Analysis of *trans*-18:1 Isomer Content and Profile in Edible Refined Beef Tallow

Corinne C. Bayard and Robert L. Wolff*

ISTAB, Laboratoire de Lipochimie Alimentaire, Universite Bordeaux 1, Talence, France

ABSTRACT: The *trans* 18:1 acid content and profile for several samples of edible refined beef tallow were determined monthly over a period of one year. For this purpose, gas–liquid chromatography was combined with silver-ion thin-layer chromatography. The mean content of *trans*-18:1 isomers was 4.9 ± 0.9% (n = 10) of total fatty acids with a minimum of 3.4% and a maximum of 6.2%. The distribution profile of individual isomers was also established. As in other ruminant fats (milk fat, meat fat), the main isomer is vaccenic (*trans*-11 18:1) acid. Other isomers, with their ethylenic bonds between positions 6 and 16, were found in lesser amounts. However, some slight but definite differences exist between beef tallow and cow milk fat. The relative proportion of vaccenic acid is higher in the former than in the latter. However, the distribution pattern of *trans*-18:1 isomers in beef tallow closely resembles that in beef meat fat (lean part).

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KEY WORDS: Beef, distribution profile, fatty acid composition, tallow, *trans*-octadecenoic acids, vaccenic acid.

Although beef tallow is commonly used as an ingredient in the food industry, and less often for household cooking, little attention has been paid to its *trans*-18:1 acid content and profile. Since 1928 (1), such isomers have been shown to occur in ruminant fats. However, few reliable quantitative data are available in the literature, and they generally apply to a single sample of adipose tissue from individual animals or to fats extracted from foods of poorly defined origin (2–6). To our knowledge, no systematic studies of *trans*-18:1 acids in beef tallow have been reported. Also, early data were frequently obtained through infrared absorption measurements at 968 cm^{-1}, a method which is now recognized as somewhat inaccurate for samples of low *trans*-acid content. The aim of this study was to fill this gap, by providing realistic and precise data for dietary evaluation. We have analyzed ten samples of beef tallow prepared from the fatty tissues of cattle slaughtered in the same abattoir. Because it is known that the *trans*-18:1 acid content of milk fat varies with the season (7), we have made a monthly follow-up of beef tallow with particular attention to possible seasonal variations of its fatty acid composition. *Trans*-18:1 acids were analyzed by combining gas–liquid chromatography (GLC) and silver-ion thin-layer chromatogaphy (Ag–TLC), a precise and accurate method. Because the capillary column used in this study is sufficiently efficient to allow resolution of several *trans*-18:1 isomers (7,8), a partial insight in their distribution pattern (after isolation by Ag–TLC) could also be obtained.

*To whom correspondence should be addressed at ISTAB, Laboratoire de Lipochimie Alimentaire, Université Bordeaux 1, Allée des Facultés, 33405 Talence Cedex, France.

EXPERIMENTAL PROCEDURES

Samples. Edible refined beef tallow samples were kindly provided each month between March 1994 and January 1995 by the Soprorga Society (Saint Denis, France). The animals from which adipose tissues were taken were slaughtered in the same abattoir near Paris. Individual *trans*-18:1 isomers used for identification purposes were synthetic compounds that were kindly donated by Dr. Svensson (Pharmacia, Stockholm, Sweden).

Fatty acid isopropyl esters (FAIPE) preparation, fractionation, and analysis. Two drops of melted tallow were transesterified in hexane and isopropanol in the presence of concentrated H_2SO_4, as described in detail elsewhere (8). An aliquot of the resulting FAIPE solution was fractionated by Ag–TLC (8). The separated saturated and *trans*-monoenoic acid fractions were collected together and analyzed by GLC. Palmitic and stearic acids present in the saturated acid fraction were used as internal standards for the quantitation of *trans*-18:1 isomers. GLC analyses were performed under conditions described at length in a previous publication (8) with a 50-m CP Sil 88 fused-silica capillary column (Chrompack, Middelburg, The Netherlands).

RESULTS AND DISCUSSION

The fatty acid composition of beef tallow is summarized in Table 1. Our results are in excellent agreement with those published for 47 samples of beef tallow by the Institute for the Study of Fats and Oils (ITERG) (9). At least for the major components, we were unable to detect any noticeable seasonal variations (Fig. 1), such as those observed with butterfat (10).

