



Prize Winner

Scientific Inquiry

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CHOCOLATE CHIP COOKIE MODIFICATION FOR DIVERTICULAR DISEASE

Effect on sensory appeal

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Effect on Sensory Appeal

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CHOCOLATE CHIP COOKIE MODIFICATION FOR DIVERTICULAR DISEASE EFFECT ON SENSORY APPEAL

DIVERTICULAR DISEASE – A COMMON HEALTH PROBLEM

Diverticular disease is a condition characterized by the formation of pouches (diverticula) in the lining of the bowel. Prior to the 20th century, diverticular disease was rare, but over the past century diverticular disease has become one of the most common health problems in the Western world due to the increased consumption of processed foods.¹ Previously mainly effecting the elderly community, diverticular disease is now also occurring in individuals under the age of 40.²

Diverticular disease predominantly effects the sigmoid colon but can occur everywhere in the large bowel.³ It includes two conditions, diverticulosis and diverticulitis. The presence of diverticula is called diverticulosis. Diverticula develop when naturally weak spots in the bowel wall give way under pressure, causing pouches to protrude⁴. Diverticulitis is a condition which develops when faeces becomes trapped in the diverticula, thus encouraging bacterial growth, inflammation and potential infection (see figure 1).⁴

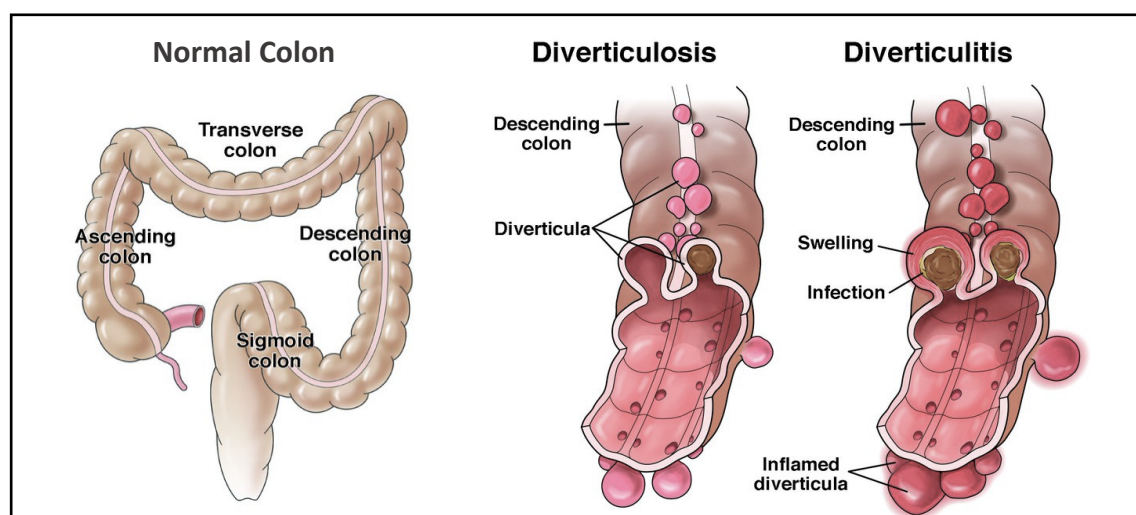


Figure 1: Normal colon vs colon with diverticulosis or diverticulitis

Diverticulosis may remain asymptomatic when diverticula are small and few.⁵ However, with increasing number and size the diverticula can inhibit the normal functioning of the large bowel and lead to symptoms such as excess flatulence, abdominal pain, blood in faeces and bowel movements alternating between constipation and diarrhoea.⁵ Diverticulosis may develop into diverticulitis at any stage and thus causing more significant symptoms, including fever due to infection, abdominal pain, nausea and distention of the abdomen.⁴ Complications of diverticulitis often result from a perforation of the bowel, allowing the bowel content to leak into the abdominal cavity, potentially causing a life-threatening infection.⁴ The complications of a diverticulitis can be viewed in table 1⁶. Mild diverticulitis can be treated with rest, changes in diet and antibiotics.⁷ Severe or recurring diverticulitis may require surgery.⁷

¹ Ambrosetti, P., Gervaz, P. and Fossung-Wiblishauser, A., 2012. Sigmoid diverticulitis in 2011: many questions; few answers. *Colorectal Disease*, 14(8), pp. e439-e446.

