Presence of Inulin and Oligofructose in the Diets of Americans[1]

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ABSTRACT The U.S. Department of Agriculture 1994–1996 Continuing Survey of Food Intakes by Individuals was used to estimate the intake of naturally occurring inulin and oligofructose by the U.S. population. Two nonconsecutive 24-h dietary recalls from >15,000 Americans of all ages were conducted, and a special database of inulin and oligofructose was developed specifically for the analyses. American diets provided on average 2.6 g of inulin and 2.5 g of oligofructose. Intakes varied by gender and age, ranging from 1.3 g for young children to 3.5 g for teenage boys and adult males. When standardized for amount of food consumed, the intakes showed little difference across gender and age. Significant differences in intake of these components were seen between categories within region of the country, season, income, and race and origin; however, the actual differences were relatively small. Major food sources of naturally occurring inulin and oligofructose in American diets were wheat, which provided about 70% of these components, and onions, which provided about 25% of these components. The estimation of the presence of inulin and oligofructose in the diets of Americans has not been published to date. J. Nutr. 129: 1407S–1411S, 1999.

KEY WORDS: • *inulin* • *oligofructose* • *humans* • *Continuing Survey of Food Intakes by Individuals* • *National Nutrition Monitoring and Related Research Program*

MATERIALS AND METHODS

Study sample. The analyses presented here are based on data from the 1994–1996 Continuing Survey of Food Intakes by Individuals (CSFII). The CSFII is conducted by the Agricultural Research Service of the USDA and forms an integral part of the National Nutrition Monitoring and Related Research Program (FASEB/LSRO 1995). This survey is the 10th nationwide food consumption survey conducted by the USDA since the 1930s. The objective of the survey was to measure the kinds and amounts of food eaten by Americans. The survey comprised a nationally representative sample of noninstitutionalized persons residing in the United States. An independent sample was drawn for each year of data collection and then combined for a 3-y sample of 16,103 individuals of all ages. Data were weighted to make the estimates representative of the U.S. population during the 3-y time period. National estimates were produced by an estimation procedure that used sampling weights to adjust the sample for variable probabilities of selection and differential nonresponse. The procedure also calibrated the sample to the national population along characteristics believed to be determinants of food intake, including such factors as age, race, ethnicity, income, employment status and day of the week.

Data were collected on all individuals by trained interviewers and included a variety of sociodemographic and household characteristic data in addition to an in-person, in the home, 24-h dietary recall for two nonconsecutive days for each individual. The two dietary recalls were spaced 3–10 d apart. The individual d 1 response rate was 80%, and 76% for d 2. The analytical sample for these analyses consisted of all respondents (excluding breast-fed infants) who provided 2 d of dietary data totaling 15,170 individuals of all ages.

Dietary data. The dietary recall administered by interviewers in the Continuing Survey included multiple passes to aid the respondent in remembering everything they had eaten and drunk over the previous 24-h period. The first pass was the quick list in which the respondent was asked to report everything he or she ate or drank the previous day between midnight and midnight in any way they wanted to recall. The second pass comprised the detailed probes for descriptions and amounts. During this pass, interviewers were required to use the USDA Food Instruction Booklet, which provides standardized text to probe for details and amounts of foods grouped into >100 food categories. The third and final pass reviewed all foods eaten and probed for any additional foods before the first eating occasion, after the last eating occasion and in between all previously noted eating occasions. Further information regarding the sampling, methodology, survey questionnaires and data collection procedures are available in the CSFII Design and Operation Report (Tippett and Cypel 1997).

