(1963).
3. Zinkel, D.F., L.C. Zank and M.F. Wesolowski, "Diterpene Resin Acids. A Compilation of Infrared, Mass, Nuclear Magnetic Resonance, Ultraviolet Spectra and Gas Chromatographic Retention Data (of the methyl esters)," Forest Products Laboratory, Madison, WI, 1971.
4. Emken, E.A., C.R. Scholfield and H.J. Dutton, JAOCS 41:388 (1964).
5. Scholfield, C.R., and T.L. Mounts, Ibid. 54:319 (1977).
6. Adlof, R.O., and E.A. Emken, Ibid. 58:99 (1981).
7. Rohm and Haas Co., Amberlyst XN-1010 Preliminary Data Sheet, 1978.
8. Adlof, R.O., H. Rakoff and E.A. Emken, JAOCS 57:273 (1980).
9. Zinkel, D.F., and L.C. Zank, Anal. Chem. 40:1144 (1968).
10. Ishigami, M., Y. Inoue and T. Agawa, Yukagaku 25:10 (1976).

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Effectiveness of Several Polyunsaturated Seed Oils as Boll Weevil Feeding Deterrents

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ABSTRACT

Prompted by the previous discovery that (9Z,11E,13E)-9,11,13-octadecatrienoic acid (α-eleostearic acid) was one of the components responsible for the boll weevil feeding deterrency of tung oil, the seeds of 11 other plant species were extracted with pentane and the oils were evaluated for their feeding deterrency in the laboratory. The oils of *Calendula suffruticosa*, *Centranthus macrosiphon*, *Jacaranda mimosifolia* and *Momordica cochinchinensis* were effective feeding deterrents for the boll weevil.

INTRODUCTION

(9Z,11E,13E)-9,11,13-octadecatrienoic acid (α-eleostearic acid), the principal fatty acid of tung oil from the seeds of *Aleurites fordii* Hemsl., has recently been identified (1) as one of the components responsible for boll weevil feeding deterrency ascribed to the oil in 1966 (2). The boll weevil, *Anthonomus grandis grandis* Boheman, is the most destructive insect pest of cotton in the U.S. and Mexico. Although α-eleostearic acid is too unstable for practical use as a feeding deterrent under field conditions, its methyl ester has been shown to be much more stable and equally effective as a deterrent (1,3). We were interested in determining whether a number of other seed oils known to contain conjugated polyunsaturated C_{18} fatty acids would also be effective deterrents. This paper reports the results of our investigation.

EXPERIMENTAL PROCEDURES

The dry whole seeds of each plant were ground in a blender at room temperature with several portions of pentane and the combined extracts were freed of solvent at 25 C and 15 mm pressure. The oils obtained were analyzed for conjugated unsaturation and geometric configuration by standard means of ultraviolet and infrared spectrophotometry, using absolute ethanol as UV solvent and KBr discs for IR determinations. Aliquots of each oil were tested in the laboratory against boll weevils by the method of Hardee and Davich (2) at 25-27 C and 30-42% relative humidity. Hexane was used to prepare a 1% (w/v) solution of the oil (except tung oil, which was tested in pentane), and an unpunctured, debracted square (bud) from a cotton plant was dipped momentarily in the solution. Ten 1- or 2-day-old adult weevils, unfed from time of emergence or starved for 24 hr, were placed in a petri dish with 1 treated bud and 1 control bud (dipped in solvent only) and held for 4 hr.

TABLE I

Yield and Boll Weevil Feeding Deterrency of Seed Oils

Plant name	Plant family	Oil yield/conjugated trienoic acid content (%)	Number of feeding punctures	
			Oil solution	Solvent
Aleurites fordii Hemsl.	Euphorbiaceae	30.0/50	2	21[a]
Calendula arvensis L.	Compositae	5.2/41	62	47
Calendula suffruticosa Vahl.	Compositae	6.1/62	18	50[a]
Catalpa bignonioides Walt.	Bignoniaceae	17.0/38	47	35
Centranthus macrosiphon Boiss.	Valerianaceae	22.6/56	16	87[a]
Impatiens balsamina L.	Balsaminaceae	4.9/22	46	77
Impatiens flemingii Hook. f.	Balsaminaceae	52.3/46	60	57
Jacaranda mimosifolia D. Don.	Bignoniaceae	23.1/37	21	52[a]
Momordica cochinchinensis Spreng.	Cucurbitaceae	22.5/58	27	74[a]
Punica granatum L.	Punicaceae	5.2/71	30	35
Santalum album L.	Santalaceae	33.7/69	38	45
Tricosanthes anguina L.	Cucurbitaceae	22.7/45	46	63

[a]These results differed significantly by the chi-square test ($p < 0.001\%$).

Five control and 5 test dishes (5 replicates) were prepared for each oil. The number of feeding punctures/bud was counted under a dissecting microscope.

