

Abstract

Sweeteners have become increasingly popular as a replacement for sugar in food products. The food industry is using these artificial additives to lower the energy in many foods including drinks, sweets and some reduced fat items such as yoghurt. Although these artificial sweeteners (AS) are regulated and tested to ensure they are safe to consume, they can be viewed as harmful and unhealthy by the general public. The media has a considerable influence on the general public, particularly when it involves the topics of weight loss, disease and health. It has been proposed that many of these reports are not evidence-based and may confuse or ill advise the public. To investigate the knowledge and perceptions of AS in the general public, a questionnaire was distributed to a group of participants aged over 18 years. In total 40 questionnaires were analysed to investigate the public's awareness, knowledge and consumption of AS. Results revealed evident confusion in the participants regarding AS knowledge and awareness. For example, the well-established health benefits, such as preventing dental caries, is not well known; while the poorly researched negative claims, such as cancer causing properties, seem a prime concern for the public. Subsequently the inconsistencies in knowledge and awareness were reflected in consumption. In conclusion there needs to be more clear and direct information published on AS, stating the facts from reputable peer reviewed research papers to diminish the public's confusion on AS consumption and empower their decisions using education and clear public health messages .

Introduction

Artificial sweeteners (AS), also known as non-nutritive sweeteners, are typically calorie free chemical substances used as a sugar replacement (Diabetes.uk., 2018). AS are a controversial topic, with many health claims and negative consequences associated with consuming them. This is a topic which has sparked a lot of confusion among the general public with the media stating allegations for and against the consumption of sweeteners. Many media reports present AS in a very negative light. One of the latest accusations in the newspapers is the link between consuming AS in soft drinks may lead to developing stroke and dementia, with a headline stating “Diet drinks TRIPLE your risk of stroke and dementia”(Daily Mail Newspaper cited in NHS, 2017) (NCBI, 2017). However, the study which this article was based on does not directly link the consumption of AS and developing stroke and dementia exclusively, as this was a cohort observational study and there were many other lifestyle factors contributing to the results; therefore it cannot be confirmed from this study that AS alone causes stroke and dementia (Pase et al., 2017). This highlights the mixed messages received by the public.

The current studies carried out on the safety of consumption of AS are mainly animal trials, many using rats (Pearlman et al., 2017) and cohort studies (Azad et al., 2017). There is a lack of evidence to confirm health claims associated with AS but also not many studies to state they are particularly harmful either. Additionally consumer education on this topic is very limited. As a result there is a need to analyse the knowledge the general public have towards AS and how this affects consumption.

The health claims associated with AS include prevention of dental caries, which has been proven in many studies to be accurate (Tanzer, 1995) (Nayak et al., 2014). One meta-analysis of the current studies investigating the effects of sweetener consumption on the prevalence of dental caries focused on sorbitol or xylitol sweeteners and included studies from 1966 to 2001 (Hayes,

2001). The findings highly praised and supported the use of these sweeteners in prevention of caries due to results of human experiments (Hayes, 2001). However, this analysis failed to fully explain how sweeteners protect dental health. A more recent meta-analysis on the effect of xylitol in preventing dental caries by Janakiram et al. (2017) confirmed Hayes' (2001) earlier findings. Their research, however, also reveals how xylitol works to protect teeth by destroying one of the common bacteria that are responsible for dental caries called mutans streptococci (Janakiram et al., 2017). This bacterium usually consumes sucrose or glucose and excretes acid after metabolism of the sugars. The acid breaks down the enamel on the teeth, leading to erosion and dental caries. Using xylitol does not give the bacteria anything to feed on and additionally kills the bacteria by affecting the energy production cycle in the bacterial cell; because of this, xylitol is used in many chewing gums (Janakiram et al., 2017). This research demonstrates a positive health claim to consuming AS however, this is not advertised as widely as some negative claims, taken out of context by the media. This shows how the public can be misinformed and confused about AS. Moreover, there is a perception that it is only the sugar in soft drinks that cause caries, when in fact carbonated gas also can greatly damage teeth (Frank et al., 2018). This is also adds to the confusion when choosing foods containing AS, in particular soft drinks.

Another positive benefit to using AS is to assist good glycaemic control. A study conducted in 2003 investigated two different diets on a group of male type 2 diabetics. One group was given a diet which followed general healthy eating guidelines for type 2 diabetics, the other diet consisted of a low calorie diet, using AS to replace sugar and reduce fat content. Both groups also had to complete an exercise regime each day (Reyna et al., 2003). Results revealed that while both groups benefited from the intervention, the participants on the low calorie diet which used the AS showed greater improvement, in particular with lower HbA1c levels. This research demonstrates promising results, indicating that AS may be beneficial in managing type 2

diabetes. However, the main weakness in this theory is that there were other factors to the intervention which may have affected the final result. For example, as well as AS, the participants ate lower fat foods; therefore it is difficult to state conclusively that the AS consumption was the beneficial agent (Reyna et al., 2003). Furthermore, there are studies which promote that the best diet for good diabetic control is one low in both sugars and AS “While moderate use of non-nutritive sweeteners (NNS) may be useful as a dietary aid for someone with diabetes or on a weight loss regimen, for optimal health it is recommended that only minimal amounts of both sugar and NNS be consumed” (Shankar et al., 2013), since AS may also be broken down to glucose in the body (Leibowitz et al., 2018). This questionnaire aimed to investigate if any of these health benefits were widely known by the general public.

It is presently very common for people to limit their diet for various reasons, such as intolerances, dislikes and other health reasons (de Ridder et al., 2017). AS have become very popular in the last few years as obesity has become a more common issue (Drummond et al., 2018). As AS are non-nutritive sweeteners, they provide little or no calories for the body as they are not well absorbed and also not stored for energy in the body (Grenby, 1996). Benton acknowledged that consuming sugars in a drink can contribute more to weight gain than in foods (Benton, 2007). Therefore strategies have been put in place to substitute sugar with low calorie AS in beverages in order to help aid weight loss in the general public (Azad et al., 2017). A study conducted last year in the UK used data such as the National Diet and Nutrition Survey to calculate the amount of calories consumed in sugar sweetened drinks. It is estimated that “a 40% reduction in free sugars added to sugar-sweetened beverages over 5 years would lead to an average reduction in energy intake of 38.4 kcal per day”(Ma et al., 2016). In Ireland, where this study took place, a sugar tax was brought in on the 1st of May 2018. The tax enforces an increase of 20cent per litre of drinks that have 5 to 8 grams of sugar per 100ml and 30cent per litre to any drinks with over 8g per litre (INDI, 2018). This tax prompted the beverage industry to change

the recipes of the sugar sweetened beverages and reduce the sugar, thus using more AS in order to protect sales (INDI, 2018). This innovation could help tackle the obesity epidemic, and although this is a positive start, this is just tackling one of many problems contributing to the growth in obesity. One survey carried out by Euromonitor found that the need for artificially sweetened foods has come from consumer attitudes towards added sugars (Euromonitor, 2014); products labelled zero or less calories seem like the healthier option and weight conscious consumers are likely to choose them. It may also be proposed that choosing low calorie options can lead to over consumption of other foods by compensation (Bellisle et al., 2012). Subsequently growth in consumption of AS is inevitable with an extensive range of diet drinks available.