Three technical databases were used to code the food data collected in the CSFII 1994–1996 and to calculate the nutritive values of those foods. They are the Food Coding Database, the Recipe Database and the Survey Nutrient Database. The Food Coding Database contains ~7300 unique food codes representing all of the foods reported in the survey. The Recipe Database contains a recipe entry for each food code that includes ingredient(s) and their amount(s), as well as information for determining changes that may occur in nutrients during cooking. The purpose of the Recipe Database is to provide information used to generate the Survey Nutrient Database (Perloff et al. 1990). The Survey Nutrient Database contains values for nearly 50 nutrients and dietary components for all foods reported in the survey. However, values for the inulin and oligofructose content of foods do not exist in the Survey Nutrient Database for the

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TABLE 1

Inulin and oligofructose content of foods eaten by Americans

	Inulin		Oligofructose	
	Range[1]	Midpoint[2]	Range	Midpoint
	g/100 g			
Banana				
Raw	0.3–0.7	0.5	0.3–0.7	0.5
Raw-dried	0.9–2.0	1.4	0.9–2.0	1.4
Canned	0.1–0.3	0.2	0.1–0.3	0.2
Aparagus				
Raw	2.0–3.0	2.5	2.0–3.0	2.5
Boiled	1.4–2.0	1.7	1.4–2.0	1.7
Chicory root	35.7–47.6	41.6	19.6–26.2	22.9
Dandelion greens				
Raw	12.0–15.0	13.5	9.6–12.0	10.8
Cooked	8.1–10.1	9.1	6.5–8.1	7.3
Garlic				
Raw	9.0–16.0	12.5	3.6–6.4	5.0
Dried[3]	20.3–36.1	28.2	8.1–14.5	11.3
Globe artichoke	2.0–6.8	4.4	0.2–0.7	0.4
Jerusalem artichoke	16.0–20.0	18.0	12.0–15.0	13.5
Leeks				
Raw	3.0–10.0	6.5	2.4–8.0	5.2
Onions				
Raw	1.1–7.5	4.3	1.1–7.5	4.3
Raw-dried	4.7–31.9	18.3	4.7–31.9	18.3
Cooked	0.8–5.3	3.0	0.8–5.3	3.0
Wheat				
Bran-raw	1.0–4.0	2.5	1.0–4.0	2.5
Flour-baked	1.0–3.8	2.4	1.0–3.8	2.4
Flour-boiled	0.2–0.6	0.4	0.2–0.6	0.4
Barley				
Raw	0.5–1.0	0.8	0.5–1.0	0.8
Cooked	0.1–0.2	0.2	0.1–0.2	0.2
Rye				
Baked	0.5–0.9	0.7	0.5–0.9	0.7

[1] Source: Van Loo et al. (1995) and personal communication with Dr. Jan Van Loo, December 1997.
[2] Calculated as an average of the range.
[3] Calculated using a total solids approach.

TABLE 2

Mean daily intakes of inulin and oligofructose in diets of Americans[1]

		Inulin			Oligofructose		
Age group	*n*[2]	Range	Midpoint		Range	Midpoint	
		g	*g*	*g/4.18 MJ*[3]	*g*	*g*	*g/4.18 MJ*
Children							
≤5 y	3017	0.55–2.13	1.34	0.94	0.54–2.10	1.32	0.92
6–11 y	1432	0.90–3.52	2.21	1.19	0.87–3.47	2.17	1.17
Males							
12–19 y	696	1.34–5.41	3.37	1.25	1.30–5.34	3.32	1.23
20–49 y	2358	1.36–5.59	3.47	1.37	1.31–5.49	3.40	1.34
50+ y	2393	1.20–4.70	2.95	1.46	1.15–4.62	2.88	1.43
Females							
12–19 y	702	0.91–3.69	2.30	1.27	0.87–3.62	2.25	1.24
20–49 y	2319	0.94–3.80	2.36	1.42	0.90–3.73	2.31	1.39
50+ y	2253	0.88–3.47	2.17	1.48	0.85–3.41	2.13	1.45
All individuals	15,170	1.04–4.16	2.60	1.34	1.00–4.09	2.54	1.31

[1] Values presented in this table are weighted population estimates from the 1994–1996 Continuing Survey of Food Intakes by Individuals using the specialized database developed for inulin and oligofructose.
[2] n is unweighted sample size.
[3] 4.18 MJ = 1000 kcal.

