

## Original Article

# Artificial Sweeteners Consumption among Alexandria University Students, Egypt

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## Abstract

**Background:** The consumption of artificial sweeteners has increased in many countries worldwide. In the Arab world, there is little data about consumption pattern of artificial sweeteners especially among university students for their own eating practices and behaviors.

**Objective(s):** This study aimed to identify the rate of artificial sweetener consumption among Alexandria University students, and to determine its levels in relation to acceptable daily intake (ADI) set by Food and Drug Administration (FDA).

**Methods:** A cross-sectional study was carried out including 400 Alexandria University students of both sexes. The studied sample was equally allocated and randomly selected from four faculties. Data on demographic characteristics, medical history, dietary pattern, and pattern of artificial sweeteners usage were collected from each participant.

**Results:** The consumption of artificial sweeteners was reported by 31% of Alexandria University students. The most commonly consumed types of artificial sweeteners were Sucralose (0.59±0.2 mg/kg body weight/day) followed by Aspartame (0.03±0.01 mg/kg body weight/day). Daily levels of consumed artificial sweeteners in relation to ADI levels were 11.86±4.2% for Sucralose and 0.05±0.02% for Aspartame.

**Conclusion:** Daily level of consumed artificial sweeteners by Alexandria University students was less than ADI set by the FDA. Further follow up studies are needed to investigate possible side effects of long term artificial sweeteners usage. Furthermore, large epidemiological studies must be carried out to investigate artificial sweeteners consumption pattern among different age groups.

**Keywords:** Aspartame, Sucralose, low calories sweeteners, university students.

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## INTRODUCTION

A sweetener is a food additive, which mimics the effect of sugar on taste. Therefore, they are called sugar substitutes.<sup>(1)</sup> Consumers often select those foods, which are composed of low calorie sweetener because they want the taste of sweetness without added calories. The dietary option that such product provides may be especially helpful in the management of obesity or diabetes mellitus. The consumption of these types of sweeteners has increased in many countries worldwide.<sup>(2)</sup> The Food and Drug Administration (FDA) has approved the use of 6 artificial sweeteners; each one is far sweeter than regular sugar, they include: Acesulfame-K, Aspartame, Advantame, Neotame, Saccharin, and Sucralose. The FDA has established acceptable daily intake (ADI) for each sweetener. The maximum amount considered safe to consume each day from Acesulfame K is 15 mg/kg body weight, from Aspartame is 50 mg/kg body weight, from Advantame is 32.8 mg/kg body weight, from Neotame is 0.3 mg/kg body weight, from Saccharin is 5

mg/kg body weight and from Sucralose is 5 mg/kg body weight.<sup>(3)</sup>

The health benefits of artificial sweeteners are controversial. For example, adults trying to wean themselves from sugary soda; diet soda is a possible short term substitute. However there are conflicting researches surrounding the health benefits of artificially sweetened drinks.<sup>(4)</sup> Long term studies showed that regular consumption of artificially sweetened beverages reduced the intake of calories and promoted weight loss. Multiple factors undoubtedly contribute to the link between consuming artificial sweetened beverages and weight gain. Other studies showed no effects or even weight gain.<sup>(5-7)</sup> Both sugar sweetened beverages and artificially sweetened beverages are linked with an increased risk of developing type 2 diabetes and cardiovascular diseases.<sup>(7-9)</sup>

Consumption of artificial sweeteners in both beverages and foods increased over time. The rate was 15% among US population consuming artificial sweeteners in 2003-2004.<sup>(10)</sup> The rate of consuming diet drinks was 20% in 2009-2010,<sup>(11)</sup> and was as high as

30% in another study (2014).<sup>(12)</sup> University is a critical period regarding unhealthy changes in eating behaviors in students.<sup>(13)</sup> About one-fifth of university students in the US ate at least one food that contained artificial sweeteners.<sup>(11,12)</sup>

In the Arab world, there is little data about artificial sweeteners consumption and how much is spent on it. So it was important to conduct this study aiming to estimate the rate of artificial sweetener consumption among Alexandria University students, identify the most commonly used artificial sweetener, and determine the level of sweeteners consumption in relation to the ADI level approved by FDA.

