and palmitic acids. Physical properties of these mixes were determined, resulting in data showing composition versus titer, melting point, refractive index, hardness, shrinkage, and crystallinity.

Refractive index measurements did not give desired accuracy when applied to commercial products although they appeared to be accurate when using pure acids.

A definite, easily perceptible crystalline range is between 50/50 and 60/40 palmitic/stearic ratio. The addition of palmitic or stearic as necessary to determine limits of the crystalline range permits calculation of the unknown with a fair degree of accuracy.

The composition versus titer curves were found to be reproducible and accurate. Composition of a sample may be determined directly when the titer falls on the steep part of the curves. Samples with titer on the eutectic or on the flat part of the titer curve require the addition of stearic or palmitic acids to obtain a titer on the steep part of the curve. The composition of the unknown is then calculated from the composition determined on the mix. The myristic acid content is estimated from the source of the sample, and oleic acid is calculated from iodine value determination.

Of the three methods presented in this report, the titer method proved to be the most versatile and reliable. The use of crystal inspection was surprisingly accurate but had the disadvantages of requiring several mixes, and accuracy relied on visual inspection of crystals. The use of refractive index for composition determination, although rapid in nature, only had an accuracy of about 5.0%.

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Nomographs for Calculating the Fatty Acid Composition of Oils and Fats From Iodine and Thiocyanogen Values

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NOMOGRAPHY is a rapid and relatively accurate means of graphic analysis. In a nomographic or alignment chart an index line intersects three scales of values which satisfy an equation involving three variables. When more than three variables are present, auxiliary lines are also constructed to read the value of a variable when the other variables are known. The precision of these charts depends on the selection of scale and the design and accuracy of the graduations on the axes.

Nomography has been frequently employed in chemical engineering to avoid multiplicity of routine calculations in operating a process or designing equipment and also in industrial laboratories for analytical control purposes. Few nomographs are found in the literature which are applicable to oils and fats. Wan and Ho (1) constructed a nomograph for correction and consequent calculation of the iodine value of tung oil at standard conditions from the iodine value determined at different temperatures, times of contact, and excess of reagent. Osburn, Wood, and Werkman (2) published an alignment chart for the partition determination of volatile fatty acids in a ternary mixture of acids. Using the half distillation value, Suomalainen and Archimo (3) prepared a nomograph for the calculation of the quantitative relations of the lower molecular weight fatty acids in a binary mixture of acids. Illarionov and Torchinskii (4) described a nomograph for determining the iodine values of oils from their refractive indices at different temperatures. However no nomographs have been published for the calculation of glyceride composition of oils and fats from their physical or chemical constants.

The present report describes the construction of nomographic charts for the calculation of glyceride composition of oils and fats. Equations published in the Official Methods of the American Oil Chemists' Society (5) relating the glyceride composition and the iodine and thiocyanogen values were used in constructing the nomographs by the application of the technique described in detail by Davis (6).

Construction of the Nomographs

Equations (5) for the calculation of the glyceride composition when the iodine and thiocyanogen values are determined on the triglycerides, and (A) *when no linolenin is present, are:*

(1) % Linolein, $Y = 1.246\ IV - 1.253\ TV$
(2) % Olein, $Z = 2.525\ TV - 1.348\ IV$
(3) % Saturated + Unsaponifiable, $S = 100 - (Y + Z)$

a) For the equation

(1) % Linolein, $Y = 1.246\ IV - 1.253\ TV$

(4) $$IV = \frac{Y}{1.246} + \frac{1.253}{1.246} TV$$

(5) $$IV = 0.8025\ Y + 1.0056\ TV$$

If the desired length of the scale for the Y- and TV-axes is 20 inches, and the range of change of Y, TV, and IV is between 0 to 100 units, and if m_Y, m_{TV}, and m_{IV} are the moduli[2] for Y, TV, and IV, respectively, then

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[2] The modulus is defined as the length of line that represents a change of one unit in the function of a variable.

$$m_Y = \frac{20}{0.8025\ (100\text{-}0)} = 0.24922;$$

$$m_{TV} = \frac{20}{1.0056\ (100\text{-}0)} = 0.19888;$$

$$m_{IV} = \frac{m_Y \times m_{TV}}{m_Y + m_{TV}} = \frac{0.24922 \times 0.19888}{0.24922 + 0.19888} = 0.1106.$$

The calculated data required for constructing the nomograph using equation (1) are given in Table I.

