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RESEARCH ARTICLE

Non-nutritive sweeteners: consumer awareness and inclusion in food and beverage products in South Africa

Shakun Naicker[a]*, Ashika Naicker[b] and Evonne Singh[a]

[a]*Department of Consumer Sciences, Durban University of Technology, Durban, South Africa*
[b]*Department of Food and Nutrition, Durban University of Technology, Durban, South Africa*
**Correspondence: shakun.naicker@outlook.com*

Background: The widespread use of non-nutritive sweeteners (NNSs) in the food and beverage industry has become a global trend.
Objective: A study was undertaken to assess the level of awareness of South Africans of NNSs and to create a scientific product database of NNSs in a sample of packaged products in South Africa.
Design: A cross-sectional survey design was chosen.
Setting: The study was carried out online in South Africa .
Subjects: The study participants were South African adults ($n = 388$).
Outcome measures: A consumer awareness survey on NNSs and a scientific product database were created to identify products formulated with NNSs.
Results: A large proportion of participants were unfamiliar with most NNSs by name; however, a significant 61% ($n = 238$) ($p < 0.001$) of participants were most aware of xylitol, and 45% ($n = 174$) were aware of aspartame. Despite this, a significant number of participants consumed products labelled 'sugar-free' and/or 'diet' ($p < 0.001$). Participants were aware of health concerns and health benefits associated with the consumption of NNSs. A scientific product database consisting of 419 products containing NNSs was created during the study. A combination of NNSs was used in the formulations of 65% ($n = 273$) of the products, while 35% ($n = 146$) of the products were formulated with a single NNS.
Conclusion: The outcome of this research highlights key consumer insights into NNSs and their widespread use in product formulations in South Africa. The outcome of this study shows the need for continuous monitoring of the effects of the increasing use of NNSs in product formulation and their impact on health and diet. Consumer education would advance consumer awareness of NNSs.

Keywords: consumer awareness, database, widespread, non-nutritive sweeteners

Introduction

Globally, the burden of obesity and diabetes has had a direct influence on the inclusion of non-nutritive sweeteners (NNSs) in product reformulation.[1,2] Extensive evidence exists to show how the consumption of NNSs has increased among obese individuals and diabetics.[3–6] Evidence indicates that the global market for NNSs grew by 5.1% annually between 2008 and 2015.[2] Alsunni describes the recent surge in the use of sweeteners as being the result of the global spread of obesity.[4] This increase could be seen as a response to implementing public policies to reduce added sugars. A report from Mordor Intelligence describes how large the sweetener market has become over time.[5] According to the report, the global food sweetener market was valued at US$ 85.92 billion in 2020 and is projected to see a compound annual growth rate (CAGR) of 2.49% during the forecast period (2021–2026).[5] Consumers are demanding a greater variety of low-kilojoule products as they strive to make healthier food choices, resulting in the increased consumption of NNSs worldwide.[6, 7] A sweetener is classified as a food additive.[8] It mimics the effect of sugar on taste receptors.[9] Sweeteners are called sugar substitutes and can be natural or synthetic. Natural sweeteners are defined as sweeteners that are found in nature, occurring naturally in fruit. Natural sweeteners carry a nutritional value and are non-carcinogenic as compared with some synthetic sweeteners such as saccharin, aspartame and sucralose.[9] Synthetic sugar substitutes are commonly referred to as artificial sweeteners, low-calorie sweeteners or NNSs.[9] Nutritive sweeteners are also known as polyols.[9] Polyols are a specific group of sugar alcohols formed through catalytic hydrogenation of carbohydrates, add sweetness with less energy, and are often used in combination with other polyols or NNSs because of the bulking property of some polyols.[9] Sweeteners have become a favourable sugar replacer in product formulation. Small amounts of NNSs can be used due to their high-intensity sweet taste and are therefore believed to be helpful in supporting low-kilojoule diets.[8] Saccharin, acesulfame, aspartame, neotame, sucralose and advantame have been commonly consumed and used NNSs since their Food and Drug Administration (FDA) approval in the early 1980s.[9, 10] In 2017, sucralose was the most widely NNS consumed, and it accounted for one-third of the global market.[4]

