Physiological and Other Factors That Influence Color Readings*

By P. McG. SHUEY

President, Shuey & Co., Inc.,
Savannah, Georgia

On account of the unusual season we have just had with respect to damage to cottonseed in the southeastern section, the color of most of the shipments of cottonseed oil have been found off grade, which has given greater importance than ever to this determination of refined oil.

Our color committees have done a good work towards standardizing our method, and our Lovibond glasses have been well standardized both by the Bureau of Standards and the Electrical Testing Laboratory, and what I have to say here is to mention a few of my own observations and point out briefly some of the factors that influence results with the end in view that an increase in the understanding and appreciation of these factors, chemists will obtain results that are closer together.

Sometime ago I made a check on the reading of a sample of oil in three different laboratories using the same tube of oil, the same type of instrument and color glasses in each case. The sample was not of a high red color, but the differences found were sufficient to cause me to look into the cause.

The results found by three observers in each laboratory, who agreed with each other, was as follows:

Laboratory No. 1—35 yellow, 4.4 red.

Laboratory No. 2—35 yellow, 4.0 red.

Laboratory No. 3—35 yellow, 4.3 red.

The only difference in making the three observations was in the location of the instruments with respect to the outside light. In laboratory No. 1, the tintometer was placed inside of a hood that was enclosed on all sides except the open end from which the observations were made; in laboratory No. 2 the instrument was left open near the middle of the laboratory that got light from the top through sky lights, while in laboratory No. 3, it was practically enclosed with a window near by, otherwise the enclosure was of dull black walls.

It is noteworthy that the readings made in laboratories No. 1 and 3, in which conditions were somewhat similar, are in close agreement but in the case of No. 2 in which the instrument was placed in the open laboratory there was considerable difference.

Those experienced in reading colors have also observed differences in the same laboratory depending upon the amount of outside light present, and that one result will usually be obtained on a bright sunny morning while another will likely be obtained in the afternoon or on a cloudy day, and after taking this matter up with eye specialists, I find that the cause of the differences is mainly physiological on account of differences in the adjustment of the eye under different conditions.

I have also found by experiment that when readings are quickly taken, after which the eyes are closed for a period of two minutes and then taken again that slight differences are sometimes found, but I have noticed from experiment that far greater differences occur depending upon whether the instrument is located in a hood or in the open laboratory, and a table of results giving the results of some experiments by two observers is here attached. This table also shows comparisons between immediate reading and those obtained after closing the eyes for two minutes; also the rather indefinite results found on a very dark sample when read at full depth (5¼ inches) with very definite readings obtained when taking one-half and one-fourth of the standard depth, and employing 35 and 20 yellow glasses respectively.

The purpose of using a 20 yellow glass was in the nature of an experiment as some may take the position that when the depth is reduced, the amount of yellow should be reduced proportionately. Of course, a proportionate amount would be a 17.5 yellow glass for reading a 2⅝ inch column sample; however, my experiments show that in some cases results were identical whether a 35 or 20 yellow glass was used, while in other cases there was considerable difference.

Since we do not make readings higher than 50 red, which is a rather indefinite realm as far as accuracy goes, and as one can make a reading of 25 red quite definitely, it appears that the 2⅝ inch column fits into the picture very nicely when reading very dark oils, and I am sure that chemists would come much closer together by following such a procedure.

Another point is that at times when a reading is made which at the moment appears quite a definite match, after a few moments of observation, the red color is separated more distinctly after which a change in the glasses is necessary in order to obtain a match. This difference between the first and second read-

TABLE I.

Results Found in Making Color Readings Under Different Conditions		Inside of Hood (Red)		Open Laboratory (Red)	
Full amount, 5¼" ..... Immediate reading	35-Y	.....	22.0	.....	22.5
" " " ..... After closing eyes 2 min...	35-Y	.....	22.0	.....	21.4
Half the amount, 2⅝" .. Immediate reading	35-Y	11.2x2	22.4	10.6x2	21.2
" " " " .. After closing eyes 2 min...	35-Y	11.2x2	22.4	10.6x2	21.2
" " " " .. Immediate reading	20-Y	11.0x2	22.0	11.4x2	22.8
" " " " .. After closing eyes 2 min...	20-Y	11.0x2	22.0	11.2x2	22.4
Second Sample:					
Full amount, 5¼" ..... Immediate reading	35-Y	.....	†36.8	.....	†37.0
" " " ..... After closing eyes 2 min...	35-Y	.....	†36.0	.....	†35.5
Half the amount, 2⅝" .. Immediate reading	35-Y	16.8x2	*33.6	16.8x2	*33.6
" " " " .. After closing eyes 2 min...	35-Y	16.7x2	*33.4	16.7x2	*33.4
" " " " .. Immediate reading	20-Y	16.0x2	*32.0	16.0x2	*32.0
" " " " .. After closing eyes 2 min...	20-Y	15.9x2	*31.8	16.0x2	*32.0
¼th " " 1⅛" .. Immediate reading	35-Y	8.5x4	*34.0	8.3x4	*33.2
" " " " .. After closing eyes 2 min...	35-Y	8.5x4	*34.0	8.3x4	*33.2
" " " " .. Immediate reading	20-Y	8.5x4	*34.0	8.3x4	*33.2
" " " " .. After closing eyes 2 min...	20-Y	8.5x4	*34.0	8.3x4	*33.2

†Reading indefinite. *Reading definite.