TABLE 3

Population estimates by socioeconomic and demographic categories of Americans[1]

Category	% Population
Poverty threshold, %	
<131	19
131–350	42
>350	39
Race/ethnicity	
White	73
Black	13
Hispanic	11
Other	3
Region	
Northeast	20
Midwest	23
South	35
West	22

[1] Percentages in this table are weighted population estimates for the United States used in the 1994–1996 Continuing Survey of Food Intakes by Individuals.

CSFII 1994–1996. Therefore, a special database was developed that contained the content of inulin and oligofructose naturally occurring for each food code in the CSFII 1994–1996.

Table 1 lists food sources of inulin and oligofructose eaten by Americans that served as the basis for the specialized database. A range of upper and lower concentration values of naturally occurring inulin and oligofructose in grams per 100 g of each food are provided, based on values reported by Van Loo et al. (1995). The average of the range was calculated to determine the midpoint values. The food sources include one fruit, eight vegetables and three cereal grains. Bananas contain 0.5 g per 100 g each of inulin and oligofructose. For vegetables, chicory root is the best source of these components, providing 42 g of inulin and 23 g of oligofructose per 100 g. Raw dandelion greens, dried garlic, Jerusalem artichoke and dried onions have the next highest amounts ranging from 13 to 28 g per 100 g of inulin and 11 to 13 g per 100 g of oligofructose. For cereal grains, wheat is the best source, providing ~2.5 g/100 g of each component in raw bran and baked flour.

The specialized database was created for every food code in the 1994–1996 CSFII that included a food source of inulin and oligofructose. The amount of inulin and oligofructose in each food was calculated to yield inulin and oligofructose values for ~2700 food codes in the Food Coding Database. The established retention factor methodology used to generate the CSFII 1994–1996 Survey Nutrient Data Base was applied in creating the database for inulin and oligofructose (Powers and Hoover 1989).

TABLE 4

Effects of race and origion on mean daily intakes of inulin and oligofructose by Americans[1]

	White	Black	Hispanic
		g	
Inulin	2.7[a]	2.2[a,b]	2.3[b]
Oligofructose	2.7[a]	2.1[a,b]	2.3[b]

[1] Values presented in this table are weighted population estimates from the 1994–1996 Continuing Survey of Food Intakes by Individuals using the specialized database for inulin and oligofructose.
[a,b] Differences between estimates with common superscripts are significant at $P < 0.05$.

TABLE 5

Effects of income on mean daily intakes of inulin and oligofructose by Americans[1]

	Percentage of poverty threshold[2]		
	<131%	131–350%	>350%
		g	
Inulin	2.3[a]	2.5[b]	2.8[a,b]
Oligofructose	2.3[a]	2.5[b]	2.8[a,b]

[1] Values presented in this table are weighted population estimates from the 1994–1996 Continuing Survey of Food Intakes by Individuals using the specialized database for inulin and oligofructose.

[2] Income defined by percentage of poverty threshold, which accounts for household size and income.

[a,b] Differences between estimates with common superscripts are significant at $P < 0.05$.

Statistical analysis. Estimates of inulin and oligofructose intake were calculated for all individuals (excluding breast-fed infants) providing 2 d of intake in CSFII 1994–1996 by using reported food intakes and the special database for inulin and oligofructose. Analyses were performed using SPSS-X (SPSS, Chicago, IL) and SUDAAN (Research Triangle Institute, Research Triangle Park, NC) software, which are appropriate for use with complex samples. ANOVA was used to test differences in means between groups. The groups analyzed were defined by gender and age, poverty category, origin and race, geographic region and month of the first day of intake. The contribution of inulin and oligofructose from food sources consumed was also calculated. Food sources were categorized by 71 ARS-defined food groups used in the 1994–9696 CSFII (USDA 1998).

