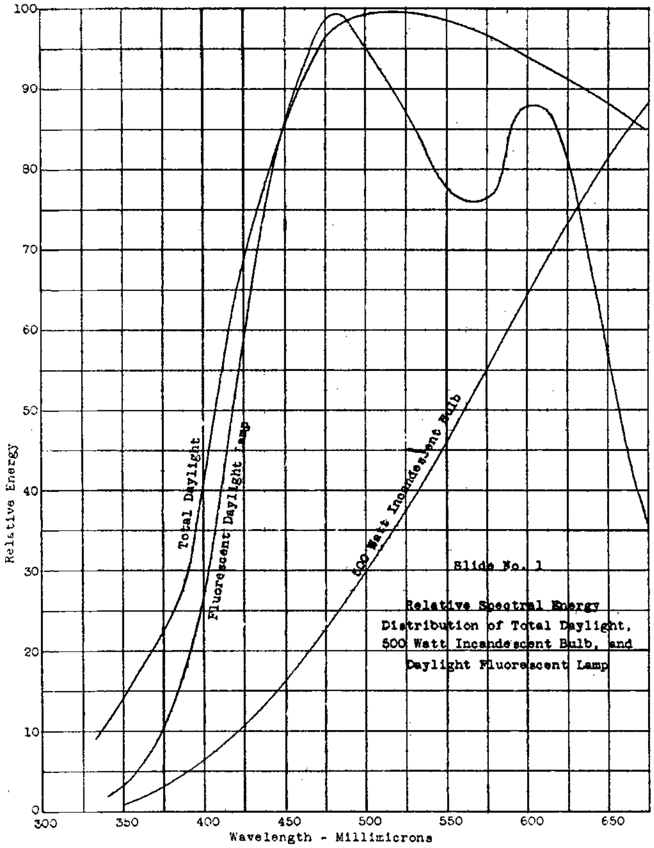
When metal was disallowed for shortening cans, there were only two noncritical substitute materials available in sufficient quantity to meet the industry's needs, namely, paper and glass. Several concerns adopted paper containers that were cellophane-laminated or ones that had inserted cellophane bags, while others selected glass jars.

In view of the large number of papers published during the past ten years dealing with the effect of light on vegetable oils, the influence of light on shortenings is one of the most important points to be evaluated from a commercial standpoint when considering packing in glass containers.

With the exception of a brief reference to the literature, the remainder of this paper deals with the influence of light on shortenings in glass. Messrs. Greenbank, Holm, Coe, and LaClerc (1), who have reported the major portion of the work carried out in this country dealing with the effect of light on vegetable oils, all agree that light accelerates autoxidation and that certain portions of the spectrum are more effective in promoting these changes.

Most of us are apt to consider light as being only that narrow region of the spectrum to which our eyes are sensitive, that is, between about 450 and 700 millimicrons. In reality, light extends considerably below and above this range, the region down to about 100 millimicrons being called the ultraviolet and that above 700 the infrared. From a practical standpoint, however, we are not concerned with light below about 325 millimicrons for several reasons, the principal one being that daylight does not extend below 275-300 millimicrons, and even if it did, the fact would be of no commercial importance because ordinary jar glass screens or filters out light below 300-325 millimicrons. In addition, window glass cuts out light completely below about 320 millimicrons and permits only about 25% of the light to pass at 340.

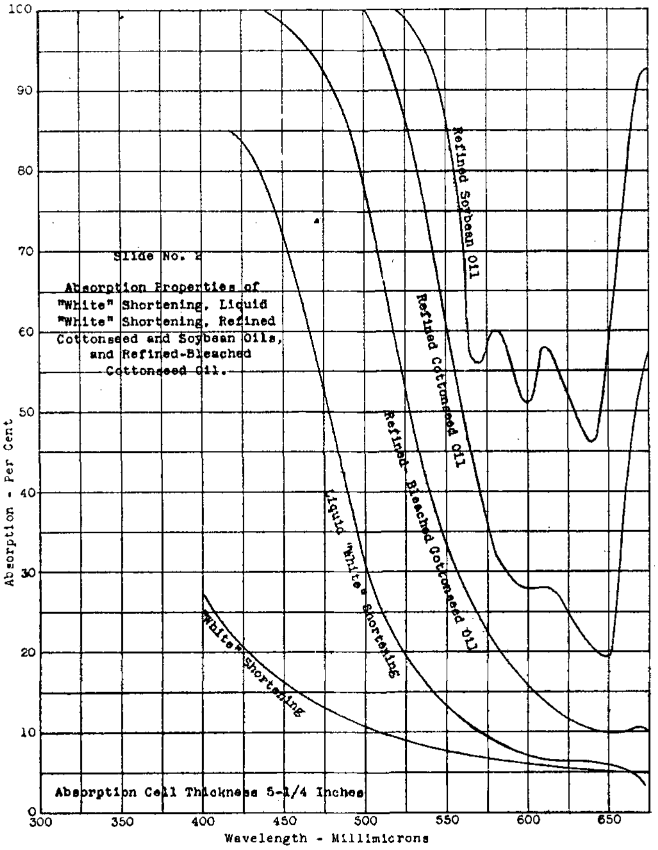
Light from incandescent bulbs does not extend lower than about 350 millimicrons and even the portion below 450 is relatively weak, as may be seen in the first graph. Daylight fluorescent lamps closely approximate the spectral energy distribution of solar light in their energy characteristics and should, therefore, be suitable as a light source for test work.



