A Simple and Rapid Polarimetric Method for Quantitative Determination of Castor Oil

S. Babu*, **R.V. Sudershan, R.K. Sharma, and Ramesh V. Bhat**
National Institute of Nutrition, Hyderabad, Andhra Pradesh 500007, India

ABSTRACT: A simple and rapid polarimetric method is developed for quantitation of adulteration of castor oil in edible oils such as cottonseed, coconut, mustard, olive, palm, peanut, rice bran, safflower, soybean, and sunflower. The method is based on the optical activity of ricinoleic acid (12-hydroxy octadecenoic acid), a major constituent of castor oil. There is a good correlation between optical rotation and castor oil content in admixtures above 5%. Highly colored and viscous oils interfere in the measurement of optical activity. The method is highly specific and cost-effective. No solvents and chemicals are required for the analysis because no sample processing is involved in the present method.
JAOCS 73, 397–398 (1996).

KEY WORDS: Castor oil, edible oil adulteration, optical rotation, polarimetry.

Adulteration or accidental contamination of edible oils with cheaper oils or toxic oils has been reported in the past from different parts of the world (1–4). A recent survey, conducted in state food laboratories spread all over India, indicated that castor oil is the major adulterant in edible oils because it is cheaper than other vegetable oils (5). The consumption of castor oil is known to have deleterious effects on human health (6). The methods presently available for detection and quantitation of castor oil are time-consuming, need elaborate extraction procedures and sophisticated instruments (7–11). Rancid oils interfere in the analysis and give false-positive results (12). Because of these limitations in the analytical procedures, food control authorities often fail in their attempt to legally prosecute the traders involved in willful adulteration. Hence, there is an urgent need to improve or develop a simple and rapid method to quantitate castor oil in other edible oils. Castor oil is strongly dextro-rotatory because of the asymmetric carbon atom in ricinoleic acid (12-hydroxy octadecenoic acid). Based on this unique property, a new and rapid method with a polarimeter is developed to quantitate castor oil in edible oil admixtures.

MATERIALS AND METHODS

Different oils, both commercial and authentic, extracted from the respective seeds, were used in this study. The common edible oils that are consumed in different parts of the world, viz., cottonseed (*Gossypium herbacium*), coconut (*Cocos nucifera*), mustard (*Brassica nigra*), olive (*Olea europaea*), palm (*Elaeis quineensis*), peanut (*Arachis hypogea*), rice bran (*Oryza sativa*), safflower (*Carthamus tinctorius*), sesame (*Sesamum indicum*), soybean (*Glycine max*), and sunflower oils (*Helianthus annus*), were purchased from the market for analysis. Eight castor oil samples from different locations were collected at random for analysis of the extent of variation in optical rotation.

*To whom correspondence should be addressed.

Determination of optical rotation. The optical rotation of each oil sample was measured by an Automatic Polarimeter AA-10, manufactured by Optical Activity Ltd. (Huntingdon, Cambridgeshire, England), in a 100-mm tube. The analysis consists of filling the tube with test sample without trapping any air bubbles, then placing it in the polarimeter for recording optical rotation.

Quantitation of castor oil. Admixtures of castor oil with peanut oil, ranging from 1 to 90%, were prepared, and the optical rotation was measured. A standard curve was obtained by plotting concentration of castor oil in the admixture vs. optical rotation.

Effect of heating oil on the optical rotation. The castor oil and its admixtures were heated in glass beakers at 180°C for 2 h and cooled before optical rotation of the samples was measured.

Statistical methods applied. The relation between optical rotation and castor oil content in the admixture was assessed by the calculation of Pearson's product–moment correlation coefficient (13). Analysis of variance with a least significant difference of 5% was utilized for evaluation of differences among the replicates and standard admixtures.

RESULTS AND DISCUSSION

Various physical, chemical, and chromatographic methods to detect castor oil adulteration in edible oils have been described. However, these methods have certain limitations. Rajnish (14) developed a chemical method with ammonium molybdate in sulfuric acid for detection of castor oil in quantities as low as 0.1% in other edible oils. The method is purely qualitative. The thin-layer chromatographic method gives a false-positive test if the oil becomes rancid (12). Subsequent studies have shown that rancid oils require bleaching before analysis (15). The gas–liquid chromatographic method (9) is specific for castor oil, but it requires preparation of fatty acid derivatives. The high-performance liquid chromatography method (10) is not satisfactory for

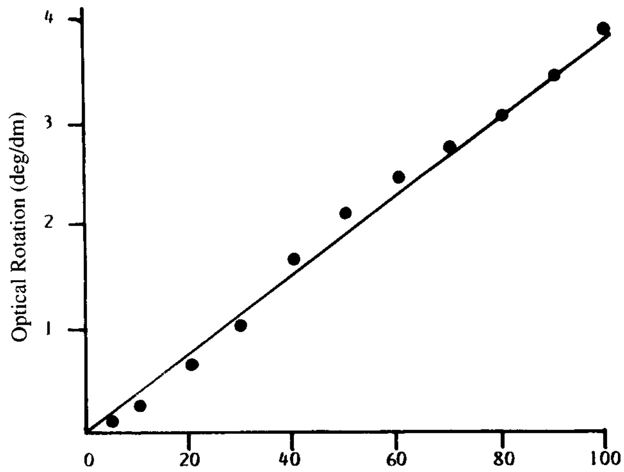

FIG. 1. Relationship between optical rotation and castor oil concentration in the admixtures. Castor oil % = 23.1771 × Y + 1.341 where Y = optical rotation.

oils that contain more than 0.2% free fatty acids (FFA) or for heat-abused oils because FFA and degraded products co-elute with triricinolein present in castor oil. Thus, all current methods are time-consuming due to the requirement of sample processing.

