Effects of Microwave and Conventional Baking on the Oxidative Stability and Fatty Acid Composition of Puff Pastry

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ABSTRACT: The effects of microwave and conventional baking on the fatty acid and *trans* fatty acid compositions of puff pastries, which contain high amounts of hydrogenated fat, were investigated. In addition, free fatty acids, peroxide value, and induction time for oxidative stability by the Rancimat method have been compared for microwave- and conventionally baked puff pastries. The data indicate there were considerable changes in acidity, peroxide value, and Rancimat induction time in both microwave- and conventionally baked samples. Although the content of saturated fatty acid such as palmitic and stearic and the ratio of saturated to unsaturated fatty acids did not change significantly, an apparent increase was determined in *trans* oleic acid levels by both baking methods. In addition, a significant decrease in linoleic acid content of the samples was found by microwave baking.

Paper no. J9499 in *JAOCS 77*, 543–545 (May 2000).

KEY WORDS: Fatty acid composition, microwave baking, puff pastry, Rancimat induction time, *trans* fatty acids.

Microwave energy, with its unique heating ability, offers many advantages for both home and industrial food applications such as baking, cooking, thawing, blanching, dehydration, pasteurization, sterilization, and tempering. Penetration and heating of foods by microwave energy are instantaneous (1,2). Microwave energy effects on various food components could differ significantly from those of conventional cooking. For example, it has been speculated that reactive free radicals may be formed by exposure to microwave energy, especially in those applications that result in abnormally high temperatures, as with frying and toasting. Various chemical reactions are induced by microwave energy. In vegetable oils exposed to microwave energy, the higher the amount of polyunsaturated fatty acids in the oils, the greater was the rate of quality deterioration of the oils. The levels of free fatty acids also increase in vegetable oils heated in a microwave oven (3).

Some reports suggest that nutrient retention, such as vitamins in microwaved foods, is improved because cooking time is shortened (4,5). However, other studies suggest that nutrient retention in microwave processing is not much greater than that in conventional cooking (6,7).

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The objectives of this study were to determine the effects of microwave thawing and microwave and conventional baking methods on the oxidative stability, fatty acid composition, and *trans* fatty acid content of puff pastries, which contain considerable amount of hydrogenated fat (approximately 22%).

EXPERIMENTAL PROCEDURES

Puff pastry samples (75-g pastries) were purchased locally and total fat content was given as 22% on the label, was confirmed by analysis. Frozen samples to be cooked with microwaves were thawed in a consumer model microwave oven (Beko Microwave Oven, Istanbul, Turkey) for 20 s, and the baking was performed at 2450 mHz, 30% power level until a golden crust color was obtained (5 min). For conventional baking, puff pastries were thawed at room temperature, and the baking was done in a conventional electric oven at 200°C for 15 min at which time the desired color was obtained, (as in microwave baking). Samples that had been thawed at room temperature but that were otherwise uncooked were used as a control. Prior to heating, frozen samples were stored at –18°C. Fatty acid methyl ester (FAME) standards (99% purity) were purchased from Nu-Chek-Prep Inc. (Elysian, MN).

Fat extraction. Lipid extraction from the samples was carried out with hexane under the operating conditions specified in ICC Standard No. 136. Results are expressed as a percentage by mass of the product as received (8).

Preparation of FAME. FAME were prepared from the fats after alkaline hydrolysis, followed by methylation in methanol with BF_3 as catalyst. The final concentration of the FAME was approximately 7 mg/mL in heptane (9).

Capillary gas–liquid chromatography (GLC). Analyses of the FAME by capillary GLC were carried out on a Hewlett-Packard 6890 chromatograph, equipped with a flame-ionization detector (FID) on a split injector (Chrompack, Middelburg, The Netherlands). A fused-silica capillary column was used for the FAME analysis; CP™-Sil 88, 50 m × 0.25 mm i.d., 0.2 μm film; Chrompack. The column was operated isothermally at 177°C, injector and detector were kept at 250°C. The carrier gas was helium at a flow rate of 1 mL/min.

