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Chemical and Sensory Evaluation of Lipid Blends used in Pie Crusts

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ABSTRACT

Blends of lipids were used in pie crust baking to replace lard, which is widely used by industry. Blends prepared were 20% butter/80% margarine, 40% butter/60% margarine, 20% butter/80% shortening and 40% butter/60% shortening. Blends were tested for color, iodine value, solid fat index, melting point, fatty acids profile and peroxide values for 5 weeks storage period. Difference and preference tests for pie crusts were determined. Results showed that lard as a standard had a wider range of SFI, lower iodine value and higher saturated fatty acids profile than all blends. Neither lard nor any of the blends attained high enough peroxide values to be rejected. The blend of 20% butter/80% shortening was the most acceptable blend to replace lard in pie crust baking.

INTRODUCTION

Lipids have long been recognized as important nutrients in the human diet. They have a pronounced positive effect on the food flavor, texture and

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physical appearance. Through the years, consumption of lipids as measured *per capita* for each kind has varied. Between 1960 and 1980 lard consumption has decreased from 7·5 pounds to 2·4 pounds *per capita* and butter from 7·51 to 4·5 pounds. Margarine consumption has increased from 9·3 pounds to 18·3 pounds (Anon., 1983).

Evidence linking saturated lipids with heart disease, along with concerns over obesity, has dramatically affected consumption of lipids. There has been a shift to vegetable oils, and as a result of this shift, the share of saturated lipids in the diet decreased from 37% in 1960 to 33% in 1982 (Bunch & Hazera, 1985).

Although there is a growing trend toward utilization of vegetable-derived shortening, animal lipids continue to provide a significant quantity of shortening to the bakery industry.

Pie crust is one product that has been, and still is, produced traditionally with lard as a standard shortening throughout the years (Weiss, 1983). Because of the development of margarine and shortening production, and the advancement of bakery automation, butter blend products have reached several facets of the food industry (Norton, 1984). Industry is attempting to bring back the original butter flavor to baked goods with less calories and less cost. The public prefers butter to margarine and can differentiate between the two (Anon., 1986).

As the public moves from the consumption of animal fats to vegetable oils and their derivatives, it seems appropriate to investigate the possibility of replacing animal fat used exclusively in baked goods with satisfying quality and taste which the consumer can enjoy and appreciate.

The purpose of this study was to determine the best blend of lipids to use in pie crust to replace lard (a standard currently used in the bakery industry) by means of chemical, physical, and sensory evaluation using four lipid blends in pie crust.

MATERIALS AND METHODS

All of the butter, margarine, lard, vegetable shortening, and flour were purchased from a local supermarket.

Blends prepared were (A) 20% butter, 80% margarine, (B) 40% butter, 60% margarine, (C) 20% butter, 80% shortening, and (D) 40% butter, 60% shortening.

Each of the combinations was placed into a glass mixing bowl and mixed together using a rubber spatula until a homogeneous blend at room temperature was attained.

The pie crusts were prepared using a recipe developed by Dreher *et al.* (1983). Each of the blends was cut into flour placed in bowls with a pastry cutter. Thirty-three grams of water at 8°C were added to each mixture gradually and with minimum handling. The dough was rolled out with a marble rolling pin, and placed into an aluminum pie crust pan. The crust was baked in a rotary oven at 218°C for 10 min.

Sensory evaluation

Sensory evaluation tests were conducted on pie crusts only after being cooled at room temperature. This was to determine if there was a significant difference between sensory attributes (color, flakiness, flavor and tenderness) of pie crusts made with lard and the blends.

A Difference Test and Preference Test were performed at the Beatrice/Hunt-Wesson Corp. Research and Product Development Laboratory in a temperature-controlled, and noise and odor-free room.

The trained test panel consisted of four females and five males ranging in age from 27–59 years old.

