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## **Assessment of knowledge and intake of artificial sweeteners among type II diabetic individuals and perspectives of registered dieticians in India**

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## ORIGINAL STUDY

# Assessment of Knowledge and Intake of Artificial Sweeteners Among Type II Diabetic Individuals and Perspectives of Registered Dietitians in India

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### Abstract

**Background:** The beneficial effects of artificial sweeteners (AS) on the prevention of non-communicable diseases have been noticed with various ambiguity outcomes. The knowledge of AS among consumers and healthcare providers can facilitate in making informed decisions about its usage. Therefore, this study, aimed to assess the knowledge, attitude and practice and usage of AS among type II diabetic patients and the conception of registered dietitians on usage of AS, as a sugar substitute.

**Study design:** The study was a cross-sectional, descriptive study.

**Methods:** The data on AS consumption, discomforts, and health consequences of chronic consumption from type-II diabetics (n = 51) and the opinion of dietitians (n = 53) on AS recommendations were gathered using a pretested questionnaire online through email via [docs.google.com](https://docs.google.com). The association or correlation between AS consumption, discomforts, and awareness was analysed by chi-square and Spearman correlation tests.

**Results:** The results indicated that study subjects consumed AS in the form of tabletop sweeteners (86.3%), sweets (35.3%), and beverages (31.4%). Saccharin (29.5%), sucralose (27.3%), and aspartame (27.3%) were the major tabletop sweeteners consumed. 77% of subjects consumed AS from 1 to 3 years, while others from 4 to 5 years. 59% of participants consumed AS without consultation, and only 5.9% expressed discomfort after consumption. However, a significant association was noticed between discomfort and beverage consumption. 58.8% were unaware of the health consequences, and KAP analysis showed that knowledge was negatively associated with practice and attitude was positively associated with it. The survey among dietitians revealed that 73.6% were not recommending AS, mainly due to less reliable information, particularly regarding safety issues, and ambiguity on the use of AS in dietetic practice. While others consumed AS over natural sugars in glycemic control, weight management, and lifestyle factors.

**Conclusion:** Majority of diabetic patients did not know the side effects of chronic AS consumption, while dietitians had divergent views on AS due to insufficient research regarding the safety and side effects of chronic AS consumption. Therefore, more precise studies are required to understand the consequences of chronic consumption of AS on health benefits.

**Keywords:** Artificial sweeteners, Dietitians, Recommendation, Type II diabetes, Health disorders

## 1. Introduction

Artificial sweeteners (AS) are carbohydrate or protein derivatives having the property of higher sweetness than sugar and containing few to no calories [1–3]. This property of AS makes it a

sugar replacer, as excessive consumption of sugar-rich foods is one of the major factors contributing to the global increase in the prevalence of metabolic disorders, including weight gain, obesity, and diabetes [4–6]. Considering the impact of sugar on health status, the WHO limits sugar intake to less

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than 5–10% of total energy intake per day [7]. Therefore, both international (FDA/FAO) and national food agencies (FSSAI) approved AS products for use as table top sweeteners and food additives in beverage industries, baked products, and diabetic foods as per guidance to maintain palatability of food [1,8,9].

The AS has been shown to be beneficial in the regulation of appetite [10], energy intake [10], glycaemic control [11], prevention of elevation of blood glucose (fasting and postprandial) in diabetic status [10,11], weight management [12], and lower risk of type II diabetes and coronary artery disease in subjects who consumed AS, as compared to sugar intakes in short-term intervention studies [10]. Based on the beneficial outcomes of AS, many individuals in the categories of obesity and diabetes have considerably increased their consumption of AS nowadays [9,10,15]. Further, the American Heart Association has suggested a caution nod on the use of AS, as a sugar replacer in the regulation of metabolic syndrome [13], calorie reduction, and weight management [14].