In Ireland there are organisations such as Board Bia, Safe Food and Behaviour and Attitudes (B&A) that monitor and regulate the food and beverage industry. B&A inspect consumer habits; for example the 2017 confidence tracker reported that in 2016 only 56% of the population buy their weekly groceries in one shop (Behaviour & Attitudes, 2017). This indicates more accessibility to shops and supermarkets but also a greater risk of influence by advertising in shops, for example lower fat products which contain AS. Board Bia stated in a report published October 2016 that many consumers associate AS with negative consequences therefore prefer to choose an option which is lower in natural sugar and not replaced with AS (Board Bia 2016). Additionally, Safefood carried out research on a number of different topics; one report published in 2009 investigated the knowledge of consumers in relation to drinks for children. The main findings reported that many parents are aware of hidden sugars in drinks but are confused about which option is most healthy, for example terms labelled on drinks such as ‘diet’ or ‘contains real fruit juices’ can be misleading and cause further confusion (Safefood, 2009).

It is apparent that consumers are interested and concerned about eating healthy and choosing the best option however, many are confused as to what the healthier option is and if consuming AS is safe. The main body in Europe responsible for assessing the safety of consumption of AS and the scientific evidence supporting the health claims associated with AS is the European Food Safety Authority (EFSA). They have permitted 11 AS for use in food products in Europe. These include: Acesulfame-k, Advantame, Aspartame, Cyclamate, Neohesperidine dihydrochalcone, Neotame, Saccharin, Steviol Glycosides, Sucralose, Thaumatin, Aspartame-and Acesulfame salt (EFSA, 2017). These AS have been deemed safe for consumption by the European Commission, Parliament and Council. It is the EFSA's responsibility to ensure all AS on the market have passed rigorous testing, as well as continuously monitoring current sweeteners and the health claims associated with them (EFSA,2017). The EFSA has also set out rules for labels of foods containing AS, stating that the name of the sweetener must be included in the ingredients list, identified as a sweetener (EFSA,2017).

The British Dietetic Association (BDA, 2016) brought out a new policy on sweeteners in November 2016 which takes the findings of the ESFA policies and other recent studies. From this the BDA drafted a document which states the current recommendations on safe consumption and attributes of AS. However, there continues to be many mixed messages and opinions aimed at the general public, which is fuels confusion. This emphasizes the lack of clear concise guidelines on sugar and AS consumption and the importance of rectifying this through research and accessible public health information. To date there is a lack of evidence and studies investigating the public's knowledge and attitudes towards AS exclusively and their current intake of AS. Obtaining this data is important to understand how the information and food labels could be amended and enforced by dietitians in order to help consumers make informed choices.

Methods

Sample

The participants in this study consisted of both males and females aged over 18 years, from a range of occupations and backgrounds. The sample group was recruited from first aid training groups as these particular groups range in ages varying from 18 to 50+ years, education levels and backgrounds. Some participants had more nutritional knowledge than others and in this way it represented the general public, as this is the group of interest. Participants behaviour towards the guidance and current research of the consumption of AS was investigated to evaluate how accurate the general public's knowledge of AS is. The study did not investigate any particular disease or disorder; however, it explored the positive and negative aspects of the consumption of AS. A questionnaire was distributed to 46 participants over a period of six weeks from July 2017 to August 2017. 6 participants declined to fill out the questionnaire leaving 40 completed questionnaires. All 40 questionnaires were filled out correctly and therefore were all regarded in the data results, a response rate of 100%.

Data Collection

The majority of participants were recruited using opportunistic sampling. The organisation running the first aid training was asked for permission and was supportive of the study. This setting was ideal for a questionnaire as the participants were sitting down at a desk and had the time to answer the questions. Ethical approval was granted by an ethics board in Cardiff Metropolitan University prior to collecting data. Other participants were friends and family of the researcher. All participants were recruited and supervised by the researcher and questionnaires were self-distributed.

A relatively large sample size was recruited, ensuring a variable cross-section of the general public, with respect to gender, age, and profession. The larger the sample size the more consistent and accurate the data. This is outlined in Barlett et al., (2001), which gives guidance on determining the required sample size for research studies. In addition, the questionnaires were distributed over a period of six weeks and was returned to me at immediately, anonymously placed into a sealed box by participants. Once the questionnaire was in the box, participants could not reconsider or retract their entry and this was made clear at the start.

Design

The study was designed to investigate the general public's knowledge and awareness of AS, while also examining the consumption of AS in the diet. The questionnaire contained both multiple choice questions and short answer questions see appendix six. This type of questionnaire generated both qualitative and quantitative data. Having both types of data is beneficial in gathering information on how much AS the general public consume, as well as the public's opinions of this topic. The participants were asked in the first question if they felt they had a sweet tooth or not. The main purpose of this question was to ease the participant into the questionnaire. Krosnick (2018) stated that the first few questions in a questionnaire should be pleasant and not difficult to answer, as well as having an element of interest. This style of questioning is more appealing to participants than those requiring long answer or opinion questions (Dillman et al., 1993). Previous nutritional experiments (Bazzano et al., 2002) successfully used a similar method of questioning when investigating consumption. Lindelland and Whitney's Method Variance Model was used in this study to determine assumptions based on current research to help draft the questions for the questionnaire. With this model, common method variables in a cross-sectional study can be identified in order to prevent biased results (Lindelland and Whitney, 2001).

The questions in the survey were chosen to investigate consumer's knowledge on AS by using contradictory questions, for example first asking participants to identify a list of foods they would usually eat which contain AS, and following up by asking them if they consume AS. If the participant provides contradicting answers to each of these questions, it becomes evident that it is not obvious to the general public which foods contain AS. This can eliminate participants providing false data on preference rather than truth (Zaller and Feldman, 1992).

Alternatively, another approach to investigating the public's perceptions of AS and what influences them to consume AS, is to first assess their knowledge with a questionnaire and then give them a leaflet to read with evidence based information regarding AS on it. Afterwards the participants are given a quiz or alternatively asked to take part in an interview or focus group to give their opinions on sweeteners. This method was used by Shim et al. (2011) to examine the effectiveness of leaflets and posters in imparting information to the general public. This approach was not appropriate for this study as it examines the perception and change in knowledge of consumers after information is given, not the current knowledge of the general public towards AS. This method could identify which approach and information method is best for educating the general public on the topic of AS consumption for further research.

