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Intake of intense sweeteners in Germany

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Süßstoffverzehr in Deutschland

Zusammenfassung: Die Verzehrsmengen von Aspartam, Cyclamat und Saccharin wurden 1988/89 in der Bundesrepublik Deutschland ermittelt. Im ersten Teil der Studie wurde der Süßstoffverzehr in einer repräsentativen Stichprobe der Bevölkerung untersucht. Vollständige Angaben über die Art und Menge aller während 24 Stunden verzehrten Nahrungsmittel und Getränke wurden von 2291 Personen erhalten. Aus dem Süßstoffgehalt sowie der Verzehrsmenge der verschiedenen Lebensmittel wurde für jede Person die tägliche Einnahme jeden Süßstoffes errechnet und in mg/kg Körpergewicht ausgedrückt. 35,9 % der Teilnehmer verzehrten einen oder mehrere Süßstoffe am Erhebungstag. Cyclamat und Saccharin wurde am häufigsten genossen, da Aspartam zum Zeitpunkt der Studie nur unter Ausnahmegenehmigung verwendet werden konnte und Acesulfam K zum Zeitpunkt der Befragung noch nicht im Markt eingeführt war. Personen, die am Erhebungstag Süßstoffe zu sich nahmen, verzehrten pro kg Körpergewicht durchschnittlich 0,15 mg Aspartam, 2,62 mg Cyclamat und 0,25 mg Saccharin. Personen mit hohem Süßstoffverzehr (90. Perzentil) nahmen etwa 2,5mal größere Mengen ein. Die Befolgung einer Diät (Diabetes, Gewichtskontrolle) war nicht mit einer wesentlich höheren Süßstoffaufnahme verbunden. Tafelsüßen und kalorienarme Getränke stellten die wichtigsten Süßstoffquellen dar und trugen zusammen mehr als 80 % zur totalen Süßstoffaufnahme bei. Ein Überschreiten der duldbaren Tagesdosis („Acceptable Daily Intake", ADI) wurde nur in wenigen Fällen beobachtet (eine Person überschritt den ADI von Saccharin und 16 Teilnehmer den ADI von Cyclamat). Im zweiten Teil der Studie wurden die Verzehrsmengen von Aspartam, Cyclamat und Saccharin über 7 Tage bei den 41 Personen weiteruntersucht, die in der 1-Tages-Befragung mindestens einen dieser Süßstoffe in einer Menge von mehr als 75 % des ADI eingenommen hatten. Vollständige, 7-Tages-Ernährungsprotokolle wurden von 40 dieser ausgewählten Teilnehmer erhalten. 19 dieser Personen waren weniger als 19 Jahre alt. Während der 7tägigen Beobachtungsperiode betrug der mittlere tägliche Verzehr von Aspartam, Cyclamat und Saccharin in dieser Gruppe 0,13, 4,53 und 0,42 mg/kg Körpergewicht. Diese Mengen entsprechen 0,33, 41 und 17 % der entsprechenden ADI-Werte. Keiner der Teilnehmer überschritt den ADI von Saccharin oder Aspartam an irgendeinem der Untersuchungstage. Der ADI von Cyclamat wurde im 7tägigen Mittel von 4 Personen überschritten. Die Resultate belegen, daß zum Studienzeitpunkt die damals gültige deutsche Regelung der Süßstoffverwendung den Verbraucher hinreichend schützte und daß der Süßstoffverzehr bei 99,8 % der befragten Personen unterhalb der empfohlenen Höchstwerte lag.