Despite the abundance of evidence demonstrating the benefits of AS, some studies have discovered a link between AS consumption and changes in gut microbiota, metabolic homeostasis, adverse effects on cardiovascular functions, and an increase in the risk of cancer development [16–21]. Hence, chronic consumption of AS has been highly alarming with respect to the health status of consumers.

In a study the status of insulin resistance were found significantly high among AS consumers than non-consumers of type II diabetic subjects from tertiary care hospital in central India, where duration of use of artificial sweeteners had a direct impact on insulin resistance [22]. Further, the estimated maximum daily intake (EDI) of saccharin through pan was found to be 137% of the ADI, and those who consumed maximum pan masala or pan were more susceptible to toxic effects of saccharin, including bladder distension, elevated urine osmolality and bladder cancer [23]. A KAP study on consumption of AS among type II diabetes patients found that well educated subjects consumed AS over natural sugars in their diet to control blood sugar level, however they had less knowledge on the content and proper consumption of sweeteners, different types of sugar substitutes, health benefits and hazards of sweeteners. Therefore, the study concluded that there is a dire need to promote knowledge about AS among diabetic patients in order to prevent any long-term complications related to the consumption of these sweeteners [24]. In another study, half of the diabetic patients had

moderate knowledge and attitude concerning the consumption of AS and it was suggested that appropriate educational programs need to be designed and implemented to overcome this information gap [25]. Another study stated that compliance or adherence problems were common in diabetes management and that factors like demographic, psychological, social, health care provider and medical system, and disease-related and treatment-related factors played a major role in it [26].

Therefore, knowledge of AS among consumers and healthcare providers can help in obtaining informed decisions about the consumption of AS. Dietitians play a major role in recommending corrective measures that may guide the planning, organization, and delivery of care for chronic metabolic diseases [27,28]. Therefore, the current pilot study was aimed to assess type II diabetes patients' knowledge, attitude, and practice of consumption of AS and the opinion of dietitians on AS for diet management.

## 2. Materials and methods

The pilot survey was conducted during February–March 2020 through an online portal via email using the platform [docs.google.com](https://docs.google.com). It was a cross-sectional, descriptive pilot study, representative of the targeted population of the general public that included only patients with type II diabetes who consumed AS. The study was approved by the Institutional Ethics Committee, as per the guidelines of Indian Council of Medical research- National Institute of Nutrition (IEC–NIN–12/IV/2020), India.

The sampling method for the study was non probability convenience sampling where the study participants with known type II diabetes were requested to participate in the online survey programme which involved the filling up of questionnaire via email. After their willingness, a consent form was obtained and data was collected through questionnaire sharing.

The inclusion criteria required that the subject be a type II diabetic patient who consumed AS and were over the age of 18. Pregnant, lactating women and children below the age of 18 years were excluded from the study.

The questionnaire was a semi-structured, researcher-made, which was validated and participant comprehension of the questionnaire was tested prior to the online survey with the help of doctors and dietitians from the Institute (ICMR-NIN). Minor amendments in the text were made following the test. The questionnaire included closed and a

few open-ended questions. The demographic details in the questionnaire for AS consumption by type II diabetes individuals included age, educational qualification, gender, occupation, duration of diabetes in the first part while the second part of the questionnaire consisted questions related to knowledge of AS, attitude towards AS and practice on consumption of AS which were accessed through seventeen questions (six each related to knowledge and practice, and five for attitude) and were given scores.

The data for examining the opinion among dietitians on AS was also collected through online survey. The details of registered dietitians were collected from the IDA website (Indian Dietetic Association). E-mail was sent to dietitians who were regular practitioners to express their willingness to participate in the study, followed by questionnaire through online survey link to collect data on registered dietitians' attitudes and beliefs on the use of artificial sweetener. Most of the questions in the semi-structured questionnaire were closed-ended, that measured the response of dietitians to the use and health effects of artificial sweeteners, that was graded with the Likert scale [29].