² Floch, M., 2008. Colonic Diverticulosis and Diverticulitis: National Diverticulitis Study Group, 2008 Update. *Journal of Clinical Gastroenterology*, 42(10), pp.1123-1124.

³ Fong, S., Tan, E., Foo, A., Sim, R. and Cheong, D., 2011. The changing trend of diverticular disease in a developing Nation. *Colorectal Disease*, 13(3), pp.312-316.

⁴ Floch, M., 2008. Colonic Diverticulosis and Diverticulitis: National Diverticulitis Study Group, 2008 Update. *Journal of Clinical Gastroenterology*, 42(10), pp.1123-1124.

⁵ Floch, M., 2008. Colonic Diverticulosis and Diverticulitis: National Diverticulitis Study Group, 2008 Update. *Journal of Clinical Gastroenterology*, 42(10), pp.1123-1124.

⁶ Ambrosetti, P., Gervaz, P. and Fossung-Wiblishauser, A., 2012. Sigmoid diverticulitis in 2011: many questions; few answers. *Colorectal Disease*, 14(8), pp. e439-e446.

⁷ Ambrosetti, P., Gervaz, P. and Fossung-Wiblishauser, A., 2012. Sigmoid diverticulitis in 2011: many questions; few answers. *Colorectal Disease*, 14(8), pp. e439-e446.

Table 1: Diverticulitis complications

| Diverticulitis complications | |
|------------------------------|---|
| Abscess | A painful and infected pus-filled collection associated with the bowel. |
| Fistula | An abnormal connection between two hollow organs. The most common fistula caused by diverticular disease is in between the large bowel and the bladder. |
| Obstruction | A blockage of bowel causing faeces build up |
| Peritonitis | Infection of the abdominal cavity as a result of the perforation of the bowel wall and leakage of bowel content. |
| Sepsis | A life-threatening reaction to an infection which leads to the failure of multiple organs |

Constipation and straining to pass hard stool can cause increased pressure within the bowel, which is one of the main reasons for the formation of diverticula and a subsequent diverticulosis⁸. Therefore, regular exercise, fibre intake and lifestyle management are key factors in improving gut motility and protecting against diverticular disease.⁹

DIET MODIFICATION FOR DIVERTICULAR DISEASE

Obesity, diets high in saturated fat and low in fibre, ageing and lack of exercise all increase the risk of developing diverticular disease.¹⁰ Diet modification plays a pivotal role in the prevention of diverticulitis. Fibre is especially important as it helps the digestive system to function more effectively, allowing the faeces to pass readily through the gastrointestinal tract, thus reducing the amount of pressure on the intestinal walls.¹¹ Food selections are therefore essential for prevention and management of diverticular disease.¹²

The aim of this investigation is to modify a recipe for chocolate chip cookies to make them more suitable for the prevention and management of diverticular disease. This will be achieved by reducing saturated fat content and energy as well as increasing levels of fibre to help the passage through the gastrointestinal tract. The ingredients and their substitutions can be seen in table 2.

