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Improving the quality and oxidative stability of vegetable oil shortening using fermented dairy products and wheat gluten

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Abstract

Trails were carried out to produce vegetable oil shortening based on blends of palm oil and palm stearin. Simulation of ghee flavor by using some fermented dairy products as well as improving the oxidative stability using natural antioxidant, were also attempted. Blending palm oil with 5% palm stearin resulted in a shortening with acceptable melting and textural properties. Boiling the acceptable shortening blend with 2% of either sour cream or fermented milk (yoghurt) improved the flavor of the resultant shortening without significant effect on its physical properties. A comparison between the synthetic antioxidant butylated hydroxytoluene (BHT) and wheat gluten, as a natural antioxidant, was carried out. Oxidative stability of the shortening was enhanced due to the addition of wheat gluten more than by BHT. © 2000 Elsevier Science Ltd. All rights reserved.

1. Introduction

Recently, more interest has been directed towards the quality, safety, nutrition and health aspects of food products. It is possible to modify the physico-chemical properties of oils and fats with the aid of modern techniques such as hydrogenation . However, this results in some changes in triglyceride composition and is therefore subject, to safety and health considerations. Blending has recently been widely applied in the manufacture of some fatty dairy-like products based on vegetable oils. But these products are less desirable for consumers who are accustomed to ghee flavor. Therefore, several attempts have been made to induce ghee-like flavor in these blends and to improve their oxidative stability.

Patel and Gupta (1983) tried to simulate ghee flavor in hydrogenated vegetable fat. They boiled vegetable fat blends with skim milk, cultured milk or cultured cream. The resultant product had a flavor similar to that of Indian ghee or butter oil, and cultured cream was the most effective. Nor Aini, Embong, Abdullah, Ali and Che Maimon Che Ha, (1995) applied the process of blending in the production of shortening having acceptable creaming properties as well as good baking performance. They produced shortening based on blends of hydrogenated oils and palm stearin with other liquid oils. Nor Aini, Adbullah, Embong and Hassan, (1991) also reported that palm oil was a valuable ingredient for shortening formulation and it could be blended with butter oil for use as biscuits shortening to give the desirable buttery taste. Synthetic antioxidants, such as butylated hydroxyanisole (BHA) and BHT, are widely used to prolong the storage stability of fats and oils. But some of these chemicals are believed to be carcinogenic. Therefore, attention has been directed towards the use of natural antioxidants (Refaat, 1996). The aim of this study was to produce acceptable quality shortening based on blends of palm oil and stearin. Simulation of ghee flavor in the product, by using fermented dairy products and improving oxidative stability by using natural antioxidant, were also goals of this work.

2. Materials and methods

Malaysian refined bleached and deodorized palm oil and palm stearin (Hap Plantation Mill Sdn Bhd, PO Box 666, Tawau, Sabah, Malaysia) were used in this experiment. Commercial shortening, sour cream, and fermented milk (yoghurt), obtained from the local market, were used. Wheat gluten (BDH Chemicals Ltd. Poole, England) was used as a natural antioxidant. Shortening samples were made according to the method described by Nor Aini et al., (1991). The experiment was carried out at three stages. The first stage aimed to select the best blend from palm oil and stearin to give the best

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acceptable texture. Stearin was added to palm oil at zero, 5, 10, 15, and 20%. All blends were converted to shortening. Samples were analyzed for melting point (MP), iodine values (IV) and sensory evaluation. In the second stage, shortening was made from blends of palm oil with 5% stearin and zero, 1, 2, and 3% of either sour cream (35% fat) or fermented milk (yoghurt). All blends were heated at 120±2°C for 2–3 min with a constant stirring. A brown residue of non-fat milk solids was formed. As a result, the blends were then cooled and filtered. Samples were subjected to chemical analysis and sensory evaluation. The third stage aimed at improving the oxidative stability of the vegetable shortening with the most acceptable flavor. Two blends were made from palm oil with 5% stearin and 2% of either sour cream or fermented milk. Each blend was divided into 4 portions. The first was left without additives. Wheat gluten (WG) was added at levels of 0.15 and 0.30% to the second and third portions, respectively, while BHT was added to the fourth portion at a level of 200 ppm. All portions were heated at 120±2°C for 2–3 min with a constant stirring then cooled, filtered and packed into dark glass containers, then incubated at 60±2°C for 21 days to accelerate the oxidation development. Samples were taken at zero, 3, 7, 14, and 21 days and analyzed for peroxide value (PV), thiobarbituric acid (TBA) and flavor score. Melting point, iodine value, and peroxide value were determined according to the procedures described by the American Oil Chemists Society (1964), while TBA was determined as given by Keeny (1971). Sensory evaluation was performed by panelists for color, texture and flavor based on a 10 point scale. Samples scoring 8 points were classified to be excellent, 7.9–6 as good, 5.9–4 as fair and below 3.9 as poor according to Chand, Kumar, Srinivasan, Batish and Chander, (1986).

