Grading Cottonseed by Net Kernel and Fatty Acid Methods

From Addresses Delivered Before the Interstate Cottonseed Crushers' Convention and American Oil Chemists' Society

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Last year I had the honor of discussing with you some of the arguments which had led me to advance the theory that the net kernel content of the "as is" ton of cottonseed was an index of the value of the seed. At that time, I had very little data in the way of analyses on which to prove the case. This was because in the past practically all analyses have been made on a clean seed basis. My argument, therefore, was based very largely on the results of studies of cottonseed that had been made in connection with the breeding of cotton varieties and on mathematical deductions.

I attempted to show also that if this theory of grading cottonseed were true and it were possible to construct a machine by which the kernels could be extracted from a fully representative sample, the grade could be determined at the time of loading a car as well as on its receipt at the oil mills. Check determination would therefore be possible by both shipper and receiver and the way would be prepared for the development of some plan for official sampling and grading similar to that now employed in the grading of grain.

I was limited in my discussion to the question of quantity of products possible in prime seed and did not discuss quality, since, as I stated, it was my belief that the present method of determining quality, by cutting one hundred seed and noting the percentage of kernels showing discoloration, was not only scientifically unsound but was fallacious in that it did not indicate the true quality of the oil.

During the past season, we have secured very complete analyses of over 4,000 cars of seed, representing seed produced in practically every state from North Carolina to Oklahoma. These are being carefully studied and we have already prepared several graphs from them.

Grading for Quality

First, let us consider the question of quality. Very shortly after the last convention, the American Oil Chemists' Society appointed a special committee for the purpose of studying methods of determining damage in cottonseed. This committee, as many of you doubtless already know, found that the cut method was of dubious accuracy and has brought about a new method, by which the actual percentage of free fatty acid in the oil is determined. I have been so fortunate as to secure the analyses of nearly 3,000 cars in which damage was determined by both the cutting method and by the method in which the free fatty acid in a sample of the oil is determined by titration. From these data graphs of the analyses of cars originating in each state have been made, but

I believe one or two of the graphs will suffice to illustrate the point and make it clear that the color of the kernels, which is the basis of the cutting method of determining damage, has no apparent relation to the quality of the oil.

In the first graph, the analyses of one hundred cars have been arranged in order of increasing rank of percentage of damage as deter-

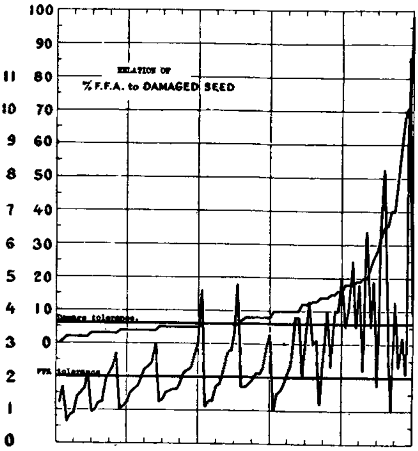

Fig. 1. *Relation of damaged seed (discolored meats) to Free Fatty Acid in cottonseed oil. Analyses of* 100 *car lots arranged in sequence of increasing damaged seed*

mined by the cut method. These range from 100 per cent sound to 98 per cent damage, as shown by the top curve. The corresponding free fatty acid content of each of these cars is shown by the jagged line.

Out of these 100 cars, 51 were rated as prime seed by the cut method. But 18 of these 51 cars, or 35.2 per cent of them analyzed above 2 per cent free fatty acid in the oil. In two cases, the free fatty acid content was higher than was the free fatty acid in 43 of the cars that cut above 6 per cent damaged seed, including the cars that cut 40, 50, 60, 70 and 98 per cent damage. Of the 49 cars that cut above 6 per cent damage, 12 cars, or 24.5 per cent, produced oil with less than 2 per cent free fatty acid.

To sum up, in 100 cars, 49 cut off seed, or above 6 per cent damage, and practically 25 per cent of these produced prime oil. 51 of the cars cut prime seed and 35 per cent of these produced off oil.

Two of the cars cutting above 35 per cent damaged seed produced prime oil. 23 of the cars cut 15 per cent or more damaged seed but only 8 of these showed above 4 per cent free fatty acid. Of the 56 cars of off oil 19 cut prime seed. Of the 49 cars of damaged seed, 12 gave prime oil. The car cutting the highest damaged seed showed less than 4 per cent free fatty acid and nearly 1 per cent less free fatty acid than 2 cars that cut prime seed.