TABLE I

Data Used for Constructing Nomograph From Equation (1)

Axis	Modulus	Scale (modulus × function)	Range	Length of the scale, inches
Y	0.24922	0.2 Y	0-100	0.2(100-0) = 20
TV	0.19888	0.2 TV	0-100	0.2(100-0) = 20
IV	0.1106	0.1106 IV	0-100	0.1106(100-0) = 11.06

The nomograph for equation (1) is shown in Figure 1, where the a-, c-, and e-scales represent thiocyanogen values, iodine values, and percentages of linolein, respectively. The three axes Y, TV, and IV should be parallel to each other. The Y- and TV-axes may be any distance apart but the IV-axis is so spaced between them that $ac : ce = m_{TV} : m_Y$. If the Y- and TV-axes are 8 inches apart, the IV-axis lies 3.55 inches from TV-axis and 4.45 inches from Y-axis.

When TV equals 30 and Y equals 11.004, it may be determined by calculation from equation (1) that IV equals 39. This point is located on the IV-axis by drawing a line from 30 on the TV-scale to 11.004 on the Y-scale and noting the point where the line cuts the IV-axis. From the point IV equals 39 the scale on IV is marked. To find the direction of increase of the scale another value of IV is calculated by substituting values for TV and Y and solving the equation as before. The scales for TV and Y may be located anywhere on the axes but are usually centered for symmetry. The scales increase in the same direction because the sign between the functions of TV and Y is positive; they increase in the opposite directions if the sign is negative.

b) Similarly for the equation

(2) % Olein, $Z = 2.525\ TV - 1.348\ IV$

(6) $TV = 0.3960\ Z + 0.53386\ IV$

The calculated data required for constructing the nomograph using equation (2) are given in Table II.

TABLE II

Data Used for Constructing Nomograph From Equation (2)

Axis	Modulus	Scale (modulus × function)	Range	Length of the scale, inches
Z	0.50500	0.2 Z	0-100	20
IV	0.37463	0.2 IV	0-100	20
TV	0.21507	0.21507 TV	0-100	21.507

In Figure 1 the scales designated as a, b, and e represent iodine values, thiocyanogen values, and percentages of olein, respectively, for equation (2). When the IV- and Z-axes are constructed 8 inches apart, the TV-axis lies 3.41 inches from IV-axis and 4.59 inches from Z-axis.

c) For the equation

(3) % Saturated + unsaponifiable, $S = 100 - (Y + Z)$.