Sweetener toxicity has been heavily trialled and evaluated to determine safe levels of intake.[10] The FDA conducts clinical studies examining NNSs, reviewing the nutritional consequences of and the physiological responses to their use to determine potential toxicity levels.[10] Toxicity must be examined thoroughly because NNSs may be ingested in larger quantities than traditional additives.[10] The key determinant in the safety evaluation of a food additive is the relationship between its probable human intake from use in food to the level at which adverse effects are observed in toxicological studies.[10] Safety standards called acceptable daily intakes (ADIs) and estimated

daily intakes (EDIs) guide decisions regarding safe consumption levels.[10] The ADI is an estimated, conservative amount of NNSs that can be safely consumed daily by any person in the population over a lifetime without risk from exposure.[10] Despite this, there are many conflicting arguments around the advantages and disadvantages associated with human health and the consumption of NNSs;[6] however, NNSs are positioned in the market as a product that can support weight loss or assist in maintaining a healthy weight.[3] According to a recent systematic review by the World Health Organization (WHO) in 2021, there has been no confirmation as to whether NNSs can deliver long-term weight loss or have an association with any other long-term health benefits such as prevention of diabetes as a result of habitual intakes in accordance with the ADI.[11]

A potentially increased risk for cancer is a starting point for many debates around the safety of NNSs.[12] Aspartame, saccharine and sucralose have come under scrutiny for their carcinogenic side effects, causing consumers to become increasingly concerned about their use.[12] Despite prolific research detailing the pros and cons of the inclusion of sweeteners in food and beverage products, controversy continues to surround the use of NNSs, with sugar substitutes being criticised for their long-term effects on health.[2, 12]

It is well known that obesity and diabetes have become a global public health concern.[13, 14] A countermeasure to improve the health outcomes of South Africans in support of the strategic health plan in South Africa is the Health Promotion Levy (HPL) on sugary beverages, which is aimed at reducing obesity in South Africa.[15] The HPL was implemented in 2018 and has impacted manufacturers in the sugar-sweetened beverage (SSB) industry. This involuntarily compelled the beverage industry to reformulate their products without sugar, thus introducing a wide range of sweeteners into SSBs. Furthermore, researchers concur that governments are establishing regulations that compel consumers to reduce their sugar consumption while simultaneously prompting the food and beverage industry to include NNSs in their products.[16] There is a high probability that South Africans unknowingly consume multiple products containing NNSs daily. It would also be interesting to investigate whether consumers read ingredient labels prior to purchasing a product. The main objectives of this study were to assess the level of awareness of South Africans of NNSs through an NNS consumer survey and to create a scientific product database detailing a breakdown of NNSs in a sample of packaged products available in a sub-sample of retail outlets in South Africa through product label analysis.

Materials and methods

Study sample

In this cross-sectional study, convenience and snowball sampling methods were used to recruit 388 participants (South African adults, ≥ 18 years, male and female of all races) for the NNSs consumer survey. The sample size for a consumer survey with a population size of +1 000.00 with a 95% confidence level and a 5% margin of error was calculated at 385. The final consumer survey was disseminated through social networks, LinkedIn™, Facebook™ and WhatsApp™. The expected time to complete the survey was projected at 15 minutes; the survey was open for five months, and was available on two accessible survey platforms (Google Forms and Microsoft Forms). A survey link was provided, and participants could click on the link to access the survey. The introductory paragraph of the survey described the background and the aim; a letter of information and ethical approval for the study were hyperlinked onto the survey as a compulsory read question. The survey was set up so that the potential participant had to click on the 'provide consent button' or 'do not provide consent button'. If the potential participant provided consent, the participant was directed to the survey, while the survey closed for potential participants who did not provide consent. Participants were requested to share this survey link within their networks, which supported the recruitment of more participants. The platforms chosen to disseminate the survey were constantly monitored, and a regular reminder was sent through daily updates on the status prompt user of LinkedIn™, Facebook™ and WhatsApp™ to take the survey.

Measurement tools

NNSs consumer survey

The NNSs consumer survey tool was designed to assess consumers' awareness of NNSs. The NNSs consumer survey was adapted using a validated questionnaire that was trialled and tested in a study by Farhat *et al*. in 2021, who embarked on a similar study in the United Kingdom, measuring consumer awareness and perception of NNSs.[13] The consumer survey was piloted among 10 participants who were then excluded from the main study. The method used to validate the pilot survey tool included content and construct validity tests. The reason for applying the content validity test was to ensure that the pilot survey was a validation step to check that the survey was representative of what it aimed to measure before it was disseminated as the final survey. The statistician assessed the chronological flow of the survey to ensure the acceptable order; the questions were also evaluated to ensure that these were not ambiguous or confusing for the participants and to ensure that they would speak to the objectives of the study. Feedback from the pilot study advised the finalisation of the survey. The first section of the survey included demographic information regarding the participants. Sequentially, the next set of questions were related to the participants' general health and their awareness of NNSs. The survey then flowed into a regulatory section that gave further insight into participants' level of awareness and perceptions of, and trust in NNSs. The survey concluded with a list of products likely to contain NNSs, and participants were asked to select which products they consumed.