Table 2: TASTE.com chocolate chip cookie ingredients vs the modified chocolate chip cookie ingredients

| Original recipe | Modified recipe for diverticular disease |
|---|--|
| 150g butter | 50g margarine |
| | 100g cooked mashed sweet potato |
| ½ cup brown sugar | ½ cup brown sugar |
| ½ cup caster sugar | ½ cup caster sugar |
| 1 egg | 1 egg |
| Pinch of salt | Pinch of salt |
| 1 tsp baking soda | 1 tsp baking soda |
| 1 ¾ cup plain flour | 1 ¾ cup wholegrain flour |
| 1 tsp vanilla extract | 1 tsp vanilla extract |
| ½ cup plain chocolate chips | ½ cup plain chocolate chips |
| ½ cup dark chocolate pieces, plus 1 tsp extra | ¾ cup wholegrain oats |

⁸ Ambrosetti, P., Gervaz, P. and Fossung-Wiblishauser, A., 2012. Sigmoid diverticulitis in 2011: many questions; few answers. *Colorectal Disease*, 14(8), pp. e439-e446.

⁹ Narula, N. and Marshall, J., 2010. Role of probiotics in management of diverticular disease. *Journal of Gastroenterology and Hepatology*, 25(12), pp.1827-1830.

¹⁰ Kim, Y., Kim, Y., Bae, I., Lee, H. and Lee, S., 2013. Preparation of dietary fibre-enriched materials from preharvest dropped apples and their utilisation as a high-fibre flour substitute. *Journal of the Science of Food and Agriculture*, 93(8), pp.1974-1978.

¹¹ Kim, Y., Kim, Y., Bae, I., Lee, H. and Lee, S., 2013. Preparation of dietary fibre-enriched materials from preharvest dropped apples and their utilisation as a high-fibre flour substitute. *Journal of the Science of Food and Agriculture*, 93(8), pp.1974-1978.

¹² Ambrosetti, P., Gervaz, P. and Fossung-Wiblishauser, A., 2012. Sigmoid diverticulitis in 2011: many questions; few answers. *Colorectal Disease*, 14(8), pp. e439-e446.

As can be noticed in table 2, the substituted cookies contain 50g of margarine and 100g of cooked mashed sweet potato instead of 150 grams of butter. The substitution of the butter removes a source of saturated fat and cholesterol in the cookies and lowers the energy provided by the fat component from 4,119kj per batch to 1,844kj.¹³ The reduction in energy density of the cookies can be helpful for the management of obesity, a major risk factor for diverticular disease. The addition of sweet potato not only reduces the energy content of the cookies but also increases the soluble fibre content, adding 3 grams of dietary fibre per cookie batch.¹⁴ Similarly, the addition of wholegrain oats in place of the dark chocolate pieces also increases the soluble and insoluble fibre content by adding 7.2 grams of dietary fibre, and reduces the energy density of the modified cookies.¹⁵ The addition of the oats in place of the dark chocolate pieces also reduces the sugar content of the cookies, which can be beneficial in preventing obesity. Oats have also been shown to aid the reduction of blood cholesterol levels.¹⁶ Finally, the flour in the cookies has also been modified by substituting wholemeal flour for plain flour. Though this has no major effect on the energy content, wholemeal flour is less processed than plain flour and contains higher levels of fibre. In white flour most of the fibre has been removed through the milling process, whereas the less processed wholemeal flour still contains much of natural fibre. Therefore, the use of wholemeal flour adds 26.5 grams of dietary fibre per batch of cookies.¹⁶

Overall, through changes of the recipe, the modified cookies contain less than half the amount of cholesterol, less than 1/5 of the saturated fat and almost 7 times the amount of dietary fibre per cookie than the original ones. The nutritional values per cookie for the unmodified and modified recipe are listed in figures 2 and 3.¹⁷

| Nutrition Facts | |
|--|----------------|
| Servings: 17 | |
| Amount per serving | |
| Calories | 181 |
| | % Daily Value* |
| Total Fat 9.2g | 12% |
| Saturated Fat 5.6g | 28% |
| Cholesterol 29mg | 10% |
| Sodium 138mg | 6% |
| Total Carbohydrate 24g | 9% |
| Dietary Fiber 0.4g | 1% |
| Total Sugars 13.3g | |
| Protein 2.1g | |
| Vitamin D 6mcg | 29% |
| Calcium 9mg | 1% |
| Iron 1mg | 5% |
| Potassium 25mg | 1% |
| *The % Daily Value (DV) tells you how much a nutrient in a food serving contributes to a daily diet. 2,000 calorie a day is used for general nutrition advice. | |

