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Knowledge and Awareness of the usage of Artificial Sweeteners among Indian type 2 diabetes individuals in a tertiary diabetes institute

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Background: Diabetes mellitus is a chronic metabolic disease primarily attributable to unhealthy, untimely food habits and lack of physical activity. Good glycemic control is one of key aspects of preventing complications. This has led to shift in replacing sugar with artificial sweeteners amongst diabetic population. It is not known whether this is aimed to maintain blood glucose levels or satisfying sweet cravings. There is lack of awareness of type and long-term side effects of artificial sweeteners among people with diabetes. **Objectives:** This study was conducted to assess awareness and knowledge of usage of artificial sweeteners among adults with type 2 diabetes visiting a tertiary diabetes institute. **Materials and Methods:** The study population involved 297 adults (≥18 years) with type 2 diabetes attending a tertiary diabetes institute. Data were collected from face-to-face interview techniques along with pre-validated questionnaire. **Results:** The total number of subjects (n=297) comprised 126 females and 171 males of age 18-88 with a mean age of 56.5 years. Sucralose was most popular sugar substitute amongst the subjects (45%) followed by Aspartame (32%), 13% of them are completely not aware of type of artificial sweetener that they consumed. About 36.7% of subjects belonged to pre-obese category with a BMI of 25-29.9kg/m2 with women on the upper scale. 57.91% of the respondents started consuming artificial sweeteners in recent years i.e., between 1to 5 years. 87% of the subjects consumed artificial sweeteners in form of pellets in tea or coffee as medium and 51% consumed it to manage blood glucose levels. 51.2% had gastrointestinal side effects. A significant number of subjects (81.5%) were unaware of long-term side effects of artificial sweeteners. **Conclusions:** The study findings highlight high rate of unawareness amongst subjects regarding the side effects of long-term consumption of artificial sweeteners. Hence, reading nutrition label on products, judicious consumption of artificial sweeteners and nutritional education can help make wise food choices.

Keywords: Knowledge and Awareness, Artificial Sweeteners, type 2 diabetes

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Introduction

In recent years, the awareness and trend towards health and fitness have increased. The energy imbalance between calories consumed and calories expended, long working hours, sleep disorders, sedentary lifestyles, and excessive consumption of sugary foods along with increased fat consumption, especially saturated fats is leading the Indian population to obesity and diabetes. According to International Diabetes Federation, in 2021, globally 537 million adults are living with diabetes and it is estimated to increase by 1.5 times by 2045. In India, 74.2 million people are living with diabetes and it is predicted to rise by 1.7 times (125 million) by 2045. Diabetes is a chronic metabolic disorder that results in hyperglycemia which when uncontrolled can lead to complications. Good glycemic control can be achieved by a healthy balanced diet that focuses on the choice of carbohydrates, portion control and wholesome fibre-rich foods along with regular physical activity which helps in regulating the blood glucose levels.

The growing health awareness today has increased the demand for food products that support better health. Consumers are demanding a greater variety of low-calorie products as they strive to make healthier food choices. Artificial sweeteners are synthetic food additives that duplicate the effect of sugar on taste. It is about 200 times sweeter than sugar but with less food energy and is considered during the management of diabetes. Six high-intensity sweeteners are FDA-approved as food additives in the United States: saccharin, aspartame, acesulfame potassium (Ace-K), sucralose, neotame, and advantame [1].

With increased consumer interest in reducing energy intake, food products containing non-sugar sweeteners (NSSs) rather than simple sugars (monosaccharides and disaccharides) have become increasingly popular [2].

These sugar substitutes differ from sugars not only in their taste properties but also in how the body metabolizes them [3]. and how they in turn affect physiological processes [4]. NSSs are generally sweeter than sucrose but contain far fewer or no calories. Each sweetener is unique in its sweetness intensity, the persistence of the sweet taste, the coating of the teeth, and after taste effect [5].

The food and beverage industries are replacing sugar or corn syrup with artificial sweeteners in a range of products. This will be regulated by the US Food and Drug Administration as food additives. Food additives must be approved by the FDA, which publishes a Generally Recognized as Safe (GRAS) list of additives [6].