Data Analysis

The data was analysed using a coding system shown in the appendix. Each answer was given a number from one to three, according to the option chosen on the quantitative circle answer questions. Giving each answer a number meant it was easier to identify patterns and analyse the data using computer programs. To analyse the qualitative answers in relation to knowledge of AS a marking system was used. The answers which displayed good knowledge of AS were given a point and the answers which did not reflect accurate knowledge of AS were not. This grading system was not to grade the question wrong or right as there is no wrong or right

answer, but rather to monitor the accurate information given by participants to examine their knowledge of AS. For example, in question ten any food may contain AS but good knowledge of AS is shown by a more specific answer, such as sugar-free jelly. See the marking scheme in table one.

The qualitative questions were also used to analyse the consumption of AS and the reasons for this. This was investigated by grouping the answers which displayed accurate knowledge and calculating the percentage of participants who shared the same view.

Results

The study consisted of 40 participants, comprising the full response rate; 30 were female and 10 were male. The largest cohort of participants was in the 40-54 age category with 38% of the participants. The next biggest cohort was over 55 years with 23%, while the 26 to 39 year group was made of 22% of all participants and 17% were between 18 and 25 see figure 1. The mean age of all participants was 43.

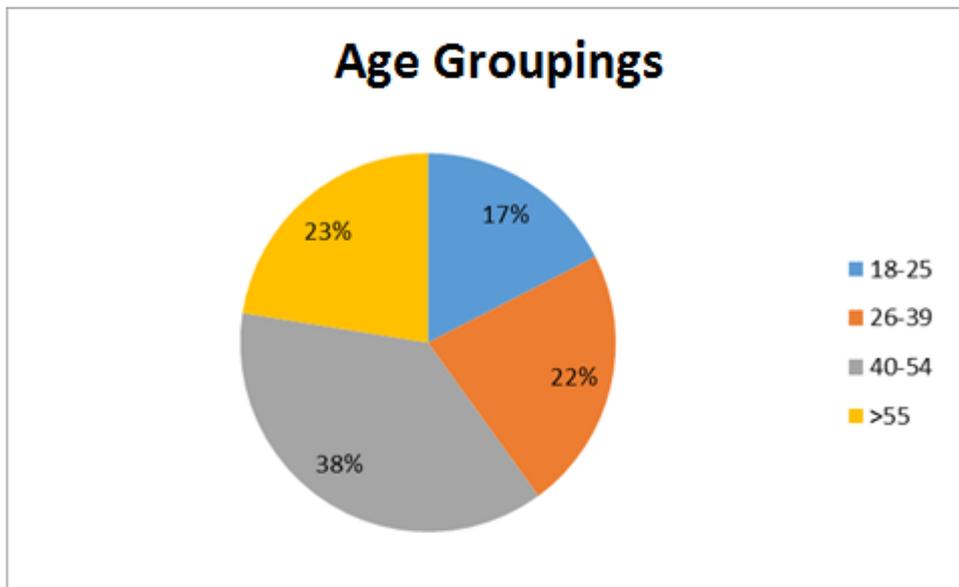


Figure 1 Pie chart displaying age groupings in the population

The dispersal of education levels was as follows: 17 participants completed the Leaving Certificate only, 12 held a Bachelor’s degree, 2 had a Master’s degree and 9 circled other. The participants were asked in the first question if they felt they had a sweet tooth or not as stated earlier, 27 people declared that they had a sweet tooth, 6 of these participants were male and 21 were female. However, because of the unequal numbers in gender, this does not mean more women have a sweet tooth than men. This question is also very subjective as to what is considered to be a sweet tooth.

Only four participants stated that they consciously chose AS instead of sugar. Three of these were female. The known consumption of artificial sweeteners by participants in question six is shown in figure 2. In the questionnaire 40% of participants stated they do consume AS whereas 37% said they did not.

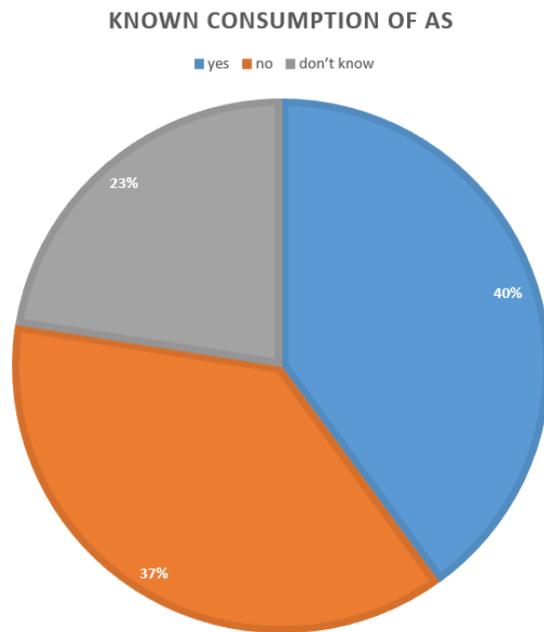


Figure 2 Pie chart displaying percentage of participants with known AS consumption

There were various explanations given for why the participants consumed AS. The main findings were that the majority of participants that consume AS do so because it is in foods they like and avoiding AS entirely is difficult as it is in so many products. All responses are listed in appendix three.

In the multiple-choice questions participants were shown images of different food products: one option with no AS and the other option contained AS. The participants were asked which option they would choose. Firstly the participants were asked about ketchup then yoghurt, squash, jam and soft drinks. The results are shown in the bar chart below. The full sugar options were more popular for all items except for the squash and soft drinks.

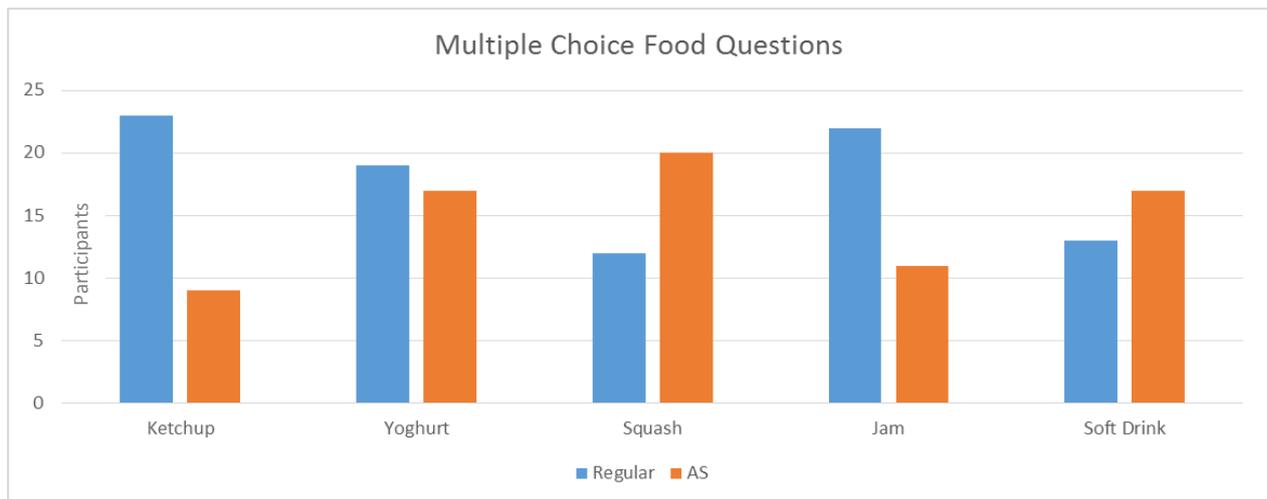


Figure 3 Results of multiple choice food questions of AS containing and regular option foods

When asked if participants would look for and choose a product containing AS over a product sweetened with sugar, 33 responded no. The majority of the cohort stated that they would prefer to choose the sugar sweetened product. There was a large range of answers for question ten which asked participants to list other known foods which contain AS. The most common answers were sugar free options, diet beverages, protein bars, sweets, confectionary and chewing gum. Of all participants, 11 did not answer the question and a further 16 stated they did not know of any other foods.