Summary: The dietary intakte of aspartame, cyclamate, and saccharin was evaluated in Germany (FRG) in 1988/89. In the first part of the study the sweetener intake was evaluated in a representative sample of the population. Complete 24-h records of the amount and type of all foods and drinks consumed were obtained from 2,291 individuals. The total daily intake was calculated for each person from the sweetener content of each product and was expressed in mg/kg body weight (bw). 35.9 % of the participants ingested one or more sweeteners on the examination day. Cyclamate and saccharin were the prominent sweeteners because aspartame was at that time permitted only under special regulatory exemption, and products containing acesulfame were not yet available. For users of intense sweeteners the mean intakes of aspartame, cyclamate, and saccharin were 0.15, 2.62, and 0.250 mg/kg bw/day, respectively. At the 90th percentile of intake, i.e., for the heavy consumer, the ingestion of cyclamate and saccharin was about 2.5 times higher. Persons who adhered to a diet (diabetes, weight control) did not ingest sweeteners in substantially higher amounts. Tabletop sweeteners and beverages were the most important sources of sweeteners, and they contributed more than 80 % of the total intake. Consumption of sweeteners in excess of the Acceptable Daily Intake (ADI) was rarely observed (saccharin: one person, cyclamate: 16 persons). In the second part of the study, the sweetener intake was further evaluated during a 7-day period in those subjects who in the 1-day study ingested any of the sweeteners in excess of 75 % of the ADI. Complete 7-day food records were available from 40 out of the 41 subjects who fulfilled this criterium. In this selected subgroup in which 19 subjects were less than 19 years old, the mean daily intakes of aspartame, cyclamate, and saccharin were 0.13, 4.53, and 0.42 mg/kg body weight (bw), respectively. These levels correspond to 0.33, 41 and 17 % of the corresponding ADI values. No subject exceeded the ADI of aspartame or saccharin on any day of the study. For cyclamate, the mean daily intake over the 7-day period exceeded the ADI in 4 subjects. The results indicate that at the time of the study the then valid German sweetener regulation protected the consumer adequately, and that the sweetener intake was in 99.8 % of all examined persons within recommended limits.

Schlüsselwörter: Aspartam, Cyclamat, Saccharin, Süßstoff, Ernährung

Key words: Aspartame; cyclamate; saccharin; sweetener; diet

Introduction

In view of the harmonization of the EEC regulations governing the use of sweeteners in food, it appeared appropriate to evaluate the current sweetener intake. It was thought that such data would be useful in the elaboration of a new sweetener regulation which must adequately protect the consumer, but which at the same time should provide sufficient flexibility to allow for product innovation and consumer choice.

In the present study the intake of intense sweeteners was determined in a representative sample of the population of Germany within the limits of 1988/89. Reasons for selecting this EEC Member country for the survey included the fact that a) the market for low-calorie beverages and tabletop sweeteners is well developed in this country; b) the German regulations valid at the time of the study allowed for the highest concentrations of cyclamate and saccharin in beverages (UK and Ireland permitted higher levels for saccharin, but did not accept cyclamate); and c) a reliable and representative cohort was available for the planned investigation.

The study was designed to have two parts, namely, a) a 1-day survey to obtain mean intake data from a representative sample of the population, and b) a 7-day follow-up survey in a subgroup of consumers, selected for high sweetener intake during the 1-day survey. It was considered that average sweetener intake of the sample could be determined from 1-day food records, but that this method was inadequate to assess the sweetener intake of individual subjects because day-to-day intra-individual variations may exceed the inter-individual variations of intakes (8). From a regulatory point of view, persons with the highest intake of sweeteners merit particular attention because they might exceed the ADI, i.e., the amount of an additive that can be consumed without harm for a lifetime (9, 13). In the EEC, the Scientific Committee for Foods has allocated ADI's of 40 mg/kg bw for aspartame, 11 mg/kg bw for cyclamate, and 2.5 mg/kg for saccharin.

Subjects and Methods

Assessment of sweetener intake in a representative sample of the population using complete, 1-day food records

From a representative ad hoc cohort of 7500 German-speaking, private households, 2800 individuals were selected in such a way that the resulting sample was representative of the German population in terms of sex, age, and geographical location. An explanatory letter, a questionnaire on some individual characteristics and a 24-h food diary was mailed to all prospective participants. The study was described as a general survey on nutrition. Assessment of sweetener intake was not identified as a specific aim.

The general questionnaire asked for information on the age, sex, height, body weight, and any special dietetic practices of the participant. In the food diary all foods and liquids ingested had to be recorded, including information about the time and place of intake (at home/not at home) and the precise name (brand) and flavor or variety of each product consumed. The quantity ingested had to be recorded in ml or g, or, if this was not possible, in terms of household measures (a slice, a spoonful, a glass, etc.).

Particular columns of the food diary were reserved for recording the use of tabletop sweeteners, sucrose, and salt. Questionnaires and diaries of children below the age of 10 were completed by their parents.

The survey was conducted in the week of September 24 to 30, 1988. Groups of 400 participants were allotted to each of the 7 days from Saturday to the following Friday. From the target group of 2800 persons, 2335 individuals responded by returning their questionnaires and food diaries. Upon receipt, the records were immediately checked for completeness and accuracy and, where necessary, missing information was collected by telephone interviews. In total, the records of 2291 participants were adequate for inclusion in the present study.

