SHORT COMMUNICATION

Comparison of Four Accelerated Stability Methods for Lard and Tallow With and Without Antioxidants

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ABSTRACT: The oxidative stability of lard and tallow with and without antioxidants was evaluated by four accelerated stability methods, the active oxygen method (AOM), the oxygen bomb test, the Rancimat method, and the Schaal oven test. The results indicated that the oxidative stability of animal fats and the relative effectiveness of an antioxidant in the fats could have different mechanisms. When the protective index was used to demonstrate the relative effectiveness of the antioxidants, the results suggested that the Rancimat Method may be the least reliable method compared with AOM, oxygen bomb test, and Schaal oven test. More than one accelerated stability method is recommended for evaluating the effectiveness of an antioxidant or the oxidative stability of fats.
JAOCS 75, 1441–1443 (1998).

KEY WORDS: Active oxygen method, antioxidants, lard, oxygen bomb, projective index, Rancimat, Schaal oven, tallow.

Accelerated stability methods are designed to expedite the oxidation process by manipulating pro-oxidant conditions, such as temperature, metal catalysts, oxygen pressure, shaking, and light exposure, in order to determine the oxidative stability of fats or fat-containing foods within a short time (1). These methods are widely used in industry and academic research (1–5). However, due to the limitation of these methods as well as the diversity of fats or fat-containing foods, the results based on these accelerated stability methods are usually difficult to interpret or to compare (5). In this study, four accelerated stability methods for fat oxidative stability, the active oxygen method (AOM), the oxygen bomb test , the Rancimat method, and the Schaal oven test were conducted for lard and tallow with and without antioxidants. The demonstration of antioxidant activities in different fats by different accelerated stability methods provides a useful reference for the selection of methods to assess antioxidants and the oxidative stability of fats.

EXPERIMENTAL PROCEDURES

Lard and tallow were purchased from the local market and rendered in the laboratory. Antioxidants were Termox™, a blend of butylated hydroxyanisole (BHA) and butylated hydroxytoluene (BHT), and Naturox™, a blend of δ-rich tocopherols and rosemary (*Rosmarinus officinalis* L.) extract. Both antioxidants are made by Kemin Europa NV (Herentals, Belgium).

For the AOM (AOCS method Cd 12-57) (6), 20 g of fat sample was placed in a test tube. The tube was then incubated in an oil bath at 98°C. Dry air (140 mL/min) was continuously bubbled through the fat. One gram of fat sample was withdrawn every 2 h for peroxide value (PV) determination according to AOCS method Cd 8-53 (8) until the PV exceeded 20 meq/kg.

For the oxygen bomb test (a modified ASTM procedure) (7), 50 g of fat samples was placed in a glass container fitted in a metal container (bomb). The bomb was pressurized with pure oxygen (50 psi) and incubated in an oil bath at 99°C. The pressure drop was measured continuously for 24 h.

The model 617 Rancimat (Metrohm Ltd., Herisau, Switzerland) was used for the Rancimat method test. A fat sample (2.5 g) was put into a glass tube. Dry air was set at 20 L/h and the temperature of the heating block was set at 120°C. The outlet vapors were collected in deionized water in which the conductivity was monitored continuously at 21°C until the induction was researched.

A modified Schaal oven test was conducted by placing 50 g of fat sample in loosely sealed glass containers. These containers were incubated at 65°C, and the PV were measured every 2 d according to AOCS method Cd 8-53 (8) until the PV exceeded 20 meq/kg.

Induction time was obtained by extrapolating the tangent back to the chart baseline of the data plotted as a function of time (2). All the tests were conducted in duplicate and the results are reported as the average.

