terations in the FA composition of human diets. We agree with Dr. Kummerow's call for a full review of the hydrogenated fats, and his concerns about the substantial exposure in some populations to the high-*trans* FA content of candies and frostings.

REFERENCES

1. Anderson KT, Grande F, Keys A: Hydrogenated fats in the diet and lipids in the serum of man. J Nutr 75:388–394, 1961.
2. Vergroesen AJ: Dietary fat and cardiovascular disease: possible modes of action of linoleic acid. Proc Nutr Soc 31:323–329, 1972.
3. Kritchevsky D: *Trans* fatty acid effects in experimental atherosclerosis. Fed Proc 41:2813–2817, 1982.
4. Mensink RP, Katan MB: Effect of dietary *trans* fatty acids on high-density and low-density lipoprotein cholesterol levels in healthy subjects. N Engl J Med 323:439–445, 1990.

Mary G. Enig, PhD, FACN
Joseph Sampugna, PhD
Mark Keeney, PhD
Department of Chemistry and Biochemistry
University of Maryland
College Park, Maryland 20742

Subodh Atal, PhD
Department of Medicine
Emory University School of Medicine
60 Butler Street, SE
Atlanta, Georgia 30303

Received February 1991.

Information about the level of *trans* FAs in the American diet is scarce, so the recent paper by Enig et al [1] is welcome. However, in spite of the thoroughness with which the authors present their paper, it is likely to exacerbate rather than resolve the debate about *trans* FA consumption of the average American.

One source of contention is the discrepancy between disappearance or availability of fats and actual consumption. Lack of data on *trans* FA content in foods and in representative duplicate diets forced Enig et al to use food availability data. They calculated the average amount of *trans* FAs available from the food supply to be 13.3 g/person/day. Some readers may infer that this is the amount the average American eats, when, in fact, the figure applies only to people whose fat consumption equals the 166 g of fat which disappears in the United States per person per day. Due to wastage and bookkeeping errors, actual consumption is much lower. The average US intake of energy is unlikely to be > 2700 kcal/person/day. If 38% of these calories are provided by fat, then mean fat intake is 114 g/day.

Dr. Enig and colleagues seem to agree with others that 6–8% of dietary fat may be *trans* [1, p 477], and their own measurements produced a figure of 6–12% [1, p 478], but without details of samples, methods, and results, these figures are difficult to interpret. Six to 8% of 114 g is 7–9 g of *trans* FAs/person/day, significantly less than the availability or disappearance figure of 13.1 g/person/day quoted by Enig et al in their abstract.

A second possible source of confusion in the Enig et al paper is the use of ranges instead of means. The authors provide only lowest and highest values found by them in foods [1, Table 6] and duplicate diets [1, p 478], but do not report means or medians. For example, the percent *trans* in corn snacks is quoted as 0.8–22.00 [1, Table 6]. The person eating a snack with 22% *trans* today may eat one containing 0.8% tomorrow. Average exposure of a subject to *trans* FAs over the years is best calculated from average *trans* FA contents in foods. Such averaging also reduces the impact of errors which occur even in the best laboratory and generate extreme values.

Similar problems hold for estimates of total fat intake. Enig et al quote fat intake at 40–258 g/day for adult men screened in the Lipid Research Clinic's Prevalence Study, and use these extremes to calculate a range of *trans* intakes. Some of the subjects indeed may have reported a fat intake of 258 g for the day on which they were interviewed, but regression to the mean plus a distended stomach will have ensured that they ate considerably less the next day. Again, the proper figure to use is group mean. Even if one is interested in subgroups with continuously high intakes, 258 would still be an overestimate because the range of intakes in a single 24-hr recall of a group of subjects is much higher than the range of mean long-term intakes of these same subjects.

It is unfortunate that we have little solid information about *trans* FA levels in foods, especially since high intakes have now been reported to cause unfavorable changes in blood lipoproteins [2]. Estimates of the mean *trans* content of industrial shortenings, used in many foods, range from 17 [3] to 41% [1]. Enig et al's claim that shortenings contain 41% *trans* [1, p 475] was refer-

enced to a published paper; the figure of 17% was provided by industry representatives, but no data were given on samples, analytical methods, or results. Thus, it is impossible to judge which of the two figures is correct.

