• TECHNICAL

The Relationship Between Seed Density and Oil Content in Flax[1]

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Density and oil content of seeds of 20 varieties of flax were found to be negatively correlated; $r = -0.96$. The density was determined by using the Beckman Model 930 Air Comparison Pycnometer. It is suggested that seed density can be used as a criterion for effective screening and selecting of flax lines with high oil content.

TWO FACTORS of prime importance in the development of new varieties of flax and other oilseed crops are the oil content and oil quality. Plant breeders have used iodine value as a measure of oil quality for many years. Although it does not reveal the exact fatty acid composition of the oil, it does indicate the relative amount of unsaturated fatty acids present. With the development of gas chromatography and its application to the analysis of fatty acids, the exact fatty acid composition of an oil sample can be determined in less than 25 min. This rapid analysis allows the plant breeder to use the fatty acid composition of the oil as an additional criterion for selecting and developing superior varieties of flax. The oil content of flaxseed is an equally important factor to be considered in the selection and breeding of new varieties and is perhaps of even greater importance on a commercial basis. Oil content has been traditionally determined by the Soxhlet extraction method. More recently the use of the Steinlite Oil Tester has provided a more rapid method of determining oil content (1). With this method relatively large samples of seed (about 60 g.) are required. In 1958 Comstock and Culbertson (2) developed a small-sample method for determining the oil content from 1 g. of flaxseed, and two persons can analyze 125 to 150 samples per day. However it takes a relatively long time to complete the analysis of a single sample. The objectives of this work were to study the relationship between density and oil content of flaxseed with the air pycnometer and to investigate the use of seed density as a means of screening different varieties for varying oil content.

Experimental

Materials. To determine the seed density, one must weigh the seed and determine its volume. The seed was weighed with an automatic single-pan balance. The volume of the seed was obtained by use of the Beckman Model 930 Air Comparison Pycnometer. V. E. Comstock, Agricultural Research Service, University of Minnesota, St. Paul, provided a series of 20 flax varieties, grown in 1960 at several locations in Minnesota. Their oil content was based on a single determination by the Steinlite method.

Method. The volume of the sample was read directly from the Air Comparison Pycnometer in hundredths of a cc. Two adaptations of the pycnometer were necessary for precise measurements. The first was the addition of a hairline to the differential-pressure indicator scale to eliminate considerable parallax error in making the final reading. The second adaptation was a reference mark on the reference hand wheel to assure the operator that he was placing the reference piston in the same position each time a volume determination was made. After placing the seed in the sample cup, the latter was put in the instrument and the sample was allowed to equilibrate for 1 min. before closing the valve between the two pistons. Adjustment of the measuring handwheel was always made in a clockwise direction. After adjustment, an equilibration period of 1 min. was allowed before taking the final reading from the counter. Time required for a single analysis was 6 min.

Results and Discussion

The weight-volume relationship for a single variety was first ascertained. Volume measurements were made with sample sizes ranging from 5 to 35 g. of seed; when weight *versus* volume was plotted, a highly significant linear relationship was observed. The standard deviation of the density values for the 5-g. sample based on 10 subsamples from the same variety was 0.00337, which was significantly greater than standard deviations for the 10-g. and 20-g. samples, which were 0.000703 and 0.000745, respectively. The last two values were not significantly different.

Two 20-g. samples were used to determine the mean density for each of 20 varieties. The mean seed densities were plotted against oil contents and are shown clustered about the regression line in Fig. 1. The regression line was drawn from the regression equation $\hat{Y} = 298.46 - 222.31X$, in which Y = oil content and X = seed density. The two variables were negatively correlated, and the correlation coefficient of $r = -0.96$ was highly significant. The variance of a predicted oil value was $0.341 + 176.6\ (X - 1.1692)^2$.

Correlation coefficients were computed between oil content and seed density from a single determination on a 10-g. sample and on a 20-g. sample of each of the 20 varieties. For the 10-g. sample $r = -0.90$, and

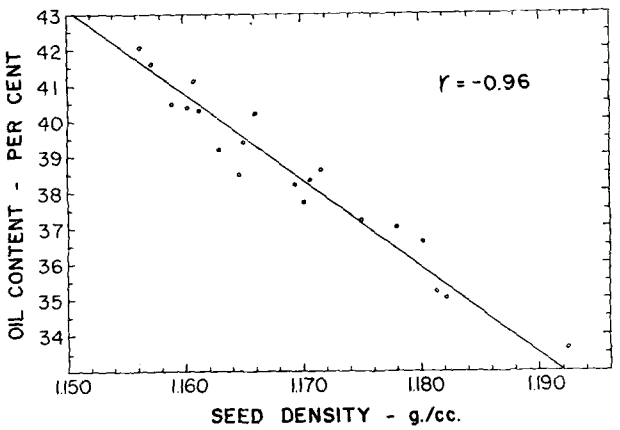

FIG. 1. Regression of oil content on seed density for 20 varieties of flax.

