A Modified VERI-FRY® Quick Test for Measuring Total Polar Compounds in Deep-Frying Oils

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ABSTRACT: The AOCS official method for the determination of total polar compounds in deep-frying oils is often used to estimate frying oil degradation. It can be accurate and reliable, but with sacrifices of time and expense. The TPM VERI-FRY® PRO (Libra Technologies, Inc., Metuchen, NJ) quick test provides a quick and easy way to measure polar compounds in frying oils. The modified quick test measured at 490 nm has a good correlation with the AOCS official method ($r = 0.975$, $P < 0.001$) and provides a good estimate of polar compound accumulation in oils over 80 h of deep-frying. Using the quick test to measure polar compounds is fast, convenient, economical and reliable.

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KEY WORDS: Canola oil, deep-frying oil, quick test, spectrophotometry, total polar compounds.

Deep frying is a very popular practice in food industry due to its convenience and enhancement of fried food flavor. Frying oil, used continuously or repeatedly at high temperatures, is subject to a series of degradation reactions and the formation of decomposition compounds. These decomposition compounds have a negative effect on flavor and nutritional value of the fried foods. Chemical analyses are reliable ways to measure decomposition compounds in the frying oil. Among these chemical methods, measurement of total polar compounds (TPC) in frying oil is the most popular (1). TPC represents cumulative degradation of a frying oil and is defined as the sum of the materials that are not triglycerides (2). TPC is a good indicator of frying oil quality, and frying oils with 25–27% TPC content have deteriorated to the point where they should be discarded (3–5). Regulations in some countries specify that deep-frying oils should contain less than 25–27% TPC (6). Official methods for the determination of TPC content can be accurate but time-consuming and expensive. This article describes a modified VERI-FRY® quick test that has a good correlation to the AOCS official method for measuring TPC in frying oil.

EXPERIMENTAL PROCEDURES

Using the VERI-FRY® (Libra Technologies, Metuchen, NJ) quick test to estimate TPC in deep-frying oils was one of the chemical methods used in two studies evaluating new lines of canola oils in deep-frying applications at Food Science Australia. Only the information relevant to this work is provided below.

Oil samples and potato chips. In the first study (7), six oils were used to deep-fry potato chips over two replicates of 80-h trials. They were three high-oleic canola oils containing 2.6, 5.2, and 5.3% linolenic acid, respectively; a refined, bleached, and deodorized standard canola oil containing 8.4% linolenic acid; a partially hydrogenated canola oil; and a high-oleic (86%) sunflower oil. Each trial lasted 10 d (8 h/d). For calibration, two sets of oil samples were sent to the State Chemistry Laboratory of Victoria (Australia) for TPC analysis using the method of Sebedio *et al.* (8). The oil samples were the day 0, 1, 3, 5, 6, 8, and 10 samples of the high-oleic canola oil containing 5.2% linolenic acid and the partially hydrogenated canola oil, respectively.

In the second study (9), six oils were used to deep-fry potato chips over two replicates of 80-h trials. They were three high oleic canola oils containing 2.5, 4.4, and 6.8% linolenic acid, respectively; a sunflower oil; a palm olein oil; and a partially hydrogenated canola oil. Each trial lasted 10 d (8 h/d). For calibration, TPC in a set of 11 oil samples taken on day 0 to day 10 of the high-oleic canola containing 6.8% linolenic acid were analyzed using AOCS Official Method Cd 20-91 (10).

Edgell (Grade A) 13-mm quick-frozen straight-cut chips (Melbourne, Australia) were used in the two studies. They had been precooked by the manufacturer in refined tallow for 1 min and were stored at −18°C before use. Oils (7.5 L/each) were placed in Roband fryers with temperature control (Woodson Australia Pty. Ltd., Melbourne, Australia) and not topped up over 80 h of deep-frying. The oil was heated to 190 ± 2°C and kept at this temperature for 8 h/d. Potato chips (200 g) were fried in each oil for 6 × 3.5 min/h (from 11:00 A.M. to 1:00 P.M. on days 1, 4, 6, 8, and 10 for each trial), and 100 g of chips were fried for 3 × 5 min/h at other times. Oil samples (~100 mL) were taken at the end of the day for analysis and stored at −32°C.

