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ARE FAST FOOD "*TRANS*-FAT" CLAIMS TRUE? AN INFRASPEC VFA-IR SPECTROMETER ANALYSIS OF *TRANS*-FAT CONTENT IN FAST FOOD FRENCH FRIED POTATOES

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ABSTRACT. Many U.S. fast food chains now claim that their food items, particularly French fries, have "no *trans*-fat". The purpose of this study is to assess the accuracy of fast food *trans*-fat labelling and the validity of "no *trans*-fat" claims. To accomplish this objective, we determined the percent *trans*-fat in oil extracted from fries obtained from 13 popular fast food restaurants and compared our findings with the percent *trans*-fat found in each restaurant's literature. French fry samples were purchased at relatively the same time of day on four separate days over two years from selected restaurants within Michigan City, Indiana. Variable Filter Array (VFA) IR spectroscopy was used to assess the *trans*-fat content of oil extracted from the samples. In June of 2008, seven of the thirteen restaurants sold French fries with *trans*-fat levels ranging from 13–43% of the total extracted fat. In most cases, these values were significantly higher than the amount of *trans*-fat reported in each restaurant's literature. Our study suggests that *trans*-fat content in fast food fries may be much higher than what is actually disclosed in a restaurant's literature. In addition, a restaurant's "no *trans*-fat" claims may not necessarily hold true for all the individual restaurants within its chain. Since there is no U.S. federal regulation of *trans*-fat content in fast foods, it is important that *trans*-fat claims and *trans*-fat labelling are accurate and up to date so that consumers are able to make healthy and informed food choices when dining in these establishments.

Keywords: Fat, *trans*-fat, fast-food, fries, ATR-FTIR, Variable Filter Array Spectrometer, VFA-IR

Studies linking high *trans*-fat diets to coronary heart disease (CHD) have prompted the need to regulate, limit, or completely ban *trans*-fat from all commercial food products, including fast foods (L'Abbe et al. 2009; Hu et al. 1997; Willett 2006; Leth et al. 2006). A *trans*-fat, which is a fat molecule containing one or more unsaturated fatty acids in the *trans* configuration, is produced industrially by a process called hydrogenation. Hydrogenation transforms unsaturated liquid vegetable oil into a partially hydrogenated semisolid fat, producing frying oil that has an increased oxidative stability and shelf life (Graf et al. 2008).

Trans-fats provide no known benefits to human health (FDA Consumer Magazine, 2003). In fact, studies show that diets high in industrially produced *trans*-fats raise low-density lipoprotein (LDL) or "bad cholesterol", decrease high-density lipoprotein (HDL), and increase the risk of strokes and coronary heart disease (CHD) (Hu, et al. 1997; Willett 2006; Willett & Mozaffarian 2007, 2008; Stender et al. 2006). Recent findings have also linked *trans*-fat consumption with sudden death, adiposity, type 2 diabetes, obesity, and other chronic illnesses (Hu et al. 1997; Willett & Mozaffarian 2007, 2008). The consumption of just 5 g of *trans*-fat a day has been linked to a 25% increase in the risk of ischemic heart disease, and Americans intake an average of 5.8 grams of *trans*-fat a day (FDA Consumer Magazine 2003; Willett & Mozaffarian 2008). In order to help reduce the risk of disease, the American Heart Association recommends limiting the amount of dietary *trans*-fat consumption to less than 2 grams a day (American Heart Association 2009). In addition, in 2003 the U.S. Food and Drug Administration (Food and Drug Administration 2003), amended its regulations on nutrition labelling to require

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that "…*trans* fatty acids be declared in the nutrition label of conventional foods and dietary supplements" to help consumers make healthy dietary choices. According to this amendment, if a packaged food item contains less than 0.5 gram of *trans*-fat per serving, then the *trans*-fat content "shall be expressed as zero" or "*not a significant source of trans fat*" should be placed at the bottom of the table of nutrient values. However, although there are no fast food *trans*-fat regulations mandated by the FDA (FDA Consumer Magazine 2003; American Heart Association 2009); many fast food restaurants have voluntarily switched to "no *trans*-fat" frying oils(Graf et al. 2008; Borra et al. 2007). As of July 2008, New York City banned the use of *trans*-fat in all food service establishments (New York City Department of Health and Mental Hygiene 2006). Since this ban, many fast food chains, such as McDonald's and Burger King, claim to have eliminated *trans*-fat from selected food items, particularly from French fries (American Oil Chemists' Society 1999).