The Difference Test was performed using the multiple-comparison method (Larmond, 1977). Panelists (four females and five males) were asked to compare each coded sample with the reference sample (STD) on the basis of color, flakiness, flavor and tenderness.

The Preference Test was performed using a five-point hedonic scale. Panelists were asked to indicate their preference of colour, flakiness, flavor, tenderness and overall acceptance.

Chemical analysis

All analyses for all blends were carried out in triplicates. Blends were tested for Iodine value, melting point, Solid Fat Index according to AOCS methods (1985). Also a fatty acid profile was determined for each blend using HPLC using a Hewlett–Packard Chromatograph according to AOCS method (1985) and Hunter Lab colors were evaluated using white tile No. CS 23448 as a reference according to manufacturer's specifications.

A storage study was carried out to evaulate the oxidative stability of the blends over 5 weeks at room temperature, 20°C. Each of the blends (150 g) was placed in a clear glass bowl. Covered with clear plastic wrap, each sample was checked weekly for oxidative stability by chemical analysis for peroxide value using the AOCS (1985) method.

RESULTS AND DISCUSSION

Table 1 shows initial peroxide values (PV) for blend A which contained 0·08 meq/kg (highest initial PV of the blends) due to the fact that it had the

TABLE 1
Peroxide Values for the Lipids over the Storage Time

Lipids	*Initial*	*First week*	*Second week*	*Third week*	*Fourth week*	*Fifth week*
Lard	0·75	1·25	2·40	2·30	2·35	2·35
	SD	±0·1	±0·1	±0·2	±0·15	±0·028
	CV	0·8	4·1	8·6	6·3	1·22
Blend A[a]	0·80	0·90	2·80	2·90	2·60	2·20
	SD	±0·18	±0·18	±0·26	±0·3	±0·2
	CV	2·00	6·4	8·9	11·5	9·0
Blend B[b]	0·60	0·80	2·00	2·25	2·25	2·25
	SD	±0·8	±0·2	±0·25	±0·21	±0·13
	CV	10·8	10·0	11·1	9·6	5·6
Blend C[c]	0·00	0·35	0·8	0·90	0·85	0·9
	SD	±0·0	±0·08	±0·13	±0·08	±0·1
	CV	14·2	10·0	14·6	9·4	10·5
Blend D[d]	0·00	0·50	1·00	0·90	0·95	0·90
	SD	±0·08	±0·02	±0·03	±0·13	±0·08
	CV	16·0	2·0	3·75	13·6	9·0

Values given in milli equivalents per 1 000 grams.
SD, Standard deviation; CV, coefficient of variation.
[a] A is 20% butter, 80% margarine.
[b] B is 40% butter, 60% margarine.
[c] C is 20% butter, 80% shortening.
[d] D is 40% butter, 60% shortening.

highest percentage of unsaturated fatty acid. The results were in agreement with those reported by Sherwin (1978). Blends A and B were both more susceptible to oxidation than the others in disagreement with Saltar *et al.* (1976), who reported that there was no relation between PV and unsaturation. The lard had a slightly lower initial PV because it had butylated hydroxytoluene (BHT) and citric acid added as antioxidants.

Blends C and D did not show any initial PV. This is possibly due to the fact that they contain less unsaturated fatty acids. Another reason (to a lesser extent) could be because of the tocopherols found naturally in both the soybean oil and butter (Syvaoja *et al.*, 1986).

When any lipid is exposed to air, light, heat, enzyme and metals, hydroperoxides are formed (Sherwin, 1976). Subsequent oxidation of hydroperoxides results in formation of aldehydes. These aldehydes have an off-flavor and odor (Weiss, 1983).

As for the increase of the PV with storage time, it was obvious that lard attained its highest PV by the second week, as shown in Table 1; after that there was a slight decrease which might be due to the breakdown of PV into aldehydes.

Blends C and D produced a buttery off-odor which Seals and Hammonds (1970) believe is produced by the diacetyl in soybean oil, in the first stages of oxidation at room temperature.