In the questionnaire, 19 participants declared themselves as parents and only one said they would give AS to their children and added a note to specifying that they would rarely do this, as their child was type one diabetic.

In the questions investigating knowledge of AS and food labels, 15 participants were confident that they could identify AS on labels. Of this 15, 5 participants had a degree and one had a masters. When asked to list any known AS 22 said they could name some AS. Aspartame was the most commonly named with 15 participants identifying it. Canderel which is a brand name

of an AS product was listed by 7 participants. Stevia which is classed as a natural sweetener was named 7 times also.

In the qualitative questions there was a lot of discrepancy in the responses. To analyse the participants answers in relation to knowledge, a grading system was designed, see appendix one. A point was given for every answer showing good knowledge of AS. The points were totalled together, see appendix two. Using the scoring system it was calculated that 24% of the cohort answered the qualitative questions with an accurate knowledge of AS. Males had less knowledge as they only made up 2.5% of the 24%.

The qualitative answers given for each question are listed in appendix two with the comments that participants included. In question eighteen, 24 participants said they either do not know of the health consequences or do not think there are any for example any diseases or symptoms associated with consuming AS. In question nineteen, enquiring if participants believed AS consumption had negative consequences, 29 comments indicated negative consequences such as long term effects of consuming AS linked to cancers, diabetes as well as immediate effects on bowel movements and bloating. The negative effects associated with AS being artificial, manmade products were also a common theme.

Discussion

The population consisted of a wide range of ages, relatively evenly distributed, see figure 1. This allowed quantities of AS consumption and knowledge of AS to be obtained from a range of ages over 18, thereby reflecting the general population. The main aim of the study was to investigate the general public's awareness of AS in foods, and knowledge and consumption of AS; therefore results are discussed under these headings.

Awareness

Question ten exposed confusion about foods containing AS as 16 participants answered that they do not know of other foods which contain AS, and 11 did not answer the question. In contrast to the multiple-choice food questions, where 33 participants stated they would not choose AS containing food products, question eight revealed that 14 of these participants would choose diet soft drinks over regular soft drinks. These results highlight poor awareness of AS containing foods.

The qualitative question asking why participants consciously consume sweeteners revealed that there is some confusion around the products that do and do not contain AS, as there were some discrepancies in the results. For example some participants indicated they do not consume artificial sweeteners while contradicting this by stating they consume AS in foods they like, showing lack of awareness of AS in food products. One female participant stated that she does not like sugar in question 7 but chose full sugar ketchup, squash and jam in the multiple-choice questions, showing evident confusion. Additionally, two participants stated that they prefer the taste of artificial sweeteners in some products. This theme of preferring the AS sweetened products was also displayed in other questions, such as question 10, where some participants reported preferring diet products such as soft drinks. The health benefits of consuming diet drinks did not seem to be a significant factor when choosing an answer, as only one participant

stated dental health as a positive to consuming AS instead of sugar. This highlights inconsistencies in the general public's awareness and preferences of food products containing AS. Moreover, taste preferences may have changed as AS were initially designed to substitute the sweet taste of sugar (Sclafani and Clare, 2004) for various reasons. Examples of these include AS not contributing to weight gain and AS are cheaper to use (Miller and Frattali, 1989) as saccharin is 200-700 times sweeter than sucrose therefore less is needed to sweeten foods (Grenby, 1996). However, the data suggests that the participants chose the AS sweetened drinks as they preferred the taste ultimately and not for other reasons, such as health. It has been proposed that the preference for the taste of AS could be genetic, for example an interesting finding by Bachmanov (2001) states the gene *Tas1r3* responsible for the T1R3 receptor plays a function in the perception of sweet taste. Bachmanov (2001) examined 30 different strains or polymorphisms of this gene in mice in relation to preference for saccharin using DNA sequencing and bottle taste tests. Results displayed that some polymorphisms of *Tas1r3* gene increase the preference for saccharin, therefore the saccharin may act as a substrate to bind and activate the T1R3 G coupled receptor (Bachmanov et al., 2001). Therefore genetics may be the reason why some people prefer the taste of AS to sugar and actively choose to purchase artificially sweetened products (Reed et al., 2004). Furthermore, if the general public now prefer the taste of the AS sweetened products over the sugar sweetened products this raises the question of whether AS will be used instead of sugar in greater numbers of food products in the future, leading to unsafe amounts of AS consumption. Further research should be carried out to investigate if consumers taste preferences are changing with the evolution of new foods products and new methods of manufacturing. The health implications of this will also have to be investigated along with the amount of AS consumed on a daily basis if all food products contained AS.

Additionally AS consumption trends and the reasons why consumers choose AS containing foods over sugar sweetened food products, or vice versa, is currently poorly studied and understood. Reasons for consumption patterns may be due to more behavioural attitudes and taste preferences rather than health benefits. Therefore despite any of the guidelines, the public may choose to consume the food products they enjoy and prefer the taste of regardless of whether they are AS or sugar sweetened which raises the question, is the current generation so accustomed to consuming AS in food products that it is now the preferred taste. Behavioural studies investigating what are the motivational factors that influence food choice in the general public could also help guide future promotions of AS to the public in order to limit confusion.

Knowledge

It was evident from the data that the cohort had poor knowledge of AS and the foods they are in. Only 25% of the qualitative questions were answered showing an accurate knowledge of AS according to guidelines, see appendix one and two. Females had more knowledge of foods containing AS as the responses for question seven were mainly from females. Additionally only 2.5% of the accurate answers in the qualitative questions were given by males, see appendix 1 and 2. Out of the 10 males, one responded yes to AS consumption and stated they do not take sugar as the reason why. Moreover half of the males surveyed stated they did not know if they consciously consumed AS. Two males answered question 7, and one of these answers stated that fruit contained AS, which is misinformed information and shows a lack of knowledge. However, there was some bias in this cohort as 75% of participants were female.