The demographic details of the study participants were given as mean  $\pm$  SD, and the data was statistically analysed using IBM-SPSS 21 software and by using descriptive statistics and were presented as a valid percentage for the qualitative data and mean  $\pm$  SD for the quantitative data. Chi-square test and Spearman correlation tests were employed to determine the association or correlation between variables at a significance level of  $p \leq 0.05$ .

### 3. Results

Fifty-one type II diabetic individuals from different cities in India participated in the study. The demographic details of the participants were tabulated in Table 1. The age group of these individuals ranged from 22 to 63 years, with an average of  $50.37 \pm 10.14$  years. Among the participants, 45% were in the age group  $> 55$  years, 28% were between 45 and 55 years, and only 4% were between 18 and 24 years. The duration of onset of diabetes for these individuals ranged from 4 months to 25 years, and the average was found to be  $10.2 \pm 8.32$  years. The data indicated that 57% of the participants were male, while 43% were female. About 82% of the participants were above graduate level, and 49% were working. The study indicated that most of the participants, were well educated, and had knowledge about the consumption of AS, such as table top sweeteners and sugar-free sweets.

Table 1. Demographic details of Diabetic participants

Variables	N (51)	Percentage
<b>Gender</b>		
Male	29	56.9
Female	22	43.1
<b>Age (years)</b>		
18–24	2	3.9
25–34	3	5.9
35–44	9	17.6
45–55	18	27.5
$>55$	19	45.1
<b>Educational qualification</b>		
Matriculation	6	11.8
Intermediate/Pre-degree	2	3.9
Graduates	34	66.7
Postgraduates	8	15.7
None	1	2.0
<b>Occupation</b>		
Homemaker	13	25.5
Student	3	5.9
Part-time employee	5	9.8
Full-time employee	20	39.2
Retired	10	19.6
<b>Years since diagnosed of diabetes</b>		
$<1$	3	5.9
1–5	23	45.1
6–10	9	17.6
10–20	13	25.5
$>20$	3	5.9
Mean $\pm$ SD	$10.2 \pm 8.32$	

**Knowledge, attitude, practice and use of AS:** Regarding AS, about 29.4, 31.4, 19.6, and 6% of the participants came to know of it through the internet/media, from doctors, dietitians, and through the newspaper (Table 2). Among participants, 57% of subjects knew of the availability of AS-containing products in the form of sweets, beverages, and tabletop sweeteners, while only 18% knew either in the form of beverages or tabletop sweeteners, and 7% only in the form of sweets. Among these participants, 35% consumed sweets (Fig. 1A) made with AS purchased from sweet shops or home preparation, and these were eaten at a frequency of once per week (39%) or rarely ( $> one month$ ) (44%) (Table 2). About, 31% participants consumed sugar-free beverages (Fig. 1A), which was either zero coke, diet coke, or fruit juices, but consumed them rarely ( $> one month$ , 63%). The survey revealed that 86% of subjects consumed table top sweeteners, among which saccharin, sucralose, and aspartame products were consumed equally (25–30% each). About 48% consumed it on a daily basis, at least twice a day (57%) (Fig. 1B). About 77% of the individuals consumed table top sweeteners for 1–3 years. The majority of people who consumed AS mixed them with liquids such as tea, coffee, or sweet buttermilk. About 59% consumed these AS on their own without consulting a doctor or dietitian (Table 2).