More and better measurements are needed, published with enough detail so readers may judge validity. The *trans* FA content of foods can be determined by collecting and analyzing representative samples of relevant foods from supermarkets and restaurants. Such data can then be inserted into a nutrient database, and existing dietary surveys can be reanalyzed to yield true intakes for *trans* FAs.

The debate about mean intakes can also be solved by chemical analysis of simulated total diets; such duplicates probably already have been collected for toxicological surveillance and similar purposes, and a few extra analyses should not be too costly. That could resolve a debate which has generated much heat and little light in the last 10 years.

REFERENCES

1. Enig MG, Atal S, Keeney M, Sampugna J: Isomeric *trans* fatty acids in the US diet. J Am Coll Nutr 9:471–486, 1990.
2. Mensink RP, Katan MB: Effect of dietary *trans* fatty acids on high-density and low-density lipoprotein cholesterol levels in healthy subjects. N Engl J Med 323:439–445, 1990.
3. Hunter JE, Applewhite TH: Isomeric fatty acids in the US diet: levels and health perspectives. Am J Clin Nutr 44:707–717, 1986.

Martijn B. Katan, PhD
Wageningen Agricultural University
Department of Human Nutrition
Bomenweg 2, PO Box 8129
6700 EV Wageningen
The Netherlands

Received October 1990.

RESPONSE TO DR. KATAN

We believe that Dr. Katan's unfamiliarity with US food availability/consumption data may have led to misinterpretation of our analyses [1], the intent of which was to give multiple approaches to evaluating levels of *trans* FAs for both availability and consumption data. We used ranges for *trans* FAs rather than averages intentionally, because of wide ranges found in foods. The data for Smith et al [2], with which we did comparisons, were reported only as ranges. In 1983, we published data for over 200 individual foods analyzed in our laboratory in 1978–80 [3]. Using those data, Van den Reek et al [4] predicted 70% of *trans* FAs in diets of adolescent subjects. Since then, we have analyzed hundreds of additional samples. The preliminary data for 125 samples were reported [5]; a tabulated report is in preparation. We agree with Dr. Katan about the need for additional data for nutrient databases.

The 1984 US Department of Agriculture's (USDA) value of 166 g/capita/day of fat available in the United States which we referenced [6] assumes an average value of fat available for all Americans, including infants, children, and the elderly. Actually, intakes of these three groups are substantially and proportionally lower than those of adolescents and adults ages 20–65. Many adults have fat intakes greater than 166 g/day; approximately 20–25% of men and 5% of women in the Lipid Research Clinic (LRC) reported intakes of ≥166 g/day [7].

When comparing our calculations with other published data that had used per capita data without weighting by age group, we did likewise. However, weighted averages can be estimated using US Department of Commerce data [8] for 1984, and USDA data [9] and LRC [7] data for proportions of fat intake at different ages, and *trans* FAs values can be estimated for an adult population. For example, 7.5% of the 1984 population was < 5 years of age; this group consumes approximately 48% as much fat as adults. Children ages 6–9 years represented 6.9% of the population with a fat consumption about 64% that of adults. Elderly subjects (over age 65) were 11.8% of the population and consumed only 74% as much fat as younger adults. Based on calculations using this weighting, the amount of available fat for adults ages 20–65 (as well as adolescents and teenagers who have similar intake ranges) is approximately 186 g/person/day. Availability of *trans* FAs for 186 g/adult/day, using the 8% conservative estimate that Hunter applied to total fat availability data [10], is 14.88 g/adult/day.

We dispute the accuracy of using only 6–8% to calculate average *trans* FAs intake for a 2700 kcal diet with 114 g fat. An actual intake of 114 g fat should not necessarily be evaluated with the same coefficient used for evaluating fat availability data. Availability data include animal fat sources (approximately 52%) which have very low or negligible amounts of *trans* FAs. Of fat intake, 48% is from vegetable sources (54.7 g), of which 70% is partially hydrogenated (38.3 g), from which we get 11.5 g *trans* FAs using a weighted average of 30% *trans* FAs [1]. This is 10% (11.5/114) of the total fat and is at the midpoint of the Institute of Shortening and Edible