2.1. Experimental design

The experimental design used was a randomized complete block design. A general linear model (GLM) procedure using PC-SAS (SAS software ver. 6.11. SAS Institute, Cary, NC, USA) was used to analyze the data. A multiple comparison statistical procedure using Fisher's least significant difference (LSD) procedure was used to determine the significance of the differences among various experimental treatments.

3. Results and discussion

3.1. Sensory analysis and some physical properties of shortening based on both palm oil and stearin

Results presented in Table 1 show that the level of added stearin significantly affected the texture score, melting point and iodine value of the resultant shortening. It could be noticed that shortening made from palm oil plus 5% stearin gained the highest score points and had the best sensory quality. However, increasing the stearin level showed lower score points, especially for texture. The higher level of added stearin (20%) gave a very hard texture for the resultant shortening. Moreover, it could be observed that increasing the ratio of added stearin to palm oil increased the melting point of the resultant shortening and this was associated with a decrease in the iodine value. It could be noticed that both melting point (40°C) and iodine value (51.2) of shortening made from palm oil plus 5% stearin were very close to that of commercial shortening. Berger (1985) reported that the best melting point of cake shortening should be about 40°C. The shortening should not melt too quickly during baking. Nor Ani et al. (1995) reported that crystal habit is affected by the palmitic acid content of the fat. Palm oil is rich in palmitic acid and is stable in the β-form, resulting in a shortening of good creaming properties.

In the light of the above results, the production of vegetable shortening from palm oil with the addition of 5% stearin is recommended. However, further trials should be made to improve its flavor and oxidative stability and this was the goal of the other trials of this work.

3.2. Improving the flavor of shortening made from palm oil treated with 5% stearin

Table 2 summarizes the average score for sensory properties and both melting point and iodine value of vegetable shortening boiled with either sour cream or fermented milk (yoghurt) at different levels. Boiling the vegetable shortening with either sour cream or fermented milk significantly improved the flavor of the resultant shortening. Sour cream was more effective in this respect than fermented milk. Addition of 2% of either sour cream or yoghurt showed the best sensory score for the resulting shortening compared with the addition of 3% shortening which gave less score for color. This could be explained on the basis of both sour cream and fermented milk containing non-fat milk solids which may result in a Maillard reaction and formation of brown color. Therefore, shortening treated with the higher level (3%) of sour cream or fermented milk gained a lower score for color and this was more marked for fermented milk- treated shortening. Improving the flavor of the resulting shortening could be due to the simulation of ghee flavor as a result of its boiling with sour cream or fermented milk. Bhatia (1978) simulated ghee flavor in butter oil by heating it with sweet and sour buttermilk. Patel and Gupta (1983) tried to simulate ghee flavor in hydrogenated vegetable fat by boiling the latter with milk solids from skim milk,

Table 1
Some physical and sensory properties of vegetable oil shortening based on blends of palm oil and stearin[a]

Stearin (%)	Melting point (°C)	Iodine value	Sensory properties			
			Color (10)	Texture (10)	Flavor (10)	Total (30)
Zero	38.50e	54.8a	9.0ab	5.0c	6.0ab	20.0b
5.0	40.0d	51.2a	10a	9.0a	7.5a	26.5a
10	42.0c	48.7b	9.0ab	8.0ab	7.0a	24.0a
15	43.5b	46.1c	9.0ab	6.0bc	6.0ab	21.0b
20	45.4a	45.2c	8.0b	4.0c	5.0a	17.0c
CS[b]	40.5d	49.8b	10a	9.0a	7.0a	26.0a

[a] Within each column, means with the same letter are not significantly different.
[b] CS, commercial shortening.

Table 2
Some physical and sensory properties of vegetable oil shortening based on blends of palm oil with added 5% stearin boiled with fermented dairy products[a]

Additives %	Melting Point °C	Iodine value	Sensory properties			
			Color (10)	Texture (10)	Flavor (10)	Total (30)
Control	40.5a	54.2a	9.0a	9.0a	4.0d	22.0c
1% SC[b]	40.3a	53.9a	9.0a	9.0a	7.0cb	25.0ab
2% SC	39.9a	53.5a	8.5a	9.0a	9.5a	27.0a
3% SC	39.5a	52.9a	8.0a	8.5a	9.5a	26.0ab
1% FM[c]	40.1a	54.0a	9.0a	9.0a	6.0c	24.0bc
2% FM	40.2a	53.8a	8.5a	8.5a	9.0a	26.0ab
3% FM	40.1a	53.5a	7.5	8.5a	8.5ab	24.5abc

[a] Within each column, means with the same letter are not significantly different.
[b] SC sour cream.
[c] FM, fermented milk.

cultured milk or cultured cream. Sarkar, Kuila and Mirsa (1993) tried to improve the ghee flavor by incorporation of concentrated starter of *Streptococcus lactis* var *diacetylactis* at 1% level. This treatment enhanced the flavor of the resulting ghee. In the light of these results it could be concluded that boiling vegetable shortening with 2% of either sour cream or fermented milk will enhance its flavor so as to be comparable with that of ghee. Moreover, these treatments showed insignificant effects on melting point, iodine value, color and texture scores.

