

Consumers' opinions, use of food labels and knowledge of food additives

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Abstract

Purpose – This study aims to determine what consumers take into consideration while buying food and to increase awareness. We also demonstrated food additives knowledge, and the association between food additive consumption and illness.

Design/methodology/approach – An online survey was used to collect data from respondents ($n = 433$).

Findings – Gender and knowledge of food additives and E numbers were found to be statistically different, as were education status and knowledge of food additives ($p < 0.05$). When purchasing foods, 40.0% of the respondents seldom read labels and also 34.9% were reading for each buy who verified the product's expiration date (94.2%), followed by brand name (84.8%). Sucralose, Acesulfame potassium (Ace-K) and aspartame consumption were associated with type II diabetes mellitus (T2DM). Additionally, sulfite consumption was linked to diarrhea/constipation.

Research limitations/implications – This study has some limitations. First, the study was cross-sectional, which does not allow the establishment of causal relationships for the associations found here. Second, the study was limited to one city in Turkey. Therefore, the study's findings cannot be extrapolated to Turkey.

Practical implications – Nutrition education should be given by the experts, and the policies should be implemented so that food labels may be used more effectively. Furthermore, nutritional education and policies can increase the general public's awareness of food additives.

Social implications – Nutrition education should be given by the experts, and the policies should be implemented so that food labels may be used more effectively. Furthermore, nutritional education and policies can increase the general public's awareness of food additives.

Originality/value – Consumers must be knowledgeable about food additives and E numbers. However, the findings revealed that the majority of Turkish consumers seldom read product labels, and the use of several food additives resulted in negative health repercussions. Therefore, professionals should provide nutrition education, and legislation should be put in place so that food labels may be used more effectively.

Keywords Food additives, Food environment, Food label, E numbers, Label use

Paper type Research paper

Introduction

Current trends reveal that considerable changes in society's diet have occurred as a result of the world population growth, development of technology, and time constraints. Therefore, the tendency of people to consume ready-to-eat foods has increased the consumption of food additives (Bosi *et al.*, 2007; Bayram and Ozturkcan, 2020).

Funding: This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.



Food additives are substances that are commonly used in the production, processing and packaging of food in order shelf life, or enhance flavor, taste or appearance (Zhang *et al.*, 2014). There are over 25,000 permitted food additives currently being used worldwide (Carocho *et al.*, 2014; Zhang *et al.*, 2014). The provisions of food additives are established by the Codex Alimentarius and national regulatory bodies such as Joint Expert Committee on Food Additives, a committee established jointly by two United Nations bodies, the Food and Agriculture Organization (FAO) and the World Health Organization (Galli *et al.*, 2008). Furthermore, the Codex Alimentarius Commission's primary goal is to provide sound, internationally agreed-upon rules for national food control systems based on consumer health protection and fair trade practices, while taking into account the requirements and concerns of all countries. As a result, among its many responsibilities is regulating the permissible levels of additives, as well as reducing trade barriers and unifying all countries under one umbrella (FAO, 2022). Codex Alimentarius and national regulatory bodies recommend permitted levels of use of food additives; a higher amount of intake of these has negative health consequences (Sachithanathan, 2017).

Food packaging attracts the attention of consumers in-store and communicates information that enables them to distinguish product alternatives through features such as food labels (van der Merwe *et al.*, 2014). Food labels have become the most important and influential factor in the decisions of consumers when purchasing food (Prinsloo *et al.*, 2012; Bayram and Ozturkcan, 2021). Labels may provide information about food additives, production parameters, storage, portion scale and preparation in addition to influencing consumer decisions before they buy the food (van der Merwe *et al.*, 2014).

Food labels play an important role for consumers to make healthier choices (Gezmen-Karadağ and Türközü, 2017; Bayram and Ozturkcan, 2021). For example, one study reported that utilizing nutrition labels was associated with a lower risk of dyslipidemia (Kim *et al.*, 2016). Another study found a link between reading nutrition labels and a lower incidence of metabolic syndrome (Kang *et al.*, 2013). Consumers need first to know some general information in order to use food labels to make healthy choices. However, the majority of consumers have thought that the food labels are confusing or complex. As a result, food labels are unable to provide consumers with useful or clear information (Besler *et al.*, 2012; Soederberg Miller and Cassady, 2015).