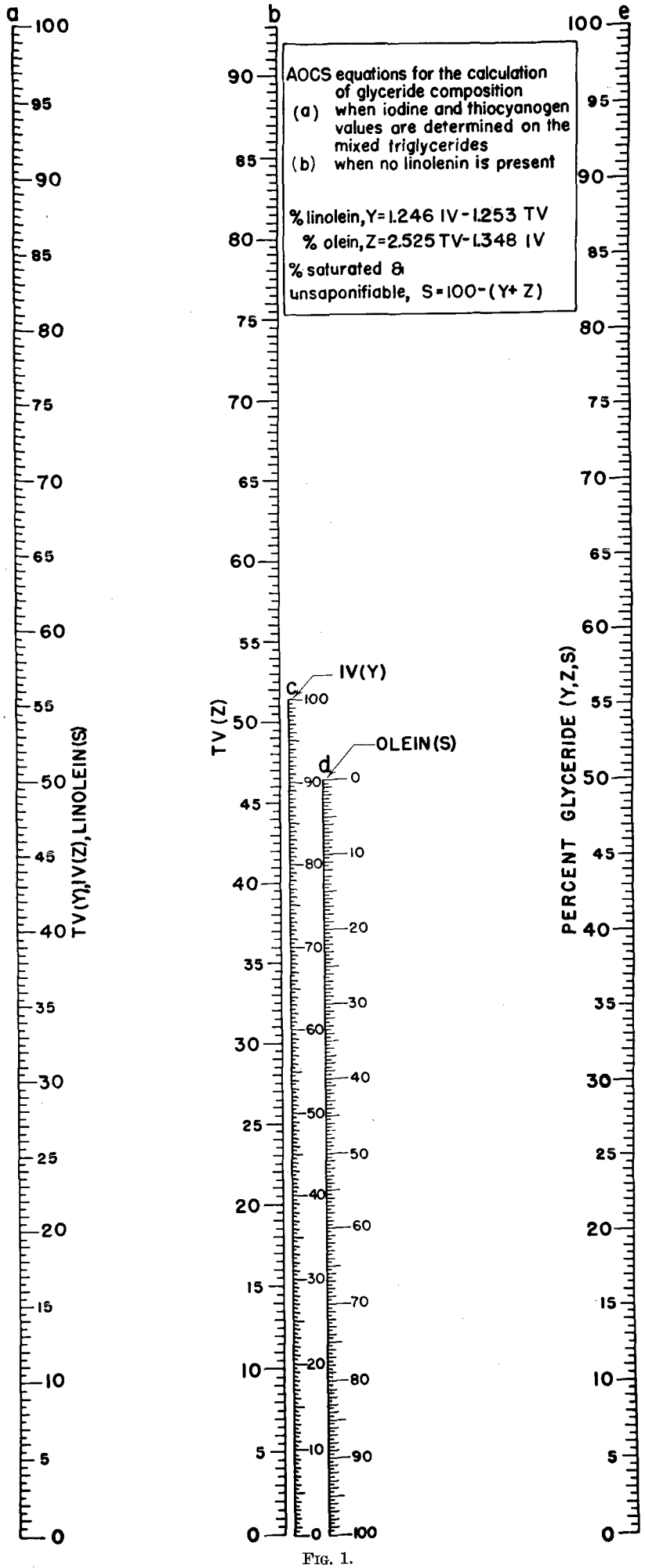

FIG. 1.

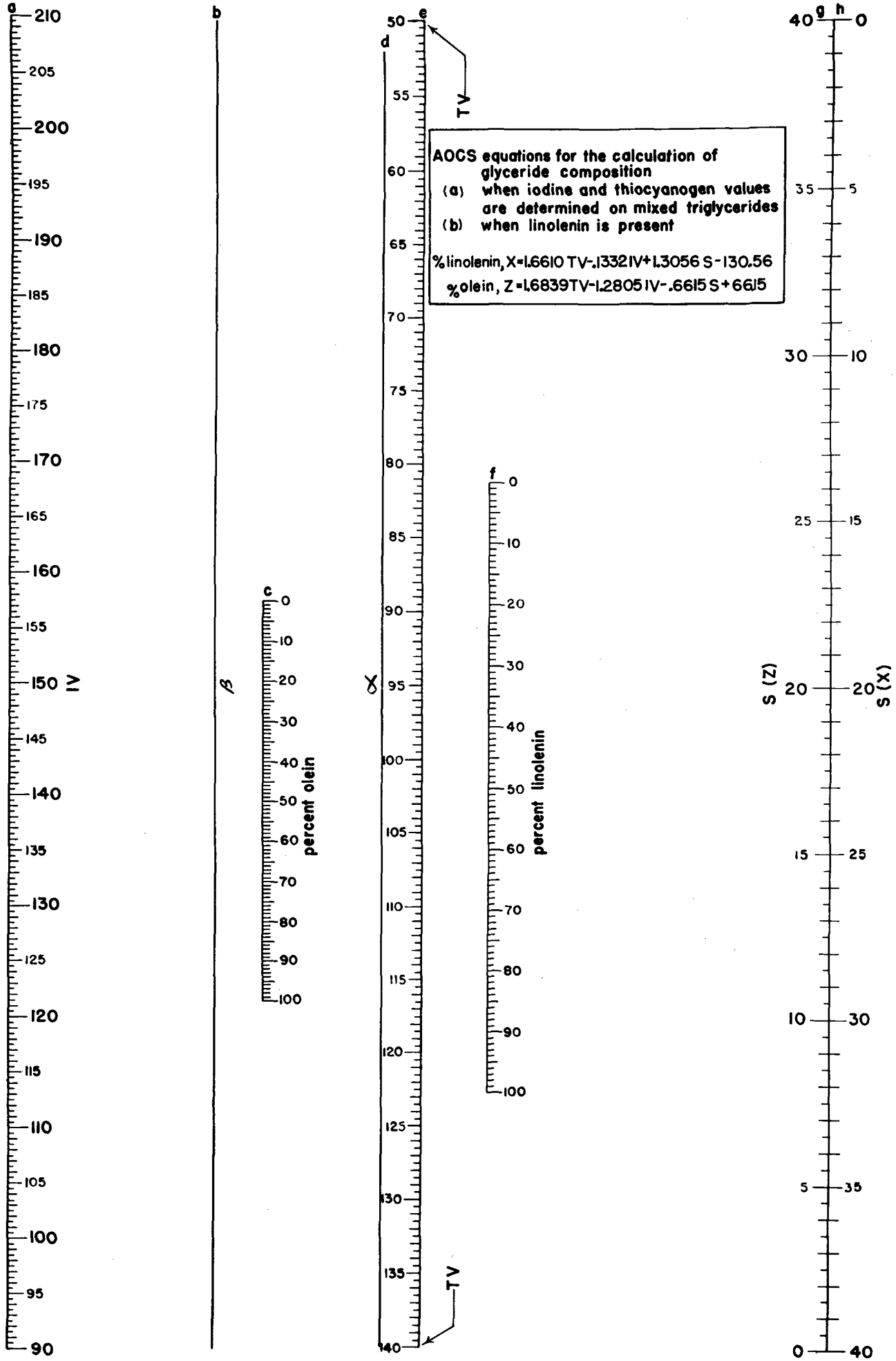
a
b
c
d
e
f
g
h
IV
β
percent olein
X
TV
percent linolenin
S (Z)
S (X)
AOCS equations for the calculation of glyceride composition
(a) when iodine and thiocyanogen values are determined on mixed triglycerides
(b) when linolenin is present
% linolenin, X = 1.6610 TV - .1332 IV + 1.3056 S - 130.56
% olein, Z = 1.6839 TV - 1.2805 IV - .6615 S + 66.15