TABLE 1
Fatty Acid Composition (weight percentages of total fatty acids) of Edible Refined Beef Tallow

Fatty acid[a]	Mean ± SD (n = 10)	Minimum values	Maximum values
12:0	0.18 ± 0.08	0.10	0.36
iso 14:0	0.07 ± 0.03	0.02	0.13
14:0	3.33 ± 0.41	2.99	4.41
iso 15:0	0.23 ± 0.02	0.20	0.26
a-iso 15:0	0.26 ± 0.02	0.21	0.30
14:1	0.48 ± 0.05	0.40	0.58
15:0	0.51 ± 0.05	0.46	0.62
iso 16:0	0.23 ± 0.02	0.19	0.26
16:0	24.05 ± 1.15	22.54	26.57
iso-17:0	0.50 ± 0.05	0.42	0.57
16:1	0.22 ± 0.03	0.18	0.28
a-iso 17:0	0.76 ± 0.10	0.56	0.90
16:1n-7	2.21 ± 0.16	2.07	2.54
16:1	0.04 ± 0.01	0.03	0.05
17:0	1.30 ± 0.14	1.04	1.56
17:1	0.79 ± 0.08	0.59	0.90
18:0	21.43 ± 1.31	18.49	22.75
cis + *trans* 18:1	38.54 ± 0.43	38.01	39.21
18:2 isom.[b]	1.12 ± 0.32	0.55	1.68
18:2n-6	1.62 ± 0.58	1.18	2.73
20:0	0.17 ± 0.03	0.12	0.24
18:3n-3	0.58 ± 0.13	0.41	0.77
20:1	0.06 ± 0.04	0.04	0.07
18:2 conj.[c]	0.92 ± 0.37	0.60	1.67
Others	0.40 ± 0.08	0.31	0.56

[a]Fatty acids are listed in their order of elution from the column.
[b]Geometrical and/or positional isomers of 18:2n-6 acid.
[c]Conjugated 18:2 acid.

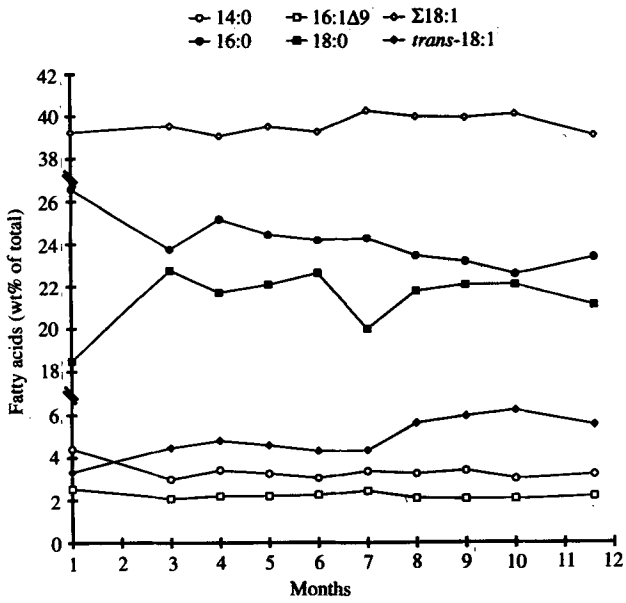

FIG. 1. Monthly follow-up of the fatty acid composition (main components, as weight percent of total fatty acids) of edible refined beef tallow.

For the ten samples analyzed in the present study, the mean *trans*-18:1 acid content is 4.91 ± 0.87% of total fatty acids, with a minimum value of 3.40% and a maximum value of 6.18% (Table 2). The mean value in tallow is higher than that found in butterfat [mean annual value, 3.3% (10)], or in meat fat, 2.0% (8). There is an apparent trend toward higher values between July and October (4.3 to 6.2%), whereas the *trans*-18:1 acid content is constant between March and July (*ca.* 4.5%) (Fig. 1). However, we hesitate to draw conclusions about true seasonal variations, because the animals from which the fat was removed are heterogeneous with regard to age (calves, young beefs, old cows) and feed. Moreover, the proportions of animals of each category surely vary from month to month. The observed variations may thus be attributable to chance only. However, we did not obtain values greater than 6.2%, such as those reported by Kaufman and Mankel (2): approximately 15 and 10% for calf and beef adipose tissues, respectively (determined by infrared absorption). Slover *et al.* (6) reported values in the range 6.2–6.8% for the fat surrounding beef cuts (single-step GLC analyses), whereas Hay and Morrison (3) found 3.6% *trans*-18:1 acids in one sample of ox perinephric fat (determined by infrared spectrometry and Ag–TLC coupled with GLC). Christie and Moore (11), who used the same experimental procedure as in the present study (combination of GLC and Ag–TLC and use of saturated acids as internal standards), found 4.2–4.4 mole% of *trans*-18:1 acids in sheep adipose tissue, and 1.6–4.5 mole% in triglycerides from different organs and muscles. No details on the distribution profile of individual *trans*-18:1 acids were given in their study.