Stability to oxidation (automated Swift Test with Rancimat). Approximately 2.5 g of fat was heated for 10 min at

TABLE 1
Effects of Microwave and Conventional Baking on Free Fatty Acidity, Peroxide Value, and Rancimat Induction Times of Puff Pastries[a]

Treatment	Acidity (%)	Peroxide (meq O_2/kg)	Rancimat IT (h, at 110°C)
Control[b]	0.47 b	0.89 c	2.50 c
Microwave thawing	0.50 b	1.00 c	2.15 b
Microwave baking[c]	0.64 a	1.49 a	1.50 a
Conventional baking[d]	0.61 a	1.24 b	2.05 b

[a]Each value is an average of three determinations, and values in each column followed by the same letter are not significantly different ($P < 0.05$); IT, induction time.
[b]Frozen samples were thawed at room temperature.
[c]Frozen samples were thawed in the microwave oven before microwave baking.
[d]Frozen samples were thawed at room temperature before conventional baking.

110°C in the Rancimat heating block (679 Rancimat Instrument, Metrohm-Herisau, Switzerland). The dry air feed and the collection vessel were then connected. The measurement of the conductivity curve then started. The breaking point was equal to the induction time (h) (10). Fat samples extracted from puff pastries were subjected to analyses for free fatty acids and peroxide value according to IUPAC methods no. 2.201 and 2.501, respectively (11).

Statistical analyses. The analysis of variance and multiple range test were done on the analytical data collected for three replications of each treatment. The analysis was carried out using MSTAT software program, and the least square differences test was applied in case of high significance.

RESULTS AND DISCUSSION

Free fatty acids, peroxide values, and the Rancimat induction times of puff pastry samples before and after microwave and conventional baking are shown in Table 1. An appreciable change in acidity and peroxide as well as Rancimat induction time (at 110°C) was observed in the samples after both conventional and microwave baking ($P < 0.05$). But the effect of microwave baking was greater when compared with conventional baking. For instance, the average peroxide value of three replications determined in the control samples was 0.89 meq O_2/kg, whereas it was 1.24 and 1.49 meq O_2/kg in conventionally and microwave-baked samples, respectively. Acidity was also significantly greater in both microwave and conventional baking in comparison with control samples ($P < 0.05$). However, there were no significant differences in acidity between microwave and conventional baking methods ($P > 0.05$). As with peroxide value and acidity, oxidative stabilities were decreased by baking ($P < 0.05$), and microwave baking dramatically decreased the stability. On the other hand, microwave thawing slightly increased peroxide values and acidity of the puff pastries compared to controls but not significantly ($P > 0.05$). In contrast, microwave thawing substantially decreased the Rancimat induction time and, interestingly, Rancimat values of microwave-thawed and conventionally baked samples were not significantly different ($P > 0.05$). The buildup of free fatty acids apparently did not differ between the hydrogenated and unhydrogenated oils (12).

TABLE 2
Effects of Microwave and Conventional Baking on the Fatty Acid Composition and *Trans* Fatty Acids of Puff Pastries[a]