There are several studies on reading food labels to ensure that consumers get adequate and healthy foods; however, studies on this subject in Turkey are very limited. Additionally, consumers' concerns regarding food additives have grown in recent years. This study aimed to determine the issues and raise awareness about the concerns that consumers consider when purchasing food. We also revealed food additives knowledge, and the association between food additives' consumption and illness.

Material and methods

Study design and respondents

A descriptive and cross-sectional study was conducted in Istanbul, Turkey, between April 4, 2021, and January 11, 2021. Power analysis was performed in the sample selection; the prevalence was calculated as 20%, type 1 error rate $\alpha = 0.05$, type 2 error rate $\beta = 0.20$ and test power $1 - \beta = 0.80$. As a result of the analysis, the total respondent value was determined to be at least 219 adults. The survey was sent to 500 people, 433 of whom accepted, and 67 of whom declined, and a total of 433 adults were enrolled in the study. Inclusion criteria were subjects above the age of 18, and exclusion criteria were age under 18, more than one individual from the same household.

The online survey approach has many advantages over other approaches. Some of the advantages of conducting research online include easier access, larger sample sizes, lower costs, more timely data collection, reliable data and respondent anonymity (Wright, 2005; Vaske, 2011; Rice *et al.*, 2017). Therefore, we used an online survey method in this study. Google Docs was used to administer the survey. The survey included: demographic characteristics, label reading status, knowledge, opinions, use of food label parameters, knowledge of food additives and a validated food frequency questionnaire (FFQ). Table 1 shows the types of questions and their justifications. Additionally, anthropometric measurements (height and body weight) were taken by respondents' statements. According to this information, body mass index (BMI) (body weight [kg]/height [m²]) were calculated.

Ethical statement. Written approval to use the document was secured, and ethical approval was obtained from the Noninvasive Clinical Research Ethics Committee (Approval number: E-77366270–302.08.01–2570) at Istanbul Gelisim University. Informed consent was obtained from all respondents.

Dietary intake

A validated FFQ was used for evaluating the dietary intake of food additives. The FFQ included 46 food items and was divided into nine specified food groups, including meats and meat products, snack foods, dried fruits, breakfast products, low-calorie products, sauces, spices, nonalcoholic beverages and miscellaneous. Respondents reported how many times per day, week or month they consumed specific food items and the approximate serving sizes of each food item during the last month. The frequency of food consumption was recorded in six categories: never, once a month, once every 15 days, 1–2 times a week, 3–4 times a week, 5–6 times a week and every day.

Each food or beverage item's portion size was defined in terms of units or common portions (e.g. 1 slice, 1 packet or 1 average portion) or household measurements (e.g. glass, cup or teaspoon). For the specific food groups, the size of the portion (e.g., 1 slice, 1 packet, 1 average portion) was determined by using a validated picture booklet called "Food and

Table 1.
Knowledge status of
food additives and
label reading

Question	Justification
(1) Do you know what food additives are?	This was to determine how consumers assessed their own level of understanding of food additives. Because knowledge of food additives is important to enable consumers' worries to understand risk-benefit-appraisals, and to focus on the consumer and food production (Bearth <i>et al.</i> , 2014; Bearth and Siegrist, 2016; Kayışoğlu and Coşkun, 2016; İsmail <i>et al.</i> , 2017).
(2) Do you know what E numbers are?	This was to determine how consumers assessed their own level of understanding of E numbers. E numbers are the code numbers determined by the European Union for each food additive. However, consumers may not know that E numbers and food additives are the same expressions (Kayışoğlu and Coşkun, 2016; İsmail <i>et al.</i> , 2017).
(3) Do you read labels when buying food?	This was to determine how important food label reading is to consumers (Shamim <i>et al.</i> , 2022).
(4) When reading food labels, which information do you review most often?	This was to determine how important the additive list was in comparison to the other information on food labels (İsmail <i>et al.</i> , 2017).

Nutrition Photograph Catalog” (Rakıcıoğlu *et al.*, 2017). The intake of food was calculated as the frequency and the portion size of the product.

Additionally, we used the maximum permissible levels (MPL) of food additives in foods to determine the estimated mean daily intake. The MPL of food additives was obtained according to the Turkish Food Codex (Ministry of Health of Turkey, 2013).