Blends C and D attained lower PVs throughout the storage time but they encountered a microbiological mold deterioration by the third week.

It is typical for contaminants to occur in any butter blend (Hankin & Hanna, 1983). Blends A and B, however, did not grow moldy due to the fact that the margarine had benzoate of soda added as a preservative during production. Tsourides (1968), in his specification for the chosen lipid for pie crust, determined the maximum acceptable PV to be 4·0 meq/kg of lard. Although blends A, B and lard attained high PVs, they were acceptable for pie crust baking.

Color

As noted in Table 2, the four blends were higher than lard in *L* (lightness) value. Margarine and butter blends (blends A and B) had a considerably higher *b* (yellow/blue color) value than the butter and shortening blends (blends C and D). According to Carden and Meisner (1970), margarine contributes 'rich color' to baking products.

The higher yellowish color in margarine and butter samples played a significant role in the color evaluation during the sensory testing. It was more preferred by sensory panelists because of its richer color.

Melting points

Melting point is another major lipid property because the chosen lipid for pie crust ingredients should not melt during mixing (Weiss, 1983).

As shown in Table 2, lard had a lower melting point (MP) than the butter-shortening blends. Blends A and B had fairly low MPs, which made them difficult to use for pie crusts. Though A and B blends were chilled in the refrigerator until usage, they melted before finishing cutting them into the flour. This produced a less flaky and less tender crust compared to crusts made with blends C, D and the lard. Thus, it was concluded that higher MP lipids produce better pie crusts.

Iodine values

Iodine is another important factor because it is a measure of the relative susceptibility of a lipid toward rancidity development. Tsourides (1968)

TABLE 2
Physical Characteristics of the Lipids

Lipids	*Iodine value*	*Melting point (°C)*	*Hunter color*			*Solid fat indexes*				
			L	*a*	*b*	*Selected temperatures*				
						10·0°C	*21·1°C*	*26·7°C*	*33·3°C*	*40·0°C*
Lard	62·78	41·27	70·78	−1·26	2·68	29·60	23·05	16·88	5·85	3·50
SD	±0·23	±0·31	±1·29	±0·07	±0·32	±0·44	±0·27	±0·38	±0·08	±0·05
CV	0·36	0·75	1·82	5·55	11·94	1·49	1·17	2·25	1·36	1·42
Blend A	81·20	34·55	88·88	−0·92	27·51	20·74	11·55	8·75	2·60	0·75
SD	±0·423	±0·057	±0·54	±0·053	±0·56	±0·2	±0·07	±0·16	±0·28	±0·71
CV	0·52	0·16	0·61	5·7	2·03	1·03	0·617	1·82	10·7	10·14
Blend B	70·34	35·20	89·98	−1·44	26·49	21·30	11·27	7·47	2·82	0·60
SD	±0·44	±0·529	±5·34	±0·16	±0·22	±1·69	±0·2	±0·97	±0·27	±0·08
CV	0·62	1·5	0·43	11·1	0·83	5·6	0·22	13·0	9·7	14·4
Blend C	77·46	46·06	88·83	−1·94	10·13	21·25	17·84	15·60	14·50	9·55
SD	±0·217	±0·23	±1·5	±0·22	±0·52	±0·25	±0·37	±0·37	±0·5	±0·45
CV	0·2	0·5	1·68	11·34	5·13	11·8	2·09	2·4	3·4	4·7
Blend D	68·89	45·27	88·50	−1·85	12·50	20·48	17·11	15·80	13·15	8·50
SD	±3·9	±0·33	±2·4	±0·26	±0·12	±0·65	±0·75	±0·76	±0·78	±0·66
CV	0·566	0·73	2·7	14·05	0·96	3·1	4·3	4·8	6·61	7·76

specified the optimum iodine value (IV) for pie crust production to be 65 ± 1·5.

Table 2 shows that lard had the lowest IV. Blend A had the highest followed by blend C.