Measuring total polar compounds. The method of Sebedio *et al.* (8), which is a scaled-down version of the AOCS method and correlates well with AOCS results, was used for calibration in the first study. AOCS Official Method Cd 20-91: Determination of Polar Compounds in Frying Fats (10) was used for calibration in the second study. TPM VERI-FRY® PRO quick-test gel tubes (Libra Technologies Inc.) were used to estimate TPC contents in all the oils of the two studies.

The same oil samples used for either the AOCS or Sebedio method were also used for the quick test measured at 490

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and 590 nm, respectively. Oil samples were placed in a 60°C oven for 30 min. The warm oil samples were filled into the test tubes to the fill line and mixed well with the reagent gel in the tube. The tubes were then put back in the oven for 15 min before measurement.

The modified VERI-FRY® quick test was measured spectrophotometrically at 490 nm instead of 590 nm (as recommended by the company). Air (without a test tube in the cell) was used to zero the spectrophotometric reading. As a control, the same test tube, without the reagent gel in it, was filled with unused oil and measured at 490 nm.

Statistical analysis of data. The data were statistically analyzed using correlation and regression. The curves and the equations of the curves in the following figures were fitted using Microsoft Excel (Redmond, WA).

RESULTS AND DISCUSSION

Chromatographic method for the measurement of TPC in frying oils can be accurate, with time and expense sacrifices. The TPM VERI-FRY® PRO quick test provides a quick and easy way to estimate TPC in frying oils. The basis for the test is the detection of multiple decomposition compounds in the used frying oils. The TPC reagents are surface-charged dye particles which are encapsulated in a SAFE-GEL™ (Libra Technologies) matrix. The principle of the quick test is that, when the reagent gel is mixed with used frying oil, the charged particles interact with polar (hydrolyzed, oxidized, polymerized, emulsified, and pyrolyzed) materials. The interacted materials yield a color that is in proportion to the concentration of the interacted materials in used frying oils and can be determined at 590 nm (11).

In the first study, for calibration of the quick test, TPC contents of seven samples of high-oleic canola oil and seven samples of partially hydrogenated canola oil were determined using the Sebedio method. These oil samples were a sample of unused oil and six samples taken after 8, 24, 40, 48, 64, and 80 h of deep-frying, respectively. When measured at 590 nm, as recommended by the company, the absorbance readings of the unused oils and the day 1 samples (fried for 8 h) were greater than the day 3 samples (fried for 24 h) and similar to the day 4 samples (fried for 32 h) in the oils tested (Figs. 1 and 2). The actual differences in the TPC contents of the unused oils and day 4 samples were between 2 and 15%. After using wavelength scanning and comparison of absorbance readings measured over a range of wavelengths, 490 nm was the optimal wavelength for testing the oil samples. The reasons as to why the modified test measured at 490 nm is better than that measured at 590 nm are explained as follows. Maximal absorbance is around 490 nm rather than 590 nm, and better spectrophotometric responses for the tested oil samples were obtained when measured at 490 nm. Measuring the oil samples from 0 to 32 h of deep-frying at 590 nm would give false results since the samples containing 2% TPC had similar or greater absorbance readings than the samples containing 15% TPC. When an oil sample containing 47% TPC was measured at 590 nm, the absorbance was less than 0.5. However, when measured at 490 nm, the absorbance was 2.7, which would provide a much greater absorbance range and more accurate results for the samples tested. Comparing the TPC contents measured at the two wavelengths in the same oils, as shown in Figures 1 and 2, it is evident that there were much larger variations for the TPC contents measured at 590 nm than at 490 nm. There was also a higher r^2 value for the equation of the fitted curves between the two methods when measured at 490 than at 590 nm (Figs. 3 and 4). For a regulatory control, the correlation coefficient of the quick test and the official method should be ≥0.9. The coefficient of the quick test and the Sebedio method was 0.902 when measured at 490 nm, while at 590 nm, it was 0.872. For these reasons, TPC contents in all the oil samples of the studies were quick-tested at 490 nm.