The qualitative questions regarding knowledge of AS were scored quantitatively and used to quantify and compare the level of understanding that the different age groups of participants displayed. For this comparison the cohort was split by age into two groups: under forty years N=16 and over forty years N=24. Analysing the participants answers in both groups by a scoring

system and comparing them, it was evident that the under forty age group had a more accurate knowledge of AS. However, interestingly this was not reflected in the consumption of AS, comparing the consumption of sweeteners in each group in question 5 or 6 showed a similar percentage for each group: 41% in over 40's N=10 and 43.7% in under 40's N=7.

Only one parent said they would give their child AS and they stated that it was because their child had type one diabetes. This shows that parents do not think it is safe enough to give to children. Interestingly many participants who stated that they would not to give it to their children also chose AS sweetened options in the multiple-choice questions and were not able to identify AS on the labels of foods, indicating that they could be giving AS to children unknowingly.

In the qualitative data the main impression the participants seem to have about AS consumption is negative. In total, 29 comments in question nineteen indicated that the majority of the general public think it is harmful to consume AS. Some participants said AS consumption can lead to cancer, diabetes and liver disease. Conversely there were 10 comments promoting health claims in question eighteen. These comments mostly stated health benefits, such as weight loss and reduction to blood sugars. Only one participant, who was female, said that AS can prevent dental caries; no other participant even mentioned dental implications. This shows that even though the prevention of dental caries with AS consumption is highly researched and proven, (Hayes, 2001) the general public either do not know this information or do not feel this is important to them, which may be because taste preference is more important as mentioned earlier. Moreover, the information which is not widely researched, such as AS consumption causing cancers, seems to be greatly believed by the general public. The media is responsible for a lot of what the general public see and believe (NCBI, 2017). Using the data in this study could help formulate useful

information tools directed to the general public on topics such as AS consumption to limit the confusion.

Consumption

The consumption questions asked on the questionnaire revealed that 16 participants actively chose AS while 15 did not and 9 were not sure. It was interesting to note 13 of the participants who declared that they do not consume AS, chose AS options in the multiple-choice questions. A statistical analysis was carried out to investigate the difference in consumption between males and females. Results showed no difference in consumption between gender, p value= 0.878 not significant. Furthermore, 16 participants said they would consume AS, however, 32 stated they were not healthy to consume as shown in figure 4. This re-emphasises the issue of what is influencing the public to choose AS options even when they may feel they are not healthy.

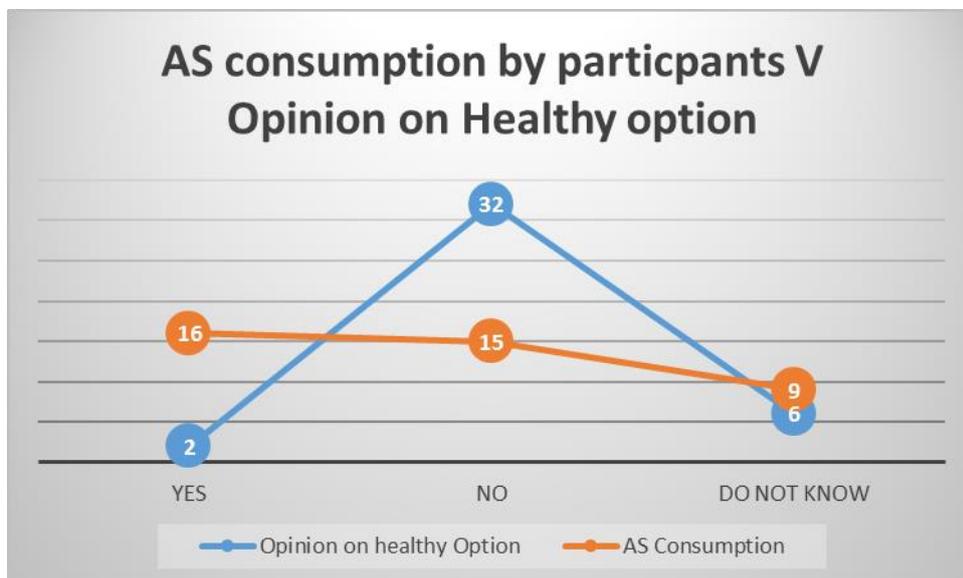


Figure 4 Chosen AS consumption by participants V opinion on healthy option

A chi squared t test was conducted to analyse and compare the difference in consumption of AS in the three education levels; leaving certificate, degree or masters, results showed a non-

significant p value of 0.276. This result establishes that there is no influence in education level on the consumption of AS.

It is interesting to note that 11 participants in the cohort answered question seven revealing they only consume AS because it is in the foods they like to eat and not because they would like to choose AS over sugar. One participant stated it is difficult to avoid them, showing that the consumption of AS is not always optional and consumers may feel a loss of control in the food products.

Also for dental health and reducing the population's obesity problems, many sugary drinks will reduce sugar and replace with AS which again limits the public's choice and makes it difficult to avoid AS in products. This is evident in preparations for the sugar tax introduced this year (INDI, 2018). If consumption of AS is to increase because of taxation and less sugar sweetened options available, then accessible and clear information and knowledge provided to the general public should also increase. More detailed food labelling clearly stating the AS contained and how much is in the product is important to quantify consumption to ensure safe limits.

Limitations

There were limitations to this study; the cohort size could have been bigger for more significant statistical analysis and participants recruited from different parts of the country to ensure less bias in the data. There was also a big discrepancy in the amount of males versus females, which may have skewed the results. More questions to investigate where the participants got their information from would be beneficial to make further recommendations. To investigate why the public choose the food products they consume and what is most important to them when

choosing a product, further research exploring the reasons behind the answers on the questionnaire would be beneficial.

Conclusion

In conclusion, the general public are confused and do not fully understand the health benefits or negative consequences associated with the consumption of AS. Also there is a clear lack of awareness of foods containing AS and a poor knowledge of what they are. There should be clearer messages and information directed towards the general public on AS. As stated, more research into consumption trends, reasons for food choice and sources of information used by the public would be beneficial. AS consumption is increasing with the introduction of the sugar tax, therefore this may be an area public health dietitians should focus on.