Extensive studies are being conducted and established regarding the ill effects of artificial sweeteners, yet there is a lingering unawareness among a significant proportion of the population. Hence, a study was designed to assess the awareness and knowledge of artificial sweeteners used among the population in tertiary diabetes care in India.

Study design: This study is an observational survey involving 297 adults (≥ 18 years of age) with type 2 diabetes visiting the Tertiary diabetes institute.

Inclusion criteria: The American Diabetes Association diagnostic criteria have been used for selecting the subjects with diabetes. The inclusion criteria included persons with type 2 diabetes whose FBS is ≥126mg/dl and HbA1c ≥6.5%. Exclusion criteria were type 2 diabetes subjects under the age of 18yrs and type 1 diabetes subjects.

Collection of data: Participants were briefed about the study overview and informed consent was taken before proceeding. In the study, knowledge and awareness about the usage of artificial sweeteners were assessed by face-to-face interview techniques along with filling out a pre-validated questionnaire (Annexure). History of diabetes, Information on age, sex, body weight, height, BMI, and details regarding artificial sweeteners were obtained. The BMI was tabulated and analyzed based on Asian criteria cut-off values. All collected data were statistically analyzed.

BMI classification – Asian criteria values	
Nutritional Status	BMI cut-off value (kg/m2)
Underweight	<18.5
Normal	18.5-22.9
Overweight	23-24.9
Pre-Obese	25-29.9
Obese	≥ 30
Obese Class I	30-40
Obese Class II	40.1-50
Obese Class III	>50

Results

Table 1: Characteristics of the subjects

Parameters	Values
N	297
AGE	
Mean ± SD	56.5 ± 11.5
Median (IQR)	59 (49.5, 65)
Min	23
Max	88
WT(Kg)	
Mean ± SD	69.6 ± 12.2
Median (IQR)	69 (61.9, 77)
Min	39
Max	126
Ht (cms)	
Mean ± SD	161.1 ± 8.8
Median (IQR)	162 (155, 168)
Min	143
Max	182
BMI	
Mean ± SD	26.2 ± 4.9
Median (IQR)	26.4 (23.45, 29.65)
Min	15.8
Max	50.3
IBW	
Mean ± SD	61.6 ± 9.6
Median (IQR)	62 (54.25, 68)
Min	3
Max	81
Duration Of Diabetes (In Years)	
Mean ± SD	7.7 ± 5.8
Median (IQR)	7 (4, 10)
Min	1
Max	32
How Many Substitues /Day	
Mean ± SD	3.3 ± 1.8
Median (IQR)	3 (2, 4)
Min	1
Max	12

The study population (N=297) comprised 126 females and 171 males with a mean age of 56.5 years. The mean duration of diabetes was 7.7 years. The number of artificial sweeteners in the pellet form ranged from 3 to 12 per day whereas in the form of powder it ranged between 1 to 4 sachets per day. (Table 1)

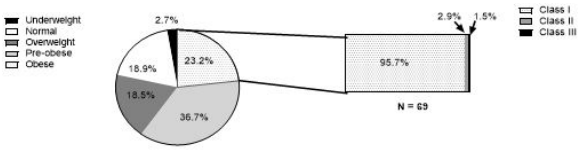


Figure 1: Distribution of study population according to BMI

Table 2: Population characteristics according to BMI category

	Underweight	Normal	Overweight	Pre-Obese	obese	obese type 1	obese type 2	obese type 3
N	8	56	55	109	69	66	2	1
Gender								
Male	7	44	34	66	20	19	1	0
Female	1	12	21	43	49	47	1	1
Age	53.1 ± 16.8	58.7 ± 11.0	56.9 ± 11.5	55.9 ± 11.9	56.0 ± 10.4	56.0 ± 10.6	50.5 ± 0.7	62
Duration of diabetes	11.5 ± 10.4	8.9 ± 6.5	7.6 ± 5.4	7.5 ± 5.7	7.1 ± 4.6	7.1 ± 4.6	8.5 ± 5.0	4
Duration of use of artificial sweeteners								
1 to 5	5	29	34	62	42	40	1	1
5-10	2	20	16	38	21	21	0	0
10-15	1	4	3	7	5	4	1	0
>15	0	3	2	2	1	1	0	0

Majority (36.7%) of the subjects belonged to the pre-obese category with a BMI of 25-29.9kg/m2. 23% belonged to the obese category with BMI >30. Striking similarities are found in the number of individuals who belonged to the overweight and normal BMI categories with 18.9% and 18.5% respectively (Figure 1). Obesity was more prevalent in females than males. The usage of artificial sweeteners by normal weight and the overweight category was between 1 to 5 years and the long duration of usage of artificial sweeteners i.e more than 10 years was seen predominantly in the pre-obese and obese subjects (Table 2).