We used VFA-IR spectroscopy to determine the total isolated *trans*-fats in oil samples extracted from fast food French fries (American Oil Chemists' Society 1999; Mossoba et al. 2007; Mossoba et al. 1996; Walker et al. 2007). This type of IR analysis (similar to ATR-FTIR) is based on a C-H "out-of-plane" deformation absorbance band at 966 cm^{-1} that is characteristic of compounds containing an isolated *trans* double bond configuration. The intensity of this absorption band can be used to determine *trans* fat content in a variety of fat samples (American Oil Chemists' Society 1999). In this study, we used the Wilks InfraSpec VFA-IR Spectrometer.

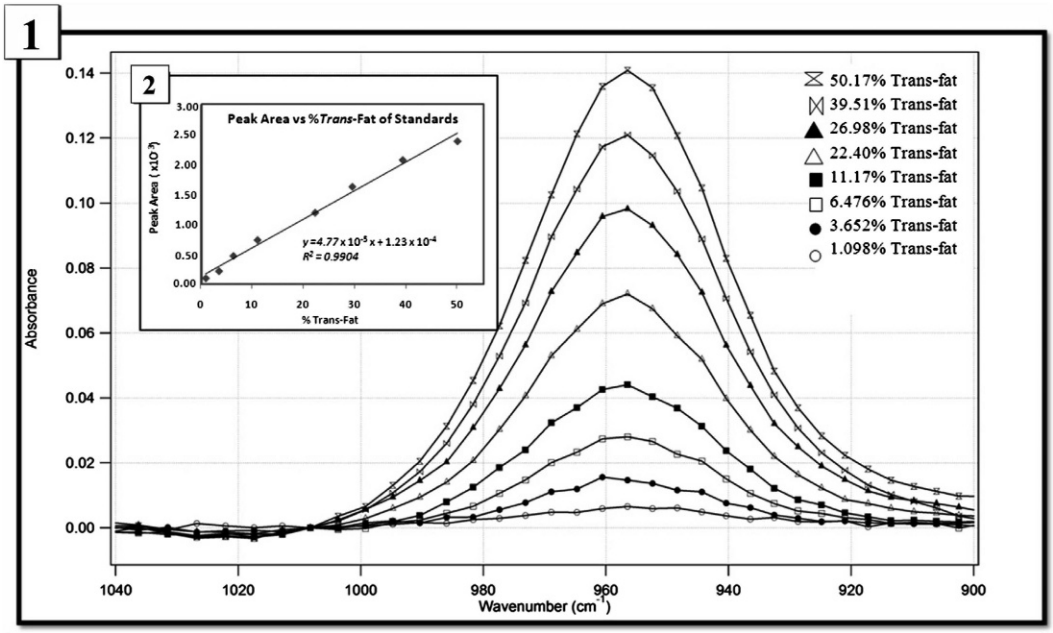
The purpose of this study is to assess the accuracy of fast food *trans*-fat labelling and the validity of "no *trans*-fat" claims. To accomplish this objective, we determined the percent *trans*-fat in oil extracted from fast food fries obtained from 13 popular fast food restaurants and compared our findings with the percent *trans*-fat found in each restaurant's literature (nutrition fact tables). It is important to note that we cannot state the statistical or quantitative significance of our data in comparison with literature values, but our findings should at the very least raise concerns about the significant amounts of *trans*-fat in fast food and the validity and/or the accuracy of restaurant literature values.

METHODS

French fry samples.—French fries were purchased from 13 different fast food restaurants within Michigan City, a small city in northwest Indiana. The largest menu size French fry sample was purchased at approximately the same time of day from Arby's, Wendy's, Burger King, McDonald's, Culver's, Steak 'n Shake, Buffalo Wild Wings, Kentucky Fried Chicken, Rally's(also known as Checkers), White Castle, Dairy Queen, Long John Silver's, and Purdue University North Central. The content of *trans*-fat in fast food French fries was studied over a period of two years in two separate trials. Trial 1 was done in June of 2008 and Trial 2 was done between April of 2009 and June of 2010 (Runs 1–3).