FIG. 2.

A line is drawn parallel to the a- and e-axes so that it lies at the center between the two axes. A point 100 is marked on this line by aligning zero marks of a and e and the scale is marked increasing in opposite direction to that on the a- and e-axes.

(B) *When linolenin is present:*

(7) % Linolenin, $X = 1.6610\ TV - 0.1332\ IV + 1.3056\ S - 130.56$

(8) % Linolein, $Y = 1.4137\ IV - 3.3449\ TV - 1.6441\ S + 164.41$

(9) % Olein, $Z = 1.6839\ TV - 1.2805\ IV - 0.6615\ S + 66.15$

a) for the equation

(7) % Linolenin, $X = 1.6610\ TV - 0.1332\ IV + 1.3056\ S - 130.56$

(10) $\alpha = 1.6610\ TV - 0.1332\ IV$

(11) $X = \alpha + 1.3056\ S - 130.56$

A chart is prepared for equation (10) with the α-axis lying between the IV- and TV-axes. Using the same α-axis which need not be graduated, a similar chart is constructed for equation (11). The data for constructing the nomographs for equations (10) and (11) are given in Table III.

TABLE III

Data Used for Constructing Nomograph From Equation (7)

Axis	Modulus	Scale (modulus × function)	Range	Length of the scale, inches
TV	0.13379	0.22223 TV	50-140	20
IV	1.25125	1.66667 IV	90-210	20
α	0.12087	.....	.....	....
S	0.38297	0.5 S	0-40	20
X	0.09187	0.09187 X	0-100	9.187

If the distance between the IV- and TV-axes is 6 inches and also the TV- and S-axes are 6 inches apart, then the distances between the other axes are: ad = 5.420, de = 0.580, df = 1.578, and fh = 5.002 inches. A starting point for the X-scale on f is found by substituting values for IV, TV, and S in the equation and tracing through the solution by means of the dash index lines. The nomograph for equation (7) is shown in Figure 2, where a, d, e, f, and h represent iodine value, α, thiocyanogen value, percentage of linolenin, and percentage of saturated glycerides, respectively.

b) Similarly for the equation

(9) % Olein, $Z = 1.6839\ TV - 1.2805\ IV - 0.6615\ S + 66.15$

(12) $\beta = 1.6839\ TV - 1.2805\ IV$

(13) $Z = \beta - 0.6615\ S + 66.15$

The calculated data required for constructing the nomographs for equations (12) and (13) are given in Table IV. If the IV- and TV-axes are 6 inches apart

TABLE IV

Data Used for Constructing Nomograph From Equation (9)

Axis	Modulus	Scale (modulus × function)	Range	Length of the scale, inches
TV	0.13197	0.22223 TV	50-140	20
IV	0.13016	0.166667 IV	90-210	20
β	0.06553	.....	.....	....
S	0.75585	0.5 S	0-40	20
Z	0.06030	0.0603 Z	0-100	6.030

and also the distance between the TV- and S-axes is 6 inches, then the distances between the other axes are: ab = 2.979, be = 3.021, bc = 0.720, and eg = 8.301 inches.

Similar nomographs may be prepared for the case where the iodine and thiocyanogen values are determined on mixed fatty acids. Nomographs shown in Figures 1 and 2 were made on a 20-inch scale and were reduced to half the original size for publication.

Use of the Nomographs

The glyceride composition of an oil is calculated from the nomographs as follows:

When no linolenin is present and using the nomographs constructed for equations (1), (2), and (3) shown in Figure 1, the linolein content of an oil is found on the e-scale, where it is cut by the line extended from the thiocyanogen and iodine values on the a- and c-scales. Similarly for the calculation of olein content the a-, b-, and e-scales are used which represent the iodine value, thiocyanogen value, and olein content, respectively. The saturated acid glycerides and unsaponifiable matter may be calculated by differences or by the use of the a-, d-, and e-scales for linolein, olein, and saturated glycerides, respectively.