Non-nutritive sweeteners food and beverage database in the South African market

The scientific product database tool was created to showcase the range of several product categories that contain NNSs available in the South African market. The database development was a desktop study that combined the use of an online and in-person collection of product label data of NNS-containing products. For the validation of the products documented in the scientific database, an in-person validation was conducted for every 15th product, which was validated at the retail outlet by trained research assistants. It was decided to limit product sampling to three stores: Checkers, Woolworths and Dis-Chem. According to a report from a data and analytics company, Kantar Brandz, Checkers and Woolworths continued to hold a significant market share in South Africa and were therefore selected for the study.[17] All three retailers comprise outlets that are conveniently located.[18–20] Checkers offers a convenient shopping experience with everything under one roof.[18] Woolworths, on the other hand, mainly targets an affluent market that will spend more on quality and luxury items.[19]

Dis-Chem is one of the leading pharmacy groups in South Africa and was included for its unique health and wellness product offerings.[20] Each retailer offers a very different shopping experience for consumers and they are positioned very differently from one another. Due to budgetary constraints, the scope could not have been expanded across more stores. Product label analysis was limited to the following specific categories: snack foods, gum, confectionery, dairy products, diabetic products, baby foods, energy drinks and SSBs, due to the high volume of products that otherwise it would have been necessary to examine. Emphasis was placed on the examination of the ingredient declaration. Data were captured and exported onto a database with a detailed breakdown of NNSs found in the sample of packaged foods within the highlighted categories. The label analysis explored whether products made health and wellness claims that justified the inclusion of sweeteners according to Regulations Relating to the Use of Sweeteners in Foodstuff published under the Government Notice in No. R. 3128 (December 20, 1991)[21]. The Regulations for the use of Sweeteners in Foodstuffs under R146 section 15 (1) of the Foodstuffs, Cosmetics and Disinfectants Act,1972 (Act 54 of 1972) were also used to guide the label examination as they regulate the labelling requirements listed in the Regulation for Foodstuffs, Cosmetics and Disinfectants Act (23 February 2007).[22]

The scientific analysis indicated:

- the type of sweetener used;
- if a combination of sweeteners and polyols was used;
- if sugar was also included in the product with sweeteners;
- the variation in sweetener labelling from product to product;
- if sugar-free or diabetic-friendly claims were made.

Online data collection involved retrieving product label data by accessing the three retailers' online shopping websites, the food or beverage manufacturers' websites, and health and wellness advertising websites. This resulted in an assessment of online product specifications and product technical data sheets, otherwise commonly known as product descriptions, that were available online at the time of research. The data were captured and transferred onto the scientific product database.

Data analysis

The Statistical Package for Social Sciences (SPSS®) version 25 (IBM Corp, Armonk, NY, USA) was used as an instrument for the analysis. Descriptive statistics were used to define the proportion of responses for each question. Statistical significance was accepted as $p < 0.05$. Descriptive statistics, including means and standard deviations, were applied. The chi-square goodness-of-fit test, which is a univariate test, was used on a categorical variable to test whether any of the response options were selected significantly more/less often than the others. Under the null hypothesis, it was assumed that all responses were chosen equally. A binomial test was used to measure whether a significant proportion of participants selected one of a possible two responses.

Ethical considerations

The research study obtained full ethical approval from the Institutional Research Ethics Committee (IREC) at Durban University of Technology (Ethics Clearance Number: 136/21). This study used non-invasive methods. Participants were provided with a letter of information, and informed consent was obtained through a checkbox at the start of the online survey. Participation in the online questionnaire was entirely voluntary and anonymous, with the option to withdraw at any time from the survey. The survey had no identifying values that linked information to the participant, such as name, email address or IP address.