Fat extractions.—All fat extractions were performed using ligroine (petroleum ether) as the extraction solvent. For each trial, approximately the same mass (sample size) of French fries was used for fat extraction. French fry samples were homogenized in ligroine using a stainless steel blender, and the solvent was decanted. The extraction was repeated 3 to 4 times in order to maximize fat extraction. The extracts were combined and the solvent removed using either low heat (60–80°C) over a hot plate (Trial 1, Run 1 and 2 of Trial 2) or by open-dish overnight evaporation under a hood (Run 3 of Trial 2). For Trial 2, the fat was extracted from the French fries on the same day of purchase and for Trial 1, the French fries were stored up to one week at −20°C prior to fat extraction. All fat extracts were stored in small dark containers in a freezer at −20°C, and VFA-IR *trans*-fat analyses were done within 1 day (Run 3), one week (Run 1, 2), or one month (Trial 1).

Under certain conditions, such as exposure to extreme heat, oxygen, or upon prolonged storage, lipids may oxidize and degrade. In order to minimize lipid oxidation, solvent removal from lipids is often done under a vacuum. Hence, a fifth trial was performed to determine if our methods of solvent evaporation and sample storage had any adverse effects on *trans*-fat analysis. For Trial 3, French fries were purchased from Long John Silver's and Rally's. The fat extractions were done as described previously. For both restaurants, fat extracted from the French fries was divided into three equal portions, and the solvent was evaporated using three different methods. For



Figures 1 & 2.—Figure 1 is a VFA-IR absorbance spectrum of the *trans*-fat calibration standards. Figure 2 shows a graph of the percent *trans*-fat verses peak area (945–990 cm^{-1}) which yields a linear equation, $y = 4.77 \times 10^{-5}\times + 1.23 \times 10^{-4}$.

method 1 (heat), solvent evaporation was done in an evaporating dish on a hot plate at 60–80°C. For method 2 (vacuum), solvent evaporation was done under a vacuum using a rotary evaporator; and for method 3 (open air) the solvent was evaporated overnight in an open evaporating dish under a hood. VFA-IR *trans*-fat analyses were done immediately after solvent evaporation for Method 1 and 2 and the following day for Method 3.

VFA-IR *trans*-fat analysis.—The newly patented InfraSpec VFA-IR spectrometer represents a new concept in mid-IR instrumentation which utilizes a detector array with linear variable filter (Wilks Enterprise 2010). VFA-IR spectroscopy, based on ATR-FTIR trans-fat analysis, was used to determine the total isolated *trans* fatty acid in neat oil extracts (American Oil Chemists' Society 1999; Mossoba et al. 2007, Wilks Enterprise 2010). This method of VFA-IR *trans*-fat analysis can only be applied to oils and fats with *trans*-fat levels equal to or greater than about 1.0%. A InfraSpec VFA-IR Spectrometer (Wilks Enterprise, Inc., South Norwalk, CT) equipped with custom software that allowed for multiple calibrations and data storage was used for all spectral analysis. A typical sample size was approximately 100 ul of neat oil (Wilks Enterprise,Inc. 2010).

Instrument calibration.—Trielaidin (*trans*-fat standard) and triolein (*cis*-fat standard) were purchased from Nu-Check-Prep, Elysian, MN. Triolein is an oleic acid triglyceride containing only *cis* double bonds, and trielaidin is an elaidic acid triglyceride containing only *trans* double bonds. Eight *trans*-fat calibration standards were prepared by mixing trielaiden and triolein to give percentages of *trans*-fat between 1 and 50%by mass. Fig. 1 and 2 shows the VFA-IR absorbance spectra and calibration curve of the eight *trans*-fat standards. A plot of percent *trans*-fat versus peak area (945–990 cm^{-1}) of the standards yielded the linear equation, $y = 4.77 \times 10^{-5}\times + 1.23 \times 10^{-4}$, which was stored in the instrument as the calibration for all *trans*-fat analyses of fry oil samples.