RESULTS AND DISCUSSION

Table 1 summarizes the values of induction time for lard and tallow with and without antioxidants. As different accelerated stability methods were conducted at different conditions with different mechanisms, the comparison of the absolute value of these induction times is not meaningful. However, the relative stabilities of the lard and the tallow can be concluded based on the values of induction time of the control lard and the control tallow assessed by different methods. These results showed that the lard was more stable than the tallow

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TABLE 1
Induction Time of Lard and Tallow Under Different Accelerated Stability Methods

Lipid sample	Treatment	AOM (h)[a]	Oxygen bomb test (h)	Rancimat method (h)	Schaal oven test (d)
Lard	Control	12	4.5	15	5
	BHA/BHT	23.5	18	25	38.5
	Tocopherol/ rosemary extract	20	16	25	36
Tallow	Control	3	5	18	8
	BHA/BHT	44	41	26	70
	Tocopherol/ rosemary extract	35	22	39	58

[a]AOM, active oxygen method; BHA, butylated hydroxyanisole; BHT, butylated hydroxytoluene.

TABLE 2
Protective Index[a] of BHA/BHT and Tocopherol/Rosemary Extract for Lard and Tallow Determined by Different Accelerated Stability Methods

Lipid sample	Antioxidants	AOM	Oxygen bomb test	Rancimat method	Schaal oven test
Lard	BHA/BHT	1.96	4.00	1.67	7.70
	Tocopherol/ rosemary extract	1.67	3.56	1.67	7.20
Tallow	BHA/BHT	14.67	8.20	1.44	8.75
	Tocopherol/ rosemary extract	11.67	4.40	2.17	7.25

[a]Protective index (PI) = [induction time with antioxidant (h/d)]/[induction time without antioxidant (h/d)]. See Table 1 for other abbreviations.

TABLE 3
The Relative Effectiveness[a] of Antioxidants Based on Their PI Under Different Conditions

Lipid sample	Antioxidant	AOM	Oxygen bomb	Rancimat	Schaal oven
Lard	BHA/BHT	++	++	+	++
	Tocopherol/ rosemary extract	+	+	+	+
Tallow	BHA/BHT	++	++	+	++
	Tocopherol/ rosemary extract	+	+	++	+

[a]The relative effectiveness is a comparative value, based on PI of the substrate fat when different methods are used. The more the number of "+", the higher the value of relative effectiveness. See Tables 1 and 2 for abbreviations.

based on the results of AOM. However, the results from the oxygen bomb test, the Rancimat method, and the Schaal oven test showed that the tallow was more stable than the lard with the rank of induction time deviation between the lard and the tallow: Schaal oven test (0.63) > Rancimat method (0.83) > oxygen bomb test (0.90). Different results between AOM and Rancimat method were reported when using animal fats as the substrates (9). However, the results of AOM are inconsistent with those of Schaal oven test and oxygen bomb test, and more investigation is needed.

To compare the relative effectiveness of different antioxidants in the lard and the tallow assessed by different methods, a protective index (PI) was calculated by dividing the value for the induction time of the antioxidant-treated sample with that of the control sample. Table 2 summarizes the values of PI of different antioxidants in the lard and the tallow assessed by different methods. Once again, the absolute values of these PI are not meaningful when they are compared with the results based on different methods. However, the conclusion on the relative effectiveness of an antioxidant in the lard or the tallow can be made when the same method is used. For instance, it is clear that BHA/BHT is more effective than tocopherol/rosemary extract in both the lard and the tallow, based on the results from AOM, oxygen bomb test, and Schaal oven test. However, the results of Rancimat method indicated no difference between BHA/BHT and tocopherol/rosemary extract in the lard, and more effective protection of tocopherol/rosemary extract than BHA/BHT in the tallow (Table 3).

Our observation indicated that the oxidative stability of animal fats and the relative effectiveness of antioxidants in these

fats could have different mechanisms as tested under the conditions in this study. An in-depth discussion of these mechanisms is beyond the scope of this short communication. However, based on our results as well as the previous ones (1,9–12), Rancimat method at 120°C may be the least reliable method to evaluate the effectiveness of antioxidant in animal fats. Our observations also indicate that more than one accelerated stability method should be used when assessing the oxidative stability of fats and the effectiveness of antioxidants in particular fat.

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[Received April 21, 1997; accepted June 2, 1998]