Statistical analysis. All statistical analyses were conducted using SPSS Statistics 24.0 (Statistical Package for the Social Sciences, Inc.; Chicago, IL, United States). Categorical data (education status, BMI classification, questions about the knowledge of food additives) were expressed as the frequency, and differences were analyzed using the Fisher’s exact test (when including any expected value $p \leq 0.05$) or the chi-square test. The mean estimated daily intake of food additives was calculated as the mean $\pm$ standard deviation (SD). The Mann–Whitney U test was then used to analyze the relationship between food additive intake and disease. For the statistical test, a p -value ≤ 0.05 was considered as statistically significant.

Results

A total of 433 respondents (72.3% female, 27.7% male, mean age 25.83 ± 9.48 years) completed the study. A statistically significant difference was found between gender, education and marital status, occupation and BMI classification ($p < 0.001$). According to the BMI classification, 14.1% of the participants were underweight, 61.2% were normal, 18.0% were overweight and 6.7% were obese (Table 2).

Almost half of the respondents (46.4%) indicated they knew about the food additives, whereas only 25.6% knew about E numbers. 40.0% of the respondents seldom read labels when purchasing foods and also 34.9% were reading for each buy. There was a statistical

	Male ($n = 118$)		Female ($n = 315$)		Total ($n = 433$)		p-value
Age	30.68 ± 10.93		23.98 ± 8.16		25.83 ± 9.48		$<0.001^*$
Marital status							$<0.001^*$
Married	77	65.3	84	26.7	161	37.2	
Single	41	34.7	231	73.3	272	62.8	
Education status							$<0.001^*$
Primary school	1	0.8	3	1.0	4	0.9	
High school	35	29.7	174	55.2	209	48.3	
>University	82	69.5	138	43.8	220	50.8	
Occupation							$<0.001^*$
Academician	20	16.9	28	8.8	48	11.1	
Officer	58	49.2	59	18.7	117	27.0	
Housewife	–	–	9	2.9	9	2.1	
Retired	1	0.8	6	1.9	7	1.6	
Student	39	33.1	213	67.7	252	58.2	
Body weight (kg)	82.85 ± 16.47		58.35 ± 10.73		65.09 ± 16.66		
Height (cm)	176.31 ± 11.65		163.97 ± 5.60		167.37 ± 9.50		
BMI (kg/m^2)	27.36 ± 10.19		21.68 ± 3.70		23.24 ± 6.69		
BMI classification							$<0.001^*$
<18.5 (underweight)	2	1.7	59	18.7	61	14.1	
18.5–24.9 (normal)	56	47.5	209	78.9	265	61.2	
25.0–29.9 (overweight)	41	34.7	37	11.7	78	18.0	
≥ 30.0 (obese)	19	16.1	10	3.2	29	6.7	

Note: * $p < 0.001$, the differences between gender

Table 2.
Demographic
characteristics of
participants ($n = 433$)

difference between gender and education status and knowledge of food additives ($p < 0.001$, $p = 0.004$, respectively). Similarly, there was a statistical difference between gender and knowledge of E numbers ($p = 0.033$) and the frequency at which food labels were read ($p = 0.015$) (Table 3).

Table 4 shows the relationship between parameters related to the packaged products when buying, and gender, education status and BMI. The majority of the respondents (94.2%) verified the product's expiration date, followed by brand name (84.8%) and price (77.8%). There was a difference between gender and expiration date ($p = 0.001$), ingredient list ($p < 0.001$), nutritional value ($p = 0.012$), food additives contents ($p = 0.017$) and storage conditions ($p = 0.008$); BMI and expiration date ($p < 0.001$), ingredient list ($p = 0.018$), nutritional value ($p = 0.02$), production date ($p = 0.05$) and food additives contents ($p = 0.044$); and educational status and nutritional value ($p = 0.046$) and production place ($p < 0.001$).

According to the results in Table 5, respondents perceived the association between the consumption of sucralose, acesulfame potassium (Ace-K), aspartame and type II diabetes mellitus (T2DM). These associations were significantly different ($p = 0.004$, $p = 0.028$ and $p = 0.004$, respectively). Additionally, sulfite consumption was linked to diarrhea/constipation ($p = 0.029$).