Baseline correction, a feature built into the instrument, was used to correct elevated baselines due to occasional scattering. The instrument resolution was 25 cm^{-1}, hence the

Table 1.—This table presents a summary of all experimental and restaurant literature values obtained for the total grams of fat and *trans*-fat per serving of a large size order French fries. The data under experimental values are the percent *trans*-fat data obtained for Trials 1 and 2. Trial 1 and 2 data are reported as the mean percentages of three VFA-IR runs. Runs 2–4 are the individual runs of Trial 2. Dates are shown for each run in Trial 2 to show relative dates when changes in *trans*-fat content were observed.

	Experimental values						Literature values, 2008		
	Percent *trans*-fat (%)								
Fast food restaurants	Trial 1 *2008*	Trial 2 *2009-2010*	Run 1 *2009*	Run 2 *2009*	Run 3 *2010*	Total fat (g) *N=3*	Total fat (g)	*Trans*-fat (g)	*Trans*-fat (%)
Long John Silver's *basket combo portion*	42.7 ± 0.7	43.1 ± 0.6	40.6	41.8	47.1	15.0 ± 2.3	14.0	3.5	25.0
Burger King *king size*	38.4 ± 0.7	0.0 ± 0.0	0.0	0.0	0.0	26.1 ± 0.9	28.0	0.0	0
Dairy Queen *large*	24.6 ± 0.9	0.9 ± 1.6	0.0	2.8	0.0	18.3 ± 1.4	21.0	3.0	1.4
Steak 'n Shake *large*	18.3 ± 0.2	1.6 ± 1.3	2.4	2.2	0.0	35.1 ± 1.8	33.5	3.0	6.0
Rally's *large*	15.6 ± 0.4	18 ± 10	24.0	24.4	6.30	35.5 ± 2.6	38.0	2.0	5.3
White Castle *sack*	13.1 ± 0.6	15.8 ± 1.2	17.1	14.8	15.4	29.8 ± 2.9	34.0	11.0	32.4
Buffalo Wild Wings *potato wedges basket*	12.6 ± 0.5	11.0 ± 1.5	12.5	11.3	9.4	30.2 ± 1.8	28.0	1.0	3.6
Arby's *curly*	0.0 ± 0.0	0.0 ± 0.0	0.0	0.0	0.0	31.2 ± 3.4	36.0	0.0	0
Wendy's *large*	0.0 ± 0.0	0.0 ± 0.0	0.0	0.0	0.0	25.5 ± 1.3	26.0	0.0	0
McDonald's *large*	0.6 ± 1.1	0.0 ± 0.0	0.0	0.0	0.0	23.8 ± 1.7	35.0	0.0	0

Table 1.—Continued.

Fast food restaurants	Experimental values						Literature values, 2008		
	Percent *trans*-fat (%)								
	Trial 1 *2008*	Trial 2 *2009-2010*	Run 1 *2009*	Run 2 *2009*	Run 3 *2010*	Total fat (g) *N=3*	Total fat (g)	*Trans*-fat (g)	*Trans*-fat (%)
Culver's									
Large	0.0 ± 0.0	0.0 ± 0.0	0.0	0.0	0.0	26 ± 6	22.0	0.0	0
Kentucky Fried Chicken									
potato wedges	0.0 ± 0.0	0.0 ± 0.0	0.0	0.0	0.0	10.5 ± 3.2	13.0	0.0	0
Purdue North Central									
one size	0.0 ± 0.0	0.4 ± 0.6	1.1	0.0	0.0	22.7 ± 2.1	Not Reported	Not Reported	Not Reported

trans-fat absorption bands of standards and samples occurred at 956 cm^{-1} instead of 966 cm^{-1} which was within the resolution of the instrument. The area under the 956 cm^{-1} *trans* absorbance band was integrated between the limits of 945 and 990 cm^{-1} in order to obtain the peak area of all samples and standards. The *cis* fatty acid standard triolein was used as the background spectrum for all VFA-IR analyses (American Oil Chemists' Society 1999; Mossoba et al. 1996; Mossoba et al. 2007).