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ings is due to the adjustment of the eye which always takes time.

I have had the opportunity to see a demonstration by a physician in the use of the fleuroscope in which readings of the heart, lungs, etc., are made by the X-ray and I find that physicians who do this work allow themselves to remain in a dark room for a period of from ten to twenty minutes before taking their readings in order to allow time for the adjustment of the pupils of the eyes through dilation. The importance of waiting in a dark room in making clear and definite readings in this case was clearly shown by passing the X-ray through a thick layer of blank paper at the bottom of which were letters and figures which could not be at first read, but which later were clearly revealed. I do not intend to infer from this experiment that we should change our method to take color readings under the same conditions (although it probably would increase accuracy), but I mention this to show something of the eye-adjustment process which varies with different individuals, and here is where the personal equation comes in.

As information from the standpoint of the instrument and the non-symmetry of the eyes in the individual, I have a letter which was kindly written by Mr. Roger S. Estey of the Photometric Department of Electrical Testing Laboratories which I would like to quote:

"In my opinion, the principal conditions affecting variations in Lovibond readings (assuming the sample and the matching glasses to be identical in all cases) are:

"(a) Variations in the color of the light source. These can be reduced by agreeing to use a standard source such as, for example, a standard lamp operating in connection with a standard blue filter.

"(b) Non-symmetry in the instrument. The instrument may contain reflecting or transmitting surfaces which, due to yellowing with age or accumulation of dirt, oil films, etc., have slightly modified the color of one beam with respect to the other. This may easily amount to a few tenths red on the Lovibond scale.

"(c) Temperature of the oil sample. I do not know what the temperature co-efficient of these samples is but presume that in the most careful interlaboratory comparisons a uniform oil temperature would have to be selected and maintained.

"(d) Non-symmetry of the eye. It is well known that even perfectly normal observers do not have exactly the same color sensitivity in each of their two eyes and, furthermore, that even one eye has a color sensitivity which is non-uniform across the retinal field. This effect and the effect described under (b) above can be eliminated by grading oils with the sample on the left and repeating with the sample on the right. The grade representing the average of these two measurements would eliminate any lack of color symmetry in the instrument or in the observer. (e) Unsymmetrical reflectance in the instrument.

"(f) Brightness differences in the photometric field. These elements produce a lack of symmetry in the measuring procedure which would undoubtedly contribute to a greater or less degree to uncertainties in the values of oil samples measured.

"It is important in the interests of accuracy to have the illumination through the tintometer as bright as the observer finds comfortable. Lower illuminations will lead to discomfort and inaccuracy. As regards the use of a dark room, it is naturally important that the eyes of the observer should not have to undergo large changes in adaptation when he starts to use the instrument. The eyepiece should be shielded from stray light which would produce confusing and tiring stimulation of the margins of the visual field. I do not see how these difficulties would affect the readings directly but undoubtedly the observer would quickly become tired and confused."

In conclusoin, I feel that the main differences caused by chemists are two in number: (1) The reading of samples in the midst of the eye-adjustment process, and (2) the reading of samples that are too dark in color for comparisons to be properly made.

I believe that correction in large measure for the eye-adjustment process would be brought about by having a suitably constructed and standardized hood and requiring that chemists look into the dark spaces of the hood for a definite period before taking their readings.

Finally concordant results may be obtained in the reading of dark oils of more than 25 red by taking half the usual column, namely, 2⅝ inches, and whatever yellow glass the Color Committee might decide upon, and then multiply the reading of red by two.

REPORT OF THE SMALLEY FOUNDATION COMMITTEE*

WE are presenting herewith the 18th report of the Smalley Foundation Committee of the American Oil Chemists' Society. During these past eighteen years considerable progress has been made in the accuracy of the determination of Oil and Ammonia on cottonseed meal. According to our rules the cup, which represents the best results in both Oil and Ammonia determinations, must be won by a collaborator three times before it becomes his permanent possession. This has occurred on two occasions, the first cup having been won by Dr. H. B. Battle. This cup was presented by the Industrial Chemical Sales Corporation. The second cup, which was presented by Dr. Battle, was won by Dr. W. F. Hand, and he immediately replaced the cup by a third, which now stands as the trophy for the second year.

As usual, thirty samples of cottonseed meal were distributed to the collaborators. The results, as a whole, are on the same high plane as those of the preceding years, the differences in percentage of perfection being so small as to be almost negligible. During the year it was decided to send out one meal sample which differed from the rest. This was sample No. 10, which had a higher oil content than the others and was passed through a 20 mesh screen when it was prepared. We felt that this was not unlike samples that come into the laboratory of a great majority of the members who participated in this cottonseed work

*As presented at the Spring Meeting, A. O. C. S., New Orleans, May 28-29, 1936.