The AOCS official method provided a much higher significance and a better correlation ($r = 0.975$, $P < 0.001$) with the quick test read at 490 nm (Fig. 5) when measuring TPC in frying oil samples taken from 0 to 80 h of deep-frying. TPC contents were calculated by the quick-test readings minus the average readings of the unused oils at 490 nm and then by using

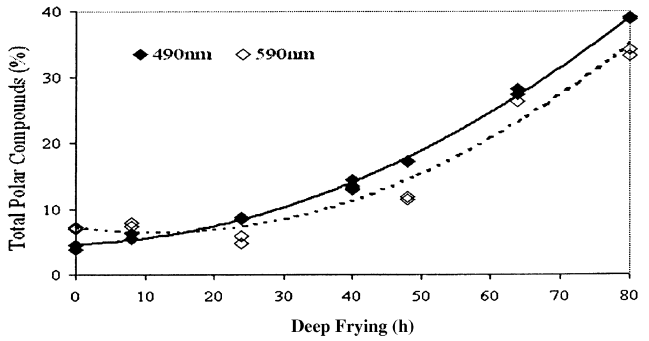

FIG. 1. A comparison of polar compounds accumulated during deep frying by using VERI-FRY® quick test read at 490 and 590 nm, respectively. The frying-oil samples were taken from a high-oleic canola oil fried over two 80-h trials. The two data points in the graph represent the two replicates.

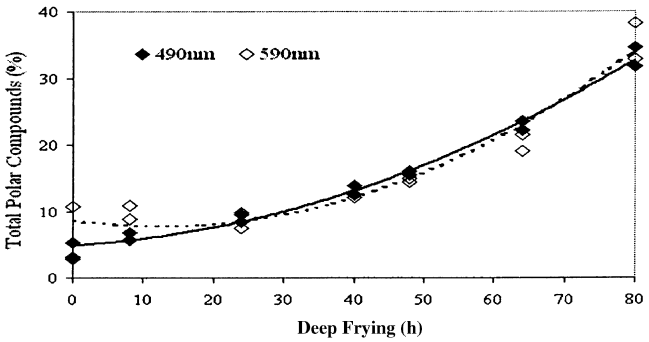

FIG. 2. Another comparison of polar compounds accumulated during deep-frying by using VERI-FRY® quick test read at 490 and 590 nm, respectively. The frying-oil samples were taken from a partially hydrogenated canola oil fried over two 80-h replicates. The two data points in the graph represent the two replicates.

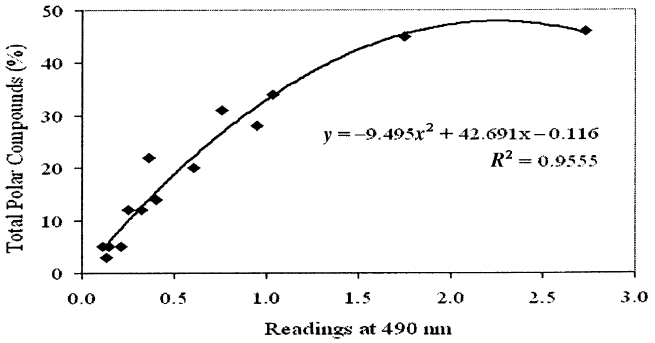

FIG. 3. Correlation of VERI-FRY® quick test readings at 490 nm and total polar compounds (TPC) in two deep-frying oils were measured using the method of Sebedio *et al.* (8). The oil samples were taken from 0 to 80 h of deep-frying.

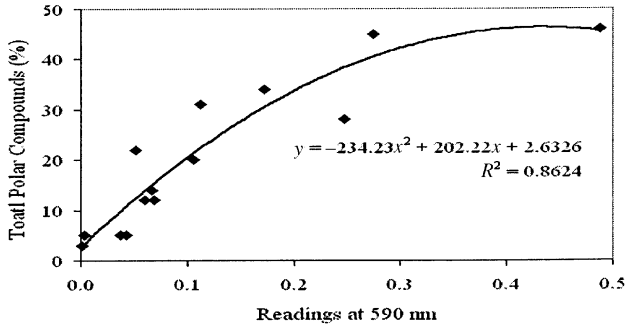

FIG. 4. Correlation of VERI-FRY® quick test readings at 590 nm and TPC in two deep-frying oils (n = 14) were measured using the method of Sebedio *et al.* (8). The oil samples were the same samples as measured at 490 nm. See Figure 3 for abbreviation.