Literature values.—The reported fat and *trans*-fat values for one large serving of French fries were obtained from each restaurant's 2008 nutrition fact table. Restaurant literature is updated frequently; hence, the nutritional data currently available to consumers may not be consistent with 2008 values. The data were reported in grams and converted to percentages in order to compare the reported values to the experimental data.

RESULTS

Table 1 summarizes all *trans*-fat experimental data and all 2008 restaurant literature values for the total grams of fat and *trans*-fat in one serving of a large size order of French fries. In the table, Trial 1 and Trial 2 data are reported as the mean (with standard deviations) percentage of *trans*-fat in fry oil samples and the mean was determined from three VFA-IR runs (N=3). The individual runs of Trial 2 are shown in the table as Runs 1–3. These individual runs were shown only to note relative dates when changes in *trans*-fat content were observed. Since most of the restaurants had reduced *trans*-fat in their French fries by the year 2009, Trial 2 (Runs 1–3) may be a better representation of present-day *trans*-fat levels in French Fries. Trial 3 data (Table 2) are reported as the mean (with standard deviations) percentage of *trans*-fat in fry oil samples and the mean was determined from three VFA-IR runs (N=3).

In Run 3 of Trial 2, the *trans*-fat data obtained for Rally's (6.3%) and Long John Silver's (47.1%) appeared to be slight outliers. In Trial 3, Long John Silver's percent *trans*-fat data (41.2%) was more consistent with the data obtained in Trial 1 and Runs 2 and 3 of Trial 2. The *trans*-fat data for Rally's (13.4%)in Trial 3 was lower than previous runs (~24%), but considerably higher than the literature values.

Table 2.—Table 2 is a summary of Trial 3 which shows the effect of various methods of solvent evaporation from fat extracts on *trans*-fat analysis. French fries were purchased from Long John Silver's and Rally's. The data are reported as the mean percentages of three VFA-IR runs on the same sample, N=3.

	Heat *N=3*	Vacuum *N=3*	Air *N=3*
Rally's	13.4 ± 0.1 %	13.4 ± 0.3 %	13.8 ± 0.1 %
Long John Silver's	41.2 ± 0.7 %	41.2 ± 0.6 %	41.0 ± 0.3 %

Therefore in order to maintain consistency, Run 3 data were retained in the calculation of the mean values for Trial 2 in Table 1.

The column in Table 1 titled ''Total Fat'' under Experimental Values reports the mean for the total amount of fat extracted from one serving of French fries. The columns in Table 1 under Literature Values are mass of fat and *trans*-fat (in grams) reported in one serving of French fries. The values were obtained from each restaurant's 2008 nutritional fact tables. The fat and *trans*-fat literature values were used to calculate the percent *trans*-fat in one serving of French fries. It is important to note that the experimental values for total fat extracted from fries were fairly close to the literature values reported by each restaurant, except McDonald's. McDonald's reported 35 grams of fat per serving compared to our findings of approximately 23 grams per serving.

In Trial 1, which was our first round of testing done in June of 2008, fat extracted from French fries obtained from six restaurants had little-to-no detectable *trans*-fats, and all six of these restaurants were reporting ''zero'' *trans*-fat in French fries in their 2008 literature. All other fry oil samples analyzed in 2008 had considerable amounts of *trans*-fat: according to 2008 experimental data, seven of the 13 restaurants were selling French fries with levels of *trans*-fat ranging from 13 to 43% of the total fat content. Fig. 3 shows a Trial 1 VFA-IR *trans*-fat absorbance spectrum for oil extracted from Long John Silver's, Burger King, Steak 'n Shake and McDonald's (2008). The 1% and 50% *trans*-fat standard curves were added as