A correlation is seen between blend C and D and Tsourides' (1968) above statement about high IV being related to high rancidity deterioration. These blends encountered rancidity (they have IVs higher than the optimum 65 ± 1·5) during the third week of the Storage Study.

Solid fat index (SFI)

As Table 2 indicates, the lard appeared to have the widest range of SFI values, and the highest percent solid at 21·1°C, which is the best working temperature for pie dough.

Blends C and D had higher SFI at 40°C due to the fact that shortening has considerable amounts of palm oils (which are solid at room temperature).

The SFI with crystal formation of a lipid indicate its plasticity and, because lard is beta prime crystal and has a wider range of SFI, it is more plastic than blends C and D.

Fatty acids profile

Table 3 shows that, although lard had 57·41% unsaturated fatty acid, the ratio of polyunsaturated to saturated fatty acid (P/S) was only 0·26.

Blends made with margarine had lower total saturated fatty acids. Blend A had the highest percentage of unsaturated fatty acid (68·94%). The off-buttery flavor in blends A and B was attributed to the presence of butyric acid.

TABLE 3
Fatty Acid Profile of the Lipids

Fatty acid	*Lard*	*A*	*B*	*C*	*D*
Butyric C:4		2·9 ± 0·02 CV (0·7)	4·41 ± 0·2 CV (4·6)	3·62 ± 0·2 CV (5·2)	3·51 ± 0·2 CV (5·9)
Caproic C:6		0·29 ± 0·05 CV (1·7)	0·68 ± 0·03 CV (11·76)	0·24 ± 0·01 CV (4·1)	0·5 ± 0·2 CV (3·3)
Caprylic C:8		0·2 ± 0·05 CV (25)	0·42 ± 0·15 CV (36·4)	0·16 ± 0·03 CV (18·7)	0·37 ± 0·045 CV (12·1)
Capric C:10		0·46 ± 0·04 CV (10)	0·97 ± 0·06 CV (6·1)	0·38 ± 0·08 CV (21)	0·88 ± 0·03 CV (3·4)
Lauric C:12	0·1 ± 0·02 CV (20)	0·54 ± 0·02 CV (3·7)	1·1 ± 0·1 CV (9·9)	0·45 ± 0·03 CV (7·5)	0·99 ± 0·05 CV (5·3)
Myristic C:14	1·68 ± 0·05 CV (3·1)	1·96 ± 0·06 CV (3·1)	3·79 ± 0·2 CV (5·0)	1·64 ± 0·36 CV (21·9)	3·19 ± 0·2 CV (6·1)
Myristoleic C:14(1)	0·04 ± 0·01 CV (25)	0·26 ± 0·05 CV (19·2)	0·52 ± 0·01 CV (1·92)	0·2 ± 0·015 CV (7·6)	0·42 ± 0·09 CV (21·4)
Palmitic C:16	26·85 ± 0·55 CV (2·04)	13·44 ± 0·09 CV (0·6)	17·31 ± 0·19 CV (1·1)	16·84 ± 1·13 CV (6·7)	18·4 ± 0·3 CV (1·6)
Palmitoleic C:16(1)	3·46 ± 0·04 CV (1·15)	0·64 ± 0·09 CV (14·8)	1·12 ± 0·07 CV (6·25)	0·6 ± 0·03 CV (5·0)	0·96 ± 0·04 CV (4·2)
Stearic C:18	12·3 ± 0·17 CV (1·38)	7·74 ± 0·76 CV (0·8)	9·11 ± 1·2 CV (13·1)	11·63 ± 0·57 CV (4·9)	10·9 ± 0·4 CV (3·6)
Oleic C:18(1)	43·33 ± 0·4 CV (0·96)	48·47 ± 0·8 CV (1·79)	43·68 ± 0·92 CV (2·1)	38·35 ± 2·6 CV (4·1)	32·57 ± 0·4 CV (1·3)
Linoleic C:18(2)	9·94 ± 0·06 CV (0·6)	17·84 ± 0·4 CV (0·2)	14·68 ± 1·74 CV (11·8)	22·38 ± 1·28 CV (5·7)	16·8 ± 0·6 CV (3·57)
Linolenic	0·64 ± 0·09 CV (14·3)	1·73 ± 0·05 CV (2·9)	1·39 ± 0·2 CV (15·1)	1·79 ± 0·04 CV (2·2)	1·34 ± 0·07 CV (5·2)
Total saturated	40·93	27·47	37·8	34·96	38·78
Total unsaturated	57·41	68·94	61·39	63·32	52·1
Total polyunsaturated	10·58	19·57	16·07	24·17	18·15
P/S	0·26	0·71	0·43	0·69	0·47