The intakes of aspartame, cyclamate, and saccharin were calculated from the reported intakes of foods, beverages, and tabletop products that were known to contain these compounds. Data on the sweetener content of the different products were obtained from the respective food manufacturers, from the declaration on the package label or, in a few cases, by chemical analysis. If the food label mentioned only the amount of sugar that was substituted by one or two sweeteners (e.g., "10 g sucrose substituted by cyclamate and saccharin"), the sweetener content was estimated by analogy from corresponding products for which the precise amount of added sweetener was known. Where the quantity consumed was reported using household measures, the following conversion factors were applied: 1 cup (150 ml);

1 glass (250 ml); a small glass (200 ml); a large glass (300 ml); 1 portion yoghurt, pudding or curd (150 g); 1 glass fruit preserve (200 g); 1 tablespoon marmalade (25 g); 1 teaspoon marmalade (10 g); 1 portion marmalade (25 g). For liquid tabletop sweeteners the following approximations were made: 1 drop (26 mg solution); 1 squirt (160 mg solution). If the applied quantity of tabletop sweetener was not reported explicitly, the following amounts were taken as a basis: 1 portion salad (2 squirts liquid sweetener), 1 cup of tea (5 squirts), 1 portion yoghurt (5 squirts). If the use of tablets was reported without precise information about the quantity applied, it was assumed that a cup of tea or coffee requires the addition of 2 tablets. For homemade products (cakes, marmalades) standard recipes were used for calculating sweetener content. If ranges of food or sweetener consumption were reported (e.g., 2–3 tablets), the mean (2.5 tablets) was used for further calculations. Cyclamate and saccharin were calculated as their free acids since this is the form described by the ADI.

Assessment of sweetener intake in a selected subgroup with high consumption of sweeteners using complete 7-day records

From the 822 participants who reported an intake of sweeteners during the 1-day examination, those individuals were selected who ingested more than 75 % of the ADI of cyclamate or saccharin (top quartile). It was found that the intakes of cyclamate and saccharin exceeded 75 % of the ADI in 38 and 3 individuals, respectively. 40 of these persons agreed to participate. One woman with high cyclamate intake was no longer available to participate.

The sweetener intake of these 40 persons was surveyed over a period of 7 days at the end of May 1989. This period was characterized by warm, dry weather which would have been excepted to increase consumption of soft drinks (2). Each participant received a 7-day food record form on which the precise type and amount of foods and beverages consumed had to be recorded daily. The completed forms were returned at the end of the examination period. From the reported food intakes and the sweetener content of the different foods, the intake of each sweetener was calculated for each subject and each day as described above. For each subject, the average daily intake was calculated as the mean of the seven daily intakes. The results were expressed in mg/kg bw/d.

Results

Sweetener intake in a representative sample of the population using complete, 1-day food records

The age and sex distribution of the 2291 respondents is shown in Table 1. This group of participants was representative of the German population in terms of age distribution and geographical location of the subjects. However, males were slightly over-represented because there were more females among the non-respondents of the entire sample of 2800 individuals. 8.8 % claimed to adhere to one or more diets such as a diabetic diet, a weight-control diet or a low-cholesterol diet. One or more intense sweeteners were ingested by 35.9 % of all participants on the examination day. The percentage of users was higher among females than among males (39.2 and 33.3 %, respectively). If a correction is made for the over-representation of males, the percentage of users is estimated at 36.2 %. Sweeteners were ingested less frequently in the young age groups ($\leq$ 13 years) than in the higher age groups ($\geq$ 35 years). A particularly high percentage (66.7 %) of users was found among participants who reported

Table 1. Characteristics of the studied sample.

Participants	All participlants		Users of sweeteners		
	n	(% total sample)	n	(% users)	(% total sample)
All	2291	(100)	822	(100)	(35.9)
males	1278	(55.8)	425	(51.7)	(33.3)
females	1013	(44.2)	397	(48.3)	(39.2)
Age groups					
–5	118	(5.2)	29	(3.5)	(24.5)
6–13	159	(6.9)	33	(4.0)	(20.8)
14–17	121	(5.3)	38	(4.6)	(31.4)
18–24	280	(12.2)	103	(12.5)	(36.8)
25–34	300	(13.1)	95	(11.6)	(31.7)
35–59	830	(36.2)	323	(39.3)	(38.9)
60+	483	(21.1)	201	(24.5)	(41.6)
Dieting habits[a])					
not on a diet	2090	(91.2)	688	(83.7)	(32.9)
low cholesterol diet	50	(8.8)	31	(16.3)	(66.7)
diabetic diet	58		47		
gout	12		7		
other diets	113		72		

[a]) multiple answers were given in some cases

Table 2. Daily intake of intense sweeteners in a representative sample of the German population.

