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Assessment of Knowledge and Perceptions of Pakistani Adults about Non-nutritive Sweeteners

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ABSTRACT

Non-nutritive sweeteners are used as a substitute for sugar and have strong sweetening properties. They can be helpful in weight management, diabetes, and other insulin sensitivity-related metabolic disorders. **Objective:** This survey intended to analyze the knowledge and risk perceptions related to the safety and benefits of Non-nutritive sweeteners in a population of Pakistani adults. The impact of knowledge dissemination on the consumption of Non-nutritive sweeteners was also assessed. **Methods:** An online survey was conducted, and 680 responses were received. **Results:** Results indicated that 55.7% reported Non-nutritive sweeteners consumption, while 44.3% denied any usage. Only 27.4% of respondents showed trust in regulatory bodies while only 26.2% had any idea about the laws surrounding their use. The second part of the study aimed to examine the effect of knowledge dissemination on Non-nutritive sweeteners consumption, but the result showed that the participants were still not convinced about the safety levels of Non-nutritive sweeteners ($p < 0.05$). The only statement that participants were persuaded by was that Non-nutritive sweeteners does not pose any risk of cancer. The main reason for consumption was attributed to the low caloric properties of Non-nutritive sweeteners. **Conclusions:** The results showed that effective communication by regulatory authorities and health professionals via the internet, social media and leaflets can be beneficial in educating the public about Non-nutritive sweeteners. The role of health care professionals is also important to assure the public of the safety of Non-nutritive sweeteners.

INTRODUCTION

The use of Nonnutritive sweeteners (NNS) can be traced back to the late 1800s with an upsurge in the number of food products containing artificial sweeteners being observed with each passing decade [1]. Nonnutritive sweeteners (synonymous to artificial sweeteners or non-caloric sweeteners) provide little to no calories and nutrients and are used as a substitute for regular tabletop sweeteners [2]. They are used in a wide range of products ranging from food and beverages to medication, supplements, and oral care products [3]. Some types of Non-nutritive sweeteners originate from plant or herbal sources while others can be derivatives of sugar itself. Some of these sweeteners can

be utilized by the body without the need for metabolism [3, 4]. Although Nonnutritive sweeteners have their own distinctive chemical and metabolic properties, they can activate taste receptors in a way practically identical to sugar [5,6]. Another distinguishable property of Nonnutritive sweeteners is the exceptional strength of their sweetness. Even small quantities can provide a taste many times sweeter than sugar ultimately allowing less overall caloric consumption [7].

Nonnutritive sweeteners allow consumers to indulge in a wide assortment of food and drinks while simultaneously utilizing healthier dietary options. The use of these

sweeteners makes it easy to follow recommendations for healthy eating regimens without much restriction of food choices. Consumers can also choose the type and amount of sweetener they wish to consume thanks to the myriad of options available. One big advantage of Nonnutritive sweeteners is that they can enhance the palatability and nutrient density of food while restricting caloric intakes [2]. Hence Low caloric sweeteners can be used to decrease energy intake and body weight [8]. Nonnutritive sweeteners have been shown to restrain energy intake and suppress appetite along with having promising effects on the homeostasis and metabolism of glucose [9]. Nonnutritive sweeteners can be especially beneficial for people with diabetes in weight management and to improve glycemic control [10]. They only contain minimal or no calories in comparison to the 16 calories in a teaspoon of sugar. These health benefits associated with Nonnutritive sweeteners prompts their use by a wide audience and is the reason why they are recommended by health care professionals [4]. This is also why they are so commonly used that many people consume them unknowingly [11]. Artificial sweeteners are still a major concern for most consumers, even though extensive safety investigations executed by the U.S. Food and Drug Administration have led to the approval of nonnutritive sweeteners as safe. The FDA has approved five nonnutritive sweeteners as food additives which include saccharin, aspartame, sucralose, acesulfame K and neotame [12]. Nonnutritive sweeteners like stevia, allulose and monk fruit have been awarded Generally Recognized as Safe (GRAS) status by the FDA [13, 14]. The use of Nonnutritive sweeteners is enveloped by many controversial theories and myths that lead to confusion among the public. Some studies have reported an association of saccharin, aspartame, and sucralose with risk of cancer [15]. Others report health risks like obesity and cardiovascular problems [16]. Risk of type 2 diabetes and impaired glucose homeostasis because of Nonnutritive sweeteners use is also subjected to controversy [17]. However, these studies were conducted on animal models and were later disputed owing to the fact that the outcomes seen in animals could not be replicated in humans due to respective biological differences. As a result of these skeptical claims many people remain cautious and question the safety of Nonnutritive sweeteners even with the assurance of health care professionals [15]. Fabricated claims about nonnutritive sweeteners are commonly found on the internet and shared via print and electronic media that constantly mislead people. It is the job of health care professionals to familiarize themselves with Nonnutritive sweeteners and related products to satisfy people and help them