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for the 20-g. sample r = −0.96. Although there is a slight decrease in the correlation coefficient from a 20-g. to a 10-g. sample, it is not significant and a 10-g. sample would appear suitable for routine determinations.

Since the moisture content of the seed will affect the observed weight for a given number of seeds and consequently the density of these seeds, the moisture contents must be considered in the density determination. The effect of seed moisture content on the correlation between oil content and seed density was determined by measuring the volume of a dried 10-g. sample from each of the 10 varieties. The correlation coefficient was r = −0.96, which is the same as that of the undried seeds. This indicates that, as long as the seed samples are of equivalent moisture content, a reliable correlation between the two variables exists. If seed samples are stored in a constant environment for four or five days, their moisture contents will all be very close (3). Thus, in determining the density, it is necessary to allow the seed to equilibrate for this period before measurements are taken. Alternatively one may first dry the seeds in an oven and, on removal, allow them to equilibrate with the atmospheric moisture. By this procedure, along with the use of a check sample, the comparative oil contents of different varieties of flax can be estimated.

The use of seed density as a measure of an absolute oil content is more involved. Before one can say that a seed sample with a given density has a certain oil content, several factors must be considered, the most important of which is moisture content. Since the moisture content will affect the seed weight and seed volume, one must know the regression equation for oil content on seed density with seed samples of varying moisture contents. The difference between the regression lines obtained with moisture-free seed and with seed containing 5.4% moisture is shown in Fig. 2. The regression line for the moisture-free acid was drawn from the regression equation $\hat{Y} = 194.06 - 136.10X$. It seems likely that a family of regression lines could be determined for different seed moisture contents. Such data would allow the determination of oil content by reference to the particular regression equation corresponding to the moisture content of the seed. In this case a periodic check of the moisture content of seed samples would be necessary to determine the proper regression equation to be used. In addition to moisture content, the maturity of the seed when harvested, and possibly other factors, may affect the density of the seed. The nature of these effects and the determination of regression lines for varying moisture contents will constitute further work in this area. The most significant feature of this method is that a comparative estimate of oil content can be obtained in a few minutes. In addition, the sample is neither destroyed nor harmed in any way and may be used for other analytical tests or for breeding purposes.

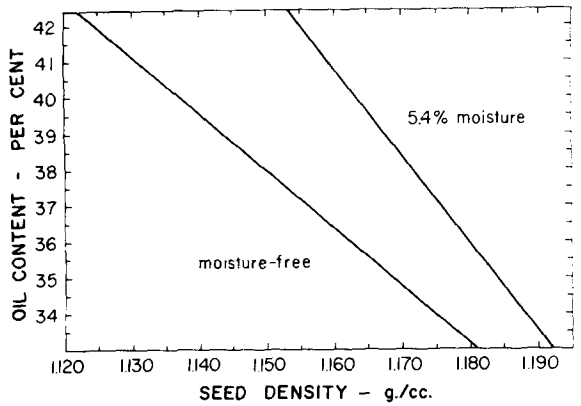

FIG. 2. Regression lines for moisture-free flaxseed and flaxseed containing 5.4% moisture.

Studies of the correlation between seed density and oil content in other oilseeds are presently being investigated with the use of the air pycnometer.

Acknowledgment

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Search for New Industrial Oils. VI. Seed Oils of the Genus *Lesquerella*[1]

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Fatty acid composition of seed oil from 14 species of the genus *Lesquerella* has been determined by gas-liquid chromatography. All but two species contain hydroxyeicosenoic acid in amounts ranging from 45 to 74%. The remaining two species contain about 50% C_{18} hydroxy acids, but none of the C_{20} hydroxy acid.

FOLLOWING THE DISCOVERY that oils from seeds of *Lesquerella lindheimerii* and *L. lasiocarpa* contain large amounts of hydroxyeicosenoic acid (4, 5), special attention was given (a) to the determination of the structure of this new hydroxy acid (lesquerolic) and (b) to the collection by the U. S. Department of Agriculture's Crops Research Division of seeds from related species in the genus in order to ascertain whether this unique compound is characteristic of all available members. The structure was shown to be 14-hydroxy-*cis*-11-eicosenoic acid (5). In 1960, samples of 14 species were collected from the wild for analysis. This paper reports the composition of these previously uninvestigated oils.

The genus *Lesquerella*, of the family Cruciferae, is native chiefly to the arid parts of western North America from east central Mexico to Alberta and Saskatchewan. Representatives also occur in limited areas of South America, Alabama, Kentucky, and

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