Table 2. Knowledge, consumption pattern and health effects of AS in diabetic participants

Questionnaires	N	Percentage
Awareness of AS?		
Yes	51	100
No	0	0
How do you know about AS?		
Doctor	16	31.4
Dieticians	10	19.6
Internet/media	15	29.4
Newspaper	3	5.9
Others	7	13.8
Food products you aware of using AS?		
Sweets	4	7.8
Beverages	9	17.6
Table top sweeteners	9	17.6
All the above	29	56.9
Are you consuming sweets with artificial sweeteners?		
Yes	18	35.3
No	33	64.7
Frequency of consumption of sweets with AS,		
Daily	1	5.6
2- 4 times per week	2	11.1
once in a week	7	38.9
Very rarely (>one month)	8	44.4
Consumption of sugar free beverages (zero coke/diet coke/fruit juices)		
Yes	16	31.4
No	35	68.6
Frequency of consumption of beverages with AS,		
Daily	2	12.5
2- 4 times per week	2	12.5
once in a week	2	12.5
Very rarely (>one month)	10	62.5
Do you consume table top sweeteners?		
Yes	44	86.3
No	7	13.7
Frequency of consumption of table top sweeteners?		
Daily	21	47.7
2- 4 times per week	11	25.0
once in a week	5	11.4
Very rarely (>one month)	7	15.9
Types of AS used as table top sweeteners?		
Aspartame	12	27.3
Acesulfame K	2	4.5
Sucralose	12	27.3
Saccharin	13	29.5
Stevia	5	11.4
Types of food in which you add table top sweeteners?		
Liquid food	29	65.9
Semisolid food	4	9.1
Both	11	25.0
Whose suggestion did you take for the use of table top sweeteners		
Doctor	15	34.1
Dietician	3	6.8
On my own	26	59.1
Since how long are you consuming table top sweeteners?		
1–3 yr	34	77.3
4–6 yr	10	22.7
Are you using the same brands of AS from the initiation of usage		
Yes	34	77.3
No	10	22.7

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Table 2. (continued)

Questionnaires	N	Percentage
Any type of discomfort after consumption?		
Yes	3	5.9
No	37	72.5
Doesn't know	11	21.6
Whether sweeteners are helpful in controlling weight and diabetes?		
Yes	12	23.5
No	9	17.6
Doesn't know	30	58.8
Whether long-term consumption of AS has any side effects?		
Yes	9	17.6
No	12	23.5
Doesn't know	30	58.8

Almost 77% consumed the same sweeteners from the beginning. In contrast, the others changed the brand of AS due to cost issues and based on market availability. Approximately 59% were unsure whether these sweeteners helped with diabetes regulation, and 73% reported no cause of discomfort, while a few reported psychological changes such as mental confusion or depression, as well as acidity. The association between AS consumption and discomforts among diabetic subjects were analysed using chi-square test and interestingly study found a strong significant association between discomforts and consumption of beverages of subjects (Table 4).

Many (66%) did not know the long-term health effects of AS consumption, while few had the opinion that artificial sweeteners were carcinogenic, caused psychological disorders and damaged organs (Fig. 1C). The knowledge about AS among participants was accessed through six questions in the questionnaire with a maximum score of 19. The average knowledge score among subjects was found to be  $8.51 \pm 3.35$ , which was  $8.91 \pm 3.50$  in the case of males and  $8.21 \pm 3.28$  for females. In the case of attitude and practice, the average score was found to be  $5.63 \pm 2.32$  and  $8.55 \pm 2.88$  for maximum score of 12 and 23 respectively. The attitude was found to be similar between male and female consumers, while in practice the average was  $8.86 \pm 2.57$  and  $8.31 \pm 3.12$  for male and female respectively. The correlation between knowledge, attitude and practice on AS consumption among type II diabetic subjects were analysed using Spearman's correlation test, and found that knowledge was positively associated with attitude and negatively associated with practice, however the association was not significant. While, positive significant association was noticed between attitude and practice among AS consumers (Table 5).