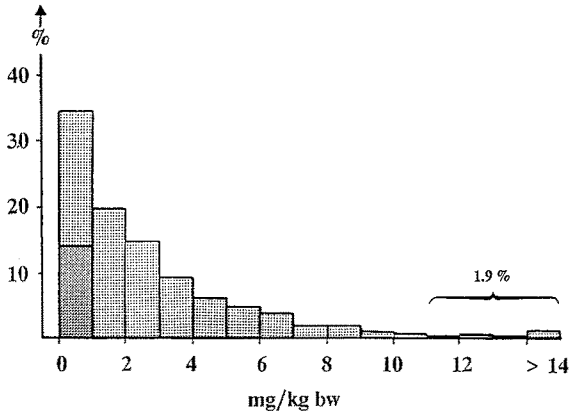
	Daily intake (mg/kg bw)		
	Median	Mean	90th Percentile
	all subjects (n = 2291)		
Aspartame	0.00	0.05	0.00
Cyclamate	0.00	0.94	3.23
Saccharin	0.00	0.09	0.29
	users of any sweetener (n = 822)[a]		
Aspartame	0.00	0.15	0.11
Cyclamate	1.78	2.62	6.08
Saccharin	0.16	0.25	0.57
	users of respective sweetener[b]		
Aspartame	0.86	1.21	2.75
Cyclamate	2.19	3.04	6.39
Saccharin	0.19	0.28	0.60
	users on a diabetic diet (n = 47)		
Aspartame	0.00	0.13	0.00
Cyclamate	1.92	2.53	6.38
Saccharin	0.15	0.30	0.75
	users on a calorie-controlled diet (n = 65)		
Aspartame	0.00	0.39	1.28
Cyclamate	1.84	3.10	6.43
Saccharin	0.15	0.27	0.64

[a]) 99 subjects consumed aspartame, 707 cyclamate, and 746 saccharin

[b]) the data represent aspartame consumption by subjects with reported intake of aspartame (with or without other sweeteners) (n = 99), cyclamate consumption by subjects with reported intake of cyclamate (n = 707), and saccharin consumption by subjects with reported saccharin intake (n = 746)

that they were on a diet, especially those adhering to a diabetic diet, of whom 81 % used intense sweeteners.

For the group of 2291 participants, the mean intakes of aspartame, cyclamate, and saccharin were 3.63, 60.5, and 5.95 mg/day, respectively. On a per kg body weight basis this corresponds to 0.052, 0.939, and 0.090 mg/kg bw (Table 2). Because less than half of the participants ingested sweeteners at the day of investigation, the median (50th percentile) intake was zero for all three sweeteners. If only users of artificial sweeteners were considered, the mean intake was 0.15 mg/kg bw for aspartame, 2.62 mg/kg bw for cyclamate, and 0.25 mg/kg bw for saccharin. At the 90th percentile of users of any sweetener the intake amounted to 0.11, 6.08, and 0.57 mg/kg bw for aspartame, cyclamate, and saccharin, respectively. This means that even for the heavy consumer intake levels of all three sweeteners were well below the respective ADI's (Table 2). This is also true if intakes were calculated for only those participants who consumed the respective sweetener at the examination day. Thus, if aspartame intake is calculated for the 99 subjects with reported intake of aspartame (singly or in combi-

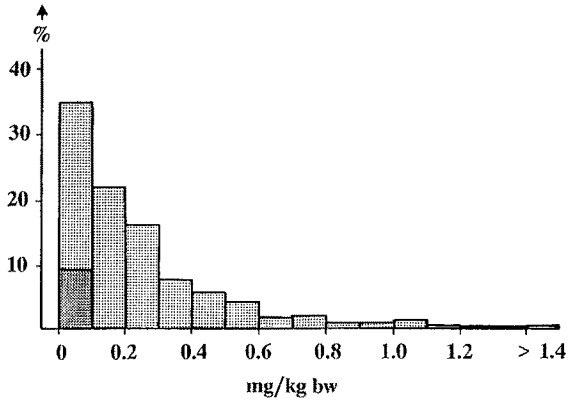


Note : 14.0 % of the 822 users of sweeteners did not consume cyclamate on the day of the study (darker hatched bar)

The ADI of cyclamate is 11 mg/kg b.w.; 1.9% of the users exceeded this level on the day of investigation