Fatty acid	Control[b]	Microwave thawing	Microwave baking[c]	Conventional baking[d]
$C_{10:0}$	0.1	0.1	0.1	0.1
$C_{12:0}$	0.5	0.5	0.4	0.4
$C_{14:0}$	0.9	0.9	0.8	0.8
$C_{16:0}$	30.5	30.5	30.3	30.3
$C_{16:1}$	0.4	0.4	0.5	0.4
$C_{18:0}$	6.6	6.6	6.6	6.5
trans-$C_{18:1}$	15.6 a	15.7 a	16.9 c	16.6 b
$C_{18:1}$	20.3	20.4	20.3	20.3
trans-$C_{18:2}$	0.9	0.9	0.9	0.9
$C_{18:2}$	22.9 b	22.7 b	22.2 a	22.7 b
$C_{18:3}$	0.7 b	0.7 b	0.5 a	0.5 a
$C_{20:0}$	0.3	0.3	0.3	0.3
$C_{20:1}$	0.1	0.1	—	—
$C_{22:0}$	0.2	0.2	0.2	0.2
Total saturated	39.1 a	39.1 a	38.7 b	38.6 b
Total monounsaturated	36.4 a	36.6 a	37.7 c	37.3 b
Total polyunsaturated	24.5 b	24.3 b	23.6 a	24.2 b
Total *trans*	16.5 a	16.6 a	17.8 c	17.5 b
Total unsaturated	60.9	60.9	61.3	61.4
Total saturated/total unsaturated	0.64	0.64	0.63	0.63

[a]Each value is an average of three determinations and expressed as wt% of total fatty acid methyl esters. Values in each column followed by the same letter are not significantly different ($P < 0.05$).
[b]Frozen samples were thawed at room temperature.
[c]Frozen samples were thawed in the microwave oven before microwave baking.
[d]Frozen samples were thawed at room temperature before conventional baking.

Microwave heating did cause some acceleration in the oxidation of the oils, negatively affecting free acidity, peroxide values, and oxidative stability (13,14).

Table 2 presents the fatty acid composition and *trans* fatty acids of conventionally and microwave-baked puff pastry samples. Major fatty acids in the samples were palmitic, stearic, *trans* oleic, oleic, and linoleic acids, while the remaining fatty acids were each less than 1%. Saturated fatty acids (such as stearic and palmitic) and the oleic acid contents as well as the ratio of saturated to unsaturated fatty acids did not change significantly ($P > 0.05$) during microwave thawing, microwave baking, or conventional baking. However, a significant change was determined between the control and microwave-baked samples for linoleic acid. Its content decreased from 22.9% to 22.2% after microwave baking. The analysis of variance also indicated a significant decrease for linolenic acid ($P < 0.05$) between the control and baked samples of both microwave and conventional baking. These reductions in unsaturated fatty acid result from oxidation that occurs during baking. Published work (3) indicates that thermal oxidative deterioration causes an increase in nonvolatile compounds such as free fatty acids and leads to disappearance of the tocopherols. Therefore, an appreciable change in fatty acids was observed after microwave heating.

Trans isomers of fatty acids are formed by partial hydrogenation of vegetable oils in the manufacture of shortenings and margarines (15). In many processed foods, such as puff pastry, partially hydrogenated fats are used in place of palm oil. Substantial new data from human metabolic studies have indicated that *trans* fatty acid consumption leads to an increase in low density lipoprotein cholesterol and a decrease in high density lipoprotein cholesterol (16–19). *Trans* fatty acids may increase coronary heart disease risk by raising serum cholesterol level and inhibiting $\Delta 6$ desaturase activity, which converts linoleic acid into the long-chain polyunsaturated fatty acids (20).

The control sample of puff pastries contained 16.5% of total *trans* fatty acids (Table 2). There were no significant differences ($P > 0.05$) between the *trans* fatty acid contents of control and microwave-thawed samples; however, during microwave and conventional baking the *trans* oleic acid content increased somewhat ($P < 0.05$), from 15.6% in control samples to 16.9% in microwave-baked and 16.6% in conventionally baked samples. The differences between both baking methods were also significant for *trans* oleic acid content whereas the difference was insignificant for *trans* linoleic acid. *Trans* linolenic acid was not present at a detectable level in all samples.

In conclusion, the results of this study indicate a decrease in the oxidative stability and the linoleic acid content, and an increase in *trans* oleic acid levels of microwave- and conventionally baked puff pastries. The effect of microwave baking exceeded that of the conventional method.

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[Received January 3, 2000; accepted March 16, 2000]