Results

A total of 388 South African adults participated in the NNSs consumer survey nationally (Table 1). Table 1 presents the demographic information on the study participants. Female participants dominated the survey with a weighted 66.5% ($n = 258$) of the responses, followed by 33.5% ($n = 130$) from male participants. All races participated in the survey, with most responses coming from Black participants (40.2% $n = 156$), followed by Indian/Asian (30.2% $n = 117$), White (18.0% $n = 70$) and Coloured participants (11.6% $n = 45$). Interestingly,

Table 1: Demographic information on study participants for the non-nutritive sweeteners consumer survey ($n = 388$)

Category	Description	% (*n*)
Gender	Women	66.5 (258)
	Men	33.5 (130)
Age (years)	18–24	24.2 (94)
	25–34	27.6 (107)
	35–44	24.7 (96)
	45–54	14.9 (58)
	55–64	5.7 (22)
	65–74	2.3 (9)
	+75	0.5 (2)
Race	White	18.0 (70)
	Indian/Asian	30.2 (117)
	Black	40.2 (156)
	Coloured	11.6 (45)
Province	Eastern Cape	10.3 (40)
	Free State	3.1 (12)
	Gauteng	31.4 (122)
	KwaZulu-Natal	29.6 (115)
	Limpopo	1.8 (7)
	Mpumalanga	1.5 (6)
	North-West	0.5 (2)
	Northern Cape	0.8 (3)
	Western Cape	19.8 (77)
Education	No formal education	4.6 (18)
	Primary school	2.1 (8)
	High school	16.2 (63)
	Tertiary	77.1 (299)

Table 2: Participant awareness of different types of non-nutritive sweeteners ($n = 388$)

Sweeteners	Frequency (%)		*p*-value
	Yes	No	
Saccharin	161 (41)	227 (59)	0.001*
Aspartame	174 (45)	214 (55)	0.048
Stevia	135 (35)	253 (65)	< 0.001*
Neotame	25 (6)	363 (94)	< 0.001*
Xylitol	238 (61)	150 (39)	< 0.001*
Maltitol	64 (16)	324 (84)	< 0.001*
Sucralose	159 (41)	229 (59)	< 0.001*
Acesulfame-K	32 (8)	356 (92)	< 0.001*

a higher participation level came from the younger participants, with 24.2% ($n = 94$) aged 18–24, 27.6% ($n = 107$) aged 25–34 and 24.7% ($n = 96$) aged between 35 and 44 years. The survey was opened to all provinces in South Africa, with the highest participation from Gauteng at 31.4% ($n = 122$) and KwaZulu-Natal at 29.6% ($n = 122$), followed by Western Cape at 19.8% ($n = 77$). The level of education of the participants varied with a higher number (77.1%, $n = 9$) of participants having a tertiary education, 16.2% ($n = 63$) a high school education, 2.1% ($n = 8$) primary school education and 4.6% ($n = 18$) no formal education.

The results presented in Table 2 indicated that a large proportion of the participants were not aware of neotame (94%, $n = 363$), acesulfame-K (92%, $n = 356$), maltitol (84%, $n = 324$), stevia (65%, $n = 253$), saccharin, 59% ($n = 227$) and sucralose (59%, $n = 229$). Interestingly, while the results showed that participants were not aware of most of the sweeteners presented in the survey, a significant 61% ($n = 238$) of the participants were aware of xylitol, $p < 0.001$. Aspartame was the second highest NNS, which 45% ($n = 174$) of the participants were aware of.

With regard to the frequency of participants consuming products labelled 'sugar-free' or 'diet', 33.5% ($n = 130$) of participants consumed them less often than once a week, 25.8% ($n = 100$) consumed products with NNSs a few times a week, 7.5% ($n = 29$) consumed products with NNSs once a week and 7.7% ($n = 30$) consumed these products daily. The chi-square goodness-of-fit test was used to test if any response option was significantly more than others. A significant number of participants indicated that they consumed products labelled 'sugar-free' or 'diet' either 'never', 'less often than once a week' or 'a few times a week', $p < 0.001$. The relevance of this result is that although a significant number of participants consumed products labelled 'sugar-free' and/or 'diet', they consumed NNSs unknowingly.

Results showed that 50.8% ($n = 197$) of the participants were aware of health concerns related to the consumption of NNSs, and 49.2% ($n = 191$) of the participants responded that they were concerned about using NNSs. When participants were asked if they would like more information on NNSs, a significant 74.5% ($n = 289$) indicated that they would like to know more about NNSs, $p < 0.001$.

To obtain an overall measure for attitudes toward NNSs, factor analysis was applied to the nine items measuring attitudes toward NNSs. This was done to determine whether there were any underlying latent factors that indicate groupings of these items. In Table 3, the results showed that the following three statements – 'I think calling them 'artificial' makes me sceptical about their safety', 'I worry about the effects that non-nutritive sweeteners can have on my body', and 'I have concerns about non-nutritive sweeteners and the risk of cancer' – were significantly agreed with.