Poverty category for each respondent was calculated as a ratio of a household's annual income to the poverty threshold appropriate for the household size and expressed as a percentage. The poverty thresholds are issued by the Bureau of the Census. Origin and race were used together to define each respondent's ethnic group. A respondent whose national origin was Mexican, Mexican American, Chicano, Puerto Rican, Cuban, or other Spanish/Hispanic was assigned to the "Hispanic" ethnic group. Race was used to assign the remaining respondents to the "white," "black" or "other" ethnic group. Due to the diverse composition of the "other" group, analyses were performed only on the Hispanic, white and black ethnic groups.

Region of the country was defined by the four census regions of the United States for the 1990 Census of the Population. The month of the first day of intake was used to define the season in which the intake occurred. Intakes reported during the months of January, February and March were classified as winter; April, May and June as spring; July, August and September as summer; and October, November and December as fall.

RESULTS AND DISCUSSION

Mean intakes. Mean daily intakes of inulin and oligofructose by Americans are provided in **Table 2**. Inulin and oligofructose intakes were estimated using the upper and lower range values and the midpoint value of the inulin and oligofructose content of foods. Results of analyses are discussed for inulin and for oligofructose according to midpoint values for each component. Mean intakes of inulin were almost identical to those of oligofructose. American diets provided on average 2.6 g of inulin and 2.5 g of oligofructose per individual per day. Mean intakes of inulin and oligofructose differed across gender and age groups. Children <6 y of age had the lowest intakes, and males 20–49 y of age had the highest intakes, 1.3 and 3.4 g, respectively. For children ≤12 y of age, mean intake of inulin ranged from 1.3 to 2.2 g. Mean intakes for males beginning in the teen years and adults 20–49 y of age was ~3.4 g and decreased to 3.0 g for males ≥50 y of age. For females, mean intake for teens and adults 20–49 y old was ~2.3 g. Mean intake decreased to 2.1 g for females ≥50 y.

TABLE 6

Effects of geographic region on mean daily intakes of inulin and oligofructose by Americans[1]

	Northeast	Midwest	South	West
		g		
Inulin	2.6	2.8[a,b]	2.5[a,c]	2.6[b,c]
Oligofructose	2.6	2.7[a,b]	2.4[a,c]	2.6[b,c]

[1] Values presented in this table are weighted population estimates from the 1994–1996 Continuing Survey of Food Intakes by Individuals using the specialized database for inulin and oligofructose.

[a,b,c] Differences between estimates with common superscripts are significant at $P < 0.05$.

The differences shown in mean intakes of inulin and oligofructose by gender and age were driven by the amount of food consumed. Mean intakes of each component per 4.18 MJ (1000 kcal) showed very little variation across gender and age groups. Intakes ranged from 0.9 g/4.18 MJ for the youngest children to ~1.5 g/4.18 MJ for adults.

Intakes by demographic categories. The effects of various demographic variables on intakes of inulin and oligofructose by Americans were determined. **Table 3** provides the percentage of the population by demographic categories during the period 1994 through 1996 when the Continuing Survey of Food Intakes by Individuals was conducted. Whites, who make up 73% of the U.S. population, consumed significantly more inulin and oligofructose than blacks or Hispanics. Mean intakes by whites was 2.7 g of each component compared with 2.3 g for Hispanics and ~2.2 g for blacks as shown in **Table 4**.

Income was another demographic variable that had a significant effect on intakes of inulin and oligofructose. **Table 5** shows the effect of income as defined by poverty categories on intakes of inulin and oligofructose. Mean intakes of both components increased as income increased. Americans in the highest income category consumed significantly more inulin and oligofructose that those in the middle and lowest income categories, i.e., 2.8 g compared with 2.5 and 2.3 g, respectively.

TABLE 7

Effects of season on mean daily intakes of inulin and oligofructose by Americans[1]

	Spring[2]	Summer	Fall	Winter
		g		
Inulin	2.6[a]	2.5[a,b,c]	2.7[b]	2.7[c]
Oligofructose	2.5[a]	2.4[a,b,c]	2.6[b]	2.6[c]

[1] Values are weighted population estimates from the 1994–1996 Continuing Survey of Food Intakes by Individuals using the specialized database for inulin and oligofructose.