Discussion

The increasing availability of packaged products contributes to poor diet quality, which has been one of the top risk factors for illness and death worldwide for more than two decades. Food labels play a vital role in influencing consumers to make healthier choices (Bayram and Ozturkcan, 2021). The present study showed that 40.0% of the respondents seldom read

	Male (n = 118)		Female (n = 315)		Total (n = 433)		P ^a value	P ^b value	P ^c value
	n	%	n	%	n	%			
Knowing the food additives							<0.001**	0.582	0.004*
Undecided	23	19.5	61	19.4	84	19.4			
Agree	42	35.6	159	50.5	201	46.4			
Disagree	20	16.9	17	5.4	37	8.5			
Completely agree	25	21.2	77	24.4	102	23.6			
Completely disagree	8	6.8	1	0.3	9	2.1			
Knowing the E numbers							0.033*	0.522	0.173
Undecided	21	17.8	70	22.2	91	21.0			
Agree	33	28.0	78	24.8	111	25.6			
Disagree	25	21.2	73	23.2	98	22.6			
Completely agree	15	12.7	62	19.7	77	17.8			
Completely disagree	24	20.3	32	10.2	56	12.8			
Frequency of reading food labels							0.015*	0.057	0.051
Reading for each buy	34	28.8	117	37.1	151	34.9			
Seldom reading	46	39.0	127	40.3	173	40.0			
Factors affecting the decision while buying the food	15	12.7	46	14.6	61	14.1			
Never	23	19.5	25	7.9	48	11.1			

Table 3.
The parameters
about the awareness
of food additives

Notes: * $p < 0.05$, ** $p < 0.001$, P^a: the differences between gender, p^b: the differences between BMI, p^c: the differences between education status

Food additives

Parameters related to the food labels	Total (<i>n</i> = 433)				<i>P</i> ^a value	<i>P</i> ^b value	<i>P</i> ^c value
	<i>n</i>	No %	Yes <i>n</i>	%			
Brand name	66	15.2	367	84.8	0.215	0.491	0.342
Price	96	22.2	337	77.8	0.796	0.350	0.948
Expiration date	25	5.8	408	94.2	0.001**	<0.001**	0.219
Ingredient list	151	34.9	282	65.1	<0.001**	0.018*	0.810
Nutritional value	255	58.9	178	41.1	0.012*	0.002*	0.046*
Production date	219	50.6	214	49.4	0.914	0.005*	0.139
Production place	362	83.6	71	16.4	0.884	0.203	<0.001**
Production permission	373	86.1	60	13.9	0.118	0.058	0.720
Food additives contents	230	53.1	203	46.9	0.017*	0.044*	0.926
Storage conditions	311	71.8	122	28.2	0.008*	0.088	0.451
Packaging	244	56.4	189	43.6	0.384	0.274	0.431

Notes: **p* < 0.05, ***p* < 0.001, *P*^a: the differences between gender, *P*^b: the differences between BMI, *P*^c: the differences between education status

Table 4.
The parameters related to the packaged products

	Estimated intake (mg/kg <i>bw</i> /day)	Obesity	CVD	DM	HT	Diarrhea/ constipation	Anemia	Allergy/ asthma
Nitrite	0.013 ± 0.035	0.165	0.202	0.460	0.349	0.126	0.379	0.677
Nitrate	0.009 ± 0.029	0.893	0.154	0.229	0.185	0.331	0.192	0.603
Sulfite	0.043 ± 0.421	0.534	0.110	0.618	0.054	0.029*	0.961	0.802
Benzoate	0.022 ± 0.170	0.077	0.646	0.935	0.626	0.287	0.671	0.709
MSG	0.002 ± 0.006	0.403	0.357	0.234	0.325	0.107	0.061	0.347
Sucralose	0.103 ± 0.612	0.790	0.608	0.004*	0.321	0.076	0.388	0.165
Ace-K	0.095 ± 0.489	0.592	0.491	0.028*	0.410	0.176	0.635	0.286
Aspartame	0.185 ± 0.960	0.743	0.749	0.004*	0.295	0.110	0.436	0.154
Saccharine	0.177 ± 0.805	0.125	0.552	0.052	0.239	0.092	0.585	0.853

Notes: **p* < 0.05, CVD: cardiovascular disease, DM: diabetes mellitus, HT: hypertension, Ace-K: acesulfame-K

Table 5.
The relationship between the intake of food additives and disease

labels when buying foods and also 34.9% were read for each buy who verified the product's expiration date (94.2%), followed by brand name (84.8%) and price (77.8%). There was a difference between gender and expiration date, ingredient list, nutritional value, food additives contents and storage conditions; as well as BMI and expiration date, ingredient list, nutritional value, production date, and food additives contents; educational status, nutritional value, and production place. Intake of sucralose, Ace-K and aspartame was associated with T2DM. Additionally, sulfite consumption was related to diarrhea/constipation.