Figure 2: Nutritional value per cookie for the **original TASTE.com cookie**, variations may occur due to differences in size of cookies and differences in ingredients used, i.e. brand

| Nutrition Facts | |
|--|----------------|
| Servings: 17 | |
| Amount per serving | |
| Calories | 159 |
| | % Daily Value* |
| Total Fat 3.1g | 4% |
| Saturated Fat 0.6g | 3% |
| Cholesterol 10mg | 3% |
| Sodium 114mg | 5% |
| Total Carbohydrate 29.1g | 11% |
| Dietary Fiber 2.7g | 10% |
| Total Sugars 10.8g | |
| Protein 4.1g | |
| Vitamin D 1mcg | 5% |
| Calcium 11mg | 1% |
| Iron 1mg | 3% |
| Potassium 52mg | 1% |
| *The % Daily Value (DV) tells you how much a nutrient in a food serving contributes to a daily diet. 2,000 calorie a day is used for general nutrition advice. | |

Figure 3: Nutritional value per cookie for the **modified cookie**, variations may occur due to differences in size of cookies and differences in ingredients used, i.e. brand

¹³ Hooper, B., Spiro, A. and Stanner, S., 2015. 30 g of fibre a day: An achievable recommendation?. *Nutrition Bulletin*, 40(2), pp.118-129.

¹⁴ Kim, Y., Kim, Y., Bae, I., Lee, H. and Lee, S., 2013. Preparation of dietary fibre-enriched materials from preharvest dropped apples and their utilisation as a high-fibre flour substitute. *Journal of the Science of Food and Agriculture*, 93(8), pp.1974-1978.

¹⁵ Fayet-Moore, F., Cassettari, T., Tuck, K., McConnell, A. and Petocz, P., 2018. Dietary Fibre Intake in Australia. Paper II: Comparative Examination of Food Sources of Fibre among High and Low Fibre Consumers. *Nutrients*, 10(9), p.1223.

¹⁶ Kim, Y., Kim, Y., Bae, I., Lee, H. and Lee, S., 2013. Preparation of dietary fibre-enriched materials from preharvest dropped apples and their utilisation as a high-fibre flour substitute. *Journal of the Science of Food and Agriculture*, 93(8), pp.1974-1978.

¹⁷ Hooper, B., Spiro, A. and Stanner, S., 2015. 30 g of fibre a day: An achievable recommendation?. *Nutrition Bulletin*, 40(2), pp.118-129.

PRACTICAL INVESTIGATION

INTRODUCTION

Diverticular disease is increasing in prevalence in the Western world, and more people than ever before are suffering from diverticulitis.¹⁸ Diverticular disease is often attributed to a diet low in fibre and high in saturated fat. Food selection can therefore be pivotal in avoiding a diverticulitis. Important factors contributing to food selection are an individual's physiological, social and economic status.¹⁹ A person's ability to afford food is one of the primary determinants to food selection, with those from a lower socioeconomic standing more frequently consuming an unbalanced diet rich on processed food²⁰. Furthermore, time constraints in the modern world also influence food choices, preventing people from choosing the healthy option instead of going for convenience.²¹

However, the basic biology underlying food intake is closely linked to pleasure.²² The pleasure and palatability of food is determined by the five senses: sight, smell, touch, taste and sound. Those senses can be used to judge a food product's taste, appearance, smell and texture, thus the sensory appeal of the food.²³ The sensory appeal of the food can increase or decrease the desire to consume it. One of the primary objectives of the food industry is therefore to determine how food products affect consumers' senses and willingness to consume them.²³ Sensory factors are also a primary concern for dietitians and nutritionists when undertaking modifications to recipes to make them healthier. As our senses act as the determinant for food consumption, consumer perception is considered a vital measure of food development.²⁴ The drive to consume pleasurable and sensory appealing food is increasing the rates of diverticular disease. Foods high in fibre and low in saturated fat, ideal for the prevention of diverticular disease, i.e. All Bran®, are often linked with low sensory appeal.²⁴ It is paramount to develop food with both a high fibre content and high sensory appeal to encourage the consumption of foods high in fibre within the population, therefore reducing the levels of diverticular disease.