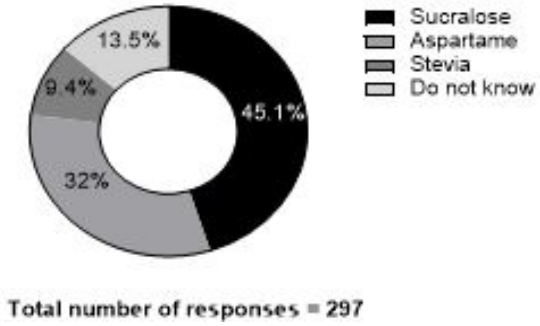


Figure 2: Distribution of type of artificial sweeteners consumed

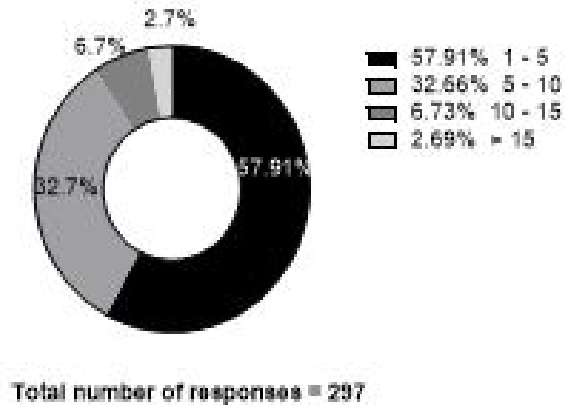


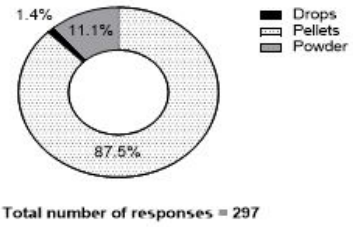
Figure 3: Duration of routine consumption of artificial sweetners.

Artificial sweeteners and consumption

Sucralose was the most popular sugar substitute amongst the subjects with 45% followed by aspartame and stevia with 32% and 9.4% respectively. 13% of them are completely not aware of the type of artificial sweetener consumed (Figure 2).

The majority (57.91%) of the respondents started consuming artificial sweeteners in recent years i.e. between 1 to 5 years, 32.7% are consuming between 5 to 10 years, and 6% between 10 to 15 years.

Long-term usage of artificial sweeteners that is more than 15 years was observed only in 2% (Figure 3).



Pellets	Sachets	Drops
Mean ± SD: 3.3 ± 1.9 Min : 1 Max: 12	Mean ± SD: 2.2 ± 0.9 Min: 1 Max: 4	3 or 4 drops a day

Figure 4: Form of artificial sweeteners used

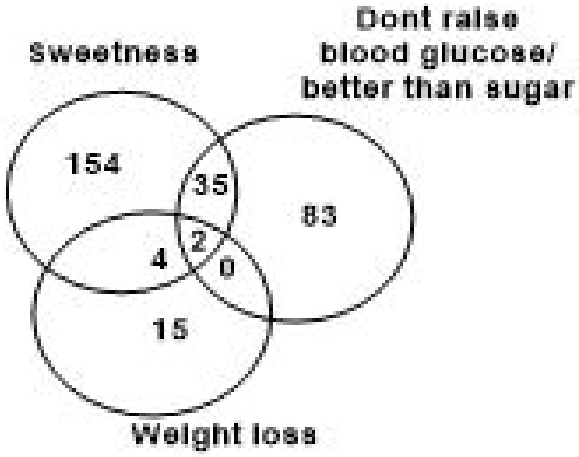


Figure 5

The usual form of artificial sweetener consumed by 87% of the subject population was a tablet/pellet in comparison to powder and drops which is 11.1% and 1.4% respectively (Figure 4 and 5). Beverages like tea, coffee or milk are the most preferred medium of sugar substitute observed in 99.3% of the subjects and a smaller population (0.67%) using in desserts. The leading motive for the inclusion of artificial sweeteners in 154 subjects was to enhance sweetness while 83 of them used it to manage blood glucose levels.