Although the percentages of unsaturated fatty acids in blends A and B were 68·94 and 61·39% respectively, the difference in attained peroxide value after storage was not at all considerable. This agrees with research done by Khattab *et al.* (1974) and Amer *et al.* (1985) which showed that the unsaturation is not a direct factor for the higher rate of oxidation.

Sensory evaluation difference test

The sensory characteristics were evaluated by multiple-comparison difference tests. The five pie crusts were to be compared to the control lard (STD).

Color
Table 4 shows that lard had the highest mean (3·88) and was significantly different from all the other pie lipids (at 0·1% significance level). The color closest to the color of the pie crusts made with lard was the pie crust made with blend C (color mean of 3·21).

Flakiness
Only pie crusts made with blend D showed the closest flakiness to that of STD.

TABLE 4
Mean Values of Sensory Attributes of the Pie Crust Made with Lard and the Blends for the Difference Test

Lipids	*Attributes*			
	Color mean	*Flakiness mean*	*Flavor mean*	*Tenderness mean*
Lard	3·88*a* ±0·95	4·50*a* ±1·05	4·24*a* ±1·28	4·12 ±1·23
Blend A	2·03*b* ±0·17	3·00*b* ±1·44	3·50*a* ±1·46	2·44*bc* ±1·13
Blend B	2·06*b* ±0·24	3·06*b* ±1·48	3·71*a* ±1·53	2·21*b* ±0·77
Blend C	3·21*c* ±1·09	3·41*b* ±1·23	3·97*a* ±1·38	3·09*bc* ±1·36
Blend D	2·97*c* ±1·09	3·68*b* ±1·39	3·82*a* ±1·29	3·35*c* ±1·32

Means of four replications and means within each attribute followed with the same letter are not significantly different. Flavor was significant at the 5% level while the color, flakiness and tenderness were significant at the 0·1% level.

Flavor

Although lard had the (statistically) highest mean at 4·24, there were no significant differences found between any of the pie crusts (flavor was significant at the 5% level).

Tenderness

Pie crusts made with lard had the highest mean (4·12) and were significantly different from the others. Crusts made with blend D were the closest to the pies made with lard. None of the blends scored higher than lard in any attribute in the Difference Test.

Preference test

Using the same trained panelists, the five pie crusts made with lard and blends A through D were evaluated on a five-point hedonic scale (Table 5).

Color and flavor

There were no significant differences between the colors and flavors of the five pies. Although not significant, the highest mean was scored by the pie crust made with blend B (40% butter, 60% margarine). This agrees with

TABLE 5

Mean Values of Sensory Attributes of Pie Crust Made with Lard and the Blends for the Preference Test