The demographics of the respondents can affect their responses to the survey questions. For example, the age distribution of respondents was not even, and there was a statistical difference between males and females. This difference in age distribution may have influenced replies to the questions (Çavuş *et al.*, 2022). This is especially true among young adults, according to the Organization for Economic Cooperation and Development (OECD),

with more than a quarter having earned a bachelor's or higher degree (OECD, 2014). Our findings revealed that the mean age of the respondents was 25.83 ± 9.48 years, and more than half (50.8%) of the respondents had a bachelor's degree or higher.

It is impossible to maintain the current quality of foods without food additives. Therefore, food additives have an essential role in the food supply (Ismail *et al.*, 2017). However, concerns about the use of food additives have increased among consumers. Additionally, most respondents found "E" numbers confusing and stated that they required more information regarding the potential health effects of food additives (Tarnavölgyi, 2003; İsmail *et al.*, 2017). In the UK, the vast majority of the respondents (78%) had little knowledge of food additives in processed foods (Ismail *et al.*, 2017), whereas in Turkey, the figure was 52.9%, and as education level increased, so did the level of knowledge (Kaya Cebiöğlu and Önal, 2016). Another study in Turkey found a link between having sufficient knowledge about food additives and the education level of respondents. Similarly, 26.3% of the respondents stated that they knew enough information about E numbers of food additives (Kayışoğlu and Coşkun, 2016). In the present study, we found that 46.4% of the respondents stated basic knowledge of food additives, although, only a quarter (25.6%) understood the E numbers. There was a statistical difference between gender and education status and knowledge of food additives. Similarly, there was a statistical difference between gender and knowledge of the E numbers. According to the literature, certain consumer groups, such as women, those who are overweight, those with a higher income and education level, those who are younger and those who have a chronic disease, are more likely to use food labels (Post *et al.*, 2010; Campos Doxey and Hammond, 2011; Anastasiou *et al.*, 2019). Similarly, we found that awareness of food additives increases with the female gender and education level.

Excessive consumption of food additives is associated with adverse health outcomes. Higher monosodium glutamate intake has been found to alter taste perception in humans and can lead to obesity by changing food intake, and increasing appetite (Pepino *et al.*, 2010; He *et al.*, 2011; Insawang *et al.*, 2012; Masic and Yeomans, 2014). Excessive nitrite and nitrate consumption have been linked to some types of cancer, especially liver, esophagus, kidney, stomach, intestine, central nervous system and lymphoid system (Xie *et al.*, 2016; Barry *et al.*, 2020). Higher consumption of benzoates and their derivatives has been found to cause urticaria, asthma, rhinitis or anaphylactic shock (Bilau *et al.*, 2008). Additionally, excessive sulfite consumption may irritate the mucosal system of the respiratory tract and cause stomach and digestive system issues that lead to vomiting and diarrhea (Mu *et al.*, 2022), and it may cause asthma in susceptible populations (Zhang *et al.*, 2014). According to a UK study, 44% of the respondents perceived that food additives were linked to allergy development, 24% perceived that they were linked to hyperactivity and 10% perceived that they were linked to asthma (Ismail and Yusuf, 2014). Our results revealed that sulfite intake was linked to diarrhea/constipation. Given the growing interest in food additives in the food supply, public awareness of food additives should be increased and food additive intake and use should be monitored.