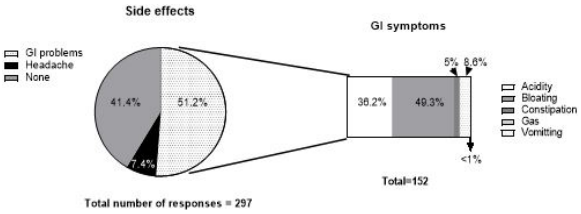


Figure 6: Common side effects and GI symptoms experienced by the study individuals

The study illustrates that 51.2% of the subjects experienced gastrointestinal issues amongst which bloating and acidity were at the highest at 49.3% and 36.2% respectively. Also, 7.4% of them had a headache regularly (Figure 6). Only 28.3% of the subjects experienced a weight change, 24.6% of them had experienced after taste of artificial sweeteners, and 17.2% of them consumed commercially prepared products containing artificial sweeteners (Table 3). About 31.6% of them think that artificial sweeteners can be consumed in large amounts, and 48.5 % believe that food containing artificial sweeteners has no calories. The majority (81.5%) are not aware of the long-term side effects of artificial sweeteners (Table 3).

Table 3: Survey response to knowledge, awareness and attitude towards the consumption of artificial sweeteners and their effects.

Question	Description		
	yes %	no %	total %
Have you experienced weight change after taking artificial sweeteners?	28.3 %	71.7 %	100%
Have you experienced taste with artificial sweeteners	24.6 %	75.4 %	100%
Do you consume commercially prepared products containing artificial sweeteners (like sweets/ice creams)	17.2 %	82.8 %	100%
Do you think artificial sweeteners can be consumed in large amounts	31.6 %	68.4 %	100%
Do you think foods with artificial sweeteners have no calories	48.5 %	51.5 %	100%
Are you aware of the long-term side effects of artificial sweeteners	18.5 %	81.5 %	100%

Discussion

A sedentary lifestyle along with a marked increase in the consumption of fast food and high-calorie foods is contributing to an alarming rise in the prevalence of diabetes throughout the world. Due to the pandemic, there seems to be a paradigm shift with health and wellness being the priorities of the consumer now. Seeking to cut sugar, calories, and carbohydrates, especially in snacks has led to the ascending demand for sugar-reducing food and beverages thereby promoting the use of low-calorie artificial sweeteners. The awareness of risks associated with diabetes is driving the Indian diabetic population's preference for artificial sweeteners. Accordingly, India's food sweetener market is forecasted to grow at a CAGR of 4.2% during the forecast period (2022-2027) [7].

Beverages like tea, coffee and desserts are the most common mediums where consumers look for sugar replacements. According to Euro monitor International [8]. India has been known as one of the tea-drinking nations and demand for it has also been consistent. Our study presented nearly 99.3% of them using artificial sweeteners in beverages like tea and coffee. These results were in accordance with the results of the recent assessment of the use of low-calorie sweeteners amongst the Indian population by Jaiswal et al [9]. Among our study population, sucralose was the most popular and commonly used substitute followed by Aspartame which was preferably consumed in beverages Like tea and coffee. The majority (87%) of the study individuals primarily consumed artificial sweeteners in the form of pellets with a range of 1 to 12 per day. This was found to be similar in a cross-sectional study by Mayasah et al[10] where respondents included 5-10 tablets/day and also in a study by Nayaka et.al [11]. that reported 80% of them use artificial sweeteners in the form of tablets, especially along with drinking tea. Concurrently natural sweeteners like Stevia have also been gaining popularity corresponding to the global emphasis on natural food products.