distinguish fact from fiction [12, 18]. Different countries have variable perceptions regarding Nonnutritive sweeteners. Understanding the basis of the trends and perceptions of Nonnutritive sweeteners consumption can provide grounds for developing successful strategies to educate the public. It is not possible to launch effective awareness and informational campaigns without estimating the extent of consumer knowledge regarding nonnutritive sweeteners [19]. An important factor to consider is the consumer ability to read and understand nutrition labels and ingredient lists. The ability to read and understand nutrition labels may influence dietary choices and can help understand change in use of Nonnutritive sweeteners. The knowledge and trust of consumers in regulatory bodies and standard recommendations also plays a part in their views on sweeteners [20]. It is, hence, crucial to address the many myths surrounding the use of Nonnutritive sweeteners by gauging the public perceptions about their safety and benefits.

We conducted this survey with the aim to evaluate the knowledge and perceptions of adult Pakistani population regarding the safety and benefits of Nonnutritive sweeteners. Multiple socio demographic factors were observed to better understand public opinion. We also aimed to assess the trust of the public in regulatory bodies of Pakistan and whether providing information about such regulatory bodies can help change the views about Nonnutritive sweeteners. The results of this survey will help in devising effective strategies to communicate with the masses and empower them to make informed dietary choices.

METHODS

On account of the Covid 19 pandemic, the mode of data collection was selected as purely online. Google Forms was used to prepare a questionnaire which was then distributed via digital platforms including social media platforms (Instagram, Facebook) to collect responses from a wider audience in the country [21]. Data collection was conducted between the months of April and May 2021. The questionnaire was formed using statements from an acclaimed qualitative study that assessed the consumer's views on food additives including artificial sweeteners along with the impact of consumer's knowledge and trust in regulatory bodies on the perceived risk of food additive [20]. The target audience was the adult Pakistani population of above 18 with sufficient digital literacy. Online consent was taken at the start of the survey and no personal information that could identify the participants was required. The term artificial sweetener was used in exchange for nonnutritive sweeteners in the survey as it is the most commonly known and understood. The two-part survey started off with basic questions related to socio-

demographic characteristics like age, gender, ethnicity, education, and profession along with estimated weight and disease history. Respondents were asked about their Nonnutritive sweetener's consumption, the main reasons for Nonnutritive sweeteners consumption, and the comprehended differences in various sweeteners. In order to judge their views on the benefits and risks of Nonnutritive sweeteners and to analyze their knowledge and trust in regulatory bodies, they were asked to rate relevant statements. The 5-point Likert scale was used to quantify responses which displayed the following options: strongly disagree, disagree, neutral, agree, and strongly agree. The second part of the survey consisted of text to communicate the beneficial role of Nonnutritive sweeteners in weight management and glucose metabolism along with dismissing the health and safety-related concerns associated with Nonnutritive sweeteners. After knowledge dissemination respondents were again evaluated on their safety and benefits perceptions. The sample size for the survey was estimated to be around 664 considering confidence interval of 99%, precision rate of 5%, and prevalence rate of 50%. SPSS version 23.0 was used for data analysis. Population attributes were represented with the help of frequencies and the reliability of the questionnaire was evaluated using Cronbach's alpha coefficient. Other analytical tests used included Pearson's Chi-square test to quantify the relationship between weight status and utilization of Nonnutritive sweeteners and Wilcoxon test was used to measure the variations in responses of benefits and risks perception before and after knowledge dissemination.

RESULTS

680 responses were collected to overrule unreliable and ambiguous statistics as the mode of data collection was purely online. Females represented 72% of the population. Most of the participants fell in the age range of 18-25 (82.8%) and a high percentage of the respondents were graduates (66.1%). More than half of the population (60.18%) self-reported their perceived weight as normal, 19.56% considered themselves to be overweight while 2.1% reported being obese. 0.9% of the population stated having type 1 diabetes, 0.9% had type 2 diabetes while the majority of the population (94.3%) reported no incidence of any medical condition. Cronbach's alpha coefficient revealed the internal consistency to be satisfactory for benefits ($\alpha = 0.87$), trust in regulations ($\alpha = 0.61$) and safety ($\alpha = 0.54$). Table 1 demonstrates the socio demographic characteristics of the population.

