Analysis of Soybean Oil from Ohio

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Five soybean cultivars—Pella 86, Ripley, Sherman, Williams 82, and Zane—were analyzed to determine the total fatty acid composition and triglyceride fatty acid composition. Palmitic, stearic, oleic, linoleic, and linolenic were the major fatty acids in these cultivars. Zane was significantly higher in saturated fatty acid content and lower in linolenic acid content than the other cultivars. Resolution by argentation thin-layer chromatography decreased with increased triglyceride unsaturation.

KEY WORDS: fatty acids, triglycerides and soybean cultivars.

The fatty acid composition of soybean oil, particularly the type of unsaturated fatty acid (1), is influenced by the genetic characteristics of the cultivars and climatic conditions (2). Fatty acid composition influences stability and nutritional value of oils. Fats or oils with substantial unsaturation of their fatty acids are more unstable than those with less unsaturation. Stability of fats may be affected by triglyceride structure. Yoshida and Alexander (3) found that unsaturated fatty acids located in the 2-position are protected significantly from thermal oxidation. The triglyceride analysis of soybean oils is of interest because the composition of fatty acid and the positional distribution of fatty acid may alter the chemical, physical, and functional properties of soybean oil (4).

Soybean oil is well-known for its high concentration of essential polyunsaturated fatty acids. It contains 2 to 13% of linolenic acid (1). Linolenic acid is frequently involved in the formation of 'reversion flavor,' an undesirable characteristic of soybean oil.

The Soybean Research Advisory Institute emphasizes the need for additional information on the composition and structure of soybean oil (5). Today, numerous soybean cultivars have been developed, but only a few have been studied for triglyceride and fatty acid composition. This study investigated the fatty acid composition of triglycerides of five new soybean cultivars.

MATERIALS AND METHODS

Five new soybean cultivars Pella 86, Ripley, Sherman, Williams 82, Zane (and a reference, Beeson 80)—were used. All were grown under the same cultural practices at the Ohio Agricultural Research and Development Center (OARDC) Southern Branch near Ripley, Ohio.

Soybean oil was extracted from the soybean cultivars with Folch reagent (6). Analytical grade solvents for thin layer chromatography (TLC) were used. Highly purified spectrograde hexane (Fisher Scientific, Blawnox, PA) was used for gas liquid chromatography (GLC) analysis. Silica gel G according to Stahl (E. Merck, Darmstadt, W. Germany) was used in TLC to isolate triglycerides from soybean oil (7). Silica gel 60G (E. Merck, Darmstadt, W. Germany), 50 g, and silver nitrate (J. T. Baker Chemical Co., Phillipsburg, NJ), 27 g, were used for silver nitrate-silica gel TLC to separate the triglycerides into different species according to the degree of unsaturation. Triglycerides were separated subsequently by two solvent systems consisting of 1% and 3% (v/v) methanol in chloroform. The TLC plates were prepared according to the method described by Mangold (8).

The GLC system was a Hewlett Packard model 5890A gas chromatograph equipped with a flame ionization detector (FID) and a Hewlett Packard model 3390A reporting integrator. The stainless-steel column (244 cm × 0.3 cm ID) was packed with 10% SP 2330 on 100/200 mesh Chromosorb W, AW (Supelco, Bellefonte, PA). The system was operated under the following conditions (9): column temperature, 190°C; detector temperature, 220°C; injection temperature, 220°C; nitrogen carrier gas at a flow rate of 20 mL/min.

One-way analysis of variance (10) was performed. Tukey's pairwise analysis (11) was further used to determine differences between any two cultivars. Dunnett's test (11) was used to compare the control with the five soybean cultivars.

