Corn content of French fry oil from national chain vs. small business restaurants

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Several issues, ranging from sustainability to health, may interest the consumers in the corn content of their food. However, because restaurants are excluded from the Nutrition Labeling and Education Act of 1990, national chain restaurants provide nonspecific ingredient information and small businesses supply none. We measured the carbon isotope composition of fry oil in French fries purchased from 68 (67%) of the 101 national chain fast food restaurants on Oahu (i.e., McDonald's, Burger King, Wendy's, Arby's, and Jack in the Box), and paired this with a similar number of small businesses (n = 66) to calculate minimum percent contribution of corn to total fry oil. We found that the majority (69%) of the national chain restaurants served fries containing corn oil, whereas this was true for only a minority (20%) of the small businesses. Corn oil is more expensive than soybean oil (for example) when purchased from a small business supplier, suggesting that large-scale corporate agreements are necessary to make corn oil frying cost-effective. When considering French fry oil along with corn-fed beef and chicken, as well as high-fructose corn syrup–sweetened soda, we see the pervasive influence of corn as an ingredient in national chain fast food.

fast food | junk food | nutrition | diet | stable isotope

Ingredient and nutrient content of fast foods are seldom available at the point of purchase within national chains (1) and are not available from small businesses. The Nutrition Labeling and Education Act of 1990 explicitly excludes restaurants, which is where Americans obtain more than 30% of their total calories (2). French fries occupy a special place in the American fast food diet: when a consumer purchases a fast food meal of a hamburger, fries, and diet soda (approximate cost = $3; 3), 20% of the total calories come from the fat added to the potatoes to make fries; the majority of the meal's fat comes from this same oil. Fries are also increasingly marketed to children at the expense of healthier side dishes (4). However, the type of oil used to prepare fries is a good example of a high-calorie–contributing ingredient for which only vague information is reported. Fries are described by the national chains as having been "prepared" or "cooked" in "vegetable oil" or "frying shortening" (5–9). Web pages also state that fries "may contain one or more of the following oils": corn, canola, soybean, cottonseed, sunflower, and palm. There are several reasons why knowledge of the inclusion of corn oil might be important to the consumer. Corn oil, although initially hailed as a highly polyunsaturated fat that could lower cholesterol (10), contains considerably more heart-harmful saturated fat (11) than canola, sunflower, or safflower oils, and less heart-protective alpha-linolenic acid (12) than soybean oil, making it the least healthy choice of the five (13). U.S. corn agriculture has been criticized for its negative impacts on the environment (14) and its conspicuous federal subsidization (15).

We compared the content of corn in frying oil between national chains (defined as >$1 billion annual revenue companies) and small businesses on Oahu within the state of Hawaii. Because the island of Oahu is geographically small (~25 miles east to west), we were able to sample 68 (67%) of the 101 national chain fast food restaurants on the island, and paired this with a similar number of small businesses (n = 66), thus capturing a profile of fast food fries available to a population (≈876,000 persons). The purchase of restaurant vs. fast food meals has been shown to differ widely between cultural groups in Hawaii, as do rates of overweight and obesity and reported efforts to diet (16); we sought to identify any systematic difference in the cooking practices between national chains and small businesses of potential relevance.

Results

We purchased fries at 134 restaurants on the island of Oahu and analyzed the expressed oil for carbon isotope value (Table S1). Approximately half (n = 68) of the restaurants were from the dominant national chains present in Hawaii: McDonald's, Burger King, Wendy's, Arby's, and Jack in the Box, and the other half (n = 66) were Hawaiian small businesses (e.g., L&L Barbecue, Grace's Inn, Kua'aina Sandwich Shop). Half of the restaurants were located within Honolulu, whereas the other half were located along the major highways of Oahu (Fig. 1); all restaurants confirmed that no animal fat is used in the production of their fries. The average $\delta^{13}C$ value of expressed oil ($\delta_{fry\ oil}$) from all fries purchased ranged between −31.1‰ and −17.0‰. The $\delta_{fry\ oil}$ values of fries purchased at national chains was significantly different from the $\delta_{fry\ oil}$ values of fries purchased at small businesses (P = 0.003); similarly, the median $\delta_{fry\ oil}$ value of fries purchased at national chains (−27.7‰) was substantially higher than the median $\delta_{fry\ oil}$ value of fries purchased at small businesses (−29.7‰).