Vegetable shortenings, especially very white ones, absorb less visible light than do refined vegetable oils. The American investigators in this field seem to have generally used refined oils. This variation is illustrated in Graph No. 2. The shortening absorbed only 10% of the light between 400 and 675 millimicrons, whereas a 5¼-inch column of the refined oil absorbed about 75%. The amount absorbed by the shortening, however, is largely independent of the jar thickness but this is not the case with oil.

This difference in absorption is due principally to the aeration and chilling of the shortening, the fat, under these conditions, acting as a very good reflector of the light. As may also be seen in Graph No. 2, the absorption by the shortening in the liquid state is likewise somewhat less than that of the refined stocks.

This is significant, however, only in that it indicates that a very white shortening will be obtained upon chilling and aeration.



There is also another notable variation in the light absorption between "white" shortenings and liquid oils, regardless of their color. Tests have shown that the comparatively small amount of light absorbed by such shortenings is dissipated within a very short distance. In contrast, oils continue to absorb throughout, and if the container is sufficiently wide, they will absorb practically all the incident light.

According to the Grotthus-Draper absorption law, only light which is absorbed can produce chemical changes, and this is only reasonable. Since, as just shown, light-colored shortenings absorb comparatively little light, it would not be surprising to find that they are relatively unaffected by indoor light of moderate intensity.

The question arises as to what is a moderate interior intensity. So far as stores are concerned, surveys have shown that with an outside intensity of 6500 foot-candles, the interior intensity measured only 15-30 foot-candles on the shelves in the front of the store, 5-15 in the middle, and 1-5 foot-candles in the shaded part (2). Thus, jars on the shelf of a store receive only 1/200 to 1/1300 as much light as they would if stored outdoors. Furthermore, light, after passing through window glass, has lost a generous amount of its invisible ultraviolet.

Hardy and Perrin (3) state that the maximum illumination due to both sunlight and skylight is approximately 10,000 foot-candles, and that the day is considered dreary if the intensity is as low as 1000 foot-candles. They comment, however, that this is in marked contrast to the levels of illumination that are ordinarily produced indoors, where the illumination is commonly in the neighborhood of 20 foot-candles by natural light and less than 10 by artificial light.

In carrying out photochemical tests, one is not usually as concerned with illumination intensity as with the power of the light. For example, even strong ultraviolet radiation has practically no illumination value, but yet this component is generally very effective in promoting photochemical changes. The mean value of the solar constant is 0.135 watt or 135,000 microwatts per square centimeter. Five to ten per cent of this is in the ultraviolet region, 35-45% in the visible and the remainder in the infrared range. Only the 35-45% visible light, however, is effective from an illumination standpoint.

Tests were carried out, by exposing shortening in commercial metal-capped glass jars to two higher indoor illumination values and one representative of average store light, namely, 250, 50, and 5-10 foot-candles. These values were due almost entirely to daylight, the samples exposed to the highest intensity being placed directly in a window. These samples had the usual jar labels and each was spaced several inches from the adjacent ones so as to give access to light from all directions except the bottom. The jars were also rotated once each day so as to insure a more even distribution of the light.

Samples from each of these three sets were examined at weekly intervals, and the peroxide values on the ones stored at the two lower light intensities showed no change even after many weeks. The peroxide value* on the specimens kept at the high intensity was only 1.5 after 10 weeks' time. From an oxidation standpoint, even this value is insignificant and very much less than those reported as being obtained on oils.