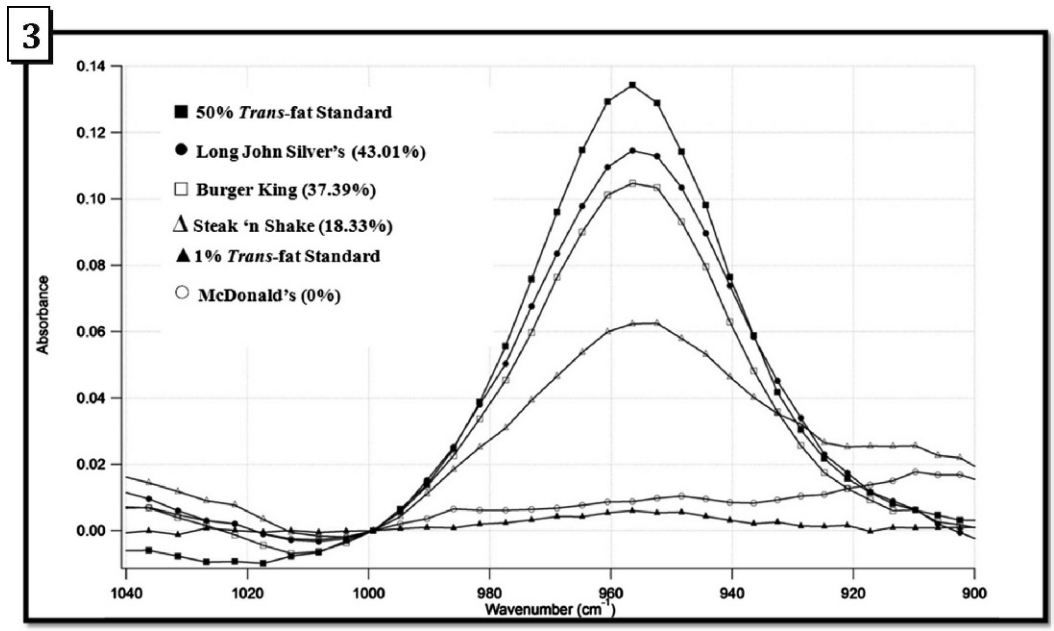


Figure 3.—Figure 3 is a VFA-IR absorbance spectrum of fry oil samples from Long John Silver's, Burger King, Steak 'n Shake and of 1 and 50% *trans*-fat standards. We did see some spectral interference in the Steak 'n Shake samples.

reference. Clearly, the Long John Silver's absorption peak is approaching the standard curve of 50%. By April of 2009 (Runs 1 and 2 of Trial 2), three more of the restaurants were selling French fries with little-to-no detectable *trans*-fat. The *trans*-fat content in French fries obtained from White Castle, Buffalo Wild Wings, Rally's, and Long John Silver's was essentially the same in June of 2010 (Run 3 of Trial 2 and Trial 3 for Rally's) as it was in the year 2008 (Trial 1).

As shown in Table 1, there were significant differences in our experimental data and the literature values. For example, in 2008, Burger King's literature reported no *trans*-fat in their French fries, while the Michigan City Burger King was still selling French fries with *trans*-fat levels as high as 38%. Dairy Queen reported 1.4%, and we found nearly 24% *trans*-fat in their fry oil samples. Steak 'n Shake was reporting 6%, when we found 18%. Surprisingly, White Castle was reporting 32.4% *trans*-fat when we found only 13% in their French fries. By June 2010, the Dairy Queen and Steak 'n Shake were reporting "zero" percent *trans*-fat in French Fries and White Castle was reporting two values, "zero" percent *trans*-fat for the New Jersey region and 8% (5 grams *trans* fat in 57 grams of fat) in all other White Castle establishments.

As stated in the methods section, we used two different methods to evaporate the ligroine from the fat extracts - heat and open air evaporation. Hence, Trial 3(Table 2) was done to determine if our methods of solvent evaporation had any adverse effects on our *trans*-fat results. Solvent evaporation using heat, vacuum, or open air resulted in similar (Table 2) *trans*-fat results. We also found that short-term storage of the fat samples did not affect *trans*-fat results. For example, the percent *trans*-fat in fat extracted from French fries purchased from Long John Silver's was 40.71% on the day of purchase (April 1, 2010) and after over three months of storage in a freezer at -20°C, the *trans*-fat content was 40.06% (July 9, 2010).