An investigation was undertaken to compare the sensory appeal of chocolate chip cookies produced with a modified recipe to help prevent diverticular disease versus cookies made with the original recipe. The modified cookies contained margarine, sweet potato, oats and wholemeal flour instead of butter, dark chocolate chips and plain flour. The aim was to increase the fibre content and to reduce saturated fat as well as energy content of the cookies. From the investigation the superior sensory appeal of one of the two cookie types and factors affecting the sensory appeal were determined.

PURPOSE

To evaluate the sensory appeal of TASTE.com chocolate chip cookies in comparison to modified chocolate chip cookies that are more suitable for people suffering from diverticular disease.

HYPOTHESIS

The original TASTE.com chocolate chip cookies will have a greater all-round sensory appeal compared to the modified cookies due to higher fat and sugar content compared to the modified version.

INDEPENDENT VARIABLE

Variation in the type of chocolate chip biscuits tested (modified chocolate chip cookie for diverticular disease (cookie B) and unmodified TASTE.com chocolate chip cookies (cookie A)).

DEPENDENT VARIABLE

The sensory appeal of the cookies (crunchiness, overall taste, overall appearance, moreishness and appetising smell)

¹⁸ Ambrosetti, P., Gervaz, P. and Fossung-Wiblishauser, A., 2012. Sigmoid diverticulitis in 2011: many questions; few answers. *Colorectal Disease*, 14(8), pp. e439-e446.

¹⁹ Lahne, J., 2016. *Sensory science, the food industry, and the objectification of taste. Anthropology of food*, (10).

²⁰ Kim, Y., Kim, Y., Bae, I., Lee, H. and Lee, S., 2013. Preparation of dietary fibre-enriched materials from preharvest dropped apples and their utilisation as a high-fibre flour substitute. *Journal of the Science of Food and Agriculture*, 93(8), pp.1974-1978.

²¹ Kim, Y., Kim, Y., Bae, I., Lee, H. and Lee, S., 2013. Preparation of dietary fibre-enriched materials from preharvest dropped apples and their utilisation as a high-fibre flour substitute. *Journal of the Science of Food and Agriculture*, 93(8), pp.1974-1978.

²² Korver, O., 1993. Dietary fats: Determinants of preference, selection and consumption. *Trends in Food Science & Technology*, 4(4), p.122.

²³ Conner, M., 1993. Understanding Determinants of Food Choice: Contributions from Attitude Research. *British Food Journal*, 95(9), pp.27-31.

²⁴ Ambrosetti, P., Gervaz, P. and Fossung-Wiblishauser, A., 2012. Sigmoid diverticulitis in 2011: many questions; few answers. *Colorectal Disease*, 14(8), pp. e439-e446.