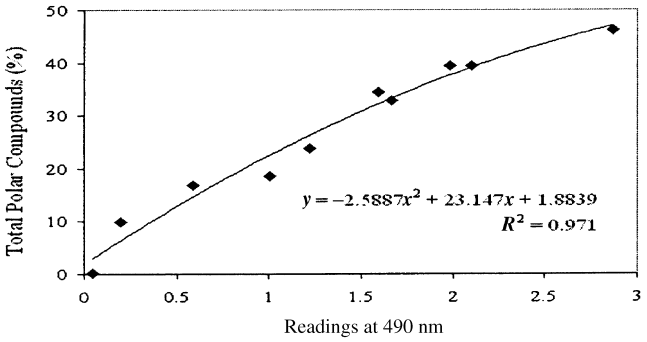

FIG. 5. Correlation of VERI-FRY® quick test readings at 490 nm and TPC in a deep-frying oil measured using AOCS official method. The oil samples were taken from a high-oleic canola oil from 0 to 80 h of frying. See Figure 3 for abbreviation.

the equation $y = -2.5887x^2 + 23.147x + 1.8839$ (Fig. 5). An example of using the quick test to measure TPC accumulation in six different types of frying oils over two 80-h trials is shown in Figure 6. It can be seen clearly that the quick test read at 490 nm gave good measurements of TPC accumulation during deep-frying. Further studies might be necessary since only potato chips were fried in the oils. It is recommended that the TPM VERI-FRY® PRO quick test measured

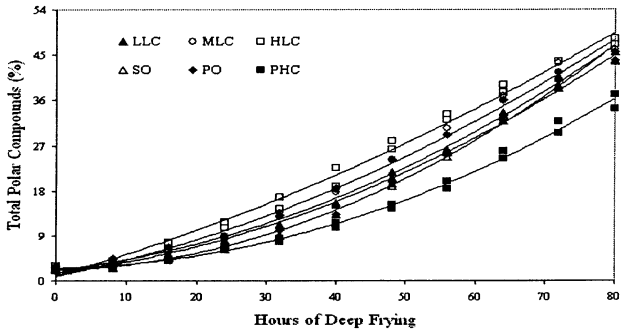

FIG. 6. An example of using VERI-FRY® quick test to measure TPC accumulated over 80 h of deep frying. The two data points in the graph represent the two replicates. LLC, high-oleic canola oil (2.5% $C_{18:3}$); MLC, high-oleic canola oil (4.4% $C_{18:3}$); HLC, high-oleic canola oil (6.8% $C_{18:3}$); SO, sunflower oil; PHC, partially hydrogenated canola oil. See Figure 3 for other abbreviation.

at 490 nm may be used as an alternative method for routine tests and research purposes, provided that a good correlation between the official method and the quick test is obtained.

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REFERENCES

1. Melton, S.L., S. Jafar, D. Sykes, and M. K. Trigiano, Review of Stability Measurements for Frying Oils and Frying Food Flavor, *J. Am. Oil Chem. Soc. 71*:1301–1308 (1994).
2. Blumenthal, M.M., The Chemistry and Technology of Deep-Fat Frying, *Food Technol. 45*:68–71 (1991).
3. Chu, Y.-H., A Comparative Study of Analytical Methods for Evaluation of Soybean Oil Quality, *J. Am. Oil Chem. Soc. 68*:379–384 (1991).
4. White, P.J., Methods for Measuring Changes in Deep-Fat Frying Oils, *Food Technol. 45*:75–83 (1991).
5. Stier, R.F., and M.M. Blumenthal, Quality Control in Deep-Fat Frying, *Baking and Snack February*:76–77 (1993).
6. Firestone, D., Worldwide Regulation of Frying Fats and Oils, *INFORM 4*:1366–1371 (1993).
7. Xu, X.-Q., H. Tran, M. Palmer, K. White, and P. Salisbury, Monitoring Deep Frying Performance of Monola and Monosun Oils, *Food Austr. 51*:157–163 (1999).
8. Sebedio, J.L., C. Septier, and A. Grandgirard, Fractionation of Commercial Frying Oil Samples Using Sep-Pak Cartridges, *J. Am. Oil Chem. Soc. 63*:1541–1543 (1986).
9. Xu, X.-Q., H. Tran, M. Palmer, K. White, and P. Salisbury, Chemical and Physical Analyses and Sensory Evaluation of Six Deep Frying Oils, *J. Am. Oil Chem. Soc. 76*, 1091–1099 (1999).
10. *Official Methods and Recommended Practices of the American Oil Chemists' Society*, 5th edn., edited by D. Firestone, AOCS Press, Champaign, 1998, Method Cd 20-91.
11. Blumenthal, M.M., A Comparison and Evaluation of Tests Designed to Measure the Quality of Restaurant Frying Oils, *Libra Laboratories, Inc.,* Metuchen, NJ, 1993, p. 30.

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