Table 1. Energy Intake Reported for US Adult Population Groups

Study group	Ages	Average kcal/day	Ref	Comments
Males (n = 767)[a]	20–34	3101	[7]	50% of group > 2700 kcal/day 5% of group > 5300 kcal/day
Females (n = 838)[a]	20–34	1998	[7]	10% of group > 3000 kcal/day
Males (n = 1786)[a]	35–64	2542	[7]	25% of group > 2900 kcal/day
Females (n = 1579)[a]	35–64	1722	[7]	5% of group > 2800 kcal/day
Males (n = 267)[b]	18–34	3886	[14]	Range 1081–7860 kcal/day
Males (n = 7)[c]	< 36	3058	[15]	Long-term (1 year)
Males (n = 6)[c]	> 35	2438	[15]	Long-term (1 year)
Females (n = 8)[c]	< 36	1903	[15]	Long-term (1 year)
Females (n = 8)[c]	> 35	1814	[15]	Long-term (1 year)

[a]Lipid Research Clinics, US Department of Health and Human Services.
[b]Uniformed Services University of the Health Sciences.
[c]Beltsville Human Nutrition Research Center, US Department of Agriculture.

Oils (ISEO) value for *trans* FAs, i.e., 5–15% [11].

Using grocery store fat sources, Craig-Schmidt et al [12] designed nutritionally adequate, unremarkable menus for lactating females that supplied 30% of calories as fat, averaging 84 g total fat/day. The menus were identical, except for fat sources that were hydrogenated or nonhydrogenated. By substituting margarine for butter, hydrogenated soybean oil for corn oil, and shortening for lard in food preparation, the average for 5 days was 11.8% *trans* FAs using hydrogenated sources, whereas nonhydrogenated fats provided 1% *trans* FAs.

Dr. Katan questions the LRC data [7] because values were obtained by 24-hr recall. However, intakes were reported to be "essentially the same" as those in the National Diet–Heart Study when the data were collected by use of a 7-day diet record [13]. The 258 g fat/day cited by us [1], as an upper limit for adults, represents the 95th percentile for 20–24-year-old males; the 95th percentile for 25–29-year-old males was 257 g/day. We did not use the 95th percentile for 15–19-year-old males, which was even higher at 274 g/day, because we were reporting the range for adults (and teenagers have higher intakes of fat). Nearly 4% of the 20–29-year-old males (representing nearly 900,000 individuals in the US population in 1985 [8]) had an intake range of approximately 240–260 g/day. Additionally, the average was above the 50th percentile, indicating that there were more individuals at the high end of fat consumption than at the low end. The highest total fat intake for a few seemed to be 380–390 g/day. In a study by DeBolt et al [14] a range of fat intake of 39–533 g/day was reported for active males (n = 267) ages 18–34 years (prior to training); the mean value was 182 g/day. Thus, we feel that our use [1] of 258 g/day as an example of an upper limit was reasonably conservative. None of the LRC total fat intakes was calculated to be outliers [7].

The average daily caloric intake (kcal/day) in the United States is > 2700 kcal/day for numerous adults. Table 1 summarizes the findings from representative studies including the LRC [7], DeBolt et al [14], and the USDA [15,16]. Outliers listed in the LRC report's appendix, but not used in calculations of averages, ranged from 7001 to 10,500 kcal/day [7]. DeBolt et al [14] obtained data from a 1-day record during periods of normal activity for 267 subjects; 1-day diet records are reported to be as reliable as 3-day diet records when large groups are studied [17]. The USDA findings [15,16] reflect long-term (1 year) data and are remarkably similar to the LRC findings. ISEO used USDA [16] energy values for their 1988 publication "Food Fats and Oils" [18].

All *trans* values originating from our laboratories have been obtained using the published methodology of Sampugna et al [19]. The published work of Smith et al [20], cited as a reference for the 41% *trans* value for shortenings, did give appropriate data on the samples, analytical methods, and results; we agree with Dr. Katan that Hunter and Applewhite [21] did not provide such information for their 17% *trans* value.