Sweeteners were introduced in the 19th century (Daher *et al.*, 2019). Their definition and classification are inconsistent across groups. For example, the European Food Safety Authority (EFSA) defines sweeteners as "Food additive substances used to impart a sweet taste to foods or in table-top sweeteners" and divides them into high-intensity sweeteners (HIS) and polyols while placing sugars in a separate category (EFSA, 2008), whereas the Food and Drugs Administration (FDA) defines sweeteners as "food additives that add sweetness with or without the extra calories," includes sugars in the definition of sweeteners and considers sugar alternatives (SA) as HIS (FDA, 2014). They are divided into nutritive

and nonnutritive sweeteners (NNS). Aspartame is classified as a nutritive sweetener, while saccharin, Ace-K and sucralose are classified as NNS (FDA, 2014). Furthermore, people's interest in sweeteners, especially NNS, has increased, which may promote the consumption of products containing sweeteners as consumers believe they are harmless compared with sugars. However, the effects of NNS on health remain controversial (Bayram and Ozturkcan, 2022). According to the literature, the excessive consumption of sweeteners (nutritive and nonnutritive) could lead to weight gain (Pearlman *et al.*, 2017; Cabral *et al.*, 2018), glucose intolerance (Cabral *et al.*, 2018), diabetes (Malik *et al.*, 2010; Imamura *et al.*, 2015; Sanyaolu *et al.*, 2018; Daher *et al.*, 2019; Hirahatake *et al.*, 2019), cardiovascular diseases (Mulligan, 2019) and metabolic syndrome (Pearlman *et al.*, 2017). Our results showed that the estimated intake of sucralose, Ace-K and aspartame was associated with T2DM. However, many factors influence the ambiguous relationship between NNS and the risk of T2DM, including adiposity, reverse causality and gut microbiota, among others. The true direction of the association is unclear. NNS consumption is directly associated with T2DM independent of obesity, or the association is due to reverse causality, in which individuals with T2DM tend to consume NNS for caloric and glycemic management, or whether adiposity plays a role in the association between NNS and T2DM (Daher *et al.*, 2019). Furthermore, respondents were not previously healthy, and T2DM risk factors were not taken into account, which could have influenced the results.

Gender, education level, age, marital status, socioeconomic status and other factors influence food labeling behaviors and manners (Besler *et al.*, 2012; Gül Aygen, 2012). We found that there was a statistical difference between the frequency of reading food labels and gender, but not education level and BMI. Similar to the study's findings, most studies have revealed that the habit of reading labels is associated with gender and is much more prevalent in women (Govindasamy and Italia, 2000; Stran and Knol, 2013; Güneş *et al.*, 2014). In this study, most of the respondents (50.8%) had a higher education level. Additionally, a comprehensive review indicated a positive relationship between increased label reading habits and weight control (Campos *et al.*, 2011), however, and no significant correlation with BMI was found in this study. The lack of a relationship between BMI and the frequency of reading food labels could be attributed to the fact that the majority of the respondents (61.2%) were within the normal BMI range.

Additionally, studies showed that consumers pay attention to the information on food labels while buying foods (Bosi *et al.*, 2007; Güneş *et al.*, 2014). It was found that most of the respondents sometimes read labels in Turkey (Gezmen-Karadağ and Türközü, 2017). However, a sizable proportion of consumers never or seldom read the label information. For example, in several studies conducted in Turkey, the habit of never and seldom reading labels ranged from 9.0% to 17.5% (Özgül and Aksulu, 2006; Gül Aygen, 2012). We found that 40.0% of the respondents seldom read labels when purchasing foods and also 34.9% were reading for each buy. When compared with previous studies, these findings revealed a decrease in the frequency of reading food labels. Furthermore, the majority of the respondents (94.2%) verified the product's expiration date, followed by brand name (84.8%) and price (77.8%). Given the increasing consumption of packaged foods, nutrition education can help to raise public awareness about the importance of reading labels to avoid negative health consequences.

The present study has some limitations. First, the study was cross-sectional, which does not allow the establishment of causal relationships for the associations found here. Second, the study was limited to one city in Turkey. Therefore, the study's findings cannot be extrapolated to Turkey.

Conclusion

This online questionnaire survey examined consumers' purchase habits and knowledge of food additives. Of the respondents, 40% said they seldom read food labels, which was a significant amount. Additionally, the majority of respondents used the label information to learn the expiration date, brand name and price. Female respondents were shown to be more likely to read food labels. Moreover, nearly half of the respondents reported being knowledgeable about food additives, although only a small percentage knew the E numbers. Solutions may be found through studies such as this one. Nutrition education should be given by the experts, and the policies should be implemented so that food labels may be used more effectively. Furthermore, nutritional education and policies can increase the general public's awareness of food additives. Our findings revealed a correlation between sucralose, Ace-K and aspartame consumption and T2DM. However, the exact mechanism of action is unknown. Future research may provide more insight on this issue.

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