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Appendix

Appendix 1: Scoring method for Qualitative questions in regards to knowledge

Appendix 2: Table of points for quantitative analysis of qualitative results

Appendix 3: Answers to Qualitative questions as stated by participants

Appendix 4: Code Sheet for statistics

Appendix 5: Ethics Committee Participant Information Sheet

Appendix 6: Questionnaire on Artificial Sweeteners

Appendix 7: Excel data

Appendix 8: Ethics approval letter

Appendix 9: SPSS Output

Appendix 1: Scoring method for Qualitative questions in regards to knowledge

Qualitative Question	Answers which are worth one point	
Q7. Why do you consume/not consume AS?	<p>If yes to question 6 :</p> <p>Weight loss or to reduce calories</p> <p>To reduce sugar intake</p> <p>Prevent tooth decay</p> <p>Prevent rise in blood sugar</p>	<p>If no to question 6:</p> <p>The possibility of causing weight gain by increasing appetite</p> <p>The possibility of changing gut bacteria</p> <p>Causes laxative effects</p> <p>Avoid because of IBS and gastrointestinal issues</p>
Q 10. Other foods that are known to contain AS	All foods that contain AS for example: Some marinades and sauces, juice drinks, sugar free jelly and spreads, chewing gum and reduces sugar sweets.	
Q15. Listing Names of AS	acesulfame potassium, aspartame, aspartame-acesulfame salt, cyclamate, erythritol, glycerol, glycyrrhizin, hydrogenated starch hydrolysate, isomalt, lactitol, maltitol, mannitol, neotame, polydextrose, saccharin, sorbitol, sucralose, tagatose, xylitol	
Q18. Health Benefits to consuming AS	<p>Weight loss or to reduce calories/ reduce obesity and obesity related diseases</p> <p>To reduce sugar intake</p> <p>Prevent tooth decay</p> <p>Prevent rise in blood sugar / for diabetics</p>	
Q 19. Negative consequences to	The possibility of causing weight gain by increasing appetite	

consuming AS	<p>The possibility of changing gut bacteria</p> <p>Causes laxative effects</p> <p>Avoid because of IBS and gastrointestinal issues</p> <p>Shown to promote cancers in high amounts in rats</p>
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Table 1 Scoring of Qualitative results

Appendix 2: Table of points for quantitative analysis of qualitative results

Qualitative Question	Scores out of 40			
	Male	Female	Total	% of correct answers
Q7. Why do you consume/not consume AS?	0	2	2	5%
Q 10. Other foods that are known to contain AS	0	12	12	30%
Q15. Listing Names of AS	1	13	14	35%
Q18. Health Benefits to consuming AS	3	8	11	27.5%
Q 19. Negative consequences to consuming AS	1	8	9	22.5%
Total:	48 points out of 200			24% of correct answers

Table 2 Scores totalled for each qualitative question

Appendix 3: Answers to Qualitative questions as stated by participants

Question	Answer
Q7. If answered yes to consuming AS why?	In foods which are liked but wouldn't add to other foods
	Only because they are in the products I consume
	Because I would prefer to limit the amount of sugar in my diet
	I don't choose but they are in the foods that I consume but I wouldn't consciously consume them.
	Possibly in products that are low in sugar
	Because I don't know enough about AS. I need to be educated more about the subject and know what to look out for.
	I do not like to consume AS but sometimes they are in foods/drinks when I do not realise
	Less calories
	Because lots of food contain sweeteners, hence consumed without realising
	I try not to eat AS as little as possible but it is in some products of choice
	I do not know as I don't have enough knowledge about sweeteners
	I don't like sugar
	I am aware of artificial sweeteners in the treats I eat cakes, ice cream, chocolate
Q16. Why do you think AS are/ are not a healthy option?	Saw on tv AS being carcinogenic and thinks sugar is fine in moderation
	They are good for weight loss, however reduced sugar foods aren't always healthy
	I know diabetics take it as an alternative to natural sugar but don't know how healthy they are.
	Because it's not real sugar
	Thought it was healthy option but I am not sure
	Because I have been told sweeteners are bad
	Artificial sweeteners can make IBS worse
	People with health issues such as diabetics need sweeteners
	There are always pros and cons of using these

They are artificial I feel.
I read literature about aspartame being very unhealthy and unnatural
Read links between weight gain and gut bacteria documentaries
Linked to cancer
stimulate receptors in the brain to want more
questioning the health implications of sweeteners
bad for you
Because they are not natural
don't know enough about them
its not a natural product and can give you a false sense of contentment
AS are not natural
Diabetes dietitian said to stay away from them to my son who is T1DM as he had diarrhoea after having sugar free sweets/ lolly pop.
Have not seen any evidence to suggest whether it's any better or worse than sugar
I think they cause cancer, diarrhoea and leave an after taste in your mouth
Too much of any type of sweetener are not good for your health
Because they are artificial
Because they contain sugar
Aspartame, saccharin proved to be unsafe, maybe xylitol/stevia are more natural safer?
It does not taste right
Enough sugar in foods we eat
No nutrition in sweeteners
I know they are not healthy but I prefer them to sugar
From watching tv programs about ingredients put in artificial sweeteners. Also facebook has articles on this.
food should not be sweet we are fooling our taste buds all the time
For cholesterol, heart and weight, it is better to avoid sugar
Unsure of benefits of sweeteners
For Diabetics and for people who consume a lot of sugary products

	Reduced kcal intake, and some health conditions
	Maybe to reduce sugar intake
Q.18 Health benefits to consuming AS	Less sugar in the diet is a good thing
	Not that I am aware of
	Not really just maybe for diabetics
	Reduced blood glucose, possibly reduces dental caries
	helps with reduction in sugar intake
	less calories than sugar
	extra energy
	No don't feel satisfied with food containing AS, eat more with sweeteners in it. Better off with less sugar but less of it
	No unless necessary to reduce weight
	Not really just maybe for diabetics
	Weight loss
Q.19 Negative consequences to consuming AS	not really, taken in moderation is probably ok. Most contain some sugar
	May be in the long run but no reason to back that up.
	may cause T2DM, Carcinogenic (aspartame) very expensive
	cancer?
	I do believe there are negative consequences but do not know what they are.
	Over indulgence on AS could be as bad as actually using real sugar
	If you get use to them and keep adding them to foods too much of it can have a negative impact.
	YES I think as they are not natural and have been proven to cause adverse effects to health
	Yes weight gain
	Diarrhoea
	high sugar diet can be toxic linked to heart disease, cancer, diabetes
	Perhaps if taken in large amounts
	yes damaging your liver
yes the fact that it is not natural and chemical based	
causes children to be hyper	

	Not any more than consuming sugar
	Sugar is natural, sweeteners contain harmful chemicals man made.
	I believe sweeteners could cause cancer
	yes because it could cause cancer
	Yes bloating and stomach cramps
	Possible cause of getting diabetes
	yes tooth decay, maybe bad for or induce diabetes
	Yes they can't be good for you in excess
	The ingredients in the AS are not healthy for our bodies
	yes they are unhealthy and bad for us in general
	yes for your heart cholesterol in general health also to maintain healthy weight
	maybe I guess a huge intake would have consequences