Fig. 1. Frequency distribution of 1-day cyclamate intake among users of intense sweeteners.

nation with other sweeteners), an intake of 2.75 mg/kg bw was observed at the 90th percentile. For cyclamate and saccharin, intakes of 6.39 and 0.60 mg/kg bw were determined at the 90th percentile using the same mode of calculation (Table 2). People who were on a diet, particularly on a diabetic diet, were more likely to use intense sweeteners (Table 2). Quan-



Note : 9.2 % of the 822 users of sweeteners did not consume saccharin on the day of the study (darker hatched bar)

The ADI of saccharin is 2.5 mg/kg b.w.; one user exceeded this level on the day of investigation

Fig. 2. Frequency distribution of 1-day saccharin intake among users of intense sweeteners.

titatively, however, the intakes of cyclamate and saccharin were only slightly higher among dieters than among non-dieters (Table 2). The biggest difference was seen between dieters and non-dieters for aspartame, but this may be a spurious observation which resulted from the limited availability of aspartame-sweetened products and, consequently, from the small number of aspartame-ingesting dieters (Table 2).

The frequency distribution of cyclamate and saccharin intake among users of sweeteners is shown in Figs. 1 and 2. For aspartame intake a meaningful graph cannot be produced because only 12 % of all users ingested this sweetener. As may be seen from Fig. 1, 14 % of the users of any sweetener did not ingest cyclamate on the examination day (darker hatched bar), 20.5 % ingested 0–1 mg/kg bw, 19.7 % 1–2 mg/kg bw and 14.8 % 2–3 mg/kg bw. 1.9 % reported a cyclamate intake of more than 11 mg/kg bw (ADI). Figure 2 which refers to saccharin intake, shows that 9.2 % of the users of sweeteners did not ingest any saccharin on the examination day. The vast majority of the users (91 %) ingested less than 0.6 mg/kg bw. From the 0.6 % users who ingested more than 1.4 mg/kg bw, one person exceeded the ADI of 2.5 mg/kg bw.

Comparison of the intake data for each sweetener with the corresponding ADI values shows that 16 out of 2291 persons exceeded the ADI of cyclamate and one person exceeded the ADI of saccharin on the examination day (Table 3). For the individual ingesting excessive amounts of saccharin, a tabletop product represented the sole source of this sweetener. Of the 16 individuals with heavy cyclamate intake, six ingested cyclamate with low-calorie soft drinks only, six ingested nearly the total

Table 3. Subjects with intake above ADI on day of examination.

Participants	Number of subjects exceeding the ADI[a])	
	Cyclamate	Saccharin
All	16 (0.70 %)	1 (0.04 %)
Age groups		
–5	3 (2.5 %)[b])	0 (0.0 %)
6–13	5 (3.1 %)[c])	0 (0.0 %)
14–17	0 (0.0 %)	0 (0.0 %)
18–24	1 (0.4 %)[d])	1 (0.4 %)[h])
25–34	2 (0.7 %)[e])	0 (0.0 %)
35–59	4 (0.5 %)[f])	0 (0.0 %)
60+	1 (0.2 %)[g])	0 (0.0 %)

[a]) percentages incidence is expressed in terms of total number of subjects of the respective group
[b]) intakes were 12.6, 14.3, and 43.3 mg/kg bw. The subject with the highest intake had a bodyweight of 14 kg.
[c]) intakes were 12.4, 14.9, 17.6, 19.3, and 21.5 mg/kg bw
[d]) intake was 14.4 mg/kg bw
[e]) intakes were 11.4 and 12.8 mg/kg bw
[f]) intakes were 12.2, 13.2, 14.7, and 15.9 mg/kg bw
[g]) intake was 17.4 mg/kg bw
[h]) intake was 2.62 mg/kg bw

amount with tabletop products, and only four persons reported an intake of several cyclamate containing products.

On a body weight basis, children ingest more food and beverages than adults. Therefore, they are more likely to exceed the ADI. In fact, it was found that eight out of the 16 subjects with excessive cyclamate intake were less than 8 years old and had a body weight of 22.3 ± 9.7 kg (mean ± SD). Adults with a cyclamate intake in excess of the ADI did not exhibit special characteristics that could explain their high sweetener intake. They had body weights in the normal range, and only two subjects declared to be on a calorie-controlled diet.