## METHODS

A cross-sectional study was conducted from October 2015 to April 2016 on 400 apparently healthy students of Alexandria University aged 18-25 years of both sexes. Diabetic students were excluded from this study. The sample size was calculated statistically assuming a 50% prevalence of artificial sweeteners consumption among adults; using precision of 5 and  $\alpha$  of 5%, the estimated required sample size was 384 which was rounded to 400 subjects. Four faculties (two practical and two theoretical) were selected at random from a list containing all faculties of Alexandria University. One hundred students from both sexes (50 males and 50 females) were selected at random from different four grades of each selected faculty with equal allocation. Students were informed about the purpose of the study and their verbal consent was obtained.

### Data Collection and Study Questionnaire:

A structured questionnaire was used for interviewing each enrolled university student and to collect data about demographic characteristics (age and sex), medical history (presence of any chronic disease other than diabetes mellitus and use of medications), dietary habits (skipping meals, snacking between meals and type of these snacks, eating outside the home, and following prescribed diet for weight management), and consumption pattern of artificial sweeteners (use of artificial sweeteners, their kinds, reasons, regularity, and duration of consumption, source of prescriptions, and presence of experienced side effects).

Daily dietary intake data was collected from every member of the selected sample using 24 hour recall method. The participants were asked to recall all foods and drinks consumed in the previous day. The data was analyzed using the Egyptian Food Composition tables of the National Nutrition Institute to get the daily intake of energy and macronutrients.<sup>(14)</sup>

Weight and height were measured for each student at the time of interview according to the criteria of Gibson.<sup>(15)</sup> Body mass index (BMI) was calculated by dividing the body weight in kilograms by the square of height in meters. Overweight student was defined as

BMI of 25-29.9 kg/m<sup>2</sup>, and obese one was defined as BMI of  $\geq 30$  kg/m<sup>2</sup>, while student was considered underweight if the BMI was  $< 18.5$  kg/m<sup>2</sup>.<sup>(16)</sup>

### Statistical Analysis

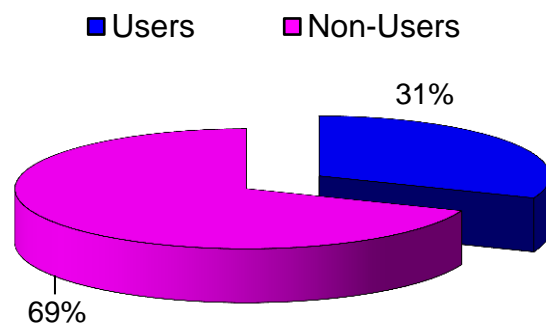
Data management was conducted using the Statistical Package for Social Science (SPSS) version "17" software (Chicago, Illinois, US). Data was presented tabular, graphically and mathematically using the mean and standard deviation (SD). For all analyses, p value  $< 0.05$  was used to detect statistically significant difference. Data were analyzed using Chi squared test for categorical data, and Student's t-test was used to evaluate the significance of the difference between means of two groups associated with Levene's test for homogeneity of variance.<sup>(17)</sup>

### Ethical considerations

This study was conducted according to the guidelines laid down for medical research involving human subjects and was approved by Ethics Committee of High Institute of Public Health, Alexandria University, Egypt. All measurements were taken following all privacy procedures and all collected data were kept confidential. All university students were informed about the study purpose, and their verbal consent was taken. The authors declare that there are no conflicts of interest.

## RESULTS

A total of 400 Alexandria University students participated in this study (198 males and 202 females). The mean age of participants was  $20.77 \pm 1.51$  years. The main reason of artificial sweeteners usage was weight reduction among the entire studied sample. Figure 1 shows that artificial sweeteners were used by 31% of the students in the studied sample.



**Figure (1): Artificial sweetener usage among Alexandria University students**

Table 1 illustrates that the rate of using artificial sweeteners was higher among females (45.5%), compared to only 15.7% of males with a statistically significant difference ( $p < 0.0001$ ). The age category from 20 years to less than 22 years had the highest

percent of users (35.3%). The table also shows that there was a significant difference in body weight status by BMI classifications between users and non-users ( $p < 0.000$ ), as 57.1% of obese students and 13.2% of overweight ones were users of artificial sweeteners. Most of artificial sweeteners users were eating the three daily main meals (82.9%). More than half of the studied sample of university students whether using artificial sweeteners (69.4%) or not (60.5%) were skipping breakfast meal as shown in table 2. Those eating outside their homes were 59.3 % among users of artificial sweeteners and 74.0% among non-users with a statistically significant difference ( $p = 0.003$ ). The majority of the studied sample of university students

whether using artificial sweeteners or not were eating snacks between meals; these snacks were diet beverages.