The odor and flavor of the samples stored at the lowest intensity remained substantially unaffected for the 10-week period and the ones kept at 50 foot-candles showed only a slight change. The specimens in the window, however, exhibited a flavor and odor change after only a few weeks, and these were very pronounced at the expiration of the 10-week period.

This flavor and odor was quite characteristic and was by no means reminiscent of rancid fat as most of us know it. The failure to develop peroxides, even at the higher light intensities, indicates that indoor light has practically no influence on the oxidation of "white" shortenings in glass jars.

It was considered of interest to determine whether certain wave length bands are more effective in promoting this odor and flavor change than others. Should this be the case, such information would be very useful in selecting a colored jar glass to overcome the effect of strong light, as well as light of moderate intensity over an extended period.

These experiments required the construction of an accelerated light testing machine having approximately the same spectral energy distribution properties as daylight, at least down to 325 millimicrons. Outdoor daylight is obviously unsuitable for this purpose because of its great variation, even from hour to hour, and the impracticability of regulating the temperature of the test specimens. Interior day-

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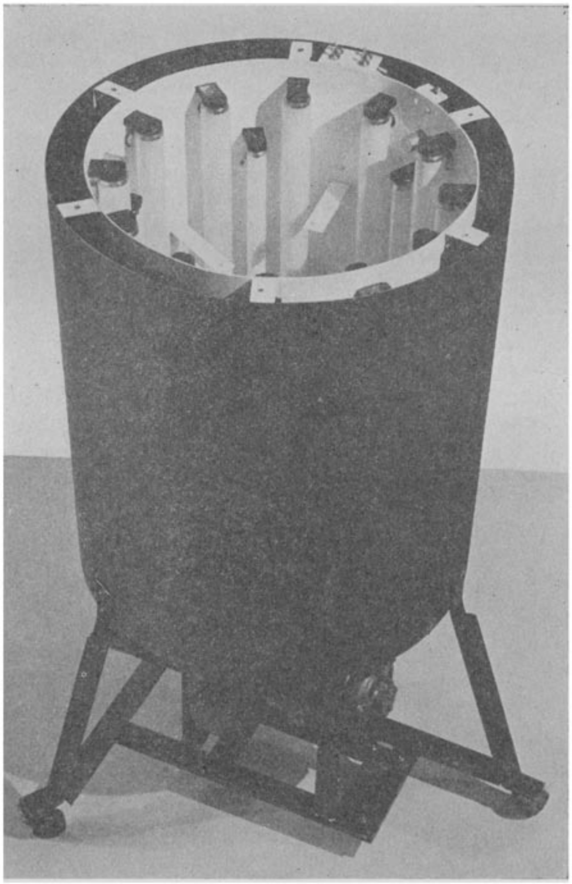
* Millimoles of O_2 per kilogram of fat.



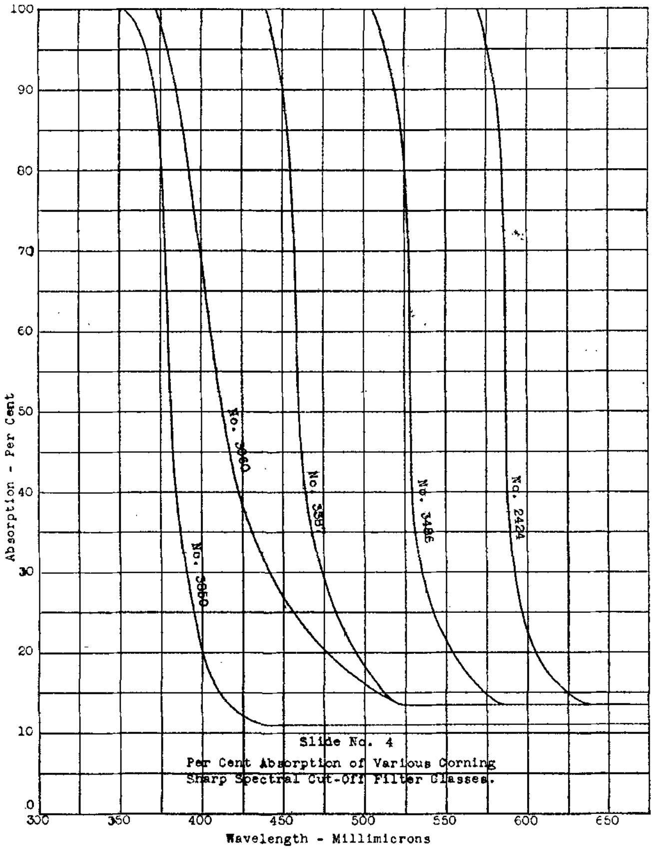
light is likewise unsuitable because of the large variation and its decreased intensity. The accelerated testing also had to be accomplished without increasing the temperature of the samples.