Furthermore, factor analysis with Promax rotation was applied to the nine items. One factor that accounted for 52.95% of the variance in the data was extracted. A Kaiser–Meyer–Olkin (KMO) measure of sampling adequacy of 0.913 and a significant Bartlett's test indicated that the data were adequate for successful and reliable extraction. Successful extraction was completed in four iterations. The composite measure for attitude for the results presented in Table 4 was formed by calculating the average of the agreement scores included in the factor, which was tested for reliability using Cronbach's alpha. An alpha of 0.909 indicated that this composite variable, which measures

Table 3: Consumer attitudes towards non-nutritive sweeteners ($n = 388$)

Awareness and risk perception statements	Mean (SD)	T	df	*p*-value
I think non-nutritive sweeteners are not natural and therefore harmful	0.965	.044	387	< 0.001*
I think calling them 'artificial' makes me sceptical about their safety	0.000	5.929	387	< 0.001*
I think non-nutritive sweeteners are bad for health	0.257	1.136	387	< 0.001*
I worry about the effects that non-nutritive sweeteners can have on my body	0.000	5.132	387	< 0.001*
I have concerns about non-nutritive sweeteners and the risk of cancer	0.000	4.528	387	< 0.001*
I think that non-nutritive sweeteners can cause people to gain weight	0.320	-.997	387	< 0.001*
I think that non-nutritive sweeteners can cause diabetes	0.513	-.655	387	< 0.001*
I think that non-nutritive sweeteners can cause allergic reactions	0.760	.306	387	< 0.001*
Pregnant women should not consume non-nutritive sweeteners	0.545	.605	387	< 0.001*

Table 4: Factor analysis of attitude and benefits towards non-nutritive sweeteners

Awareness and risk perception statements	Factor 1
I think non-nutritive sweeteners are bad for health	0.815
I think that non-nutritive sweeteners can cause diabetes	0.777
I have concerns about non-nutritive sweeteners and the risk of cancer	0.768
I think that non-nutritive sweeteners can cause people to gain weight	0.766
I worry about the effects that non-nutritive sweeteners can have on my body	0.725
I think non-nutritive sweeteners are not natural and therefore harmful	0.693
I think that non-nutritive sweeteners can cause allergic reactions	0.681
Pregnant women should not consume non-nutritive sweeteners	0.678
Benefits	Factor 1
I think calling them 'artificial' makes me skeptical about their safety	0.625
Non-nutritive sweeteners allow for diet products to be a viable option	0.824
Non-nutritive sweeteners are helpful for someone who has diabetes	0.768
Non-nutritive sweeteners bring more benefit than risks to consumers	0.751
Non-nutritive sweeteners are helpful for someone who wishes to lose weight	0.735
Non-nutritive sweeteners allow for a little indulgence without feelings of guilt	0.677

attitude towards NNSs, was reliable. A one-sample test was conducted on the attitude variables to confirm whether there was significant agreement or disagreement that a negative attitude exists towards the NNSs presented in Table 4. What can be concluded from the results presented in this table is that there was significant agreement (M = 3.11) that NNSs are not good for one's health, $p = 0.020$.

The results also indicated agreement or disagreement with the statements highlighted on the benefits of consuming NNSs. There was significant agreement on these benefit statements: 'non-nutritive sweeteners are helpful for someone who wishes to lose weight', 'non-nutritive sweeteners allow for a little indulgence without feelings of guilt', and 'non-nutritive sweeteners allow for diet products to be a viable option'. The results show that participants genuinely believe that there are benefits linked to the consumption of sweeteners, despite the negative results associated with health concerns that were presented earlier on. Factor analysis with Promax rotation was applied to these five items. One factor was extracted and accounted for 56.61% of the variance in the data. A KMO of 0.840 and a significant Bartlett's test indicated that the data were adequate for successful and reliable extraction. Successful extraction was completed in six iterations. The composite measure for BENEFIT was derived by calculating the average of the

Table 5: Intake of beverages, sweeteners and snack products ($n = 388$)