Table 3 shows that most of artificial sweeteners users followed a dietary regimen (87.0%) compared to 11.2% of non-users with a significant difference ( $p < 0.0001$ ). The source of prescription for the dietary regimen by users was a dietician (60.7%) while 61.3% of non-users depended on themselves as a source of prescription with a statistically significant difference between users and non-users ( $p < 0.0001$ ). The main reason for following the dietary regimen was weight management, as weight loss was the most common weight changes after following that regimen among both groups.

**Table (1): Description of the study sample of Alexandria University students according to artificial sweetener usage**

Item	Users (n=123) No. (%)	Non-Users (n=277) No. (%)	Total (n=400) No. (%)	p value†
<i>Sex</i>				
Male	31 (15.7)	167 (84.3)	198	0.0001*
Female	92 (45.5)	110 (54.5)	202	
<i>Age (years)</i>				
18-	17 (24.6)	52 (75.4)	69	0.054
20-	85 (35.3)	156 (64.7)	241	
22+	21 (23.3)	69 (76.7)	90	
Mean ± SD	20.67 ± 1.3	20.82 ± 1.6	20.77 ± 1.51	0.362
<i>BMI (kg/m<sup>2</sup>)</i>				
Mean ± SD	25.48 ± 2.5	26.75 ± 2.1	25.87 ± 2.41	0.0001*
<i>Body weight status</i>				
Normal weight	95 (36.8)	163 (63.2)	258	0.0001*
Overweight	16 (13.2)	105 (86.8)	121	
Obese	12 (57.1)	9 (42.9)	21	

† p value from Chi squared test and Student's t-test; BMI, body mass index; \* Significant ( $p < 0.05$ )

**Table (2): Dietary habits of Alexandria University students distributed by artificial sweetener usage**

Item	Users (n=123) No. (%)	Non-Users (n=277) No. (%)	p value†
<i>Number of main meals</i>			
1	5 (4.1)	2 (0.7)	0.0001*
2	16 (13.0)	72 (26.0)	
3	102 (82.9)	203 (73.3)	
<i>Skipping meals</i>			
Yes	72 (58.5)	157 (56.7)	0.744
No	51 (41.5)	120 (43.3)	
<i>Skipped meal</i>			
Breakfast	50 (69.4)	95 (60.5)	0.447
Lunch	3 (4.2)	9 (5.7)	
Dinner	19 (26.4)	53 (33.8)	
<i>Eating outside the home</i>			
Yes	73 (59.3)	205 (74.0)	0.003*
No	50 (40.7)	72 (26.0)	
<i>Eating snacks between meals</i>			
Yes	116 (94.3)	256 (92.4)	0.494
No	7 (5.7)	21 (7.6)	

† p value from Chi squared test; \*Significant ( $p < 0.05$ )

The daily nutrients intake by artificial sweeteners users and non-users is illustrated in table 4. The table shows that the mean daily intake of energy, fat and carbohydrates (CHO) was higher among non-users than those among users with a statistically significant difference between two groups. Mean daily plant protein intake was higher among users than that among non-users with statistically a significant difference ( $p=0.001$ ). The intake of other studied nutrients was higher among non-users than those among users with no statistically significant difference between the two groups.

The consumption pattern of artificial sweeteners among users in the studied sample is illustrated in table 5. The table shows that the most common number of sachets used were 4 sachets per day (57.7%) for less than one year duration (70.7%) on a regular basis (70.7%). The sources of prescription were dietician (56.9%) followed by friends (36.6%). The table also shows that 30.1% of users had no side effects and 48.8% perceived undesirable taste as the main side effect. Irregular use was reported by 29.3% of users.