As was shown in the first graph, incandescent light is notably deficient in the shorter wave lengths, and for this reason, was not considered satisfactory as an energy source. Such bulbs also generate considerable heat, and it would be difficult to control the temperature of the samples when using a sufficiently high intensity. Daylight fluorescent bulbs, however, closely approximate solar radiation in their distribution properties and should be suitable. Their slight deficiency below 375 millimicrons can be compensated for by using one or more General Electric 360BL Type F "Black Light" lamps. These bulbs are so termed because most of their light is invisible, their entire radiation, other than infrared, being concentrated between 325 and 400 millimicrons.

With these points in mind, a machine was constructed from a metal cylinder about 18 inches in diameter and 26 inches high. Twelve 24-inch daylight fluorescent and six "Black Light" lamps were mounted parallel to the axis on the inside of the cylinder, and they were so wired that any number of each type could be turned on at one time. It was not necessary, however, to employ any of the "Black Light" bulbs to obtain results comparable with those secured on the samples kept in the window.

A moderate sized blower was mounted on the bottom of the cylinder to control the temperature of the samples. The inside of the cylinder and its top and bottom were painted with a high gloss white paint so as to increase the reflection from the back side of the lamps. The test samples were mounted on top of each other in the middle of the shell, and measurements at the sample positions indicated an intensity of about 1000 foot-candles with the 12 daylight bulbs on. Assuming an over-all reflectance efficiency of 75%, theoretical computations indicate, however, a considerably higher intensity and a power of 0.0172 watt or 17,200 microwatts per square centimeter. The latter is about 25% of the power of direct sunlight between 300 and 700 millimicrons.

Tests were carried out with this machine on shortenings in commercial one-pound metal-capped jars by completely surrounding the jars with different sets of Corning filters. In order to accentuate any difference due to these filters, the usual paper labels were left off the samples. Each set of filters had different cut-off points, the first screening out all the light below about 380 millimicrons, the second below 420 and so on up to 590 millimicrons. The absorption properties of the filters are shown in the next graph, No. 4.



If the samples protected by the first set of filters showed any change in odor and flavor upon exposure, it would follow that this was due entirely to light above 380 millimicrons. And in a like manner, if the ones surrounded by the second set exhibited any change, this must be due to the radiation above 420 millimicrons. The transmission properties of the filters show that the ones with the lowest cut-off values transmit more total energy than the ones with the higher cut-off points. No particular effort, however, was made to compensate for this variation by turning off one or more lights as the exposure period was considered more than ample to accentuate any difference.

The samples surrounded by the first two sets of filters, that is, those cutting out below 380 and 420 millimicrons, had developed a noticeable flavor and odor change after about 200 hours, whereas the ones protected by the filters cutting out below about 460, 530, and 590 millimicrons showed little change. None of these samples, however, developed peroxide values higher than about 1.5.

These results indicate: (1) That the portion of the spectrum between 325 and 460 millimicrons is largely responsible for the flavor and odor change induced by strong light, and (2) that light above 460 has comparatively little influence. Likewise, light below 325 millimicrons probably has a marked effect, but as has been mentioned, from a commercial standpoint we are not concerned with radiation below this wave length.

In view of the low absorption and high reflectance properties of "white" shortenings in the visible range, it is not surprising, however, to find that even very strong light above 460 millimicrons has comparatively little influence on the flavor or odor.

The foregoing results indicate that almost the entire light effect could be overcome by using jar glass screening or filtering out light below 450-500 millimicrons. The general spectral transmission properties of some amber glasses indicate that these should be satisfactory for this purpose.

Accordingly, shortening was exposed in several different commercial amber glass jars in the light testing machine with all the daylight fluorescent lamps on. As was to be expected, these samples showed practically no change in flavor and odor, and their peroxide values were less than 0.5 even after 200 hours' exposure. Tests were also carried out with commercial blue and green jars, but as could be predicted from their general transmission properties, they were not so effective as the ambers.

Similar experiments were also made in opal glass jars. This type of jar is generally used for cold cream and appears to be substantially opaque. This glass was found to be only moderately better than ordinary clear glass, but this is not surprising when one studies the transmission characteristics of opal glass.