Table 3 Qualitative answers

Appendix 4: Code Sheet for statistics

Question	Variable Name	Shortened for SPSS	Coding Instructions	Type of data
1	Sweet tooth	Sweet_th	1= Y 2=N	Nominal
2	Gender	Gender	1= M 2=F	Nominal
3	Age	Age		Scale
4	Education	Edu	1= Leaving cert 2=Degree 3=Masters 4=Other	Ordinal
5	Known consumption of AS in everyday diet	consump	1= Yes 2= No 3= Do Not Know	Nominal
6	Use of AS instead of sugar	AS_sugar	1= Yes 2= No 3= Do Not Know	Nominal
7	If yes why consume AS	AS_why		Qualitative
8 A	Ketchup	Ketchup	1= Regular 2=Reduced sugar 3=Other	Nominal
8 B	Yoghurt	Yoghurt	1= Low Fat 2= Full Fat 3=Other	
8 C	Squash	Squash	1= No added sugar 2= Regular 3= Other	
8 D	Jam	Jam_A	1= Regular 2= Reduced Sugar	

			3= Other	
8 E	Soft Drinks	S_Drinks	1= Regular 2= Diet Soft drinks 3= Other	
9	Choose AS option	ASoption	1= Yes 2= No 3= Do Not Know	Nominal
10	Other AS containing foods	ASfoods		Qualitative
11	Parent	Parent	1= Yes 2= No	Nominal
12	Give AS to kids	AS_kids	1= Yes 2= No 3= Do Not Know	Nominal
13	Identify AS on labels	labels	1= Yes 2= No 3= Somewhat	Nominal
14	Names of AS	Name_AS	1= Yes 2= No 3= Do Not Know	Nominal
15	List	List_AS		Nominal
16	AS healthy option	healthy	1= Yes 2= No 3= Do Not Know	Nominal
17	Why to Q16	Why		Qualitative
18	Health Benefits	Benefits		Qualitative
19	Negative Consequences	Conseq		Qualitative

Appendix 5:

Ethics Committee Participant Information Sheet

Title of Project: Evaluate consumer knowledge of artificial sweeteners and awareness of guidance available to the general public.

Project reference number: 9252

This project involves investigating the knowledge and attitudes of the general public towards sweeteners, by carrying out research on previous studies completed as well as using a questionnaire to obtain more information. The main aim is to find out what the general public currently know about artificial sweeteners and how they consume them. We will then compare this to the public health guidelines and examine if there are discrepancies. We want to find this out in order to help develop future guidelines and analyse the current recommendations based on the research previously conducted.

- This is an invitation to you to join the study, and to let you know what this would involve. The study is being organised by Cliodhna Myles a final year BSc (Hons) Human Nutrition and Dietetic student at Cardiff Metropolitan University
- If you want to find out more about the project, or if you need more information to help you make a decision about joining in, please contact the study supervisor Katherine Gallimore on 02920205675 or email at KGallimore@cardiffmet.ac.uk

Your Participation in the Research Project

Why you have been asked

We are asking males and females aged above 18 to take part. Only friends, family and colleagues of Cliodhna Myles are being invited to take part.

What happens if you want to change your mind?

If you decide to join the study you can change your mind and stop part way through completing the questionnaire. You will not be asked why you've stopped. We will completely respect your decision. If you choose to complete the questionnaire in full, you are consenting to take part in the research. Once the questionnaire has been submitted you will not be able to withdraw at that stage as all responses are anonymous.

What would happen if you join the study?

If you agree to join the study, then we will ask you to complete a questionnaire about your opinion and consumption of artificial sweeteners. This will be given to you, and we think this would take you about 10-15 minutes to complete and hand back to us.

Are there any risks?

We do not think there are any significant risks if you take part in the study.

Any special precautions needed?

None

What happens to the questionnaire results?

Cliodhna Myles is responsible for putting all the information from the study into a computer programme. We will then analyse the data to see if there is a link between the results and the guidance for consumption of sweeteners for the general public.

Are there any benefits from taking part?

There are no direct benefits to you for taking part.

How we protect your privacy:

All the information we get from you is anonymous, and everyone working on the study will respect your privacy.

-
-
8. Please tick the options you would consume, please do not take the brands into consideration just the product itself. (If neither option applies please leave blank or state what option you would normally choose)



Normal Ketchup



50% Reduced sugar Ketchup

Other



Low fat fruit yoghurt



Full fat fruit yoghurt

Other



No added sugar



Regular squash

Other

Squash



Fruit Jam



Reduced sugar jam

Other



Soft Drink



Diet soft drinks

Other

9. If you were choosing a food product in the shop would you look for the option containing sweeteners?
know Yes No Do not
10. Are there any other foods you consume which you know contain sweeteners? _____
11. Are you a parent? Yes No
12. If yes to question 11. Would you give sweeteners to you kid/s?
Know Yes No Do not
13. Would you be able to identify foods containing sweeteners from reading food labels?
Somewhat Yes No
14. Do you know any names of sweeteners?
not Know Yes No Do
15. If yes what ones? _____
16. Do you think sweeteners are a healthy option?
Know Yes No Do Not

17. Please state why you picked the answer to question 16.

18. Do you believe there are any health benefits to consuming sweeteners?

19. Do you believe there are any negative consequences to consuming sweeteners?

Thank you for participating

Question	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19				
Question	Sweet tooth	Gender	Age	Education	AS alternative to sugar	Known consumption of AS in everyday diet	If yes why consume	Ketchup	Yoghurt	Squash	Jam	Soft Drink	Choose AS option	Other AS containing foods	Parent	Give AS to kids	Identify AS on labels	Names of AS Listed	AS healthy option	Why to Q16	Health Benefits	Negative Consequences	
Participant 1	1	1	25y	1m	2	2	2	1	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1
2	2	2	25y	2m	2	2	2	1	2	2	1	2	2	2	2	2	2	2	2	2	2	2	2
3	1	1	28y	1m	2	3	3	1	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1
4	2	2	40y	4	2	2	2	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2
5	2	2	33y	2	2	3	3	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
6	2	2	124y	11m	2	3	3	1	2	2	2	1	1	2	2	2	2	2	2	2	2	2	2
7	1	1	27y	6m	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
8	1	1	62y	1m	2	2	2	1	2	1	1	2	2	2	2	2	2	2	2	2	2	2	2
9	2	2	49y	1m	2	2	2	2	2	2	1	2	2	2	2	2	2	2	2	2	2	2	2
10	2	2	25y	6m	2	2	2	1	2	1	1	2	2	2	2	2	2	2	2	2	2	2	2
11	1	1	23y	4	2	2	2	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
12	1	1	25y	3	2	2	2	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
13	1	1	22y	9m	2	2	2	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
14	1	1	26y	1	2	2	2	1	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1
15	1	1	28y	9m	2	2	2	1	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1
16	2	2	44y	2	2	3	3	na	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
17	1	1	45y	1	2	2	2	1	2	1	1	2	2	2	2	2	2	2	2	2	2	2	2
18	2	2	40y	1	2	2	2	1	2	1	1	2	2	2	2	2	2	2	2	2	2	2	2
19	1	1	125y	3m	2	2	2	na	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
20	1	1	159y	2m	2	2	2	na	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
21	1	1	230y	5m	4	2	2	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
22	1	1	155y	3m	4	2	2	1	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1
23	2	2	45y	2	2	2	2	na	2	1	1	2	2	2	2	2	2	2	2	2	2	2	2
24	1	1	23y	1	1	1	1	na	2	1	1	2	2	2	2	2	2	2	2	2	2	2	2
25	1	1	256y	8m	2	2	2	1	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1
26	2	2	15y	1	2	2	2	1	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1
27	1	1	27y	4	2	2	2	na	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1
28	1	1	27y	1	2	2	2	1	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1
29	1	1	249y	5m	2	2	2	1	2	1	1	2	2	2	2	2	2	2	2	2	2	2	2
30	1	1	23y	2	2	2	2	1	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1
31	1	1	15y	1	1	1	1	1	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1
32	1	1	25y	2m	2	2	2	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
33	2	2	149y	7m	2	2	2	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
34	2	2	24y	4	2	2	2	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
35	1	1	14y	4	2	2	2	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
36	2	2	24y	9m	3	1	1	1	2	1	2	1	1	1	1	1	1	1	1	1	1	1	1
37	1	1	24y	4	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
38	2	2	25y	5m	2	2	2	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
39	1	1	26y	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
40	1	1	234y	9m	4	2	2	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2