The distribution of individual *trans*-18:1 isomers in beef tallow is summarized in Table 2. Several examples of the resolution of individual *trans*-18:1 acids have been given previously (7,8,12). Our data agree within certain limits with those published by Hay and Morrison (3) and by Parodi (13) for beef perinephric and subcutaneous fat, for which ozonolysis-based procedures were employed. In all instances, the main

TABLE 2
Content and Distribution Profile of *trans*-18:1 Isomers in Edible Refined Beef Tallow

	Total *trans*-18:1 isomers[a]	Individual *trans*-18:1 isomers[b]					
		Δ6–9	Δ10 + Δ11	Δ12	Δ13 + Δ14	Δ15	Δ16
Mean SD[c]	4.91 ± 0.87	7.64 ± 1.79	66.45 ± 2.78	5.05 ± 0.72	10.97 ± 0.88	4.43 ± 0.38	5.46 ± 0.54
Maximum	6.18	10.90	71.69	6.65	11.80	5.22	6.29
Minimum	3.40	4.50	63.39	4.14	9.81	4.09	4.77

[a]Weight percentages relative to total fatty acids. [b]Weight percentages relative to total *trans*-18:1 isomers. [c]Mean standard deviation of ten samples.

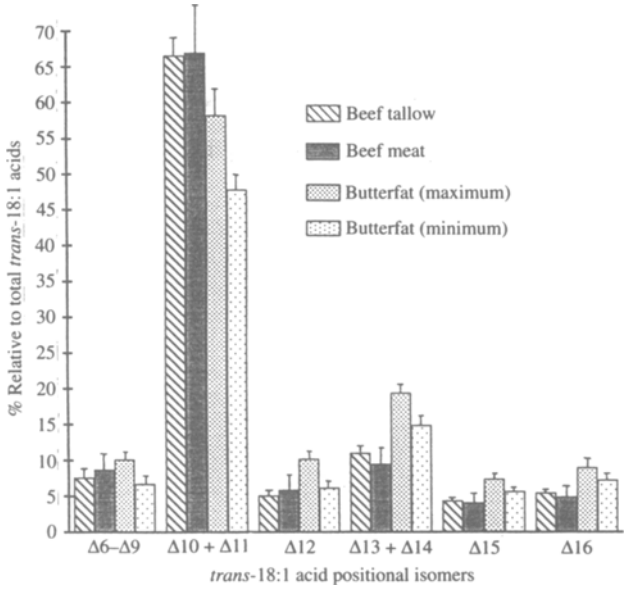

FIG. 2. Comparison of the *trans*-18:1 acid distribution pattern between beef tallow (n = 10; this study), beef meat fat (lean part, n = 10; Ref. 8), and butterfat (n = 2 × 12; Ref. 10). For this last product, minimum and maximum values reached during the year are given. Vertical bars correspond to standard deviations.

isomer is vaccenic (*trans*-11 18:1) acid; other isomers with an ethylenic bond between positions 6 and 16 were present in lesser amounts. No seasonal trends, such as observed in butterfat (10), could be detected (results not shown). The distribution of *trans*-18:1 acids in beef tallow is slightly different from that found in cow milk fat (8,10) (Fig. 2). The relative proportion of vaccenic acid (plus *trans*-10 18:1 acid) is higher in the former than in the latter: 66.5 vs. 47–58%, depending on the season. Relatively low values for vaccenic acid (plus *trans*-10 18:1 acid) also were reported for goat and ewe milk fat (45 and 57%, respectively) (8). On the other hand, the profile of *trans*-18:1 acids in beef tallow is similar to that of beef meat fat [lean part (8)] (Fig. 2). Independent of the season, the Δ13 plus Δ14, the Δ15, and the Δ16 isomers are present in slightly higher proportions in butterfat than in either beef tallow or beef meat fat. This would indicate that some subtle differences exist in the metabolic selectivity for individual *trans*-18:1 acids between the mammary gland and muscles or adipose tissues.

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