DISCUSSION

We should note that our single-phase method of fat extraction (petroleum ether) yielded total fat content in fry samples that were very close to the literature values reported by 12 of the 13 restaurants studied (Table 1). Hence, for the purposes of this preliminary study, we found petroleum ether to be a suitable fat extraction solvent.

There were substantial disparities in our 2008 Trial 1 data and the 2008 literature values. In June of 2008, the percent *trans*-fat content in fries from Buffalo Wild Wings, Rally's, Steak 'n Shake, Dairy Queen, and Long John Silver's was 1.7 to 17 times higher than the amount actually reported in their nutrition fact tables. In fact, one large order of French fries from Long John Silver's would contain as much as 6.0 grams of *trans*-fat, instead of 3.5 grams reported in the literature. In 2008, the Burger King franchise claimed to have eliminated *trans*-fat from their French fries. However, according to our 2008 study, one king size order of Burger King fries would contain just over 10 grams of *trans*-fat. As stated earlier, by the year 2009, the Michigan City Burger King, Steak 'n Shake, and Dairy Queen French fries had no detectable *trans*-fat (Runs 1 and 2 or Trial 2) – indicating a recent switch to a "no *trans*-fat" or reduced *trans*-fat frying oil. A review of the 2010 literature values showed that Dairy Queen, Steak 'n Shake, and White Castle had updated their nutrition tables to report "zero" percent *trans*-fat in French fries. For six of the restaurants that were reporting "zero" *trans*-fat, our results revealed essentially "zero" *trans*-fat. In fact, fry oil samples from Wendy's, Arby's, PNC, McDonald's, Culver's, and KFC had little-to-no detectable *trans*-fats throughout our three-year study, which is consistent with their literature.

We acknowledge that direct comparison of our experimental data with restaurant literature values could be misleading since we were not able to evaluate the statistical significance of the literature values or how the restaurant *trans*-fat analyses were done. Consequently, we cannot state the statistical or quantitative significance of our data in comparison with literature values. Nevertheless, it is clear that our data should raise concern about the significant amounts of *trans*-fat found in fast food French fries. Since the total lipid (fat) content in a raw 100-gram potato is about 0.10% and native raw potatoes do not contain *trans*-fat, we can assume that essentially all of the *trans*-fat and fat content found in our fry samples were produced or absorbed during industrial processing or primarily deep oil frying(USDA National Nutrient Database for Standard Reference 2009; Gilliard 1973).

Finally, further analysis of the percent *trans*-fat in fries obtained from 11 popular chain

restaurants (Outback Steakhouse, Applebee's, Cracker Barrel, Bob Evans, Denny's, Hooters, Red Lobster, Bennigan's, Ruby Tuesday, Chili's Grill & Bar, and T.G.I. Friday's) located in Merriville, Indiana (U.S.A.) yielded no detectable *trans*-fat.

CONCLUSIONS

New technology is now breeding a new line "no *trans*-fat" frying vegetable oils, such as mid-oleic/ultra low linolenic acid soybean oil (Warner & Fehr, 2008). These new "no *trans*-fat" oils have similar shelf lives and oxidative stabilities as the conventional hydrogenated fats. McDonald's, Wendy's and several other fast food chains have voluntarily switched to "no *trans*-fat" frying oils. In 2008, Burger King's nutritional fact tables also claimed that their fries had "no *trans*-fat"; however, at the time of our study in 2008 at least one of their restaurants was still serving fries that contained a considerable amount of *trans*-fat.

Our findings suggest that the percent *trans*-fat content in fast food fries may be considerably higher than what is reported in a restaurant's literature. In addition, a restaurant's "no *trans*-fat" claim may not necessarily hold true for all the individual restaurants within its franchise. Therefore, fast food *trans*-fat labelling may not always be valid or accurate especially if all the establishments within a particular restaurant chain are not in compliance with protocol and procedures for *trans*-fat reduction or elimination from food products. Accurate and up-to-date *trans*-fat labelling can help consumers make healthier food choices when dining in fast food establishments. In addition, out-of-date, misleading, or inaccurate *trans*-fat labelling is a public health concern prompting a need for some type of regulatory guidelines or surveillance of the nutritional value claims made by fast food establishments.

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