Table 1: Socio-demographic characteristics of population (N = 680)

Variables	Frequency (%)
Gender	
Male	191(28)
Female	489(72)
Age	
18-25	563(82.8)
26-33	68(10)
34-41	21(3.09)
42-49	16(2.35)
50-57	9(1.32)
58-65	2(0.29)
66-73	1(0.15)
Weight	
Underweight	72(10.59)
Normal weight	409(60.15)
Overweight	133(19.56)
Obese	14(2.1)
Prefer not to answer	52(7.6)
Education	
Matric/ O levels	8(1.2)
Intermediate/college	102(15)
Graduation	451(66.3)
Postgraduate qualification	119(17.5)
Occupations/Professions	
Health related professions	123(18)
Other professions	93(13.7)
Student	433(63.7)
Unemployed/retired	31(4.6)
Diabetes	
Type 1 Diabetes	6(0.9)
Type 2 Diabetes	6(0.9)
High Blood Pressure	21(3.1)
Heart Disease	5(0.7)
Cancer	1(0.1)
None	641(94.3)

Knowledge and trust of the population on laws and regulations of non-nutritive sweeteners were evaluated as displayed in Table 2. It was found that only 10.1% of the respondents were aware of food laws related to the use of Nonnutritive sweeteners, and 10.3% showed trust in the regulatory bodies of Pakistan to ensure the careful use of Nonnutritive sweeteners in food products. 7% believed that food products containing Nonnutritive sweeteners and other artificial sweeteners were tested for safety before being released on the market.

Table 2: Knowledge and trust in regulations surrounding the use of artificial sweeteners

Questions	Strongly Agree N (%)	Agree N (%)	Neither Agree nor Disagree N (%)	Disagree N (%)	Strongly Disagree N (%)
I have knowledge related to food rules/laws related to use of artificial sweeteners	69 (10.1)	109 (16)	219 (32.2)	156 (22.9)	127 (18.7)
I trust the regulatory bodies of Pakistan to monitor safe number of artificial sweeteners in food products	70 (10.3)	118 (17.4)	228 (33.5)	163 (24)	101 (14.9)
I believe that all artificial sweeteners available in market are tested and are safe	48 (7.1)	129 (19)	239 (35.1)	157 (23.1)	107 (15.7)

Participants were also asked about the most effective method of knowledge dissemination in their opinion as displayed in Figure 1. 63% of the responses indicated that the internet could be used as an effective mode of communication.

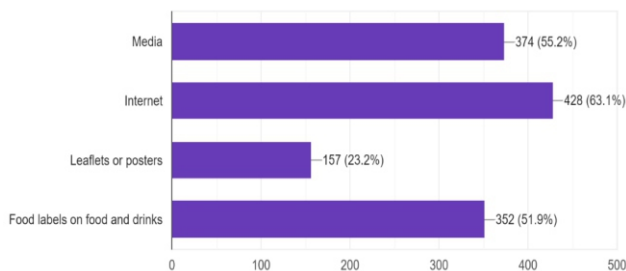


Figure 1: Effective way of knowledge dissemination.

The survey also aimed to assess consumer's perceptions of different types of Nonnutritive sweeteners. For this purpose, an open-ended question was introduced that allowed respondents to express their views. Some of the most common opinions are: "Aspartame is less safe because its end-product is methanol which is toxic for our body and brain. It also plays role in dementia", "Sucralose is calorie-free, is not considered a carbohydrate by the body and has no effect on blood sugar levels", "Because it is not heat stable and get broken into harmful substance", "Aspartame cause headaches, depression, cancer and seizures", "Aspartame could affect glucose tolerance and insulin levels", "Because its toxicity leads to bad health consequences", "Stevia consumption can cause bloating and nausea", "Stevia is a natural herb and more safe than others", "It causes severe headaches and allergic reactions", "Because it can cause diabetes or over weight", "It depends upon the RDA of the sweetener", "Stevia has less effect on our glucose level", "Aspartame less healthy than others", "Stevia can cause memory loss" and "Saccharine cause cancer". While some responses implied a preference for stevia because of it being a natural herb, others raised