In the second graph, the opposite picture has been drawn. Here are shown the analyses of 139 cars, all of which tested 2 per cent or more of free fatty acid. These analyses have been arranged in rank of increasing free fatty acid. The corresponding percentage of damage as found by the cut method is shown in the irregular line. Of these 139 cars, we find that 54 cars, or 38.8 per cent, cut prime and yet 45 of them contained above the tolerance of free fatty acid.

These two graphs are sufficient to show that the cut method of determining damage has no scientific basis and its use more frequently inures to the damage of the oil miller than to the ginner or producer of seed. The method has no apparent place at present in evaluating cottonseed. Possibly it may be found to have a place in evaluat-

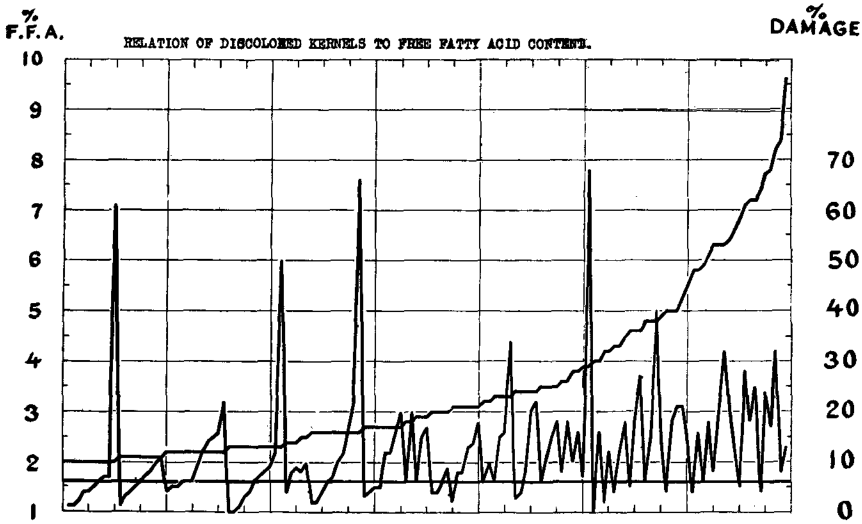

Fig. 2. Relation of Free Fatty Acid in cottonseed oil to discolored kernels (damaged seed). Arranged in sequence of increasing Free Fatty Acid

ing the color and other qualities of the meal. The direct determination of the free fatty acid content seems to be a much more sound method and has, moreover, the advantage, as your chemists will advise you, of having a direct relation to the color and manufacturing loss in the oil produced.

So much for the question of quality. Let us turn to the question of quantity or the quantitative grading of cottonseed.

Quantitative Grading

It has been impressed on me on several occasions that possibly the greatest obstacle to an understanding of the theory of grading cottonseed on the basis of their net kernel content is the difficulty of getting those engaged in the industry to think in terms of anything other than averages. Last fall I sent out a number of letters asking that certain specific data, relative to receipts of seed be kept during the current season, so that I might have material for study. In reply, generally I was referred to reports of *averages,* but I wanted data from which not only the averages for the season would be calculated, but new and unusual analyses for the purposes of these studies.

According to the dictionary, an average is "a mean proportion made out of unequal sums or quantities."

What are the unequal quantities, related to raw cottonseed, that should be considered in making the averages of seed purchases? In cottonseed we find inequalities in three characters: First, there is an inequality in the percentage of oil in the meats. Second, there is an inequality in the percentage of protein in the meats. And, third, there is an inequality in the percentage of meats in the seed.

Now, next let us see if there are any relationships between these inequalities. We do find a general and fairly constant relationship between the percentage of oil and the percentage of protein. The relationship is in inverse ratio. That is, the higher the percentage of oil, the lower the percentage of protein, and vice versa, the lower the percentage of oil the higher the percentage of protein.

But there appears to be no relation between either the percentage of oil, or of protein, in the meats and the percentage of meats in the seed. Therefore, we may have different lots of seed contrasted as follows:

Seed with:

(A) High meat percentage and high-oil-low-protein.

(B) High meat percentage and low-oil-high-protein.

(C) Average meat percentage and high-oil-low-protein.

(D) Average meat percentage and low-oil-high-protein.

(E) Low meat percentage and high-oil-low-protein.

(F) Low meat percentage and low-oil-high-protein.

(G) Seed falling between each of these.

Regardless of the current value of the oil and meal, the greatest difference in the values of any two lots of seed will be found between that lot which analyzes the extreme low kernel and oil content (F) and that other lot of seed which analyzes the extreme high kernel and oil content (A).