RESULTS AND DISCUSSION

Table I gives the plant name and family, oil yield and its content of conjugated acid, and the antifeedant test results for each of the 12 candidate oils tested. Besides tung oil, only the seed oils of *Calendula suffruticosa*, *Centranthus macrosiphon*, *Jacaranda mimosifolia* and *Momordica cochinchinensis* deterred feeding by the boll weevil. Of the latter 4 oils, *C. macrosiphon* was the most effective; this is not surprising, since the seed oil of this plant is known to contain α-eleostearic acid (4). The 9E,11Z,13Z isomer of this acid is present in the seed oils of *Punica granatum* (5), *M. cochinchinensis* (6) and *Trichosanthes anguina* (7) in both the free and combined forms, but only the oil of *M. cochinchinensis* was deterrent. *C. bignonioides* seed oil, which contains the 9E,11E,13Z isomer (5), was ineffective. The active seed oils of *C. suffruticosa* and *J. mimosifolia* contain the 8E,10E,12Z and 8Z,10E,12Z isomers, respectively, of 8,10,12-octadecatrienoic acid (8,9), but the oil of *Calendula arvensis*, which also contains the 8E,10E,12Z isomer (8), did not deter feeding. The seed oils of *Impatiens balsamina* and *I. flemingii*, both of which failed to deter feeding, contain (9Z,11E,13E,15Z)-9,11,13,15-octadecatetraenoic acid (10). *Santaium album* seed oil, which was also ineffective, is known to contain (E)-11-octadecen-9-ynoic acid (11). All conjugated acids were found to be unisomerized.

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REFERENCES

1. Jacobson, M., M.M. Crystal and J.D. Warthen, Jr., J. Agric. Food Chem. 29:591 (1981).
2. Hardee, D.D., and T.B. Davich, J. Econ. Entomol. 59:1267 (1966).
3. Jacobson, M., U.S. Patent Appl. 140,911 (Apr. 16, 1980).
4. Hopkins, C.Y., and M.J. Chisholm, Can. J. Chem. 43:3160 (1965).
5. Privett, O.S., in "Progress in the Chemistry of Fats and Other Lipids," Vol. IX, part 3, edited by R.T. Holman, Pergamon Press, Oxford, 1968, pp. 409-452.
6. Airan, J.W., and S.V. Shah, J. Univ. Bombay 11:105 (1942).
7. Crombie, L., and A.G. Jacklin, J. Chem. Soc. 1632 (1957).
8. Chisholm, M.J., and C.Y. Hopkins, Can. J. Chem. 38:2500 (1960).
9. Chisholm, M.J., and C.Y. Hopkins, J. Org. Chem. 27:3137 (1962).
10. Takagi, T., JAOCS 43:249 (1966).
11. Hatt, H.H., and A.Z. Szumer, Chem. Ind. 962 (1954).

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Effect of Plastic Fats on Thermal Stability and Mechanical Properties of Fat-Protein Gel Products

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ABSTRACT

Meat was comminuted with soybean-oil-based plastic fats of different physical properties and cooked at 2 different rates. Thermal stability of emulsion was inversely related to fat softness and heating rate. Stable emulsions were obtained when prepared with fat containing 30% solids at 16% product fat level, 40% solids at 22% level, and 50% solids at 28% level. Release of fat and water upon heating commenced about 10 C below the softening point of the fat. Compressive force (CF) increased markedly and shear force (SF) increased moderately with increasing hardness of fat. Both CF and SF reached a maximum at the 40% fat solids level. Increased total fat tended to reduce mechanical strength. Faster heating resulted in greater mechanical strength of cooked product but caused fat separation in high fat products formulated with soft fats.

INTRODUCTION

Comminuted meat products such as frankfurters and sausages are prepared by chopping meat with the addition of salt and ice to a fine homogenate which forms a stable matrix upon cooking. When the temperature of the comminuted batter reaches the melting point of the fat incorporated during chopping (1), or a flowing of fat is allowed within the matrix, the fat starts to coalesce, resulting in emulsion destabilization. A formation of large conglomerates of fat accompanied with discontinuity of protein matrix was seen photomicrographically in the batter chopped at 26 C, whereas uniform fat dispersion in a continuous protein matrix was observed in batter chopped at 16 C (2,3). Interestingly, after being cooled to 17 C by adding Dry Ice while chopping, such destabilized emulsions (chopping temperature 27 C) were restabilized (4). A recent study by Lee et al. (3) explained stabilization after addition of Dry Ice by hardening of fat which permits uniform fat distribution. This clearly indicates that emulsion stability is determined by the fat distribution pattern which, in turn, is influenced by the physical state of the fat incorporated at the time of comminution. Despite the seemingly important role of fat physical properties in emulsion stabilization, virtually no studies have been reported, particularly in relation to stability of protein-gel type emulsions. Therefore, it was decided to investigate how physical properties of fats affect the emulsion stability as well as the mechanical properties of cooked emulsion products. Parameters used in this study were physical properties of fat, thermal stability of emulsions and mechanical properties of cooked products.

MATERIALS AND METHODS

Preparation of Plastic Fats and Emulsions

Soybean-oil-based plastic fats were prepared by melting an 800-g mixture of soybean oil (IV = 120) and stearin (mp =

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