The main reason for irregular usage was being outside home (58.3%) or high cost of artificial sweetener (41.7%). The results show that 66.8% of the students did not use artificial sweeteners because they were not following a diet regimen, they believed that artificial sweeteners may cause chronic disease (13.7%), due to the undesirable after taste of artificial sweeteners (8.7%), or because they were in good health and not diabetic patients (6.8%). The table also illustrated the daily level of artificial sweeteners consumption. The mean daily intake of Sucralose was  $42.08 \pm 14.6$  mg, and  $0.59 \pm 0.2$  mg/kg of body weight compared to mean daily intake Aspartame ( $1.87 \pm 0.6$  mg) and  $0.03 \pm 0.01$  mg/kg of body weight. Daily levels of artificial sweeteners consumed in relation to the ADI levels by the FDA were  $11.86 \pm 4.2$  % for Sucralose and  $0.05 \pm 0.02$  % for Aspartame. Figure 2 shows that Sweetal® (Sucralose) was the most common type of commercial artificial sweeteners used, followed by Sugar-Match® (Aspartame), then Canderal® (Aspartame).

**Table (3): Pattern of Alexandria University students' diet regimen according to artificial sweetener usage**

Item	Users (n=123) No. (%)	Non-Users (n=277) No. (%)	p value†
<b>Following a prescribed diet</b>			
Yes	107 (87.0)	31 (11.2)	0.0001*
No	16 (13.0)	246 (88.8)	
<b>Source of diet prescription</b>			
	(n=107)	(n=31)	
Dietitian	65 (60.7)	7 (22.6)	0.0001*
Self-prescription	38 (35.5)	19 (61.3)	
Friend	4 (3.7)	5 (16.1)	
<b>Reason for following a diet</b>			
Weight management	107 (100)	31 (100)	1.000
<b>Weight change</b>			
Loss	81 (75.7)	19 (61.3)	0.121
No change	26 (24.3)	12 (38.7)	

† p value from Chi squared test; \*Significant ( $p < 0.05$ )

**Table (4): Daily macronutrients intake of Alexandria University students distributed by artificial sweetener usage**

Item	Users (n=123) Mean $\pm$ SD	Non-Users (n=277) Mean $\pm$ SD	p value†
Energy intake (kcal)	1609.7 $\pm$ 633.8	1907.9 $\pm$ 742.3	0.0001*
Total protein intake (g)	71.45 $\pm$ 25.2	74.58 $\pm$ 30.6	0.320
Animal protein intake (g)	44.21 $\pm$ 26.4	40.28 $\pm$ 24.7	0.152
Plant protein intake (g)	27.24 $\pm$ 15.9	34.30 $\pm$ 21.8	0.001*
Total fat intake (g)	55.19 $\pm$ 25.0	63.74 $\pm$ 28.6	0.004*
Animal fat intake (g)	30.39 $\pm$ 21.4	31.12 $\pm$ 20.9	0.737
Plant fat intake (g)	24.81 $\pm$ 21.5	32.54 $\pm$ 25.6	0.004*
CHO intake (g)	204.27 $\pm$ 107.5	264.25 $\pm$ 133.2	0.0001*

† p value from Student's t-test; SD, standard deviation; \*Significant ( $p < 0.05$ )

**Table (5): Consumption pattern of artificial Sweeteners among Alexandria University students and reasons for not using**

Item	Users (n=123) No. (%)
<b>Number of sachets per day</b>	
2	48 (39.0)
4	71 (57.7)
6	4 (3.3)
<b>Duration of usage (years)</b>	
< 1	87 (70.7)
≥ 1	36 (29.3)
<b>Source of usage prescription</b>	
Dietician	70 (56.9)
Self-prescription	8 (6.5)
Friends	45 (36.6)
<b>Experienced side effect of use</b>	
No side effect	37 (30.1)
Undesirable after taste	60 (48.8)
GIT disturbance	6 (4.9)
Crave for sugary foods	18 (14.6)
Headache	2 (1.6)
<b>Regularity of usage</b>	
Regular	87 (70.7)
Irregular	36 (29.3)
<b>Reason for irregular usage</b> (n=36)	
Being outside the home	21 (58.3)
Cost	15 (41.7)
<b>Daily levels of consumed artificial sweeteners</b> (n=123)	
<b>Mean±SD</b>	
Sucralose intake (mg/d)	42.08±14.6
Sucralose intake (mg/kg/d)	0.59±0.2
% Sucralose of ADI	11.86±4.2
Aspartame intake (mg/d)	1.87±0.6
Aspartame intake (mg/kg/d)	0.03±0.01
% Aspartame of ADI	0.05±0.02
<b>Non-users</b> (n =344)	
<b>N (%)</b>	
Not diabetic patient	19 (6.8)
Don't follow diet regimen	185 (66.8)
Cost	11 (4.0)
May cause chronic disease	38 (13.7)
Undesirable taste	24 (8.7)

