Stability of Coconut Oil in Food Products

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ABSTRACT

The active oxygen method (AOM) stability of refined coconut oil is generally 250 hr; however, samples with as low a stability as 30 hr have been obtained. The addition of BHA, BHT and citrate increased the AOM stability to about 350 hr even though the initial stability was 30 or 250 hr. Refined coconut oil samples which hydrolyzed from 2 to 10 times as rapidly as normal oils have been encountered. Such samples are undesirable for food production as soapy off-flavors may be produced. The rate of hydrolysis of coconut oil samples was evaluated by a simple laboratory test. Coconut oil free fatty acids produced a soapy off-flavor at a lower level in sweet foods than in salty ones. Soapy off-flavors were produced in a low moisture food containing coconut oil by the lipase activity of cinnamon.

INTRODUCTION

Coconut oil is used for the production of a number of food products because it has a relatively sharp melting point, a bland flavor and is extremely resistant to oxidation. The latter is usually true, however, a few samples with a low stability have been received. The effect of antioxidants on samples with low stability was investigated.

One disadvantage of the use of coconut oil in food products is the possible development of a soapy flavor due to the free fatty acids (FFA) produced by hydrolysis. When higher than normal FFA were obtained, the cause was initially attributed to improper processing or storage of the food product. Subsequent investigations showed that the rate of hydrolysis of refined coconut oil may vary considerably. A test procedure was established to measure the rate of hydrolysis. A soapy flavor due to high FFA was also shown to be produced by the lipase activity on the coconut oil in a low moisture food product during storage.

EXPERIMENTAL PROCEDURES

The oxidative stability of coconut oils was determined by the active oxygen method (AOM).

To evaluate the oil samples for their rate of hydrolysis, the following procedure was used. First the initial FFA content of the oil was determined. Then 2 ml of distilled water and 28.2 g of oil were placed into 2 oz sample jars (about 4 cm diam and 7 cm high) which were loosely capped and autoclaved at 15 psi (250 F) for 16 hr. After the jars had cooled, the FFA content was redetermined using the total content of the jar. The ratio of the FFA after autoclaving over the initial FFA was calculated for each oil sample. Good agreement was obtained when the same samples were run by three different laboratories. When commercial coconut oil samples were autoclaved without the addition of water, hydrolysis to the same degree occurred with most samples, but the addition of the 2 ml of water improved the reproducibility. The addition of 10 ml or more of water reduced the extent of hydrolysis in some samples which had a high rate of hydrolysis.

TABLE I

Variations in Active Oxygen Method Stability of Coconut Oils and the Effect of the Addition of Antioxidants

	Samples		
	A	B	C
Iodine value	9.8	8.4	9.3
Per cent free fatty acids	.04	.03	.02
AOM when received	255 hr	30 hr	82 hr
AOM, treatment 1[a]	272 hr	68 hr	188 hr
AOM, treatment 2	362 hr	238 hr	---
AOM, treatment 3	374 hr	340 hr	370 hr

[a]Treatments: 1—300 ppm monoglyceride citrate added; 2—100 ppm each of BHA and BHT added; 3—300 ppm monoglyceride citrate and 100 ppm each BHT and BHA added.

RESULTS AND DISCUSSION

Variations in the Rate of Oxidation

Most freshly refined coconut oil samples have an AOM stability of 180 to 250 hr; however, samples with a stability as low as 30 hr have been received. When BHA, BHT and monoglyceride citrate were added to coconut oils, the AOM stability of all samples, irrespective of their initial stability, were about 350 hr as shown in Table I. The addition of monoglyceride citrate to oil samples with high stabilities did not produce a significant change, but it improved the stability of the samples with low initial stabilities. The addition of BHA and BHT to a coconut oil sample with a low stability resulted in a much greater improvement than when added to a sample with a high initial stability.

These results suggested that the high resistance to oxidation of coconut oil might not be entirely due to its low unsaturation but due to the presence of natural antioxidants in varying amounts. Semiquantitative gas liquid chromatography analysis showed no difference in amounts of tocopherols in the coconut oils with low and high stabilities. Thewalt et al. (5) have reported detecting phenols other than tocopherols in amounts up to 100 ppm in coconut oil samples. To obtain an oil with no natural antioxidants, two mixtures of the fatty acid ethyl esters simulating the composition of coconut oil were prepared. The unsaturation in the first mixture (iodine value of 7.9) was obtained by the use of ethyl oleate. The second mixture contained 1.5% ethyl linoleate and 5% ethyl oleate (iodine value of 7.4). The AOM stability of these mixtures were 48 and 28 hr, respectively. When 100 ppm each BHA and BHT were added, the stability was increased to 410 and 148 hr. With the addition of the antioxidants and 300 ppm of monoglyceride citrate, the AOM stability of both samples exceeded 500 hr.