The initial action that a person with diabetes executes is the curbing of tabletop sugar. Artificial sweeteners take up the substitution role in fulfilling the sweet cravings of an individual. As seen in our present study, the motive of the majority of people to include artificial sweeteners was for sweetness (51%). About one-fourth of them targeted managing their blood glucose levels and a smaller population (5%) aimed for weight loss. In our study, an equal proportion of individuals belonged to the normal or overweight category. About 36.7% of the subjects belonged to the pre-obese category with BMI ranging between 25-29.9kg/m2 indicating that obesity is prevalent and those who aimed at managing weight loss with artificial sweeteners have not shown much promising results. An in-vivo experiment [12]. claims to have shown similar results where consumption of sweeteners (saccharin, cyclamate based, acesulfame-K based, and aspartame) resulted in significantly increased body weight even though the food intake did not change. This questions the effect of non-caloric artificial sweeteners on weight-loss management.

Artificial sweeteners have become a prime component in the food industry that can help to tackle diabetes and obesity. Some of the common foods which contain artificial sweeteners include soft drinks, sweets and desserts, ice creams and chewing gums. However, the safety of artificial sweeteners is questionable as it has been well established that they can cause gastrointestinal issues including bloating and acidity and several other chronic diseases. Studies [13]. indicate that aspartame, sucralose, and saccharin disrupt gut microbiota homeostasis which can lead to long-term digestive diseases like irritable bowel syndrome (IBD). Headache was observed as a regular symptom in individuals consuming artificial sweeteners, especially aspartame [9,14,15].

Which can be attributed to the formation of formic acid when aspartame breaks down resulting in metabolic acidosis.

The use of artificial sweeteners was high during the initial years of diabetes to make an evident change, however, it has to be noted that often portion control is overlooked which can eventually lead to overconsumption. In our study, only 17% of individuals consumed commercially prepared food products. Creating awareness about artificial sweeteners and their usage amongst individuals and taking an informed decision after consulting healthcare professionals can yield the expected results.

An increasing trend of unawareness about the side effects of long-term consumption of artificial sweeteners was found among individuals according to several survey studies [9][16].

The development of cancer (especially breast cancer and obesity-related cancer), is one of the gravest consequences of the consumption of artificial sweeteners. A cohort study [17]. conducted in France found that artificial sweeteners (aspartame and acesulfame-K) were associated with increased cancer risk.

Artificial sweeteners have been subjected to intense scrutiny yet there is a lacuna regarding their awareness and long-term side effects. World Health Organization (WHO) recommends that free sugars should constitute less than 10% of total calories to reduce the risk of lifestyle-related chronic diseases. According to the American Diabetes Association (ADA), there is no evidence that zero-calorie sweeteners can help lower blood glucose levels in long term. Therefore refraining from using artificial sweeteners, limiting the frequency of usage in a day or opting for natural sweeteners (like Stevia) is advisable. A carbohydrate-conscious diet is a key to managing blood glucose levels. Establishing a healthy lifestyle, regular physical activity and consuming a balanced diet under the guidance of healthcare professionals can provide the best results. Therefore, it becomes an utmost priority to educate people, especially the lower socio-economic classes who constitute a substantial part of the population in India.

Limitations of The Study: The study presents limitations wherein the side effects or weight changes declared by the subjects cannot be entirely attributed to the use of artificial sweeteners only.

Conclusion

Our study calls attention to the high rate of unawareness amongst the subjects regarding the side effects of long-term consumption of artificial sweeteners. Some of the subjects with type 2 diabetes do not know the type of artificial sweetener they consume. Common side effects of artificial sweeteners are headaches and gastrointestinal issues like bloating and acidity. Reading the nutrition label on the product help to quickly identify the key nutrients and type of artificial sweetener included in the product. Nutritional knowledge will have a positive impact on health and can help make wise food choices. Establishing a healthy lifestyle, regular physical activity and judicious consumption of food and artificial sweeteners under the guidance of healthcare professionals should be the focal point.

Abbreviations

ADA- American Diabetes Association

BMI- Body Mass Index

CAGR – Compound Annual Growth Rate

FDA- Food and Drug Administration

FBS- Fasting Blood Sugar

GRAS- Generally Recognised As Safe

HbA1c – Glycosylated Hemoglobin

IBD- Inflammatory Bowel Disease

NSS- Non-Sugar Sweeteners

WHO – World Health Organisation

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