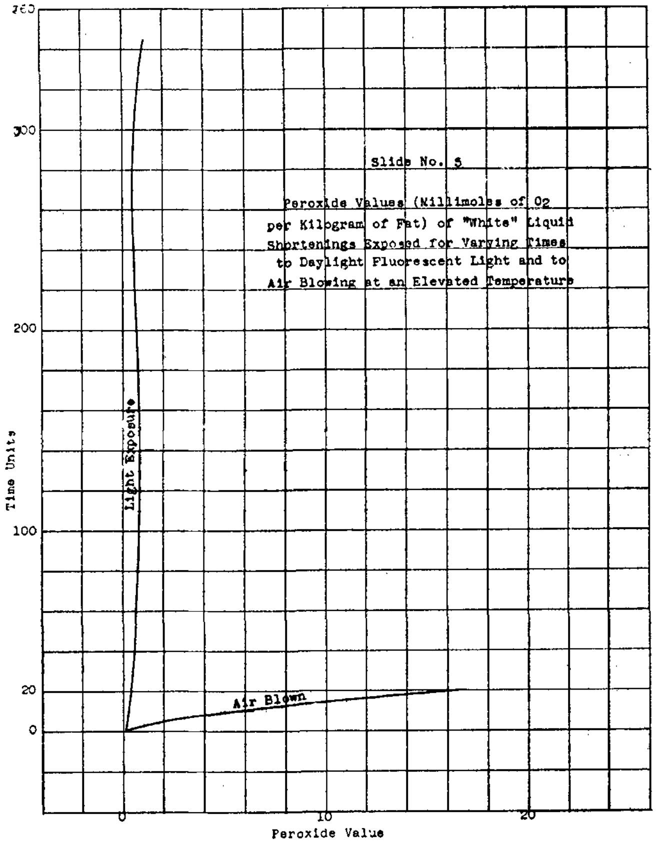
In order to further check the effect of light in the harmful 325-450 millimicron range, tests were carried out on "white" shortening in commercial unlabeled one-pound jars, using the six "Black Light" lamps only. As has been mentioned, the entire radiation of these bulbs is between 320 and 400 millimicrons with a peak at 360.

The effect on the flavor and odor was quite noticeable after only 50 hours. The intensity or power of these bulbs are very much lower than the daylight lamps, but their influence is considerably more pronounced in even a shorter exposure period. These experiments, therefore, also show that shorter wavelength light is much more harmful than the longer visible light rays.

In an attempt to gain an insight as to the changes other than odor and flavor taking place in shortenings exposed to strong light, spectrophotometric absorption curves were made on samples exposed in the light testing machine for varying lengths of time with the daylight lamps. Similar determinations were also made on a series of samples oxidized at an elevated temperature in much the same way as is the case with stocks in the Swift stability machine.

Spectrographic determinations in the ultraviolet region were also carried out on one or two samples from each of these sets. The light test samples were exposed in pyrex beakers about two inches in diameter surrounded by empty commercial one-pound shortening jars. Small beakers were used so as to increase the exposed area with respect to the amount of the shortening, and the empty shortening jars were employed to take advantage of their screening effect in the shorter wave-length region. All twelve of the daylight fluorescent lamps were on during these exposures.

As may be seen from the next graph, No. 5, the peroxide value had increased only a few tenths on the light-treated specimens even after 345 time units' exposure. Their spectrophotometric absorption properties likewise showed practically no change whatever and this was also the case in the ultraviolet region.