concerns regarding its safety and possible side effects. Aspartame was widely considered unsafe generating multiple responses that expressed alarm over its use. The 18.3% population of health care professionals also raised several points in agreement with public opinion on Nonnutritive sweeteners safety including the risk of cancer, dementia, headaches, and depression associated with Nonnutritive sweeteners use. The second part of the survey aimed to clear misconceptions surrounding Nonnutritive sweeteners use by providing authentic information about Nonnutritive sweeteners safety and benefits as indicated in table 3. The participants were advised to read the short text before moving on to the last part of the survey where they rated statements related to perceptions of Nonnutritive sweeteners again. The results showed that the participants are still not fully convinced about the safety of Nonnutritive sweeteners for health ($Z = -8.932$, $p < 0.05$). They are still dubious about the benefits of Nonnutritive sweeteners for diabetic patients ($Z = -7.361$, $p < 0.05$) and most of the participants still don't believe that Nonnutritive sweeteners can aid in losing weight ($Z = -9.598$, $p < 0.05$). However, most participants were convinced that Nonnutritive sweeteners do not pose risk for cancer ($Z = -5.941$, $p < 0.05$).

Table 3: Knowledge and perception of acceptance, safety, and benefits of nonnutritive sweeteners

Questions	Strongly Agree N (%)	Agree N (%)	Neither Agree nor Disagree N (%)	Disagree N (%)	Strongly Disagree N (%)
I actively avoid foods and drinks that contain artificial sweeteners	103 (15.1)	93 (13.7)	217 (31.9)	126 (18.5)	141 (20.7)
I do not understand the use of artificial sweeteners	79 (11.6)	96 (14.1)	176 (25.9)	148 (21.8)	181 (26.6)
I think artificial sweeteners can cause cancer	67 (9.9)	109 (16)	212 (31.2)	131 (19.3)	161 (23.7)
I think artificial sweeteners can cause diabetes	130 (19.1)	136 (20)	153 (22.5)	103 (15.1)	158 (23.2)
Artificial sweeteners can cause allergic reactions	62 (9.1)	153 (22.5)	231 (34)	88 (12.9)	146 (21.5)
I think artificial sweeteners are not safe for pregnant women	94 (13.8)	151 (22.2)	235 (34.6)	70 (10.3)	130 (19.1)
I think artificial sweeteners are completely safe to use	93 (13.7)	114 (16.8)	161 (23.7)	154 (22.6)	158 (23.2)
Artificial sweeteners are helpful for someone who wishes to lose weight	131 (19.3)	154 (22.6)	141 (20.7)	104 (15.3)	150 (22.1)
Artificial sweeteners can help in management of diabetes	125 (18.4)	163 (24)	167 (24.6)	96 (14.1)	129 (19)
I find artificial sweeteners to benefit me personally	73 (10.7)	92 (13.5)	198 (29.1)	132 (19.4)	185 (27.2)

DISCUSSION

The objective of this study was to determine the level of understanding of the general public in Pakistan about Nonnutritive sweeteners, their safety, and their benefits. We also intended to know about the effectiveness of knowledge dissemination and its impact on preconceived notions about Nonnutritive sweeteners. The data collected with this survey would help to approach the public effectively and to dispel the myths surrounding Nonnutritive sweeteners use. The information presented in this article can be used in many ways in the best interest of the public.

More than half of the sample population reported not consuming any form of Nonnutritive sweeteners 55.7%. Out of those who did report consumption, 57.9% were normal weight. Study results also indicated a small association between weight status and consumption of Nonnutritive sweeteners. Interestingly, out of the 14 individuals who reported being obese 6 stated that they consumed Nonnutritive sweeteners possibly for the purpose of weight loss [22, 23]. This trend depicts that reverse causality exists between Nonnutritive sweeteners and obesity as explained by a study [24]. It was also observed that the main source of Nonnutritive sweeteners was in the form of soft drinks followed by bakery items. It is to be noted that the consumption of Nonnutritive sweeteners in beverages like soft drinks has been associated with weight gain and obesity [25]. The reasons for Nonnutritive sweeteners consumption were mainly attributed to their low caloric content 44.4%. Only 27.5% of respondents found Nonnutritive sweeteners healthier than sugar. Most selected stevia as healthy when asked about preference in sweeteners. However, there was some criticism on its bitter after taste [26]. This again proves that consumers perceive natural and organic food as healthy and disapprove of synthetic food products. A study conducted on Female Young Adults in Zimbabwe shows that health-conscious individuals did not consider artificial sweeteners as healthy [27]. The percentage of graduates in the sample population 66.1% was higher than the percentage of graduates in Pakistan 4.38% [28]. This could be attributed to the fact that the questionnaire was promoted online mainly among university students on account of the Covid 19 pandemic. Lack of knowledge and trust in regulatory bodies was shown to be the basis for the poor judgment of Nonnutritive sweeteners by the general public. Identical results were presented by a Swiss study [29]. More than half of our respondents were unaware of the laws surrounding the safe use of Nonnutritive sweeteners. It is important to note that a considerable number of respondents relied on the "neither agree nor disagree" option which proves the lack of knowledge and