[2] Seasons are defined as follows: Spring, April thru June; Summer, July thru September; Fall, October thru December; Winter, January thru March.

[a,b,c] Differences between estimates with common superscripts are significant at $P < 0.05$.

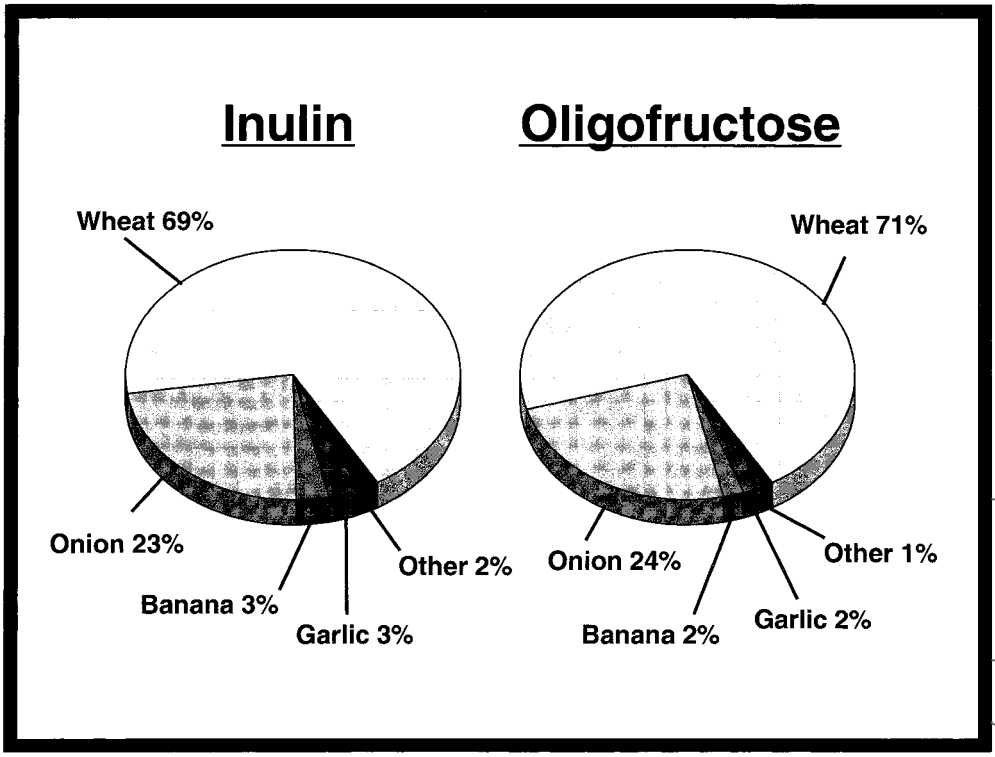

FIGURE 1 Contribution of food sources to inulin and oligofructose in American diets. Data presented in this figure are from the 1994–1996 Continuing Survey of Food Intakes by Individuals using the specialized database for inulin and oligofructose.

Both geographic region of the country and season of the year also affected intakes of inulin and oligofructose. Mean intakes were significantly lower in the South compared with the Midwest and the West (**Table 6**). The West was significantly lower than the Midwest. In the 1994–1996 CSFII, data were collected throughout the entire year; thus season of the year is equally represented in reported food intakes. Season did affect intakes of inulin and oligofructose. The lowest intakes of these components was reported in summer, defined by the months of July through September. For summer, mean intake of inulin and oligofructose was 2.5 and 2.4 g, respectively (**Table 7**). Although intakes differed within categories of each of the demographic variables analyzed, the actual differences were relatively small.