Sweetener intake in a selected subgroup with high consumption of sweeteners

In relation to the distribution of age and sex, the subgroup of 40 subjects with sweetener intake above 75 % of the ADI during the 1-day examination differs appreciably from the original group of participants from which it was selected. Females were over-represented (62.5 %) and children (≤ 9 years old) and adolescents (10–19 years old) constituted 30 and 17.5 % of the subgroup, respectively. Three persons adhered to a weight-control diet, one to a diabetes diet, and one person reported suffering from gout. All other individuals did not report any particular dietetic practices.

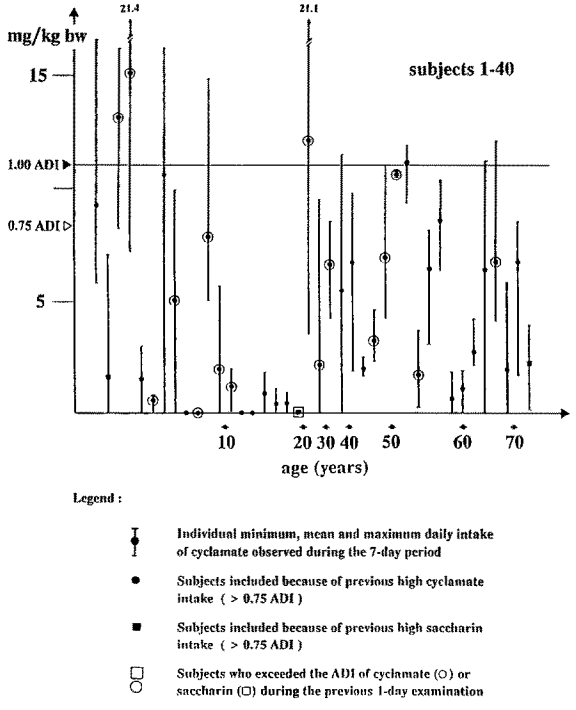


Fig. 3. Range and mean of daily cyclamate intakes in a subgroup selected for high consumption of sweeteners.

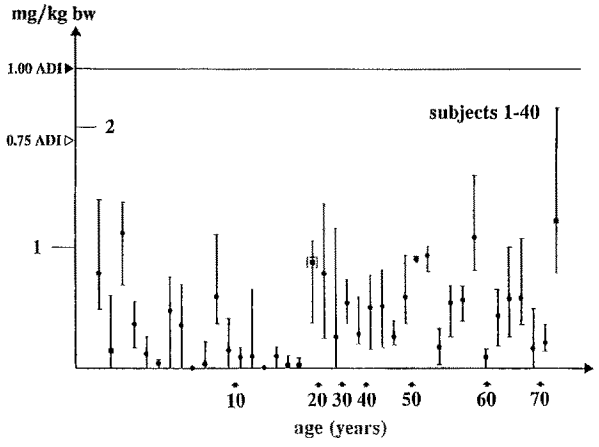


Fig. 4. Range and mean of daily saccharin intakes in a subgroup selected for high consumption of sweeteners. (For explanation of symbols, see legend of Fig. 3.)

Considering the applied inclusion criterion, it is not surprising that the intake of sweeteners was higher in this subgroup than among the 822 sweetener users from which it was selected (Tables 2 and 4). The 7-day average daily intakes of cyclamate and saccharin as well as the highest and lowest observed daily intakes are shown for each of the 40 participants in Figs. 3 and 4, respectively. The sequence of the bars, each of which

Table 4. Average daily intake observed during a 7-day period in subjects selected for high consumption of sweeteners.

	7-day average daily intake (mg/kg bw/day)	
	Cyclamate (ADI = 11 mg/kg bw)	Saccharin (ADI = 2.5 mg/kg bw)
All subjects (n= 40)		
mean	4.53	0.42
median	2.48	0.36
range	0–15.06	0–1.22
Subjects of age > 10 y (n = 28)[c])		
mean	4.09	0.45
median	2.48	0.49
range	0–12.04[a])	0–1.22
Subjects of age < 10 y (n = 12)[d])		
mean	5.56	0.35
median	3.49	0.25
range	0–15.06[b])	0–1.12

[a]) two subjects above ADI
[b]) two subjects above ADI
[c]) bodyweight: 12.5–31 kg (mean: 19.6 kg)
[d]) bodyweight: 45.5–104 kg (mean: 66.8 kg)

Table 5. Source of cyclamate and saccharin intake.