Suppose we call this extreme difference in value a "100 per cent spread."

Now let us compare the values of the products obtainable from two lots of seed analyzing as "A" and as "B". The difference in value is approximately 24 per cent of this total possible spread.

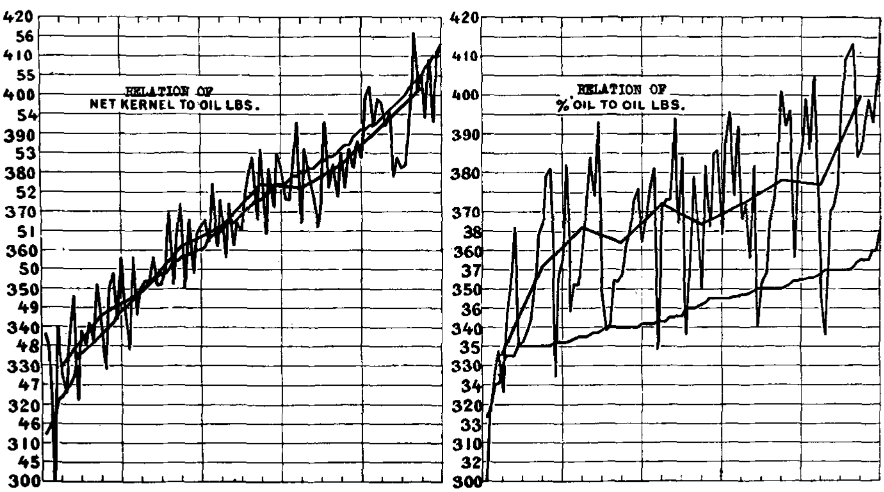

Fig. 3. Relation of the net kernel percentage of "as is" cottonseed to the total available pounds of oil. Right, same car lots arranged to show the relation of the percentage of oil in the meats to the total pounds of oil

With two lots analyzing as "C" and "D", the difference in value of the products is approximately 23 per cent of the total possible spread.

With two lots analyzing as "E" and "F", the difference in value is approximately 18 per cent.

But when we compare a lot of seed analyzing as "A" with another lot analyzing as "E", we find the difference in value of the products is approximately 82 per cent of the total possible spread.

A comparison of seed analyzing as "B" with those analyzing as "F" shows an approximate difference in value of 77 per cent of the maximum spread.

These differences are based on the extremes of oil-in-meats percentage (25 per cent to 39 per cent) and the average range of meat content. A comparison based on the usual differences in the oil-in-meats percentage makes the differences in values of the products even more contrasted. In the East during the last season about 90 per cent of the analyses showed between 34 per cent to 37 per cent of oil. In the West this runs somewhat lower, approximately 30 per cent to 33 per cent.

Possibly it might make this argument a little easier to understand if we assigned definite values in place of percentage of spread. With oil at 10 cents and 7 per cent meal at 2 cents the difference in value of the oil and meal between two tons of seed, one analyzing 42 per cent net kernel and 34 per cent oil and the other analyzing 59 per cent net kernel and 37 per cent oil, is approximately $20.00. Call this $20.00 our maximum spread.

Then the difference in value between two tons of seed analyzing as "A" and "B" would be $1.56. Between two tons analyzing as "C" and "D" $1.26, and between two tons analyzing as "E" and "F" $1.05. But the difference in value between two tons analyzing as "A" and "C" is $10.00 and between two tons analyzing as "B" and "D" is $9.70, and between "C" and "E" seed $8.95, and finally, between two tons analyzing as "A" and "E" the difference in value of the oil and meal is $18.94.

The outstanding conclusion to be reached from these figures is that in purchasing cottonseed for crushing, the kernel or meats content is the principal factor or value, since the differentials on account of oil percentages are nominal in comparison with value differentials on account of kernel percentages.

Let me remind you that for the purpose of grading seed on the net kernel content, I am proposing to consider everything as foreign matter that is not kernel, or that has to be specially processed in order to secure the kernel, such as grabots. Therefore, in preparing the graphs from the analyses secured this season, I have added together the percentage of excess moisture, the percentage of dirt and trash and the percentage of grabots and thus found the number of pounds of foreign matter in the seed. But this leaves another form of foreign matter; immature or aborted seed. Immature and aborted seed are stated in percentages, but, as you know, it is not a percentage of weight but a percentage of number. After a number of trials, I found that immature seed weighed approximately 0.36 per cent of the weight of sound seed, or 7.2 pounds per ton for each numerical percentage; therefore, to the total pounds of foreign matter found as above, 7.2 pounds was added for each per cent of immature seed. From this the net pounds of seed was ascertained, then, using the percentage of kernels in clean seed, the net pounds and percentage of kernels in the "as is" ton were easily calculated.