Products	Frequency (%)		*p*-value
	Yes	No	
Fruit juice & concentrates (excluding fresh juice)	294 (76)	94 (24)	< 0.001*
Iced tea	136 (35)	252 (65)	< 0.001*
Diet cool drinks	208 (54)	180 (46)	
Flavoured sparkling water	195 (50)	193 (50)	
Flavoured carbonated water	159 (41)	229 (59)	< 0.001*
Flavoured milk	213 (55)	175 (45)	
Energy drinks	184 (47)	204 (53)	
Protein drinks	132 (34)	256 (66)	< 0.001*
Smoothies	208 (54)	180 (46)	
Hot beverages	356 (92)	32 (8)	
Sweetener aspartame	113 (29)	275 (71)	< 0.001
Sweetener sucralose	128 (33)	260 (67)	< 0.001*
Sweetener saccharin	107 (28)	281(72)	< 0.001*
Sweetener xylitol	144 (37)	244 (63)	< 0.001*
Sweetener sorbitol	106 (27)	282 (73)	< 0.001*
Crisps	315 (81)	73 (19)	< 0.001*
Biscuits/rusks	330 (85)	58 (15)	< 0.001*
Chocolate bars	339 (87)	49 (13)	< 0.001*
Energy bars	182 (47)	206 (53)	
Sugar-free chewing gum	201 (52)	187 (48)	
Sugar-free gum drops, gummy worms/bears	158 (41)	230 (59)	< 0.001*
Sugar-free chocolate	105 (27)	283 (73)	< 0.001*
Cakes	320 (82)	68 (18)	< 0.001*
Ice cream	319 (82)	69 (18)	< 0.001*
Yoghurt – lite	135 (39)	253 (61)	< 0.001*
Yoghurt – fat free	152 (39)	236 (61)	< 0.001*
Yoghurt – sugar-free	143 (37)	245 (63)	< 0.001*
Yoghurt – low fat	248 (64)	140 (36)	< 0.001*
Yoghurt – full cream	218 (56)	170 (44)	< 0.001*

Table 6: Sweeteners used in product formulation in South Africa

Combination of NNSs found in beverages and snack foods	Count of product
Acesulfame-K, sodium cyclamate	35
Xylitol, sorbitol, aspartame, sweetener mannitol, acesulfame-K, sucralose	1
Sodium cyclamate, sodium saccharin, acesulfame-K	22
Sucralose, erythritol, steviol glycoside	2
Aspartame, acesulfame-K and sucralose, xylitol, sorbitol, mannitol	1
Aspartame, acesulfame-K, mannitol, sucralose	1
Aspartame, mannitol, acesulfame-K	1
Erythritol, stevia extract	8
Erythritol, sodium cyclamate, acesulfame-K	1
Erythritol, sodium cyclamate, acesulfame-K, maltitol	2
Isomalt and acesulfame-K	1
Isomaltitol, aspartame, acesulfame-K	1
Maltitol, acesulfame-K	15
Maltitol syrup, maltitol	1
Maltitol syrup, isomalt, sucralose	1
Maltitol syrup, mannitol, sucralose	1
Maltitol, lactitol, acesulfame-K	2
Maltitol, sorbitol, acesulfame-K	2
Maltitol, isomalt	1
Mannitol, maltitol syrup, sucralose, acesulfame-K	1
Sodium cyclamate, sodium saccharin	1
Acesulfame-K, sodium cyclamate, steviol glycosides	8
Acesulfame-K, aspartame, sucralose	5
Acesulfame-K, sodium saccharin	6
Acesulfame-K, sucralose	54
Sodium cyclamate, acesulfame-K and aspartame	4
Sodium cyclamate, sodium saccharin	2
Sucralose, acesulfame-K, sodium cyclamate	5
Nutriose, sucralose	3
Polydextrose, isomalt, sucralose	5
Sodium cyclamate, sucralose, sodium saccharin	1
Sodium cyclamate, aspartame, sodium saccharine	4
Sodium saccharin, aspartame	8
Sorbitol, aspartame	7
Sorbitol, maltitol	5
Sucralose, stevia	3
Aspartame, acesulfame-K, mannitol	1
Aspartame, acesulfame-K	42
Aspartame, sodium cyclamate, saccharin	4
Xylitol, isomalt, sorbitol, aspartame	2
Xylitol, sorbitol, aspartame, mannitol, acesulfame-K, sucralose	2
Grand total	272
Individual NNSs found in beverages and snack foods	
Acesulfame-K	1
Aspartame	11
Cyclamic acid	1
Isomalt	1
Maltitol	12
Saccharine	2
Sodium saccharin	2
Sorbitol	24

(*Continued*)

agreement scores included in the factor and was tested for reliability using Cronbach's alpha. An alpha of 0.865 indicated that this composite variable, which measures the benefits of NNSs, was reliable.

