Texture of Butters Made from Milks Differing in Indices of Atherogenicity

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Gerd Bobe[1], Research Associate, Shelly. Zimmerman, Research Associate, Earl G. Hammond, University professor emeritus, Gene Freeman, Distinguished Professor of Agriculture Emeritus, Gary L. Lindberg[2], Nutrition Consultant, and Donald C. Beitz, Distinguished Professor of Agriculture

Summary and Implications

The current study examined whether the phenotypic variation in milk fatty acid composition among cows fed the same diet was sufficient to produce butter with different textural properties. Butter samples from cows with a more unsaturated milk fatty acid composition had a lower index of atherogenicity and were more spreadable, softer, and less adhesive than were butter samples from cows with a more saturated milk fatty acid composition. Thus, selection of cows for milk fatty acid composition short-term by segregation and long-term by breeding programs can be used to produce butter that is more healthful and has a more favorable texture.

Introduction

Dairy products, in particular butter, have been considered to increase the risk of cardiovascular diseases in humans because, in comparison to other lipid sources, they contain a higher proportion of lauric, myristic, and palmitic acids and a lower proportion of unsaturated fatty acids. This ratio also contributes to the hardness and poor spreadability of butter at refrigeration temperature. Ulbricht and Southgate proposed in 1991 an index of atherogenicity (IA) for the composition of a fat based on current information about the effect of various fatty acids on serum cholesterol and low- and high-density lipoprotein concentrations. The IA is the sum of the proportion in the fat of lauric and palmitic acids and four times myristic acid divided by the proportion of total unsaturated fatty acids. According to this equation, only saturated fatty acids with chain lengths of 12 to 16 are atherogenic and myristic acid is considered four times more atherogenic than the other two. All unsaturated fatty acids, regardless of their double bond number, position, or configuration, are considered equally effective in decreasing atherogenicity primarily for lack of reliable information to assign more suitable coefficients to the various structures. When applied to various fats and oils, this equation gives IA values of 13 – 20 for coconut oil, 7 for palm kernel oil, 0.7 for cocoa butter, and <0.5 for other vegetable oils. Meat fats vary from 0.5 – 1. Milk and dairy products have a typical value of 2 and thus become the source of fat with the highest IA consumed in large amounts in western diets.

Milk fatty acid composition varies with cows' diet, stage of lactation, and between cows. Improvements in fatty acid composition and texture have been demonstrated by feeding unsaturated lipids to cows. The objective in the current study was to test whether the phenotypic variability of milk fatty acid composition among cows fed the same diet is sufficient to produce butter with different fatty acid composition and texture.

Materials and Methods

Individual milk samples were obtained from 64 lactating dairy cows of the dairy teaching farm at Iowa State University to select for cows with low- or high-IA milk. The cows were <150 days in milk, were fed *ad libitum* twice daily a diet that was formulated to meet NRC requirements, and belonged to several common dairy breeds (Ayrshire, Brown Swiss, Guernsey, Holstein, Jersey, and Milk Shorthorn). Fatty acid composition of milk from each cow was determined by forming butyl esters of fatty acids that were quantified by gas chromatography using appropriate internal and external standards. The IA was calculated for each sample. On the basis of the IA, 5 cows with the highest IA indices (2 Brown Swiss', 1 Guernsey, and 2 Jerseys) and 5 cows with the lowest IA indices (5 Holsteins) were selected. One week after the analytical samples had been taken, milk from each of the 10 selected cows was collected separately for one day as well as 30 kg of herd milk from the bulk tank.

Each of the 11 milk samples was manufactured into butter in duplicates. After the milk was weighed and pasteurized individually at 63 °C for 30 min, cream with 30% fat was separated at 20 °C by using an Elecrem Model 1 cream separator (Elecrem, Vanves, France). Butter was churned at 5 °C room temperature for 34 – 53 min by using an electric mixer (Kitchen Aid, Troy, OH). After churning, butter was adjusted to 80% fat and 1% NaCl. For comparison, one commercial butter sample and four commercial margarine samples were purchased from a local grocery store.

Hardness and adhesiveness of individual butter and margarine samples were determined in triplicates at sample

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[1] Current address: Department of Food Science and Human Nutrition, Michigan State University, 3 GM Trout Building, East Lansing, MI 48824.

[2] Current address: Nutrition Professionals, 310 Golfview Drive, Albany, MN 56307.

temperatures of 5 and 23 °C by using a TA-XT2 texture analyzer (Stable Micro Systems, Surrey, UK). A 40-degree conical probe was lowered at 1 mm/s to a depth of 12 mm from the sample surface and then was withdrawn at the same speed. The penetration force (in g) was reported as hardness, and the negative force-time values (in g x s) generated during probe withdrawal was reported as adhesiveness. Spreadabilities of butter and margarine samples at 5 °C were determined by 20 untrained panelists who evaluated 5 samples on each of 5 days on a continuous 14-cm scale from 0 (easy to spread as the softest margarine sample in the current study as determined with the TA-XT2 texture analyzer) to 14 (difficult to spread as the hardest butter sample in the current study as determined with the TA-XT2 texture analyzer). Both extreme samples were available to the panelists for comparison.

Data for milk and butter fatty acid composition and butter texture were analyzed by using mixed models procedures. The fixed variable for fatty acid composition were IA index of milk samples collected from the same cow 1 week before butter manufacture (low or high), type of dairy product (milk or butter), and their interaction. For butter hardness and adhesiveness, type of dairy product was replaced by butter temperature (5 or 23°C). Spreadability data of butter from each cow were averaged, and the means of the low- and high-IA groups were compared using a t-test.