RESULTS AND DISCUSSION

Fatty acid composition of soybean oils. Fatty acid composition of the soybean cultivars varied; but palmitic, stearic, oleic, linoleic, and linolenic were predominant (Table 1). These results agree with previous studies by Daubert (12) and Hitchcock and Nichols (13). Saturated fatty acids with more than 24 carbons seldom occur in food triglycerides, and food lipids generally contain fatty acid with an even number of carbon atoms (4). Lauric, eicosanoic, behenic, and myristic acids are commonly encountered in saturated fatty acids in soybean oil but usually in very small quantities (1, 14). The results indicate that the five soybean oils contained predominantly unsaturated fatty acids with an average of 78.89% of the total fatty acid composition. Linoleic acid accounted for the major part of the unsaturated fatty acids in all cultivars. However, the monounsaturated fatty acid, oleic acid in Williams 82 and Zane, was significantly different from Sherman, Ripley, and Pella 86. The linoleic and linolenic acid content of Zane was significantly lower than all the others.

Beeson 80 is a main soybean cultivar for commercial edible oil production. The palmitic acid content of Sherman, Williams 82, and Zane was significantly higher than that of Beeson 80 ($\alpha = 0.01$) (Table 1). Pella 86, Williams 82, and Zane were significantly greater in stearic and oleic acid content than Beeson 80 ($\alpha = 0.01$). Zane also had much lower linoleic acid content

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TABLE 1

The Principal Fatty Acids of Five Soybean Cultivars and Beeson 80[a,b]

Cultivar	Fatty acid (%)				
	Palmitic (16:0)	Stearic (18:0)	Oleic (18:1)	Linoleic (18:2)	Linolenic (18:3)
Beeson 80	10.5	4.0	21.2	56.4	7.3
Pella 86[c]	13.0	6.2*	24.9	46.8	4.2*
Ripley	11.2	3.6	21.2	56.1	7.8
Sherman	13.5*	5.4	24.2	50.0	6.0
Williams 82	13.2*	5.6	28.3*	48.2	4.5*
Zane[d]	14.0*	5.9	29.1*	39.9*	3.2*

[a]Data are means of duplicate samples.
[b]Means with asterisk in the same column are significantly different from Beeson 80 soybean oil by Dunnett's Test ($\alpha = 0.01$).
[c]A quantity of 4.9% unknown and minor acids was detected.
[d]A quantity of 7.9% unknown and minor acids was detected.

TABLE 2

Major Fatty Acid Composition of Triglyceride Fractions of Pella 86[a]

Triglyceride fraction[b]	Fatty acid (%)				
	Palmitic (16:0)	Stearic (18:0)	Oleic (18:1)	Linoleic (18:2)	Linolenic (18:3)
1	41.6	20.3	30.4	—	—
2	35.9	15.1	31.9	13.4	—
3	21.6	8.7	45.5	20.2	—
4	27.2	10.7	28.9	15.6	—
5	7.5	3.5	56.7	28.6	—
6	21.5	9.0	12.5	51.9	—
7	7.2	2.5	26.3	41.5	1.0
8	8.0	4.4	12.6	64.9	8.1
9	9.0	6.1	13.4	46.2	20.8

[a]Data are means of duplicate samples.
[b]The 1 = highest R_f value and 9 = lowest R_f value.

than Beeson 80, and Zane, Pella 86, and Williams 82 were significantly lower in linolenic acid content than Beeson 80 ($\alpha = 0.01$).

Relative to the other four cultivars and the reference soybean oil, Zane contained a large concentration of saturated fatty acids. In order to obtain a stable product with bland flavor, edible oil producers are looking for commercial soybean cultivars with low linolenic acid content, preferably under 4% (15). Therefore, it appears that Zane may be a promising cultivar which would meet the needs of low linolenic acid content needed by both plant breeders and oil producers.