A significant 81% ($n = 351$) of participants consumed crisps, 85% ($n = 330$) consumed biscuits/rusks, 87% ($n = 339$) consumed chocolate bars, 82% ($n = 320$) consumed cakes and 82% ($n = 319$) consumed ice creams. Some 73% ($n = 283$) did not consume sugar-free chocolate. Lite, sugar-free or fat-free yoghurt was not as popular as low-fat yoghurt, which was consumed by 64% ($n = 248$), and full-cream yoghurt was consumed by 56% ($n = 218$) of participants. The results of a list of sweeteners presented in Table 5 indicate that a significant proportion of participants have said 'no' to consuming sweeteners as a sugar replacement.

An important element of this research was to create a scientific product database with several products in different categories containing NNSs available in the South African market. A total of 419 products containing NNSs were found to be available across the three major stores (Checkers, Woolworths and Dis-Chem). These ranged from snack foods (crisps, biscuits, cereals, rusks, desserts), to dairy (yoghurt, cream cheese, flavoured milk, ice cream), confectionery (chocolate, candy and chewing gum), SSBs (fizzy drinks, juices), energy drinks (including meal replacement shakes) and diabetic products (desserts and dessert items, biscuits, cereals, drinks, chocolate, shakes). Interestingly, 45% ($n = 188$) of the 419 products that were examined were found to contain NNSs that came from the snack category. This was followed by the SSBs category, where 19% ($n = 79$) of the beverages examined contained NNSs. Furthermore, 14% ($n = 59$) of products with NNSs were dairy products, followed by energy drinks at 12% ($n = 52$) and gum at 3% ($n = 13$).

Table 6 is a representation of the combination of sweeteners that was used in the 419 products examined. Common NNS combinations used in products examined were acesulfame-K and sucralose (20%, $n = 54$), followed by aspartame and acesulfame-K (15%, $n = 42$). Sucralose was the most used sweetener in individual products at 16% ($n = 38$).

Discussion

The intention of an online consumer survey used in this study was to investigate consumer awareness of NNSs and to establish whether they were being consumed knowingly. The scientific product database aimed to describe product lists of various categories containing NNSs. This research mainly positioned the consumer at the forefront so that outcome could guide future consumer education on NNSs. The breakdown of results obtained through the NNS online survey from South African participants, male and female from different age groups and race, and provinces showed that a significant number of consumers were not aware of saccharin, aspartame, stevia and sucralose, which are the most commonly used NNSs in food and beverage products.[10] Interestingly, while the results showed that not all sweeteners were known, most participants were aware of xylitol. This could be attributed to the marketing power that xylitol attracts as a sugar substitute for cooking and baking.[23] Of concern is that while some participants were aware of aspartame, more than half were unaware of aspartame, which is commonly used in SSBs.[10] The results also indicated that fruit juice and concentrates are consumed more than diet cool drink options, and this could be because of their direct link to the word 'fruit' and how this ingredient is positioned in the minds of consumers. Fruits are promoted as a healthy choice and are associated with good health, therefore positioning fruit juice in a consumer's mind as a healthier choice for beverage option.[24] Trends emerging from a beverage study in 2020 in Australia indicated that some people might consciously try to make healthier beverage choices by choosing fruit juice.[24] Participants indicated through their choices that iced tea, flavoured carbonated water, energy drinks and protein shakes were not popular, and a significant number of participants did not consume these beverages. These products appeal to a very niche consumer market, attracting young people, and often are associated with masculinity and sport, unlike fruit juice, concentrates, 'diet' cool drinks and hot beverages.[24]

South Africans also indicated that they did not use sweeteners in their daily routine, but it is evident from the results of the survey that consumers are consuming NNSs unknowingly, which is worrying as consumers are not aware that they are consuming these. Data indicate that participants lacked awareness of NNSs and suggests that most participants do not read product labels or do not investigate the ingredients they are consuming, or that they are just not familiar with NNSs. This result reinforces the urgent need to introduce simple education measures for consumer awareness in South Africa. There was a general awareness of the health concerns related to the consumption of NNSs and the significant "noises" being made in the media regarding the safety of the products alongside their negative health effects and association with cancer.[11] A positive outcome from the results indicated consumer desire to know more about NNSs. Educating consumers on topics like NNSs would empower them to make informed choices that can influence their health and well-being in a positive way.[15] Results from studies conducted in the past on this topic describe how consumer education on the topic of NNSs has resulted in the acceptance of NNSs and changed negative perceptions and attitudes associated with concerns and risks to seeing more of the benefits from consuming NNSs.[13] Education through trusted health and government organisations, provided by well-trained and informed health experts, is critical for helping consumers make informed decisions regarding NNSs and their impact on health. By providing accurate and reliable information, consumers can be empowered to make choices that promote their overall health and well-being.[13]