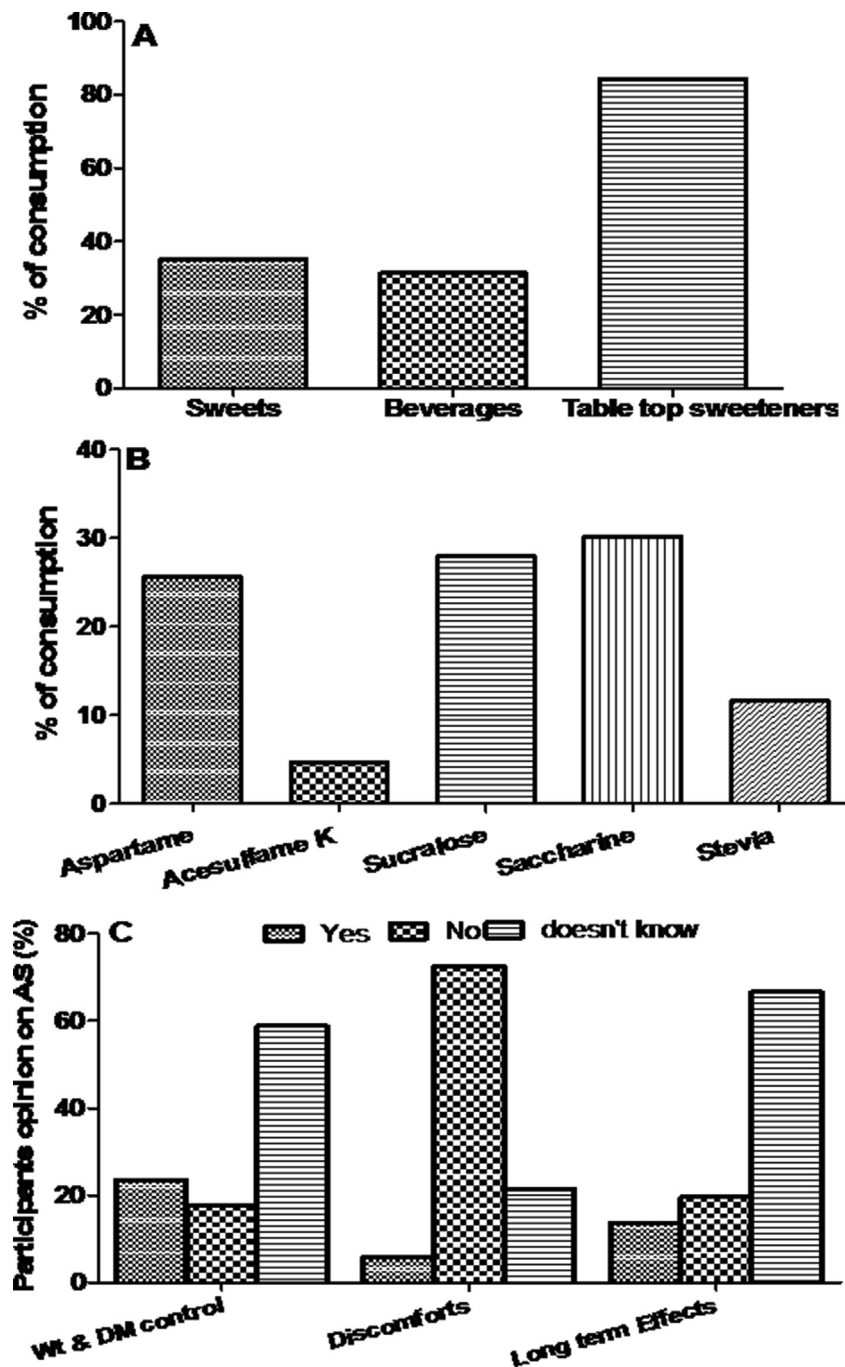


Fig. 1. The consumption and knowledge of AS among type 2 diabetic subjects. Consumption of AS in different food forms (A), types of AS consumption as a table top sweeteners in % (B), and opinion of subjects on AS in weight and diabetes management discomforts after AS consumption and opinion on long-term health effects on regular consumption of foods containing AS (C).

Overall, the type II diabetes participants of this study were well aware of the usage of AS and most of them did not suffer from any discomfort, however most of the subjects were unaware of side effects associated with chronic consumption of AS.