FACTORS KEPT CONSTANT**Table 3.** factors kept constant in the investigation

| Factor kept constant | How it is kept constant | Why it is kept constant |
|-----------------------------------|--|---|
| Sensory evaluation score card | By using the same sensory evaluation card for both the modified and the non-modified cookies | Ensures that the sensory factors, i.e. texture, flavour and scent, tested are the same and use the same scale for both cookies and can be compared across the trial. |
| Size of the cookies (sample size) | The cookies will be weighed to 15 grams to ensure that the size of the cookies is the same for both types - A and B. | To ensure that the tester is not influenced by inconsistencies in the size of the cookies. As research has shown that humans are biased towards food of bigger size and thus prefer food larger in size. ²⁵ |
| Oven used | By using the same oven for all batches of cookies baked (cookies A and cookies B) | The use of the same oven ensures that the degree of baking is not an influential factor causing differences in the sensory appeal of the two cookies which ensures that any differences between the 2 cookies is only due to the selected modifications |
| Baking time | By baking all batches of cookies for 12 min | A constant baking time for all cookies will avoid inconsistencies in the texture and flavour of the cookie due to differences in the amount of heat exposed to. Therefore, allowing effect substitutions on the sensory appeal of the cookies to be reliably determined. |
| Mass of sugar used | Use ½ of brown sugar and ½ a cup of white sugar | Sugar provides sweetness to the cookies and allows the cookie to caramelize, therefore effecting the texture and overall flavour of the cookies. Thus, maintaining an equal quantity of sugar for both cookies ensures that the effect of the designated modifications on the cookies texture and flavour can be compared. |
| Volume of vanilla extract used | By using 1 teaspoon of vanilla extract for both recipes | Vanilla extract contributes to the overall smell and taste of the cookies however is not a designated modification therefore it is ensured that the same volume of vanilla extract is used in both cookies to guarantee that all sensory differences in the cookies are only present due to the selected modifications |
| Temperature of cookies | By ensuring that the cookies are at room temperature for all testers | To ensure that the testers are not influenced by the temperature of the sample the sample temperature is kept constant. Higher temperatures of a cookie typically intensifies the flavour. Therefore, maintaining an equal temperature of samples when tested ensures that the testers are only influenced by the modifications made to the recipe rather than other factors. |

LOGBOOK

- appendix 1

PROCEDURE

- View appendix 2 and 3

RAW RESULTS and SAMPLE CALCULATIONS

- See appendix 5

PROCEDURE

- see appendix 3

SET UP

- see appendix 3

SENSORY EVALUATION CARDS

- see appendix 3

²⁵ Lahne, J., 2016. Sensory science, the food industry, and the objectification of taste. *Anthropology of food*, (10).

RISK PROCEDURE

Table 4. Risk procedure for the investigation

| Risk | Safety procedure |
|--------------------------------|---|
| Allergies | This investigation uses flour, eggs, oats and many other allergens. Therefore, any participants and investigators will be asked about allergens and will be made aware of all ingredients used. It will be ensured that if anyone has a potentially problematic allergy that they are not brought in contact with any of the products. It will also be ensured that prior to and following production that all areas of use are disinfected and cleaned to avoid the spread of allergens. |
| Cross contamination | As the experiment relies on the consumption of products, cross contamination is a great risk. Therefore, hands will be washed, areas will be disinfected prior to and following use. It will also be ensured that products are placed reasonably apart to make sure that participants only touch the sample they will consume. |
| Covid-19 | All participants will be asked to line up 1.5 metres apart and will be asked to take samples one by one, to maintain Covid-19 social distancing guidelines. Participants will also be asked to wash/sanitise hands prior to and following testing |
| Oven and hot kitchen equipment | Heat proof materials, i.e. oven mitts and tea towels, will be used when handling the oven or contents from the oven. Care will be taken when items are removed from the oven and all people in the kitchen will be made aware of the hot equipment. |
| Electrical whisk | The electrical whisk will not be used close to a source of water. It is ensured that the whisk starts at a low speed level and slowly gets faster to ensure that contents do not splatter, causing potential hazards. Hair will always be worn up to avoid getting caught in the electrical whisk. |
| Spills | Any spills will be immediately cleaned up. Everyone will be made aware if a spill occurs. Closed toe shoes will always be worn. Baggy clothing, i.e. blazers, will not be worn to avoid knocking over equipment. |

ETHICAL CONSIDERATIONS

Table 5. Ethical considerations for the investigation

| Ethical risk | Procedure |
|-----------------|---|
| Food waste | Food waste is a complex ethical issue, therefore only enough samples for the number of participants will be produced to reduce the amount of the food waste. If samples are left over, they will be eaten later rather than thrown away. |
| Confidentiality | Due to that the study involves the personal opinions of the participants regarding their sensory evaluation of the two different cookies. Therefore, to ensure that the participants right to confidentiality is maintained it is ensured that the sensory evaluation is completed completely anonymously with the omission of any names and personal details |