Separation of triglyceride species. The number of total triglyceride fractions for each cultivar was as follows: Pella 86, 9 fractions; Ripley, 10 fractions; Sherman, 10 fractions; Williams 82 , 11 fractions; and Zane, 10 fractions. Although according to Gunstone and Padley (16), argentation TLC is unable to completely separate triglycerides into pure individual triglyceride species: each fraction generally is dominated by one triglyceride species. Table 2 and 3 demonstrate a typical fatty acid composition of triglyceride fractions of Pella 86 and Williams 82. Triglyceride fraction 1 had the highest R_f value, and fractions 9 and 11 had the lowest R_f value. The triglyceride fractions of the other

TABLE 3

Major Fatty Acid Composition of Triglyceride Fractions of Williams 82[a]

Triglyceride fraction[b]	Fatty acid (%)				
	Palmitic (16:0)	Stearic (18:0)	Oleic (18:1)	Linoleic (18:2)	Linolenic (18:3)
1	41.7	19.3	29.4	—	—
2	34.2	14.7	34.9	11.5	—
3	25.4	10.0	41.0	17.9	—
4	22.4	8.4	42.2	19.5	—
5	16.6	4.6	56.6	24.0	—
6	21.8	8.5	18.3	43.3	—
7	11.8	3.1	31.0	43.3	1.5
8	11.6	3.6	14.3	63.3	1.5
9	16.6	8.2	22.6	36.4	12.4
10	10.5	6.1	19.5	40.8	14.9
11	15.5	8.6	21.2	32.0	22.2

[a]Data are means of duplicate samples.
[b]The 1 = highest R_f value and 11 = lowest R_f value.

three soybean cultivars revealed a similar pattern of fatty acid content. Palmitic, stearic, oleic, linoleic, and linolenic acids were the major five fatty acids frequently occurring in the fractions.

The triglyceride fractions with high R_f value contained more saturated fatty acids while the triglyceride fractions with low R_f value contained more unsaturated fatty acids (Table 2, 3), especially polyunsaturated fatty acids, linoleic and linolenic acids. Also, fraction resolution decreased as triglycerides became more unsaturated.

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REFERENCES

1. Pryde, E.H., in *Handbook of Soy Oil Processing and Utilization,* edited by D.R. Erickson, E.H. Pryde, O.L. Brekke, T.L. Mounts and R.A. Falb, American Oil Chemists' Society, Champaign, IL 1980, pp. 13-29.
2. Smith, A.K., and S.J. Circle, in *Soybeans: Chemistry and Technology,* AVI Publishing Co., Westport, CT, 1972, p. 61.
3. Yoshida, H., and J.C. Alexander, *Lipids 19*:589 (1984).
4. Dugan, Jr., L.R., in *Principles of Food Science, Food Chemistry,* edited by O.R. Fennema, Marcel Dekker, Inc., New York, NY, 1976, pp. 140-200.
5. Soybean Research Advisory Institute, *U.S. Soybean Production and Utilization Research,* USDA, Washington, D.C., 1984, pp. 43-47.
6. Folch, J., M. Lees and G.H. Sloane-Stanley, *J. Biol. Chem. 226*:497 (1957).
7. Litchfield, C., *Analysis of Triglycerides,* Academic Press, New York, NY, 1972.
8. Mangold, H.K., *Handbook of Chromatography, Lipids,* CRC Press, Inc., Boca Raton, FL, 1984, pp. 47-48.
9. Peng, A.C., *Lipids 9*:299 (1974).
10. Ott, L., *An Introduction to Statistical Methods and Data Analysis,* 2nd edn., PWS Publishers, Boston, MA, 1984, pp. 325-360.
11. Keppel, G., *Design and Analysis,* 2nd edn., Prentice-Hall, Englewood Cliffs, NJ, 1982, pp. 144-168.
12. Daubert, B.F., in *Soybeans and Soybean Products,* edited by K.S. Markley, Interscience Publishers, Inc., New York, NY, 1950, p. 175.

13. Hitchcock, D., and B.W. Nichols, *Plant Lipid Biochemistry*, Academic Press, New York, NY, 1971, p. 86.
14. O'Conner, R.T., and S.F. Herb, *J. Am. Oil Chem. Soc. 47*:195A (1970).
15. AOCS, *Ibid. 59*:882a (1982).
16. Gunstone, F.D., and F.B. Padley, *Ibid. 42*:957 (1965).

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