Contribution of food sources. **Figure 1** illustrates the contribution of food sources to inulin and oligofructose in

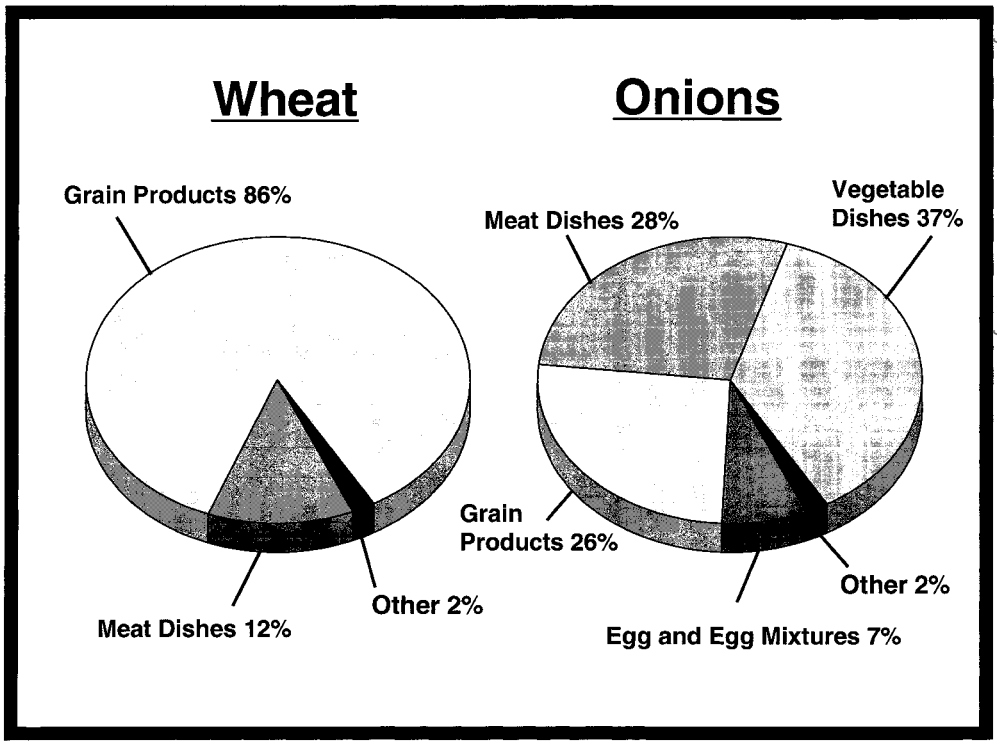

FIGURE 2 Types of foods containing wheat and onions in American diets. Data presented in this figure are from the 1994–1996 Continuing Survey of Food Intakes by Individuals using the specialized database for inulin and oligofrutose.

American diets. In terms of amounts of inulin and oligofructose in foods, chicory root provided the most concentrated source of these components. However, when consumption of food was accounted for, wheat was the most important source of both components in American diets followed by onions. Wheat and onions were consumed by >90% of Americans on any given day in 1994–1996. Wheat contributed 69% of the inulin and 71% of the oligofructose. Onions contributed ~25% of each of these components.

Figure 2 illustrates the types of foods Americans consumed that provided wheat and onions. Food items were categorized by 71 ARS-defined food groups used in the 1994–1996 CSFII. It is not surprising that grain products contributed most of the wheat in American diets. Grain products are a food group defined as items in which the grain portion is the major ingredient but could also include other ingredients. For example, items such as pizza or spaghetti with sauce were categorized as grain products in addition to items such as breads and cereals. Meat dishes, defined as items in which meat is the major ingredient, contributed 12% of the wheat. These would include items such as a hamburger on a bun and breaded and fried chicken. Onions were consumed in American diets somewhat equally in vegetable dishes, meat dishes and grain products.

In summary, Americans consume variable amounts of inulin and oligofructose depending on several factors including dietary habits, age, gender, race and season. The range of intakes will be further modified by the incorporation of inulin and oligofructose into new formulated foods.

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