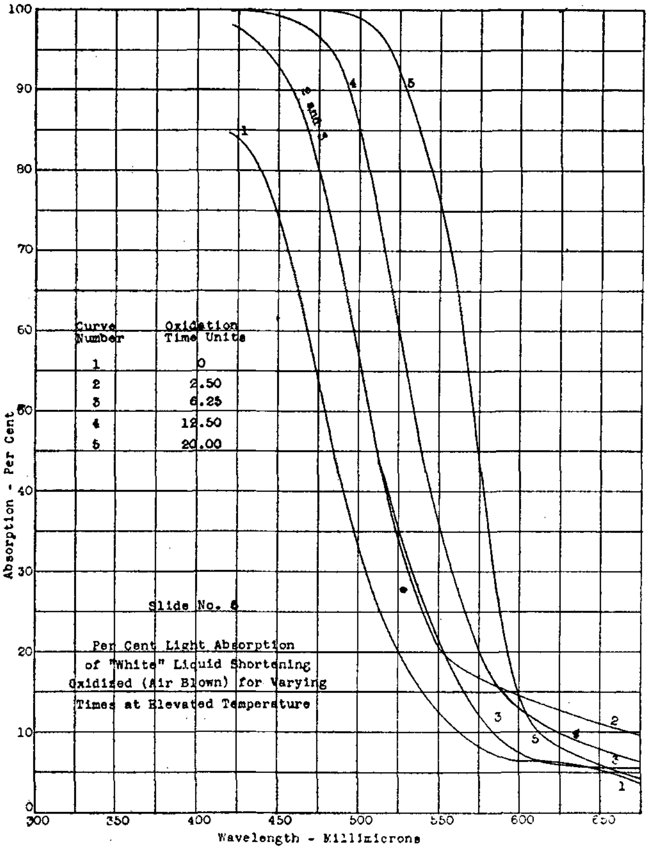


The peroxide values increased progressively on the air-blown samples, as was to be expected. Their absorption characteristics also exhibited a marked change in the visible region as can be seen in the following slide, No. 6. No particular change, however, took place in the ultraviolet region, as was the case with the light-exposed specimens.

Summary

1. Even light of very high intensity has no significant effect on the peroxide development of "white" all-hydrogenated vegetable shortenings. Strong light, however, does cause a flavor and odor change which is not characteristic of rancid fat.

2. When determining the effect of light on shortenings in the laboratory, it is essential that the artificial light source have very nearly the same



energy distribution characteristics as solar light, at least down to 325 millimicrons.

3. Light between 325 and 500 millimicrons is more effective in promoting an odor and flavor change in "white" shortenings than longer wave lengths.

4. Certain amber colored glass jars almost completely nullify the influence of light on the flavor and odor. Green and blue colored jars are helpful, but much less so than amber jars. Although appearing substantially opaque, opal glass jars are of little value in minimizing the effect of light.

5. Even strong light modifies the absorption properties of liquid "white" shortening very little in the ultraviolet and visible ranges.

6. Air-blowing liquid "white" shortening at an elevated temperature causes the absorption to increase perceptibly in the blue end of the visible range, but has no significant influence on the absorption in the ultraviolet portion.

REFERENCES

(1) Coe, Mayne R., Oil & Soap, 15: 230-6 (1938).
Coe, Mayne R., Oil & Soap, 16: 146-7 (1939).
Coe, Mayne R., Oil & Soap, 18: 241-7 (1941).
Greenbank, G. R., and Holm, G. E., Ind. and Eng. Chem., 25: 167 (1933).
Greenbank, G. R., and Holm, G. E., Ind. and Eng. Chem., 33: 1058-60 (1941).

(2) Powers, J. J., and Esselen, W. B., Jr., Ceramic Industry, 39: 36-38 (1942).

(3) Hardy, M. A., and Perrin, S. M., The Principles of Optics, 161 (1932).

Report of the A.O.C.S. Cellulose Yield Committee 1942-1943

During the past year linter samples were sent out once a month from September through March by the committee to thirteen laboratories equipped to run the cellulose yield tests. Seven sets of three to five samples each were run by nine of the laboratories. Two laboratories ran six sets and one ran five sets of samples. One laboratory ran three sets.

Results of two linter samples and one hull fibre sample were tabulated and are given below. Only those laboratories which completed all samples are included in the overall average for the year.

It is believed that sending out these samples once a month was well worth while. The check results between laboratories were surprisingly good.

Recommendations

It is recommended that samples be sent out next year at least ten months out of twelve. Also that laboratories equipped to run the yield test notify the Chairman of the Yield Committee if they would like to receive the check samples.

Lab No.	No. Sets of Samples Tested	Samples			Overall Average Year
		A Linters	B Linters	C Fibre	
1	7	79.0	73.1	69.4	73.8
2	7	78.5	72.7	68.6	73.3
3	7	78.4	72.6	68.7	73.3
4	5 (1)	78.1	72.4	68.1	
5	6 (2)	79.1	73.1	70.5	
6	7	78.7	73.2	69.7	73.9
7	7	78.2	72.6	68.9	73.2
8	7	78.6	73.6	69.7	74.0
9	7	78.7	72.9	69.5	73.7
10	7	79.1	73.5	69.9	74.2
11	7	78.6	72.8	69.4	73.6
12	6 (2)	79.0	73.5	70.5	
Avg. (seven sets only).....		78.6	73.0	69.3	73.7

(1) Two sets not run. (2) One set not run. These mills omitted from grand average.

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