**Views of Dieticians:** Fifty-three dieticians who took part in the online survey, among whom most

(79%) were postgraduates. About 70% worked in clinics and 21% were practicing privately and had experience of working with diabetes and obese patients (Table 3). The study indicated that 74% of dieticians did not recommend AS for their patients, while 26% recommended AS for weight management and glycemic control (Fig. 2A). Interestingly,

Table 3. Occupation details, recommendation and opinion of registered dietitians on AS

Questionnaires	N	Percentage
Highest Degree held?		
Bachelor	7	13.2
Masters	42	79.2
Doctorate	4	7.5
Occupational setup		
Clinical In patient/out patient	37	69.8
Community/school district	1	1.9
Food service	0	0
Private practice	11	20.8
Research	2	3.8
Sports Nutrition	2	3.8
Do you work with patients with diabetes/obesity?		
Yes	52	98.1
No	1	1.9
% of your patients visiting for diabetic or obesity related issues?	70.90 ± 1.87 (mean ± S.E)	
Have you ever consumed artificial sweeteners?		
Yes	19	35.9
No	34	64.1
Do you recommend your patients to use AS?		
Yes	14	26.4
No	39	73.6
If yes, the purpose ...		
Glycemic control	—	—
Weight Management	2	14.3
Both	8	57.1
Others (Sugar replacement, Life style)	4	28.6
Types of AS you recommend		
Sucralose	4	28.6
Aspartame	2	14.3
Saccharin	1	7.4
Acesulfame K	0	0
Stevia	7	50
Are there patients who expressed any discomfort after consumption of AS?		
Yes	11	20.8
No	42	79.2
If yes, your suggestions?		
Change the brand	2	18.2
Reduce intake	2	18.2
Discontinue consumption	6	54.5
Others (Suggest natural sweeteners/Diet management and exercise)	1	9.1
<b>Opinion based on personal knowledge and/or practice</b>		
There is insufficient research regarding the safety and/or side effects of AS?		
Strongly agree	10	18.9
Agree	28	52.8
Neutral	12	22.6
Disagree	03	5.7
Strongly disagree	00	0.0
I believe consumption of AS may increase one's sweetness threshold.		
Strongly agree	10	18.9
Agree	25	47.1
Neutral	09	17.0
Disagree	08	15.1

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Table 3. (continued)

Questionnaires	N	Percentage
Strongly disagree	01	1.9
I believe long-term consumption of AS may cause future health complications		
Strongly agree	20	37.7
Agree	27	50.9
Neutral	06	11.3
Disagree	00	0.00
Strongly disagree	00	0.00
I believe there is a link with consumption of AS with various cancers.		
Strongly agree	08	15.1
Agree	20	37.7
Neutral	23	43.4
Disagree	02	3.8
Strongly disagree	00	00
I would suggest low-calorie/glycemic index foods rather than AS for diabetic management		
Strongly agree	34	64.2
Agree	14	26.4
Neutral	03	05.7
Disagree	02	03.8
Strongly disagree	00	0.00

35% of dietitians consumed AS themselves. If any discomfort in patients was noticed, they were recommended to discontinue use of AS rather than change of brand or dose reduction in usage.

A majority of the dietitians (72%) felt there was insufficient research regarding the safety and side effects of AS during long-term consumption (Fig. 2B). 64% of dietitians strongly agreed to educate patients to consume low-calorie glycaemic foods and beverages for weight management and glycaemic control over the use of AS in foods and beverages. Most agreed that AS increases one's sweetness threshold and might cause future health complications, while few had a strong opinion that AS consumption is a risk factor for various cancers (53%) (Fig. 2B).

#### 4. Discussion

In our study, we assessed the knowledge and consumption of AS among diabetic subjects along with the perception of registered dietitians on AS for recommendation.