Results and Discussion

The IA-value of butter from low IA cows was 41% lower than was the IA values of butter from high IA cows with commercial and bulk tank butter having intermediate values ($P \leq 0.01$; Table 1). Commercial margarine samples had with 0.12 – 0.13 much lower IA values than did the butter samples. The IA was affected primarily by the contents of myristic, palmitic, and oleic acids in the samples (all $P \leq 0.01$; Table 1). These results indicate that the variation among cows fed the same diet is sufficient to manufacture butter with different IA values.

At 5 °C, butter samples from low IA cows were 38% softer, 35% less adhesive, and 46% more spreadable than were butter samples from the high-IA group (all $P \leq 0.05$; Table 2). Most textural properties of the commercial and the bulk tank butter sample were between those of the low-and high-IA group (Table 2). Commercial margarine samples were softer and less adhesive at 5 °C than were butter samples (Table 2). Increasing butter temperature decreased hardness and adhesiveness but did not affect the significance of difference between low- and high-IA group (both $P \leq 0.05$; Table 2). At 23 °C, the texture properties of margarine samples were both higher and lower than those of butter samples. These results indicate that the variation among cows fed the same diet is sufficient to manufacture butter with different textural properties.

There is a demand by consumers for dairy products with a more unsaturated fatty acid composition, and they may be willing to pay a premium for such products if the products have no flavor deficiencies. The current study indicates that one potential way to manufacture such dairy products is to segregate milk from cows with a more unsaturated milk fatty acid composition, which could be done short-term by selection of individual cows and long-term by breeding programs.

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Table 1. Fatty acid composition of different margarine and butter samples arranged according toincreasing index of atherogenicity (IA).

	Commercial margarine				Butter			
	Brand 1		Brand 2		Low IA (n = 5)	Com-mercial (n = 1)	Bulk Tank (n = 1)	High IA (n = 5)
	Tub (n = 1)	Stick (n = 1)	Tub (n = 1)	Stick (n = 1)				
IA	0.12	0.13	0.13	0.13	1.61	2.03	2.31	2.71
Fatty acids:	---				wt %---			
$C_{4:0}$	trace	trace	trace	trace	3.87	3.81	4.14	3.94
$C_{6:0}$	trace	trace	trace	trace	2.19	2.31	2.61	2.79
$C_{8:0}$	trace	trace	trace	trace	1.14	1.29	1.44	1.65
$C_{10:0}$	trace	trace	trace	trace	2.15	2.73	2.89	3.46
$C_{12:0}$	trace	trace	trace	trace	2.22	3.01	3.15	3.75
$C_{14:0}$	0.14	0.24	0.18	0.16	8.15	9.85	10.65	11.30
$C_{16:0}$	9.75	10.15	10.12	9.82	25.32	27.32	28.65	29.23
$C_{16:1}$	trace	trace	0.11	trace	1.34	1.08	1.15	0.76
$C_{18:0}$	6.21	6.32	6.93	8.53	15.08	13.68	12.41	12.94
$C_{\textit{trans}\text{-11 } 18:1}$	7.76	15.07	7.84	16.58	31.05	ND[1]	ND	21.53
$C_{\textit{cis}\ 18:1}$	27.24	27.65	23.98	30.63	3.61	27.30	25.27	3.47
$C_{18:2}$	47.33	39.31	41.43	29.07	0.60	3.25	3.18	0.69
$C_{18:3}$	0.80	0.84	6.75	4.13	0.53	0.55	0.55	0.43
$C_{20:1}$/CLA[1]	0.23	trace	0.15	trace	61.64	0.63	0.42	70.78
Saturated	16.65	17.13	18.41	19.59	33.59	65.61	67.75	24.55
Monounsaturated	35.00	42.73	33.26	47.21	4.78	29.96	27.93	4.67
Polyunsaturated	48.36	40.15	48.33	33.20		4.42	4.32	2.71

[1] ND = not determined. *Trans*-11 oleic acids coeluted with *cis*-9 oleic acids and their concentrations are included in *cis* oleic acids.
[2] CLA = Isomers of conjugated linoleic acid. Conjugated linoleic acids coeluted with $C_{20:1}$.

Table 2. Textural properties at 5 and 23 ºC sample temperatures of different margarine and butter samples arranged according to increasing index of atherogenicity (IA).

Sample	IA	Hardness (g)		Adhesiveness (g x s)		Spreadability (Scale 0-14)
		5 ºC	23 ºC	5 ºC	23 ºC	5 ºC
Commercial margarine:						
Brand 1 tub (n = 1)	0.12	44	9.1	190	79.7	0.57
Brand 1 stick (n = 1)	0.13	138	21.5	481	173.2	1.52
Brand 2 tub (n = 1)	0.13	61	8.6	222	64.5	0.69
Brand 2 stick (n = 1)	0.13	227	27.6	840	214.4	2.39
Butter:						
Low IA (n = 5)	1.61	651	11.5	1094	98.6	7.44
Commercial (n = 1)	2.03	600	18.5	1330	125.1	8.62
Bulk tank (n = 1)	2.31	1052	13.4	1617	89.3	10.59
High IA (n = 5)	2.71	1094	98.6	1683	133.6	10.88