	Relative quantity of sweetener consumed with different foods in %			
	1-day survey in users of the respective sweetener		7-day survey in a subgroup selected for high sweetener intake	
	Cyclamate (n = 707)[a])	Saccharin (n= 746)[a])	Cyclamate (n = 40)[a])	Saccharin (n = 40)[a])
Tabletop sweeteners	52	74	67	76
Low-calorie soft drinks	31	16	29	20
Other products	17	10	4	4

[a]) number of consumers

represents one individual, is according to age as indicated on the abscissa. As may be seen from Fig. 3, only eight subjects showed a 7-day average daily cyclamate intake greater than 75 % of the ADI, although 37 of the 40 subjects had exceeded this value during the preceding 1-day survey. Similarly, 16 subjects exceeded the ADI of cyclamate during the 1-day survey, but only three of them had a 7-day average intake which was also above the ADI. Two of these three subjects were 4-year-old children with a correspondingly low body weight. These results demonstrate that a high sweetener intake observed on one particular day is a poor predictor of a high 7-day average daily intake. In fact, 80 % of the subjects have been misclassified to the top 5th percentile of cyclamate consumption on the basis of the 1-day survey (38/822 subjects = 4.6 %).

The data on saccharin intake gave similar results. All three subjects who exceeded 75 % of the ADI in the 1-day survey had 7-day average daily intakes which were considerably below this level (Fig. 4). Generally, the intake of saccharin was lower in relation to its ADI than that of cyclamate. A tendency to higher intakes at younger age was seen for cyclamate, but not for saccharin (Table 4; Figs. 3, 4).

Only five out of the 40 subjects consumed aspartame during the 7-day survey. The intakes on individual days ranged from 0.09 to 6.59 mg/kg, and 7-day average daily intakes varied from 0.02 to 4 mg/kg/d. The subject with the highest aspartame intake of up to 560 mg/d (6.59 mg/kg bw/d) consumed less than 2.5 mg/kg bw of cyclamate and 0.8 mg/kg bw of saccharin on any of the 7 days. During the preceding 1-day survey, the same subject did not consume aspartame, but reported a consumption of 10 mg/kg bw cyclamate.

As during the 1-day study, it was found that tabletop sweeteners and low-calorie soft drinks contributed by far the biggest share to the total cyclamate and saccharin intake (Table 5). It was also interesting to find that many of the 40 subjects ingested the entire amount of sweetener with either tabletop products (15/40 subjects) or soft drinks (3/40 subjects) only. One of the two children whose 7-day average daily cyclamate intake exceeded the ADI received the entire dose with tabletop tablets, while the other consumed it with soft drinks. From the two adults who exceeded the ADI for cyclamate, one consumed only tabletop sweeteners, the other both tabletop sweeteners and low-calorie soft drinks.

Table 6. Effect of the availability of aspartame on the consumption of cyclamate and saccharin (1-day survey).

	Daily intake (mg/kg bw)		
	Median	Mean	90th Percentile
	users of any sweetener (n = 822)		
Cyclamate	1.78	2.62	6.08
Saccharin	0.16	0.25	0.57
	subjects with reported intake of aspartame (n = 99)		
Cyclamate	0.00	0.95	2.74
Saccharin	0.10	0.19	0.59

Discussion

Data on the daily intake of intense sweeteners are rather scarce. Older studies which were conducted more than 10 years ago are probably of limited relevance because of changes in dietary habits (3, 7). The value of some more recent studies is limited because only special groups of the population were investigated (5, 11, 12), or because the survey was carried out in a country where the choice of sweeteners was limited due to regulatory restrictions (6). Comparisons of intake data between these studies can therefore at best be made on the basis of the amount of sucrose that has been substituted by intense sweeteners.

In a Finnish study, the dietary intakes of different sweeteners was examined in over 150 diabetic adolescents by means of two 48-h recall interviews. Intense sweeteners were used by 98 % of the individuals. The mean daily intakes of all intense sweeteners were far below the ADI values and were 1.15, 0.41, and 0.28 mg/kg bw/d for aspartame, cyclamate, and saccharin, respectively. Combined, these amounts represent a sugar equivalent of about 16.9 g/d if the relative sweetness of aspartame, cyclamate, and saccharin is assumed to be 200, 30, and 300, respectively (12).

The intakes of aspartame, saccharin, and cyclamate were investigated over a period of 7 days in 38 diabetic and/or obese Swiss subjects who were encouraged to use intense sweeteners. It was found that the aspartame intake did not exceed 15 % of the ADI at any day by any consumer. The ADI for saccharin was not exceeded on 99 % of all subject days, but a cyclamate intake slightly in excess of the ADI was noted in two consumers on a total of 12 days (5). Acesulfame was not available at the time the study was conducted. Intense sweetener intake corresponded to an average sucrose intake of about 30 g/d. The results demonstrated that, even in a group of persons who are professionally advised to consume low-calorie products, the sweetener intake was generally within recommended limits.