In the current study, it was observed that the prevalence of AS consumption was high among the aged population (>55 years), with a mean age of diagnosed diabetes of 10.2 years. Majority of the consumers in the study were above-graduates and 50% of the population were working. According to existing literature, the major variables that determined AS consumption among the population were age, gender, level of education, occupation, and

Table 4. The association between AS consumption and discomforts among diabetic subjects

Source of AS	No of subjects consumed	Headache	Psychological disorders	Others	Chi Square (P value)
Sweets (Home/Bakery)	No	33 (64.7)	0 (0)	1 (3.0)	4.293 (0.117)
	Yes	18 (35.3)	0 (0)	0 (0)	
Beverages (zero coke/diet coke/fruit juices)	No	35 (68.6)	0 (0)	0 (0)	6.973 (0.031)
	Yes	16 (31.4)	0 (0)	1 (6.3)	
Table top sweeteners	No	07 (13.7)	0 (0)	0 (0)	0.507 (0.776)
	Yes	44 (86.3)	0 (0)	1 (2.3)	

The results were expressed as n (%).

Table 5. The correlation between knowledge, attitude and practice on AS consumption among diabetic subjects

Variables	Knowledge	Attitude	Practice
Knowledge	1.000	–	
Attitude	0.183	1.000	–
Practice	–0.039	0.630**	1.000

duration of diabetes [30,31]. Similar results as observed in our study were noticed in other studies [30–32], where the rate of consumption of AS strongly correlated with education and working

status of consumers, and studies concluded that well-educated participants had greater knowledge of disease management.

Studies indicated that, the education of population regarding AS can increase the usage rate and in our current study, 80% of population consumed AS based on the advice of doctors and dieticians and information obtained directly from internet or media. Similar results were also noticed by others, where media and health care providers were found to be better educators regarding AS than other sources [31,33].

Our study indicated that, about 57% of the participants were aware of the use of AS in sweets, beverages and as table top sweeteners while the remaining knew their use either as table top sweeteners or in sweets or beverages. Likewise, various other studies indicated that these AS increased food choice for diabetic patients as sugar replacer in soft beverages, sweets and various liquid and solid foods [30]. In our study, about 86% of the participants consumed AS, as table top sweeteners and among these AS, saccharin, sucralose and aspartame were the majorly preferred AS, likewise another study too showed that sucralose was the most preferred AS among Iran population [31]. In our study, 50% of the subjects consumed table top sweeteners on daily basis while similar results were also depicted in a study [34], where more than 50% of study subjects consumed AS on daily basis. Regarding discomfort, 2% of the study subjects of the present study exhibited discomfort after consumption, while other studies reported that 5–27% of participants developed discomfort like headache or nausea after AS consumption [31,32,35].

In our current study, knowledge, attitude and practice of type II diabetic patients on the consumption and use of AS was studied in order to assess their dietary habits regarding the use of AS, as tabletop sweeteners or as sweeteners in other foods and as a replacer of sugar, and to understand if these study participants knew about the benefits and health hazards of these products.

Regarding knowledge on AS, 59% of the diabetic participants were not aware whether AS can help in