ADI, acceptable daily intake; SD, standard deviation

## DISCUSSION

The prevalence of obesity has increased dramatically in adults, and is associated with adverse health conditions, including type 2 diabetes and cardiovascular diseases.<sup>(18)</sup> Epidemiologic and experimental evidence demonstrates that intake of added sugars is strongly associated with weight gain and obesity. Low- and no-calorie sweeteners (artificial sweeteners) offer an alternative to sugars, providing sweetness without significantly contributing to caloric intake. Artificial

sweeteners are widely used in thousands of beverages and other food products such as diet soft drinks, yogurts, desserts, and gum.<sup>(19)</sup> The effects of these sugar alternatives have not been well studied, and both short and long term effects have yet to be determined. In addition to widespread use in "diet" beverages, non-nutritive are increasingly being incorporated into foods.<sup>(20)</sup>

Young adults, in consideration of important lifestyle changes, are arranged to negatively modify their way of eating in terms of the variety, the consumption of fruit and vegetables, and the frequency and timing of intake. The years spent at the university represent a critical period that is able to influence both the quality of lifestyle and eating habits of the subsequent adulthood and, also, on the long-term, the health of the individuals.<sup>(13,21,22)</sup>

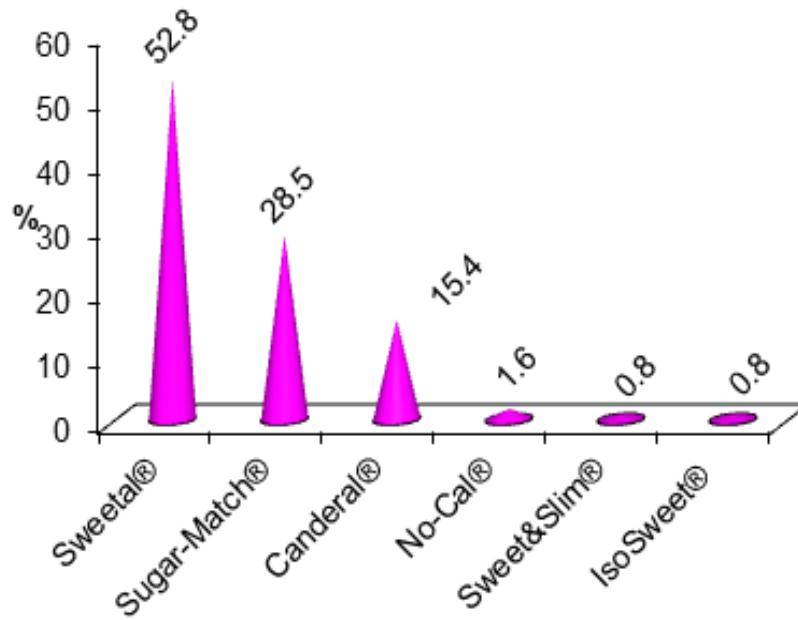
The results of the present study confirms that artificial sweeteners were used by 31% of Alexandria University students and was most common among females who were mostly following a diet regimen that necessitates the restriction of sugar intake. These results match with studies aimed to assess the trends of artificial sweeteners consumption among young adults, and revealed that the prevalence of consumption of artificial sweeteners was up to be 30% among American population in 2014.<sup>(12,19,23)</sup> The level of artificial sweeteners consumed was lower than the acceptable daily intake (ADI) set by the FDA for both Sucralose and Aspartame, which confirms that at the current level of use, artificial sweeteners does not represent a health hazard to students in this age group. This goes with other studies that reported the same results.<sup>(11,24)</sup>

One concern about artificial sweeteners is that they affect the body ability to gauge how many calories are being consumed. Some studies showed that sugar and artificial sweeteners affect the brain in different ways. The human brain responds to sweetness with signals to eat more by providing a sweet taste without any calories, however artificial sweeteners cause us to crave more sweet foods and drinks, which can add up more calories.<sup>(5,25)</sup> There may be an association between acute oral exposure to a non-energy containing palatable stimulus and augmented appetite.<sup>(26)</sup> One explanation that has yet to be explored is the possibility that intake of beverages sweetened with artificial sweeteners may be related to altered reward processing of sweet taste in the brain which may result in changes in eating behavior. Sweet taste stimulates several neurotransmitter systems (e.g. dopamine and endogenous opioids) involved in the reward response, which plays a role in the modulation of eating behavior.<sup>(25,27)</sup>