Discussion

Our determination of the contribution of corn oil to total fry oil (Fig. 1) relied on the inherently high $\delta^{13}C$ value of *Zea mays* as a C4 photosynthesizer (17) when compared with a variety of other cooking oils (Table 1). Corn oil has a conspicuously high carbon isotope composition (−15.4‰) when compared with all of the other cooking oils mentioned in national chain ingredient lists (Table 2). The isotopically heaviest noncorn oil mentioned in these lists is cottonseed oil (−28.2‰), which is also isotopically heavier than other edible oils (e.g., canola, soybean, palm, sunflower; Table 1). Therefore, we consider all fries with a $\delta_{fry\ oil}$ value of −28.2‰ or less as potentially containing no corn oil. Within the small businesses, 80% of restaurants sampled fit this criterion, whereas among the national chains, only 31% of restaurants sampled yielded $\delta_{fry\ oil}$ that could be explained without some contribution of corn oil. Based on the carbon isotope value for corn oil (−15.4‰) and the heaviest value found in all other edible oils (cottonseed oil = −28.2‰), we calculated the minimum percent contribution of corn to total fry oil ($f_{corn\ oil} \times 100\%$) for $\delta_{fry\ oil}$ greater than −28.2‰ as the following:

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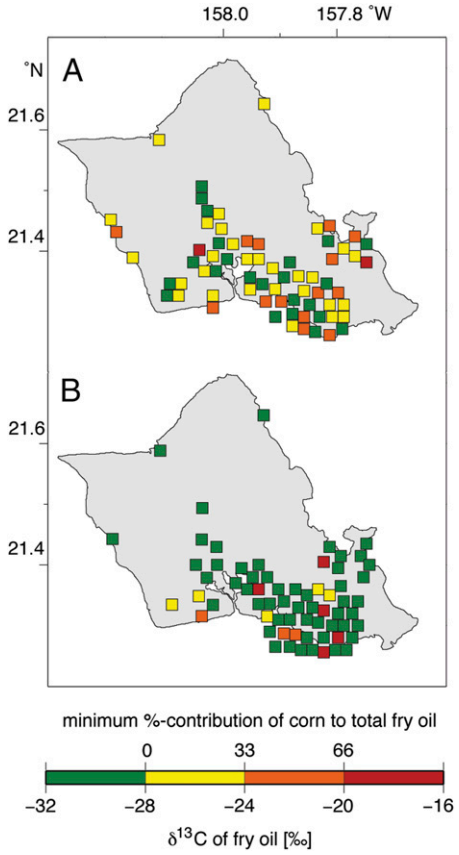

Fig. 1. Carbon stable isotope values of fry oil from all restaurants sampled on the island of Oahu, separated as national chain (*A*) vs. small business (*B*) restaurants. Stable isotope value is designated by color; minimum percent contribution of corn to total fry oil was calculated using Eq. **1**.

$$\delta_{\text{fry oil}} = -15.4 * f_{\text{corn oil}} + (-28.2 * (1 - f_{\text{corn oil}})) \qquad [1]$$

Using the above, the majority (69%) of the national chain restaurants served fries containing corn oil, whereas this was true for only a minority (20%) of the small businesses. Although the proportion of restaurants using corn-oil–dominated (i.e., >50%) oil was similar for national chains and small businesses (7% and 11%, respectively), $\delta_{\text{fry oil}}$ values indicated that corn oil comprises part of each of the national chains' frying protocols, with the exception of Jack in the Box (Table 2). With average $\delta_{\text{fry oil}} = -29.9‰$ ($n = 19$), Jack in the Box values are consistent with the canola, soybean, cottonseed, and palm oils mentioned as possible ingredients. Burger King's nutrition Web pages do not list corn oil as a possible ingredient, and yet the average $\delta_{\text{fry oil}}$ value for Burger King was −22.6‰, clearly a corn oil mixture. The average $\delta_{\text{fry oil}}$ value for Wendy's and Arby's (merged in 2008) was consistent with a 36% minimum corn oil contribution; our previous study identified that all Wendy's chicken (18) and beef (19) from across the continental United States traced back to a corn source. Our estimates of the minimum contribution of corn oil to McDonald's fries are potentially low: although corn, canola, and soybean oil are listed as possible ingredients, cottonseed is not (Table 2). Instead, canola oil is the isotopically heaviest oil listed (−30.0‰), which alters Eq. **1** such that the median minimum corn oil contribution is 16% for McDonald's restaurants sampled (Table 2). Similarly, the median minimum contribution of corn oil to Burger King fries would be adjusted to 50% based on ingredient lists.