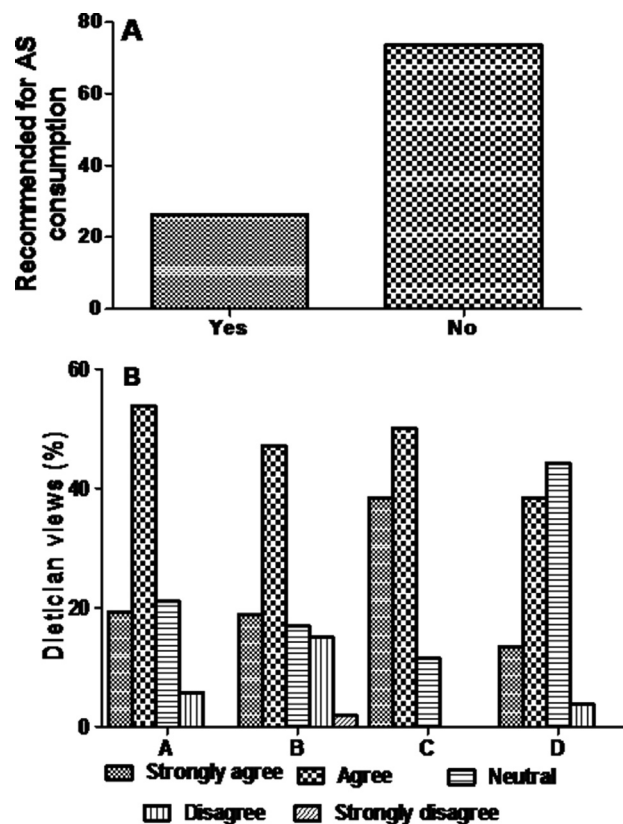


Fig. 2. The recommendation and opinion of dieticians on AS. A-% dieticians who recommended AS for consumption for their patients. B-Opinion of dieticians on AS, Insufficient research regarding the safety and/or side effects of AS (A), AS may increase one's sweetness threshold (B), long-term consumption of AS may cause future health complications (C), opinion on link between consumption of AS with various cancers (D).



the control of weight and diabetes, while 24% of the subjects expressed a positive opinion on AS for weight and diabetes management. Similar results were also observed in other studies, where 10, 16 and 68% of study subjects had an opinion that consumption of AS could improve glycaemic regulation [31], well-being [36] and weight regulation [33] respectively. However, opinions on side effects showed, only 14% of our study subjects were aware of side effects (psychological disorders, kidney disorders, and carcinogenicity) associated with long-term AS consumption and similar results were observed in other studies, where only 12 [36] and 32% [33] of study subjects had knowledge of the side effects associated with chronic consumption of AS. In our study the association between AS consumption from different AS supplemented food sources and discomfort showed strong and significant association when beverages such as zero coke/diet coke/fruit juices were consumed compared to sweets prepared at home or bakery with AS and table top sweeteners indicating the hazardous effects on consumption of beverages.

The role of nutritionists or registered dieticians in diabetes management is highly appreciated [28,37,38]. Therefore, in this study, we gathered information from the perspective of registered dieticians on the usage of AS for the management of metabolic disorders. It was observed from the study that most of the dieticians did not recommend the use of AS, and majority prescribed low glycaemic foods over AS for glycaemic regulation. Similar outcomes were also noticed in a study [39], where dieticians' perspectives on AS were uncertain, mainly due to fears about adverse health effects caused by AS and contradictory reports on the beneficial effects of AS on weight management and glycaemic regulation. Hence, more epidemiological and experimental studies are required to understand the long-term health effects of AS on chronic consumption. Therefore, outcomes can educate health professionals, and it could also be valuable in reassuring the public of the benefits or educating about the hazards of AS consumption.

## 5. Conclusion

The study findings revealed that the type-II diabetic participants had good knowledge of the use of AS either in the form of table top sweeteners or in foods such as sweets, cool drinks with positive attitude towards AS usage. Most of the study participants did not have knowledge on the implications of the long-term consumption of AS. The study inferred that knowledge correlated positively with

attitude and negatively with practice although it was not significant, while significant positive correlation was observed between attitude and practice. The study indicated the need to promote knowledge on complications involved on prolonged consumption of AS and that inappropriate practices could lead to health hazards on usage of AS among type- II diabetic patients. The study also revealed that the dieticians' views about recommending AS were divergent with the majority of them not recommending the use of AS due to ambiguity of insufficient research regarding the safety and side effects of AS during long-term consumption. As a result, more research is needed in order to educate health professionals and, ultimately, consumers about the health benefits or hazards of AS.

## Conflict of interest

The authors have no financial or personal relationships that could pose a conflict of interest and declare no potential conflict of interest.

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