REFERENCES

1. Enig MG, Atal S, Keeney M, Sampugna J: Isomeric *trans* fatty acids in the US diet. J Am Coll Nutr 9:471–486, 1990.
2. Smith LM, Clifford AJ, Creveling RK, Hamblin CL: Lipid content and fatty acid profiles of various deep-fat fried foods. J Am Oil Chem Soc 62:996–999, 1985.
3. Enig MG, Pallansch LA, Sampugna J, Keeney M: Fatty acid composition of the fat in selected food items with emphasis on *trans* components. J Am Oil Chem Soc 60:1788–1795, 1983.
4. Van den Reek MM, Craig-Schmidt MC, Weete JD, Clark AJ: Fat in the diets of adolescent girls with emphasis on isomeric fatty acids. Am J Clin Nutr 43:530–537, 1986.
5. Enig MG, Sampugna J, Keeney M: Comparison of fatty acid composition of representative baked goods and fast foods including pizzas and snack chips (1978–1988) for *trans* and saturate components. Inform 1:286 (Abstract F1), 1990.
6. Raper NR, Marston RM: Levels and sources of fat in the US food supply. In Ip C, Birt DF, Rogers AE, Mettlin C (eds): "Dietary Fat and Cancer." New York: Alan R Liss, pp 127–152, 1986.
7. US Department of Health and Human Services: "The Lipid Research Clinics Population Studies Data Book, Vol II, The Prevalence Study — Nutrient Intake," NIH Publication No 82-2014. Bethesda, MD: US Department of Health and Human Services, 1982.
8. US Department of Commerce: "Statistical Abstract of the United States 1990," 110th ed. Washington, DC: Bureau of the Census, 1991.
9. Rizek RL, Welsh SO, Marston RM, Jackson EM: Levels and sources of fat in the U.S. food supply and in diets of individuals. In Perkins EG, Visek WJ (eds): "Dietary Fats and Health." Champaign, IL: Am Oil Chem Soc, pp 13–43, 1983.
10. Hunter JE: Letter to the editor. Science 224:659–660, 1984.
11. Elson CE, Benevenga NJ, Canty DJ, Grummer RH, Lalich JJ, Porter JW, Johnston AE: The influence of dietary unsaturated *cis* and *trans* and saturated fatty acids on tissue lipids of swine. Atherosclerosis 40:115–137, 1981.
12. Craig-Schmidt MC, Weete JD, Faircloth SA, Wickwire MA, Livant EJ: The effect of hydrogenated fat in the diet of nursing mothers on lipid composition and prostaglandin content of human milk. Am J Clin Nutr 39:778–786, 1984.
13. Goor R, Hosking JD, Dennis BH, Graves KL, Waldman GT, Haynes SG: Nutrient intakes among selected North American populations in the Lipid Research Clinics Prevalence Study: composition of fat intake. Am J Clin Nutr 41:299–311, 1985.
14. DeBolt JE, Singh A, Day BA, Deuster PA: Nutritional survey of the US Navy SEAL trainees. Am J Clin Nutr 48:1316–1323, 1988.
15. Reeves VB, Matusik EJ, Kelsay JL: Variations in plasma fatty acid concentrations during a one-year self-selected dietary intake study. Am J Clin Nutr 40:1345–1351, 1984.
16. Kim WW, Kelsay JL, Judd JT, Marshall MW, Mertz W, Prather ES: Evaluation of long-term dietary intakes of adults consuming self-selected diets. Am J Clin Nutr 40:1327–1332, 1984.
17. Pao FM, Mickle SF, Burk M: One-day and 3-day nutrient intakes by individuals — nationwide food consumption survey findings. Spring 1977. J Am Diet Assoc 85:313–324, 1985.
18. ISEO: "Food Fats and Oils," 6th ed. Washington, DC: Institute of Shortening and Edible Oils, 1988.
19. Sampugna J, Pallansch LA, Enig MG, Keeney M: Rapid analysis of *trans* fatty acids on SP-2340 glass capillary columns. J Chromatogr 249:245–255, 1982.
20. Smith LM, Clifford AJ, Hamblin CL, Creveling RK: Changes in physical and chemical properties of shortenings used for commercial deep-fat frying. J Am Oil Chem Soc 63:1017–1023, 1986.
21. Hunter JE, Applewhite TH: Isomeric fatty acids in the US diet: levels and health perspectives. Am J Clin Nutr 44:707–717, 1986.

Mary G. Enig, PhD, FACN
Joseph Sampugna, PhD
Mark Keeney, PhD
Department of Chemistry and Biochemistry
University of Maryland
College Park, Maryland 20742

Subodh Atal, PhD
Department of Medicine
Emory University School of Medicine
60 Butler Street, SE
Atlanta, Georgia 30303

Received February 1991.