Table 1. Carbon isotope composition of cooking oils

Type of oil	$\delta^{13}C$, ‰
Corn (*Zea Mays*) oils	
Corn (1.7 g saturated fat per Tbs)	
Mazola* Corn Oil	−15.3
Safeway Corn Oil	−15.4
Vegetable oils	
Canola (1.0 g saturated fat per Tbs)	−30.0
Cottonseed (3.5 g saturated fat per Tbs)	−28.2
Olive (1.8 g saturated fat per Tbs)	
Safeway Select Extra Virgin Olive Oil	−29.7
Safeway Select Extra Light Olive Oil	−29.8
Palm (6.7 g saturated fat per Tbs)	
SuppliesStore.com Organic Palm Oil	−30.2
SuppliesStore.com Refined Palm Oil	−29.2
Jungle Products Organic Red Palm Oil	−30.0
Peanut (2.3 g saturated fat per Tbs)	−29.2
Safflower (0.8 g saturated fat per Tbs)	
Saffola Safflower Oil	−29.2
SuppliesStore.com Safflower Oil	−30.6
Sesame (1.9 g saturated fat per Tbs)	−28.7
Soy (2.0 g saturated fat per Tbs)	
Pure Wesson Vegetable Oil	−30.6
SuppliesStore.com Soybean Oil	−31.2
Sunflower (6.7 g saturated fat per Tbs)	
Spectrum Naturals Organic Sunflower Oil	−29.7
SuppliesStore.com Sunflower Oil	−29.2
Mixed oils	
Canola and Soybean	
Pure Wesson Best Blend (1.5 g saturated fat per Tbs)	−30.2
Canola and DHA algal	
Crisco Puritan Canola Oil with Omega-3 DHA (1.0 g saturated fat per Tbs)	−29.4
Canola, Soybean and Olive	
Smart Balance Omega (1.5 g saturated fat per Tbs)	−30.3
Soybean (partially hydrogenated) and cottonseed (fully hydrogenated)	
Crisco All Vegetable Shortening(3.0 g saturated fat per Tbs)	−30.5

*For oils with more than one brand, brand is specified.

Although the use of corn oil dominated the frying techniques of the national chains, it formed only a minor portion of small business practices. A standard commercial deep-fryer requires 32 lbs of oil, which is generally used no longer than 100 h, and may need to be replaced or augmented more often depending on the volume of food produced. Based on the prices provided by Foodservice Direct, Inc., 32 lbs. of corn oil costs $70, canola oil costs $75, and soybean oil costs $50. From a small-business profit perspective, noncorn oil makes sense, particularly given cheaper soy and soy-mixture alternatives. Therefore, to make corn oil cost-effective, it is probably necessary to contract ingredients on a large scale from preferred distributors, consistent with the basic tenets of fast food production, and representative of the pervasive inclusion of corn in fast food itself (18).

Conclusions

Multiple studies have demonstrated that knowledge of ingredients leads to changed eating habits (e.g., refs. 20 and 21), and consumers have been shown to be particularly poor at guessing the nutrient content of restaurant foods (22). Adolescents were observed to completely change their meal orders at fast food restaurants if provided with nutrition information (23). Our work demonstrates one example of the general absence of relevant information available when consumers purchase food.

Table 2. Measured mean $\delta^{13}C$ value of fry oil as well as reported oil contents for fries from national chain restaurants

Chain, *n* sampled (%)*	$\delta^{13}C$ of oil, median (range), ‰	Ingredient information	"May contain one or more of the following oils"† ($\delta^{13}C$ value), ‰					
			Corn (−15.4)	Canola (−30.0)	Soy (−30.9)	Cotton- seed (−28.2)	Sun- flower (−29.5)	Palm (−29.8)
McDonald's, *n* = 27 (55%)	−27.6 (1.4)	"Prepared in vegetable oil"	✓	✓	✓			
Jack in the Box, *n* = 19 (83%)	−29.6 (2.0)	"Cooked in frying shortening."		✓	✓	✓	✓	✓
Wendy's, *n* = 5 (100%)	−24.3 (8.4)	"Cooked in vegetable oil"	✓	✓	✓	✓		
Arby's, *n* = 5 (100%)	−22.0 (13.2)	"Contains vegetable oil"	✓	✓	✓	✓	✓	✓
Burger King, *n* = 12 (63%)	−22.6 (4.5)	"Contains soybean oil or canola and palm oil"		✓	✓			✓

*Of total number of locations on Oahu.
†$\delta^{13}C$ values are averages of the values reported in Table 1.

Methods

To sample the oil deposited on fries during cooking, we blotted three fries from each restaurant onto two stacked Whatman glass microfiber filters. The bottom filter was then allowed to dry for 2 h at RT; the top filter was discarded. Our previous studies have shown that media transfer to glass filter has no effect on carbon isotope value (24). Three 2-mm-diameter discs containing 0.3–1.9 mg of blotted fry oil were sampled from the bottom filter and then enclosed in high-purity tin capsules. For cooking oils (Table 1), three 0.5-μl aliquot samples were pipetted into tin capsules. Samples were quantitatively combusted to CO_2 in a Eurovector elemental analyzer configured with a Micromass Stable Isotope Ratio Mass Spectrometer at the University of Hawaii. Reported values represent the mean of three analyses (standard deviation of the three measurements never exceeded 0.2‰); values are reported in standard δ-notation relative to VPDB. We performed experiments frying potatoes ($\delta^{13}C$ value = −26.5‰) in corn oil ($\delta^{13}C$ value = −15.4‰) and comparing the $\delta^{13}C$ value of the fried corn oil to the $\delta^{13}C$ value of oil expressed from fries according to the methods above (−15.3‰; *n* = 10). This value also compared closely with the oil left over after frying (−15.5‰), oil squeezed from the fries (−15.4‰), and oil leached from the fries (−15.3‰). In summary, the frying process did not alter the value of the oil by more than 0.1‰.