Appendix 8: Ethics approval letter



Cardiff
Metropolitan
University

Prifysgol
Metropolitan
Caerdydd

[REDACTED]
BSc (Hons) Human Nutrition & Dietetics
Cardiff School of Health Sciences

Dear Applicant

**Re: Application for Ethical Approval: Consumer perceptions and knowledge on artificial sweeteners
Project Reference Number : 9252**

Your ethics application, as shown above, was considered by the Health Care and Food Ethics Panel on **05/07/2017**.

I am pleased to inform you that your application for ethical approval was **APPROVED**.

Minor issues may still need addressing before you commence any work – if so these will be listed below.

N/A

Where changes to the information sheet, consent form and/or procedures are deemed necessary you must submit revised versions to the relevant ethics inbox. If you are a student – your supervisor must do this on your behalf.

Note: Failure to comply with any issues listed above will nullify this approval.

Standard Conditions of Approval

1. Your Ethics Application has been given a Project Reference number as above. This **MUST** be quoted on all documentation relating to the project (E.g. consent forms, information sheets), together with the full project title.
2. All documents must also have the approved University Logo and the Version number in addition to the reference and project title as above
3. A full **Risk Assessment** must be undertaken for this proposal, as appropriate, and be made available to the Committee if requested.
4. Any changes in connection to the proposal as approved, must be referred to the Panel/Committee for consideration **without delay quoting your Project Reference Number**. Changes to the proposed project may have ethical implications so must be approved.
5. Any untoward incident which occurs in connection with this proposal must be reported back to the Panel **without delay**.
6. If your project involves the use of **human samples**, your approval is given on the condition that you or your supervisor **notify the HTA Designated Individual** of your intention to work with such material by **completing** the form entitled "*Notification of Intention to Work with Human Samples*". The form must be submitted to the PD (Sean Duggan), **BEFORE** any activity on this project is undertaken

Cardiff School of Health Sciences	TelephoneFfôn
Western Avenue,	+44(0)29 2041 6070
Cardiff, CF5 2YB	FaxFfacs
Ysgol Gwyddorau Iechyd Caerdydd	+44 (0)29 2041 6982
Rhodfa'r Gorllewin,	
Caerdydd, CF5 2YB	www.cardiffmet.ac.uk

This approval expires on **05/07/2018** . It is your responsibility to reapply / request extension if necessary.

Yours sincerely

[Redacted signature]

[Redacted]
[Redacted] **Healthcare and Food Ethics Panel**
Cardiff School of Health Sciences
Llandaf Campus
Western Avenue, Cardiff CF5 2YB

[Redacted]
[Redacted]
[Redacted]

PLEASE RETAIN THIS LETTER FOR REFERENCE

Appendix 9: SPSS Output

Crosstabs

Notes

Output Created		30-APR-2018 20:22:03
Comments		
Input	Data	H:\My Documents\dis done.sav
	Active Dataset	DataSet2
	Filter	<none>
	Weight	<none>
	Split File	<none>
	N of Rows in Working Data File	43
Missing Value Handling	Definition of Missing	User-defined missing values are treated as missing.
	Cases Used	Statistics for each table are based on all the cases with valid data in the specified range(s) for all variables in each table.
Syntax		CROSSTABS /TABLES=V5 BY V6 /FORMAT=AVALUE TABLES /STATISTICS=CHISQ /CELLS=COUNT /COUNT ROUND CELL.
Resources	Processor Time	00:00:00.00
	Elapsed Time	00:00:00.00
	Dimensions Requested	2
	Cells Available	349496

Case Processing Summary

	Valid		Cases Missing		Total	
	N	Percent	N	Percent	N	Percent
V5 * V6	41	95.3%	2	4.7%	43	100.0%

V5 * V6 Crosstabulation

Count

		V6				Total
		Yes	No	Do not know	5	
V5	Leving Cert	2	15	0	0	17
	Degree	1	11	0	0	12
	Masters	1	1	0	0	2
	Other	0	8	1	1	10
Total		4	35	1	1	41

Chi-Square Tests

	Value	df	Asymptotic Significance (2- sided)
Pearson Chi-Square	10.990 ^a	9	.276
Likelihood Ratio	9.796	9	.367
Linear-by-Linear Association	3.963	1	.046
N of Valid Cases	41		

a. 13 cells (81.3%) have expected count less than 5. The minimum expected count is .05.

Crosstabs

Notes

Output Created	30-APR-2018 20:19:23	
Comments		
Input	Data	H:\My Documents\dis done.sav
	Active Dataset	DataSet2
	Filter	<none>
	Weight	<none>
	Split File	<none>
	N of Rows in Working Data File	43
Missing Value Handling	Definition of Missing	User-defined missing values are treated as missing.

Cases Used		Statistics for each table are based on all the cases with valid data in the specified range(s) for all variables in each table.
Syntax	CROSSTABS /TABLES=V3 BY V6 /FORMAT=AVALUE TABLES /STATISTICS=CHISQ /CELLS=COUNT /COUNT ROUND CELL.	
Resources	Processor Time	00:00:00.02
	Elapsed Time	00:00:00.02
	Dimensions Requested	2
	Cells Available	349496

[DataSet2] H:\My Documents\dis done.sav

Case Processing Summary

	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
V3 * V6	41	95.3%	2	4.7%	43	100.0%

V3 * V6 Crosstabulation

Count

		V6			5	Total
		Yes	No	Do not know		
V3	Male	1	9	0	0	10
	Female	3	26	1	1	31
Total		4	35	1	1	41

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	.679 ^a	3	.878

Likelihood Ratio	1.152	3	.765
Linear-by-Linear Association	.378	1	.539
N of Valid Cases	41		

a. 6 cells (75.0%) have expected count less than 5. The minimum expected count is .24.