3.3. Oxidative stability of shortening as affected by certain additives during storage

Oxidative stability of sour cream or fermented milk-treated shortening, as affected by the addition of some antioxidants such as wheat gluten (WG) at levels of 0.15 and 0.3% and BHT at a level of 200 ppm, during storage at 60±2°C, was evaluated. As shown in Table 3, peroxide value (PV) and thiobarbituric acid (TBA) of all shortening samples were increased significantly ($P < 0.0001$) with the advance of the storage period. The antioxidants retarded the oxidation rate and significantly improved the storage stability of the shortening ($P < 0.0001$) as shown in Table 4. This was more marked for fermented milk treated shortening. This could be explained on the basis that fermented milk had higher non-fat milk solids compared with sour cream, which caused an increase in the sulfhydryl groups during the heat treatment, which is believed to be responsible for retardation of oxidation development (Abdel-Kheir, 1996; Wadhwa & Jain, 1991). Addition of WG retarded the oxidation of shortening samples and this was more noticable when it was added at the 0.3% level, compared with BHT. This could be due to the denaturation of the WG during heat treatments, coupled with the liberation of sulfur compounds including SH groups, which have antioxidant activity (Abdel-Kheir, 1996; Galhotra & Wadhwa, 1993).

Antioxidants significantly delayed the development of oxidative flavor in the different shortening samples during storage ($P < 0.0001$). Samples treated with WG at a level of 0.3% or BHT gained excellent flavor score at all storage periods (more than 8 points). Therefore, the addition of 0.3% WG as a natural antioxidant during the preparation of palm oil shortening is highly recommended. This treatment significantly improved the oxidative stability of the resultant product without any flavor defects.

Table 3
Changes in peroxide value (PV), thiobarabituric acid (TBA) and flavor score of shortening during storage at 60±2°C for 21 days

Storage (day)	Sour cream flavored shortening				Fermented milk flavored shortening			
	Control	0.15[a]	0.30[a]	BHT	Control	0.15[a]	0.30[a]	BHT
PV[b]								
zero	0.40	0.30	0.25	0.20	0.30	0.30	0.20	0.20
3.0	2.80	1.90	1.40	1.30	2.40	1.60	1.30	1.20
7.0	4.95	2.60	1.90	1.80	3.85	2.40	1.85	1.70
14	8.65	4.20	3.10	2.90	7.84	3.90	2.90	2.70
21	12.7	7.30	5.65	5.40	11.9	6.90	5.90	5.20
TBA[c]								
zero	0.03	0.03	0.02	0.02	0.02	0.02	0.02	0.02
3.0	0.14	0.11	0.08	0.06	0.11	0.10	0.07	0.05
7.0	0.22	0.17	0.15	0.14	0.21	0.16	0.15	0.13
14	0.58	0.32	0.26	0.24	0.52	0.31	0.25	0.22
21	0.78	0.43	0.35	0.31	0.72	0.39	0.32	0.29
Flavor score[d]								
zero	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
3.0	8.0	9.0	10.0	10.0	8.0	8.0	10.0	10.0
7.0	7.0	8.0	10.0	10.0	8.0	8.0	10.0	10.0
14	6.0	7.0	9.0	9.0	7.0	7.0	9.0	9.0
21	5.0	6.0	8.0	8.0	5.0	6.0	8.0	8.0

[a] Wheat gluten (%).
[b] Expressed as milliequivalent peroxides/kg fat.
[c] Optical density at 532 nm.
[d] Maximum score points are 10.

Table 4
Significant terms (*F* values) from general linear model (GLM) analysis for peroxide value (PV), thiobarbituric acid (TBA) and flavor score of shortenings under the effects of dairy products, antioxidants, and storage time[a]

Independent variable	PV	TBA	Flavor score
Linear			
Dairy products	9.13**	3.33ns	0.16ns
Antioxidant	264.86****	71.39****	21.41****
Storage time	731.52****	256.50***	26.97****
Interactions			
Dairy products antioxidant	2.39ns	0.31ns	0.34ns
Dairy products storage time	0.58ns	0.37ns	0.24ns
Antioxidant storage time	38.78****	16.08****	1.47ns
Dairy products anti oxidant storage time	0.31ns	0.05ns	0.11ns

[a] **** significant at $P<0.0001$; *** significant at $P<0.001$; ** significant at $P<0.01$; * significant at $P<0.5$; ns, not significant.

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