The main reason for using artificial sweeteners was to lose weight among students from both sexes. Those who did not use the artificial sweeteners reported that

they do not follow a diet regimen because they don't desire to reduce their weight (66.8%), or that it may cause chronic diseases. They did not know that the use of artificial sweeteners by itself does not have an effect

on body weight unless accompanied by following a low calorie diet. The use of artificial sweeteners was strongly associated with following a dietary regimen to lose weight.



**Figure 2: Types of commercial artificial Sweeteners consumed by Alexandria University students**

Sucralose, commercially known as Sweetal®, was the most commonly used artificial sweetener followed by Aspartame, commercially known as Sugar-Match® and Canderal®. The number of sachets used was more frequent as it shows that it varied between 2 and 4 sachets daily. This would replace a corresponding quantity of sugar which may vary between 2 and 4 spoons and hence it would contribute to the limitation of sugar and caloric intake, and consequently may help in reducing body weight.<sup>(24)</sup>

The fact that 29.3% of the university students were using artificial sweeteners for of one year or more indicates that it has become an integral component of their food habits. This may expose the students to the possible health effects that may be induced by excessive and prolonged use of artificial sweeteners which should be investigated. This is important because 36.6% of the students were using the artificial sweeteners according to the advice of their friends who do not have enough knowledge to prescribe such materials.

The minority of artificial sweeteners users did not use artificial sweeteners regularly because it was not available outside their home or because it was expensive. This suggests that the possibility of using artificial sweeteners would increase if the price was lower. The most common side effect of using artificial

sweeteners was the undesirable taste among 48.8% of users. The after taste of having a soft drink, coffee or tea sweetened by artificial sweeteners is unacceptable and may encourage the students to minimize the quantity used. So a better approach is to persuade the students to reduce the sugar intake instead of using artificial sweeteners. Once they accept the taste of low sugar drinks, they will be used to it and they will never have to resort to artificial sweeteners or increase their sugar intake.<sup>(28)</sup>

The results show that 14.6% of the students developed an urge to have a sugary food or drink after using the artificial sweetener. This may be attributed to the fact that excessive use of the sweeteners may lower the blood sugar level and thus create a desire to eat something sweet to restore back the normal blood sugar level. New researches suggest the possibility that sweet-taste receptors existing in the gut trigger complex metabolic/hormonal responses to artificial sweeteners. The impact of these receptors and their metabolic consequences on obesity and diabetes mellitus in humans is just beginning to be studied.<sup>(26,29)</sup> Although ingestion of foods containing artificial sweeteners may trigger a wide array of responses related to food absorption that may impact food consumption, adverse effects related to these gut receptors have yet to be identified.<sup>(30,31)</sup> A number of factors were examined

with the consumption of artificial sweeteners. They were identified as the consumption of three meals per day and eating meals outside the home. As expected, diet soft drinks were the most popular drink as snacks, simply because of its wide availability in the market. In addition, its price is similar to the normal sweetened drinks. The mean caloric intake for users was less than that for non-users. This was associated with a significant reduction in the mean carbohydrate intake in users. These results indicate that the use of artificial sweeteners and the consumption of low calorie/low carbohydrate diet should lead to weight loss, which was not observed in all subjects of the study. However, it should be noted that 57.1% of obese students and 13.2% of overweight ones were users of artificial sweeteners. Non-users were attempting to lose weight; high proportions of users had a normal weight and were using artificial sweeteners to maintain their normal weight.

## CONCLUSION AND RECOMMENDATIONS

The consumption of artificial sweeteners is reported by 31% of Alexandria University students. The most commonly used types of artificial sweeteners were Sucralose, commercially known as Sweetal®, followed by Aspartame, commercially known as Sugar-Match® and Canderol®. The daily level of consumed artificial sweeteners is less than the ADI set by the FDA. Further follow up researches are needed to emphasize the more strongly proven side effect of long term artificial sweeteners usage. Large epidemiological studies must be conducted to investigate artificial sweeteners consumption pattern among different age groups.

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