understanding regarding the statements as previously explored [30]. The large number of such uncertain responses highlights the importance of knowledge dissemination in making informed and better dietary choices. Another factor that plays into the lower acceptance of Nonnutritive sweeteners is the poor public response to "artificial products". A recent study explored the positive association between natural ingredients and consumer acceptability of a product with consumers being more open to purchasing products containing natural sweeteners as opposed to artificial sweeteners [31]. It can hence be deduced that to enhance the general public's perception of Nonnutritive sweeteners, use of natural Nonnutritive sweeteners like stevia can be employed. Survey results propose that social media platforms, media, and leaflets could be utilized effectively to educate the public on Nonnutritive sweeteners and their benefits. The internet was the preferred source of knowledge dissemination by the majority (63.1%). Many respondents also showed a positive response to the inclusion of informative messages regarding Nonnutritive sweeteners on food and drink labels. Simple and comprehensive messages need to be distributed via these resources. It was observed that trust in regulations did not have an impact on consumer's perceptions. Nevertheless, government bodies and health agencies are still highly trusted and exercise great control over public perceptions. These agencies can play a major role in educating consumers and encouraging them to change their views regarding Nonnutritive sweeteners for the better. Knowledge dissemination via questionnaire did not yield beneficial results in our population as permanent changes in perception require more time. A Korean study previously generated positive outcomes with significant improvement in consumer's views of food additives after long-term knowledge dissemination [32]. Overall results indicated that people were dubious about the health benefits of Nonnutritive sweeteners and even after knowledge dissemination most did not change their preconceived notions. The public has poor knowledge of Nonnutritive sweeteners. These results are in line with another study that observed consumer awareness of artificial sweeteners [33]. Involving health care professionals in public awareness and education can reap promising results since many people consider their family doctor an important source of nutrition knowledge [34]. Caregivers specifically associated with the treatment of non-communicable diseases such as obesity, diabetes, etc. can provide evidence-based information to their patients regarding Nonnutritive sweeteners safety and benefits. Aspartame was subject to the most negative reviews by a majority of the participants. This comes as no

surprise since aspartame has been the focus of critics on the internet based on unreliable scientific studies and myths [35]. Stevia on the other hand is more tolerable due to it being considered natural. These points need to be kept in mind while formulating effective strategies for public awareness. Keeping the results of this study in mind, we present the suggestions: Inform health practitioners and the general public about the difference between natural and healthy. It is important to dispel the notion that everything natural is healthy and that artificial does not necessarily mean unhealthy. Moreover, it would be better if stevia, a plant-based sweetener, is not grouped under the category of artificial sweeteners. Another suggestion would be to convert the labeling of all such sweeteners to Nonnutritive sweeteners or low caloric sweetener on all regulatory and informational sites. Using government regulatory bodies and health agencies to dismiss the myth surrounding Nonnutritive sweeteners could be very beneficial as the public has confidence in these bodies. They could promote authentic, validated, and evidence-based information to consumers in an easy-to-understand manner. Social media, brochures, and media can also be employed for this cause. There needs to be more research on certain attributes of Nonnutritive sweeteners to further prove their safety and benefits to the public and to health care professionals. Strengths and Limitations of the study. This study is one of the first in Pakistan that evaluated the perceptions. Pakistani adults concerning the safety and benefits of Nonnutritive sweeteners.

CONCLUSIONS

The survey outcomes indicate that there is a high-risk perception of Nonnutritive sweeteners in the sample of Pakistani adults tested. This leads to the poor acceptance of Nonnutritive sweeteners in the population on account of misinformation regarding Nonnutritive sweeteners safety and benefits. The artificial properties of Nonnutritive sweeteners are also subject to concern and disdain. There is a need to develop effective communication strategies to target the misconceptions and doubts regarding Nonnutritive sweeteners. Simple and concise messages circulated via social media, media, and brochures can play a huge role in negating controversial views and aid consumers in making choices. Health care professionals also need to be educated so that they can play their part in encouraging the public to consider Nonnutritive sweeteners.

Authors Contribution

Conceptualization: AN, MA
 Methodology: AN, BK, KA, TS
 Formal analysis: AN, MM, BK
 Writing-review and editing: MN

All authors have read and agreed to the published version of the manuscript.

Conflicts of Interest

The authors declare no conflict of interest.

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