Castor oil showed an optical rotation between 3.72 and 4.32 deg/dm with a mean ± SE value of 3.98 ± 0.193 deg/dm, which reflects ricinoleic acid content. The overall coefficient of variation for six different castor oil samples was 11.9%. This is similar to the reported variation in the ricinoleic acid content of castor oil (11). Two castor oil samples were highly colored and viscous, and did not show consistent optical rotation. No other edible oil tested showed optical activity except sesame oil, which was slightly dextro-rotatory with an optical rotation of 0.80 to 0.85 deg/dm. This activity is due to the presence of sesamin, and alkaloid present in the nonglyceride fraction of the oil. The values for the optical rotation of castor oil and sesame oil obtained in the present study are similar to the values reported in the literature (16). Heating of castor oil had no effect on optical rotation.

Figure 1 shows a linear relationship between the castor oil concentration in the admixture and optical rotation ($r = 0.995$, $P < 0.001$). Polarimetrically, castor oil can be detected in other oils at the level of 5% and above. Castor oil at the 5% level showed a mean optical rotation of 0.15 ± 0.014 deg/dm, which increased significantly at regular intervals with raised concentration of castor oil. Variation between replicate samples was less than 2.5%. Variation in the repeatability of optical rotation for the same castor oil sample was less than 1%.

The advantage of the method now proposed is that there is no need for sample processing. The sample can be analyzed directly in less than a minute. Rancid oils and the presence of any amount of FFA will not interfere in the detection of castor oil because they are optically inactive. However, the method cannot be applied to sesame oil because it exhibits slight optical activity. Also, if the oil samples are deeply colored or highly viscous, the optical rotation of the sample will be affected. The method is simple, specific, rapid, and cost-effective, and does not require solvents and chemicals for analysis.

ACKNOWLEDGMENTS

The authors thank Prof. G. Venkateshwarlu, Head, Department of Biochemistry, Osmania University, Hyderabad, for extending the facilities to carry out the work, and Dr. N. Balakrishna for statistical analysis of the data. Thanks are also due to Dr. M. Mohan Ram, Director, National Institute of Nutrition, Hyderabad, for his keen interest in the study.

REFERENCES

1. Firestone, D., K.L. Carson, and R.J. Reina, Update on Control of Olive Oil Adulteration and Misbranding in the United States, *J. Am. Oil Chem. Soc. 65*:788–792 (1988).
2. World Health Organization, Toxic Oil Syndrome. Current Knowledge and Future Perspectives, *WHO Regional Publication European Series No. 42*:1 (1992).
3. Imai, C., H. Watanabe, N. Haga, and T. Ii, Detection of Adulteration of Cottonseed Oil by Gas Chromatography, *J. Am. Oil Chem. Soc. 51*:326–330 (1974).
4. Sil, S., P. Sengupta, Mayamitra, and R.S. Gandhi, Detection of Palmolein in Groundnut Oil by Thin Layer Chromatography, *J. Oil Tech. Assoc. India 20*:33 (1988).
5. Sudershan, R.V., and R.V. Bhat, Changing Profile of Food Adulteration: Analysts Perception, *J. Food Sci. Technol. 32*:368–372.
6. Steingrub, J.S., Amniotic Fluid Embolism Associated with Castor Oil Ingestion, *Crit. Care Med. 16*:642–643 (1988).
7. Lakshminarayana, G., and V.V.S. Mani, Detection of Adulterant Castor Oil in Other Vegetable Oils by Thin Layer Chromatography, *Indian J. Technol. 2*:320–321 (1964).
8. Nasirullah, M.N. Krishnamurthy, K.S. Pashupathy, K.V. Nagaraja, and O.P. Kapur, Evaluation of the Turbidity and Thin Layer Chromatographic Tests for Detection of Castor Oil, *J. Am. Oil Chem. Soc. 59*:337–339 (1982).
9. Lakshminarayana, G., M.M. Paulose, and K.B. Neeta, Characteristics and Composition of Newer Varieties of Indian Castor Seed and Oil, *Ibid. 61*:1871–1872 (1984).
10. Taneja, V.K., N.K. Sharma, and R.D. Wagle, Detection and Quantitation of Linseed Oil in Soybean by High Pressure Liquid Chromatography, *J. Oil Technol. Assoc. India 18*:54–55 (1986).
11. Husain, S., M. Kifayatullah, G.S.R. Sastry, and R.N. Prasad, Quantitative Determination of Castor Oil in Edible and Heat Abused Oils by C^{13} Nuclear Magnetic Resonance Spectroscopy, *J. Am. Oil Chem. Soc. 70*:1251–1254 (1993).
12. Rajalakshmi, S., T. Mallika, M.N. Krishnamurthy, K.V. Nagaraja, and O.P. Kapur, Detection of Castor Oil in Rancid Groundnut Oil, *Fette Seifen Antrichm. 85*:399–402 (1983).
13. Visweswar Rao, K. (ed.), *Biostatistics—A Manual of Statistical Methods for Use in Health and Nutrition*, National Institute of Nutrition, Hyderabad, 1994, p. 113.
14. Rajnish, K., A Quick Method for Detecting Castor Oil in Vegetable Oils, *J. Am. Oil Chem. Soc. 40*:80 (1963).
15. Wagle, N.G., Some Observations on the Behavior of Rancid Groundnut Oil with Regard to the Thin Layer Chromatography Test for the Detection of Castor Oil, *Ibid. 55*:547 (1978).
16. George, S.J., in *Vegetable Fats and Oils. Their Chemistry, Production and Utilization for Edible, Medicinal and Technical Purposes*, edited by Reinhold Publishing Corporation, London, 1943, p. 239.

[Received June 20, 1995; accepted December 26, 1995]