Variations in the Rate of Hydrolysis

A freshly refined coconut oil sample, which met all established specifications but which was suspected to be the cause of an off-flavor in the production of a food product,

TABLE II

Effect of Initial Free Fatty Acid Content on Rate of Hydrolysis of Coconut Oil

Samples	Free fatty acids, %		Ratio of heated/initial free fatty acids
	Initial	Heated	
M as received	.03	.26	8.7
M plus oleic acid	.09	.66	7.4
X as received	.03	.09	3.0
X plus oleic acid	.09	.26	2.9

was evaluated in the laboratory by deep fat frying of a low moisture snack. After 5 hr of frying at 360 F, the FFA content of this coconut oil sample was 0.43%. Normal coconut oil samples under the same conditions produced a FFA content of only 0.11%.

The amount of FFA produced under milk hydrolysis conditions is greatly influenced by the initial FFA content of an oil; hence such a FFA value is not a direct measure of the rate of hydrolysis of an oil. This was illustrated with the hydrolysis test using coconut oil samples to which fatty acids had been added to change the initial FFA content as shown in Table II. The ratios of the FFA content after autoclaving, divided by the initial FFA content were of the same magnitude for the same sample with different initial FFA levels; however, the ratios differed considerably for the two samples shown in Table II—about three for Sample X and eight for Sample M. Ratios in the two to four range were obtained for most commercial coconut oil samples. A few samples of commercial coconut oils had higher hydrolysis ratios. One sample had a ratio of 30.

It was found that samples with a high hydrolysis ratio showed a more rapid increase in FFA not only when used in a food process but also during the storage of the oil. Coconut oil samples with initial FFA contents of 0.03% but hydrolysis ratios of 3, 11 and 30 had FFA levels of 0.03%, 0.09% and 0.20%, respectively, after six months storage in glass jars at 50 F.

Noble et al. (4) and Buziassy and Nawar (1) have reported that the rate of hydrolysis of triglycerides was more selective in favor of the shorter chain and unsaturated fatty acids. To determine if a small increase in the shorter chain or longer chain fatty acids affected the hydrolysis ratio, the hydrolysis test was carried out with coconut oil samples to which 5% tricaproin, trioctanoin or tripalmatin had been added. These changes in the fatty acid composition had no effect on the rate of hydrolysis. Neither was the hydrolysis ratio influenced by the addition of 0.25% to 13% of monolein or monostearin, or 0.25% of oxystearins.

The addition of less than 30 mg of sodium laurate per 100 g of coconut oil (29 ppm Na) had no effect on the hydrolysis ratio. At higher levels the rate of hydrolysis was significantly increased. This increase was greater than that obtained by the addition of equal molar amounts of lauric acid. The presence of soaps was not the reason for the higher rates of hydrolysis in the commercial coconut oil samples. The highest level of sodium found by atomic absorption in any of these samples was 2 ppm.

Deterioration Due to Lipase Activity

Halbert and Weeden (3) and Gross (2) have reported lipase activity in spices and seasonings. Such lipase activity can cause stability problems in food products containing coconut oil. A snack product with a moisture content of 3% which had been fried in coconut oil and was dusted with a mixture of sugar and cinnamon had a good initial flavor. After six weeks of storage at 100 F, the product was rated unacceptable due to a soapy flavor. The free fatty acid content of the oil extracted from the product was 0.13% initially, 0.79% after 6 weeks storage at 100 F, 0.91% after 8 weeks and 1.49% after 10 weeks.

To determine if the acid formation was due to lipase activity of the cinnamon, 1.4 g of cinnamon was mixed with 28 g of both coconut oil and light mineral oil. The FFA content of the coconut oil-cinnamon mixture was 0.06% initially and 1.27% after four weeks storage at 57 C. For the cinnamon and mineral oil mixture the FFA were 0.03% initially, and 0.06% after storage.

Coconut Oil FFA Off-Flavor

The amount of coconut oil FFA required to produce a "soapy" flavor in a food product was found to vary with the type of product and the sensitivity of the individual to this type of off-flavor. In a sweet candy product containing 30% coconut oil, 14 out of 30 tasters rated the product unacceptable when the oil had a FFA content of 0.25%. When the FFA level was increased to 0.4%, all but one taster judged the product unacceptable due to a "soapy" flavor. In contrast, a salty snack containing 30% coconut oil with a FFA content of 0.4% was rated unacceptable by only three of 30 tasters. When the FFA of the oil in the snack was 0.6%, 23 out of 30 tasters rated the product unacceptable. Three tasters of the laboratory panel were much more sensitive to coconut oil FFA than the other tasters.

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