Having determined the net kernel content and knowing the percentage of oil in the meats, the total pounds of oil in the "as is" ton was readily calculated.

In this way similar data was calculated on several hundred cars of seed originating in each state. For the purpose of graphs, this number was reduced to 100 analyses, by throwing out the duplicates and the near duplicates. Then the analyses were arranged first in order of increasing rank of net kernel percentage with the corresponding pounds in oil, as shown on the left side of Graph No. 3. You will note the close relation of the pounds of oil to the net kernel. Next, the analyses of the same cars were arranged in the rank of increasing percentage of oil in the meats with the corresponding total pounds of oil, as shown on the right side of the graph. In the first case, where the analyses are arranged in order of increasing percentages of kernel, the variation in the pounds of oil is due to the differences in the percentages of oil. Notice the narrow range of variation as compared with the variation in the pounds of oil when arranged in rank of increasing oil percentage, where the variation is due to the differences in the net percentages of kernels.

In one case I went a step further and calculated the total value of the oil and protein or cake as shown in Graph No. 4, in which I have arranged the analyses of the same 100 cars of seed in four different ways. First, in rank of increasing percentage of oil in the meats with the corresponding values of oil and meal. Second, in rank of increasing net kernel content with the cor-

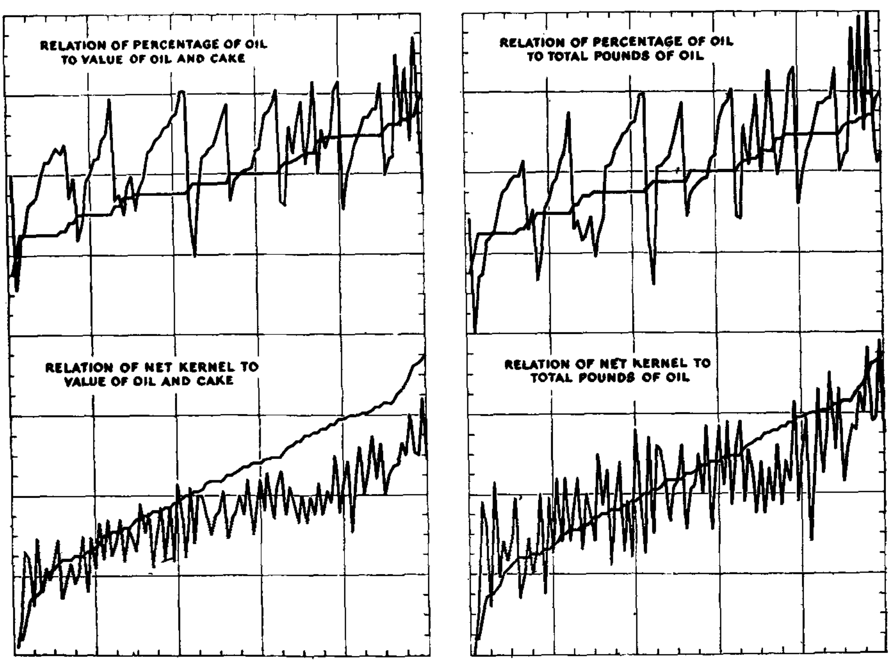

Fig. 4. Analyses of the same 100 *car lots of cottonseed arranged to show the better relation of net kernel content to both value of products and total pounds of oil, than is the relation of percentage of oil*

responding values of the oil and meal. Third, in rank of increasing percentages of oil with the corresponding total pounds of oil, and fourth, in rank of increasing net kernel content and the corresponding total pounds of oil.

Where the graphs are arranged on increasing oil percentages, the variations in value are due to differences in net kernel content and to variation in protein. The variations in total oil are the result of differences in the net kernel. Where the graphs are arranged in increasing net kernel content, the variations in value are the results of differences in the oil and protein content and in total pounds of oil resulting from differences in the percentages of oil.

You will notice that the variations in value of the products as compared to the pounds of oil are more narrow. This is because of the variable protein factor.

I believe that these charts will bear me out that the net kernel content of the "as is" seed is more frequently and a closer index of value of cottonseed than any other single factor. And it is logically so, since it is a direct index of the amount of both the oil and the cake, the two principal and frequently co-ordinate products of your industry. Moreover, the net percentage of kernels when used for grading purposes has very distinct advantages, as pointed out in my address at Asheville on July 1, last, in that it carries premiums for good cultural and ginning practices as well as penalties for the opposite, poor cultural practices and indifferent and culpable practices at ginneries.