The HPL was introduced in South Africa in 2018 in an effort to support the strategic health plan. It targeted the SSB industry, and compelled manufacturers to use sweeteners to compensate for the reduction of sugar so that the sweet taste of the product would not be altered.[15] While many consumers prefer a specific sweetener, numerous products now contain combinations of NNSs, and consumers are unaware of this.[25] By developing a product database with products containing NNSs, it was found that a substantial number of snack food products contain NNSs. While the HPL has no bearing on these products, manufacturers have found a loophole by using a cheaper form of

Table 6: Continued.

Combination of NNSs found in beverages and snack foods	Count of product
Stevia	23
Sucralose	38
Grand total	147

sweetness and have included it in food as well.[26,27] The concern with this is that through this study, it was emphasised how a small amount of NNSs is used to obtain a high potency of sweetness versus that of sugar.[9] Sweeteners are significantly sweeter than sucrose, and in what appears to be a benefit of 'lower-calorie' or 'no-calorie' products, manufacturers have now introduced much sweeter products with claims such as 'reduced sugar' or 'sugar-free', or even with no claim at all.[9,10] Manufacturers are introducing more and more products with sweeteners,[27] thus attracting consumers to high-sugar products that could eventually cause consumers to prefer, or even crave, these sweet options. These products are also not just limited to consumption by adults;[27] what manufacturers should realise is that children are also exposed to these products and could also be consuming products that contain NNSs from a young age.[27]

In summary, more often than not, NNS sweeteners are often used in combination to replace sucrose to reduce sugar content but still achieve the desired taste.[26,27] Research has shown that it is cost-effective for industry to formulate with sweeteners instead of sugar.[26,27] It is also apparent that a low-content combination of NNSs such as acesulfame-K, sucralose, aspartame and stevia is being used in numerous products.[26] This is a disadvantage to consumers who indicated they were unaware of these sweeteners. If product labels were read, this would mean that a higher percentage of consumers would have been familiar with aspartame and sucralose. A further injustice to consumers is that they are drawn to claims that focus on health and well-being. Claims usually trigger consumer behaviour and influence their product choices without them having sufficient (in-depth) awareness concerning the claims, and while they may superficially engage with the information on the product label, they will likely overlook important details regarding the ingredients. This study has confirmed the prevailing lack of consumer education as well as the initial assumption that NNSs are becoming a popular ingredient in the food and beverage industry.

Study limitations and strengths

Due to COVID-19 restrictions, the online consumer survey was limited to participants with mobile phones or computers with access to wi-fi or data. All surveys are dependent on memory recall, and some responses could be limited by memory bias. Using snowball sampling, representativeness is not guaranteed; however, every effort was made to disseminate the survey throughout South Africa using links in higher education and industry and sharing the survey on key food and nutrition social media pages. Product labelling utilising e-numbers, although legally permitted in labelling, may have affected the identification of NNSs among consumers. Product sampling was limited to specific categories: snack foods, gum, confectionery, dairy, diabetic products, baby foods, energy drinks and SSBs at three large retail stores. Some manufacturers' websites were outdated, limiting the desktop study's ability to reach a wider selection of products for label analysis. For in-store quality checks of the product database, products sampled at stores were available to the researcher at that point in time. Taking into account the rapid changes in shelf space, new products containing NNSs could have been launched, and some products that were examined may since have been discontinued. Despite the limitations, the methodology applied in the research was robust, using a validated consumer survey and aligning the database to regulations. A key strength of this study is that it confirms that NNSs are widely used in products in South Africa. It was also interesting to find that South Africans are consuming NNSs without being aware that they are doing so. Another finding was that the participants did not read product ingredient labels carefully enough and were thus unaware that they might be consuming NNSs.

Conclusion

The outcome of this research has highlighted key consumer insights, such as the significant gap identified in consumer awareness of NNSs. The data confirm that consumer education would bring about and promote consumer awareness of NNSs. Further research should be conducted to expand the database to include more or all foods and beverages available in the South African market. The outcome of this study shows the need for continuous monitoring of the effects of the increased use of NNSs in product formulation and their impact on diet and health.

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ORCID

Ashika Naicker http://orcid.org/0000-0001-7200-1756
Evonne Singh http://orcid.org/0000-0002-1873-389X

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