For the iodine values greater than 100 the same scales of Figure 1 may be used or more precise nomographs covering suitable ranges may be prepared. If

TABLE V

Glyceride Composition of Oils Calculated From Equations (1), (2), (3), and From Nomographic Charts Shown in Figure 1

Oil	Iodine value	Thiocyanogen value	Linolein, %		Olein, %		Saturated+Unsap., %	
			Calc.	Nom.	Calc.	Nom.	Calc.	Nom.
Okraseed	92.5	60.4	39.7	39.6	27.6	27.8	32.7	32.6
Cottonseed	109.0	63.9	55.8	56.0	14.4	14.0	29.8	30.0
Peanut	95.0	63.0	39.4	39.5	31.0	31.0	29.6	29.5
Sesame	112.0	76.3	43.9	44.0	41.7	42.0	14.4	14.0

TABLE VI

Glyceride Composition of Oils Calculated From Equations (7), (8), (9), and From Nomographic Charts Shown in Figure 2

Oil	Iodine value	Thiocyanogen value	Linolenin, %		Linolein, %		Olein, %		Saturated + Unsap., %
			Calc.	Nom.	Calc.	Nom.	Calc.	Nom.	
Linseed	190	120	56.5	56.5	15.2	15.2	18.3	18.3	10.0
Soybean	130	80	4.5	4.6	24.5	24.6	55.9	55.8	15.0
Hempseed	167	101.6	28.4	28.4	45.0	44.9	17.1	17.2	9.5
Perilla	200	125	59.6	59.4	17.5	17.6	15.9	16.0	7.0

the iodine value is 150 and the thiocyanogen value is 80, the glyceride content may be calculated by aligning the figures 15 and 8 on the iodine value and thiocyanogen value scales.

When linolenin is present and using the nomographs for equations (7) and (9) shown in Figure 2, for calculation of the linolenin content, iodine and thiocyanogen values on the a- and e-scales are aligned and a point is marked where this line intersects the α-axis. The point on the α-axis is then aligned with that for the saturated glyceride content on the h-scale, and the percentage of linolenin is read on the f-scale.

Similarly the olein content is calculated by using the a-, b-, c-, e-, and g-axes which represent iodine value, β, olein content, thiocyanogen value, and percentage of saturated glycerides, respectively.

The linolein content is calculated by difference or a nomograph for equation (8) may be constructed.

The glyceride compositions of different oils calculated from 20-inch nomographic charts are compared in Tables V and VI with those calculated from the equations.

Summary

The construction and use of nomographic charts for the calculation of the glyceride compositions of oils and fats have been described. Equations adopted by the American Oil Chemists' Society relating the glyceride composition with the iodine and thiocyanogen values of an oil were used for constructing the nomographs. The glyceride compositions of different oils calculated from the nomographs were found to agree reasonably well with those obtained by calculation from the equations.

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Report of the Cellulose Yield Committee April, 1950

DURING the past year four sets of samples were sent out to 10 laboratories. Two second cut linter samples and one hull fiber sample were included in each group. One laboratory, No. 9, did not return but three reports so they are not included in the overall average.

The following table gives the analyses of the laboratories, which are numbered from 1 to 10:

Lab. No.	No. Sets Samples Tested	Samples			Overall Average for Year
		A Linters	B Linters	C Fiber	
1	4	77.8	75.1	73.3	75.4
2	4	78.2	75.0	72.8	75.3
3	4	77.9	74.9	72.3	75.0
4	4	78.2	75.0	72.0	75.1
5	4	78.3	75.9	73.1	75.8
6	4	77.9	75.2	72.8	75.3
7	4	78.1	75.1	72.4	75.2
8	4	78.2	75.6	72.6	75.5
9	3*	77.3	75.3	72.9	75.2
10	4	78.1	75.0	73.0	75.4
Avg.		78.1	75.2	72.6	75.3

* Not included in average.

The overall average of the analyses was very good, as shown by the above results. Work is being continued on improving the methods so that low yield hull fiber, that is, under 55%, will give the true yield when washed by this procedure. This should be reported next year.

Recommendations: It is recommended that samples be sent out at least four times during the next year. It is felt that this is desirable even though the average of the results are good for each mill. Two or three mills per year run into trouble, which is quickly found by these check samples. Also, since practically all of the second cut linters are sold on cellulose yield basis, which during the past year amounted to approximately $25,000,000, and also settled on the basis of one or the other of the laboratories above, it is important that all laboratories keep the cellulose yield procedure and equipment up to date and in good working condition.

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