The graphs I have used are from seed originating in South Carolina. I have graphs for seed originating in some of the other states which I will be glad to show all who may be interested.

Practical Application

This brings us to the practical application of the theory of grading in the purchasing of cottonseed. First, we should decide upon a base. The average kernel content of clean seed for all analyses I received this year was 54 per cent. Suppose we split the difference between a theoretical average of 50 per cent and a practical average for clean seed of 54 per cent and make our base 52 per cent net kernel in the "as is" ton. If 52 per cent net kernel had been established as the basis during last season, the cars for which I received analyses would have fallen into the following groups:

31 per cent would have received premiums.

19 per cent would have received the basis price.

50 per cent would have received discounts.

The premiums would have been paid for clean seed of better than the average quality, and the discounts would have been based on the inferiority of the shipments resulting from the growth of nondescript varieties and excesses of foreign matter.

You will recall that last year in my discussion of the scheme of grading, I stated that the basis grade and the grade limits could be determined only after sufficient actual analyses had been made in practice. Two changes are now being proposed on the basis of the analyses we now have: First, that the basis grade be 52 per cent net kernel instead of 50 per cent, and second, that each percentage of increase and decrease in the net kernel carry its appropriate premiums and discounts. At first, I suggest-

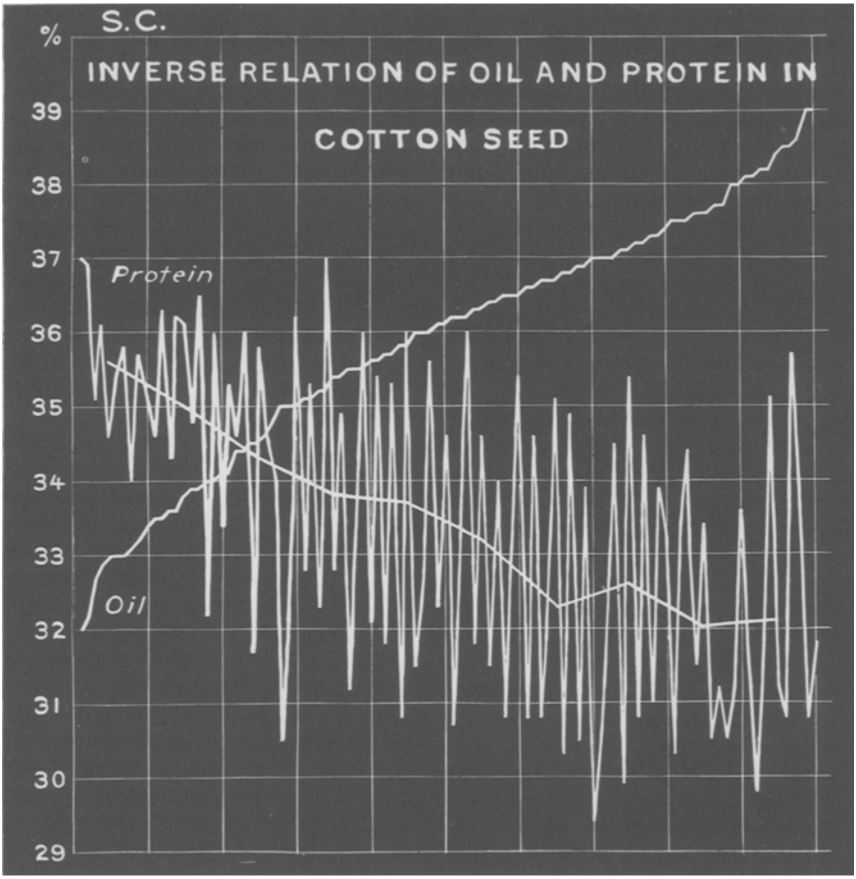

Fig. 5. Graphic representation of the inverse ratio of oil and protein in cottonseed as shown by analyses of seed from South Carolina

ed that each grade comprehend three per cent of net kernel, but experience has shown that the value differentials would be too wide and I am accordingly now suggesting single percentages of net kernel as the basis of the grades.

There is one other chart in which you may be interested, that shown in Fig. 5, above. This shows in graphic form the inverse relationship between oil and protein in cottonseed. This is not offered as a new discovery but I believe it has not been brought to your attention in graphic form before this. The results of analyses for oil are plotted on the ascending curve and the progressing average of protein analyses is represented by the line descending from left to right.