In Canada, where the addition of cyclamate and saccharin to food is not permitted, the intake of aspartame was examined in a two-wave dietary survey in a representative sample of the general population. From February to April and from July to September 1989, a 7-day food diary was distributed to over 5000 households (7500 individuals) in order to determine the consumption by category and quantity of all aspartame sweetened foods and beverages. Approximately 55 % of the respondents consumed no aspartame during the 7 days. Average daily intake in the total sample (users and non-users) was 0.56 mg/kg per day, and the intake at the 90th percentile of users was 5.54 mg/kg bw (6). The mean aspartame intake of users corresponded to approximately 16 g/d sucrose.

Considering a sugar substitution of about 17 g/d in the Finnish diabetics, 30 g/d in the Swiss patients under dietetic advice, and 15 g/d in Canadian users of aspartame, there is good agreement with the results of the present study which showed a mean intense sweetener intake equivalent to 12.1 g sucrose/d among users of sweeteners. Individuals on a diet exhibited a somewhat higher intake (14.5 g/d) than those who did not report particular dietary practices (11.6 g/d).

For the regulation of the use of food additives it is important to know where the average intake of an additive stands in relation to its ADI, and whether there are consumers or groups of consumers who regularly

exceed the ADI over a substantial period of their lifetime. The present study provides information on both aspects.

In the first part of the study (1-day survey), it was found that the mean intakes by users of sweeteners of aspartame, cyclamate, and saccharin were far below the ADI (0.36, 23.8, and 12.5 % of the ADI, resp.). Even in heavy consumers (90th percentile of users), the mean consumption was only 55.2 % of the ADI for cyclamate, 22.8 % for saccharin, and 0.3 % for aspartame. Of the 822 users of intense sweeteners, 16 subjects exceeded the ADI of cyclamate during the 1-day examination. The mean cyclamate intake of these subjects was 16.7 mg/kg, i.e., about 50 % above the ADI. Since the ADI represents "an estimate of the amount of a food additive, expressed on a body weight basis, that can be ingested over a lifetime without appreciable health risk" (13), and because it is not a threshold dose above which the ingestion of an additive is unsafe (9), this observation should not raise undue concern.

It is well known that there is a substantial intra-individual variation in the dietary intake of nutrients and other food components (8) which can considerably disturb estimates of high and low percentiles of intake. Intake estimates which are based on 1-day recall or diet records are therefore likely to overestimate the prevalence of particularly high or low intakes of certain nutrients (e.g., vitamins) or food additives (1). This error is greater for quantitatively minor or irregularly consumed nutrients or food additives than for the principal food components which are consumed every day (10). Therefore, valid data on the nutrient and food additive intake of individuals, particularly those with heavy consumption, may only be obtained from diet records which cover a period of several days (4). A comparative analysis of the results of the present 1-day and 7-day survey supports this view. The average daily sweetener intake was lower in the 7-day survey than during the previous 1-day survey, and of the 16 persons who exhibited a 1-day cyclamate intake above the ADI, only three subjects (0.4 % of users of sweeteners) had an excessive 7-day average daily intake.

Taken together, these data indicate that the consumer was adequately protected by the German food additive regulations which were in force at the time of the study (1988/89), and which restricted the use of cyclamate and saccharin to dietetic products and limited the maximum concentrations only in beverages to 800 mg/l for cyclamate and 200 mg/l for saccharin. In line with the experience from other countries, the data also suggest that the intake of saccharin and cyclamate will decrease when aspartame and acesulfame K become available as alternatives (Table 6). On the other hand, concern has been expressed that the planned authorization of sweetener use beyond dietetic foods to foods for general consumption may increase the sweetener intake. However, this concern appears to have no real basis because a person's sweetener intake is determined mainly by his ingestion of tabletop sweeteners and low-calorie beverages which are authorized already (Table 5), and because dieters who intentionally consume a variety of calorie-reduced dietetic products do not exhibit a much higher sweetener intake than non-dieters (Table 2 and (5)). Future sweetener intake studies may shed some light on the adequacy of these differing expectations. However, it should be recognized that comparisons

between the present and forthcoming investigations will be hampered by changes in sweetener regulations that have meanwhile occurred.

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