Lipids	*Attributes*				
	Color mean	*Flavor mean*	*Flakiness mean*	*Tenderness mean*	*Overall mean*
Lard	3·33*a*	3·56	4·11*a*	3·97*a*	3·78*a*
	±1·31	±1·23	±1·04	±1·11	±0·83
Blend A	3·86*a*	3·72	3·14*b*	2·44*c*	2·97*b*
	±1·15	±0·85	±1·10	±1·08	±1·0
Blend B	3·97*a*	3·64	3·47*ab*	2·97*bc*	3·42*ab*
	±1·08	±1·20	±1·13	±1·16	±0·94
Blend C	3·78*a*	3·56	3·83*ab*	4·08*a*	3·78*ab*
	±1·07	±1·05	±1·06	±0·94	±0·87
Blend D	3·86*a*	3·31	3·92*ab*	3·92*ab*	3·35*ab*
	±0·90	±0·92	±1·0	±1·03	±0·74

Means of four replications and within the same attribute followed with the same letter are not significantly different. Flavor was not significant, color was significant at the 5% level, flakiness, tenderness and overall were significant at the 0·1% level.

research done by Carden and Meisner (1970) who suggest that margarine may be preferred for baking because of its excellent shortening power, availability in plastic range, its contribution to rich color and flavor, and for economic reasons.

Flakiness

Pies made with blends C and D (butter–shortening mixtures) were significantly different from pies made with blend B (butter–margarine). This is due to the higher SFI of blends C and D as compared to blend B. As shown in Table 2, blends C and D had yet higher SFI at 21·1°C (best working temperature for pies made with lard), had the highest mean score (4·11) and were significantly different from blend A pies. The property of plasticity (degree of solidification in the lipid) refers to ratio of liquid to solid phases in any lipid.

The higher SFIs of lard, blend C and blend D agree with results of Miller and Trimbo (1970). They found that the hardness of shortening increased the flakiness of the crust.

Tenderness

Pie crusts made with blend C scored the highest mean (4·08) and were significantly different from pie crusts made with blends A and B only. This can be attributed to the fact that (as shown in Table 3) blend C had a much higher SFI at 21·1°C (17·84) than blends A and B (11·55 and 11·27, respectively). Also, blend C pie crusts were favored for tenderness over blend A and B crusts due to the high percentage of shortening (4·08). Lipid being water-insoluble, prevents the cohesion of gluten strands during mixing, thus literally shortening them and making the product tender and flaky.

The higher tenderness attributes of blend C compared to blends A and B were due to its crystalline formation of the butter-shortening moisture. Matthews and Dawson (1963) found that even distribution and high specific gravity of oil droplets of fat crystals were important to tenderness and flakiness. Also, Kincs (1985) suggested that pie shortening should have rapid melting and fast dissolving solids to give good mouth feel.

Overall acceptance

Pie crusts made with lard and with blend C (20% butter, 80% shortening) had an equal mean (3·78) and were significantly different from pie crusts made with blends A, B and D. This is due to the fact that lard and blend C jointly contained the highest amount of solids in lipids. Because of their high degree of total saturated fatty acids, they attained larger crystalline formations. This is desirable in pie crust production. These are of great importance in producing a tender, more flaky pie crust. Therefore, it is likely that blend C can replace lard in pie making.

This study attempted to develop blends of lipids to replace the lard in pie crust baking. Although physical and chemical analyses showed differences in each blend, the sensory panel was not able to differentiate color, flakiness and tenderness. Differences in flavor (lard) score were still higher than other blends. Preference tests showed significant differences in flakiness, tenderness and overall acceptance, yet color and flavor were well-blended and no significant differences were noticed in preference.

This study indicated that blending margarine and butter made it possible to bake the pie crusts with the combination because it gave margarine the solids and flavor of butter yet retained the color of margarine. From the preference test results, it was clear that both the color and flavor of blend B (40% butter and 60% margarine) were preferred. The blend of shortening and butter enhanced the plasticity of the combination and yielded stronger stability because of the higher percent of saturated fat in the butter. Again, the flavor of the butter enhanced the flavour of the pie crust made with the combination.

Further sensory evaluation research addressed to larger populations will enhance the chances for acceptance by the general public of lipids to replace lard.

It will be a timely contribution to those who are becoming more concerned about fat consumption, lower cholesterol level and substitution of lard in baked products.

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