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1. Wootan MG, Osborn M, Malloy CJ (2006) Availability of point-of-purchase nutrition information at a fast-food restaurant. *Prev Med* 43:458–459.
2. Lin B-H, Guthrie J, Frazão E (1999) Nutrient contribution of food away from home. *Agric Inform Bull* 750:213–242.
3. McDonald's Dollar Menu. Available at: http://www1.mcdonalds.com/dollar/. Accessed December 24, 2009.
4. Hurley J, Liebman B (2005) Restaurant roulette. *Nutr Action Health Lett* 32:11–15.
5. McDonald's USA - Nutrition Info. Available at: http://nutrition.mcdonalds.com/nutritionexchange/nutritionexchange.do. Accessed May 4, 2009.
6. Jack in the box-Nutrition. Available at: http://www.jackinthebox.com/nutrition. Accessed May 4, 2009.
7. Nutrition Facts & Personalize It-Wendy's. Available at: http://www.wendys.com/food/Nutrition.jsp. Accessed May 4, 2009.
8. Burger King - Menu and Nutrition. Available at: http://www.bk.com/en/us/menu-nutrition/index.html. Accessed May 4, 2009.
9. Arby's Nutrition. Available at: http://www.arbys.com/nutrition/. Accessed May 4, 2009.
10. Dayton S, Pearce ML, Hashimoto S, Dixon WJ, Tomiyasu U (1969) A controlled clinical trial of a diet high in unsaturated fat in preventing complications of atherosclerosis. *Circulation* 40:1–63.
11. Maron DJ, Fair JM, Haskell WL (1991) Saturated fat intake and insulin resistance in men with coronary artery disease: The Stanford Coronary Risk Intervention Project Investigators and Staff. *Circulation* 84:2020–2027.
12. Campos H, Baylin A, Willett WC (2008) Alpha-linolenic acid and risk of nonfatal acute myocardial infarction. *Circulation* 118:339–345.
13. USDA Nutrient Data Laboratory (2006) USDA Nutrient Database for Standard Reference: Release 14; http://www.nal.usda.gov/fnic/foodcomp/Data/SR14/sr14.html. Accessed October 1, 2009.
14. Tilman D, Cassman KG, Matson PA, Naylor R, Polasky S (2002) Agricultural sustainability and intensive production practices. *Nature* 418:671–677.
15. Horrigan L, Lawrence RS, Walker P (2002) How sustainable agriculture can address the environmental and human health harms of industrial agriculture. *Environ Health Perspect* 110:445–456.
16. Ahedo AM, et al. (2007) Factors affecting the consumption of away-from-home foods in Hawai'i residents. *Californian J Health Promot* 5:1–12.
17. Farquhar GD (1983) On the nature of carbon isotope discrimination in C_4 species. *Aust J Plant Physiol* 10:205–226.
18. Jahren AH, Kraft RA (2008) Carbon and nitrogen stable isotopes in fast food: Signatures of corn and confinement. *Proc Natl Acad Sci USA* 105:17855–17860.
19. Jahren AH, Kraft RA (2009) Reply to Chesson et al.: Carbon stable isotopes in beef differ distinctly between corporations. *Proc Natl Acad Sci USA* 106:E9.
20. Lin C-TJ, Lee J-Y (2003) Dietary fat intake and search for fat information on food labels: New evidence. *Consum Interests Annu* 49:1–3.
21. Kim S-Y, Nayga RM, Capps O (2000) The effect of food label use on nutrient intakes: An endogenous switching regression analysis. *J Agric Resourc Econ* 25:215–231.
22. Burton S, Creyer EH, Kees J, Huggins K (2006) Attacking the obesity epidemic: The potential health benefits of providing nutrition information in restaurants. *Am J Public Health* 96:1669–1675.
23. Yamamoto JA, Yamamoto JB, Yamamoto BE, Yamamoto LG (2005) Adolescent fast food and restaurant ordering behavior with and without calorie and fat content menu information. *J Adolesc Health* 37:397–402.
24. Kraft RA, Jahren AH, Saudek C (2008) Clinical-scale investigation of stable isotopes in human blood: $\delta^{13}C$ and $\delta^{15}N$ from 406 patients at the Johns Hopkins Medical Institutions. *Rapid Commun Mass Spectrom* 22:3683–3692.