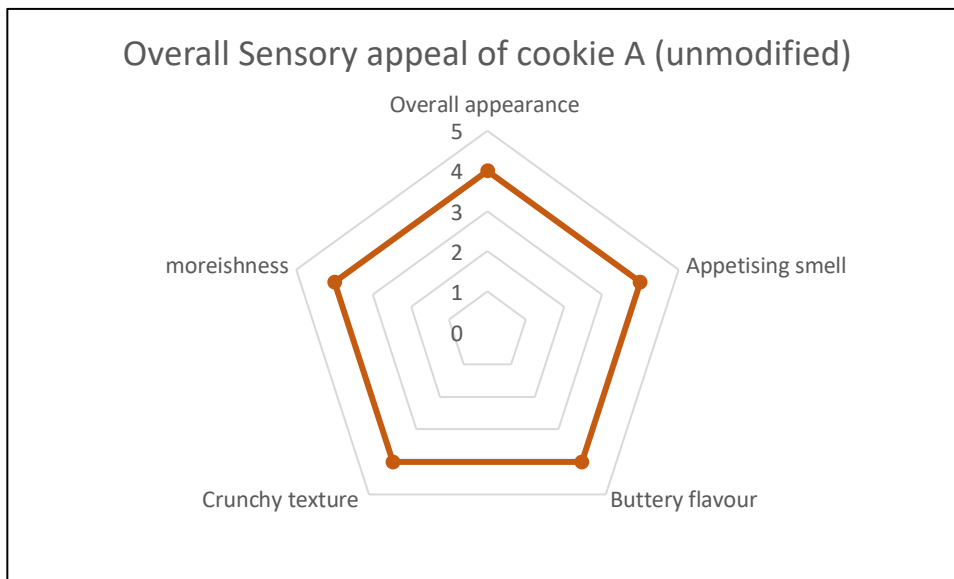
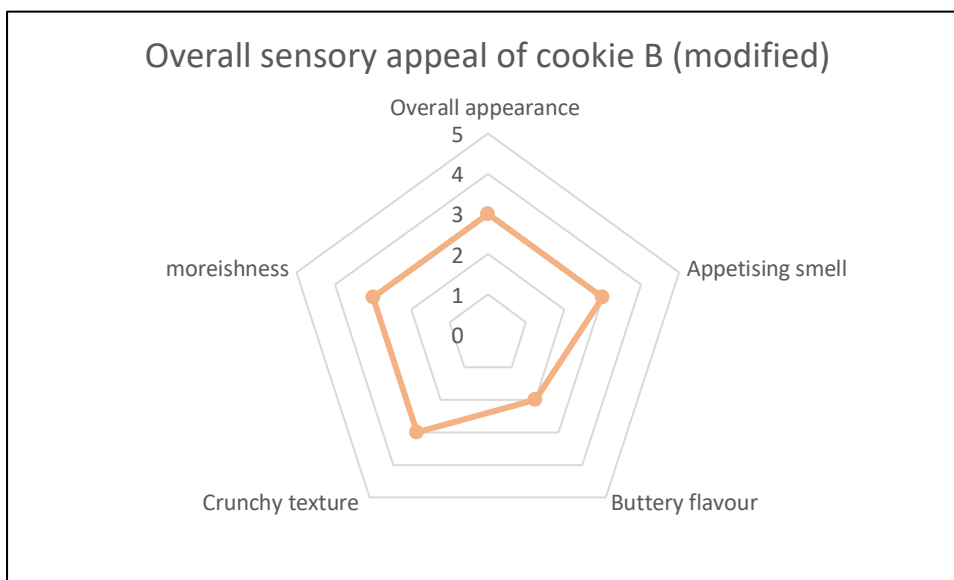
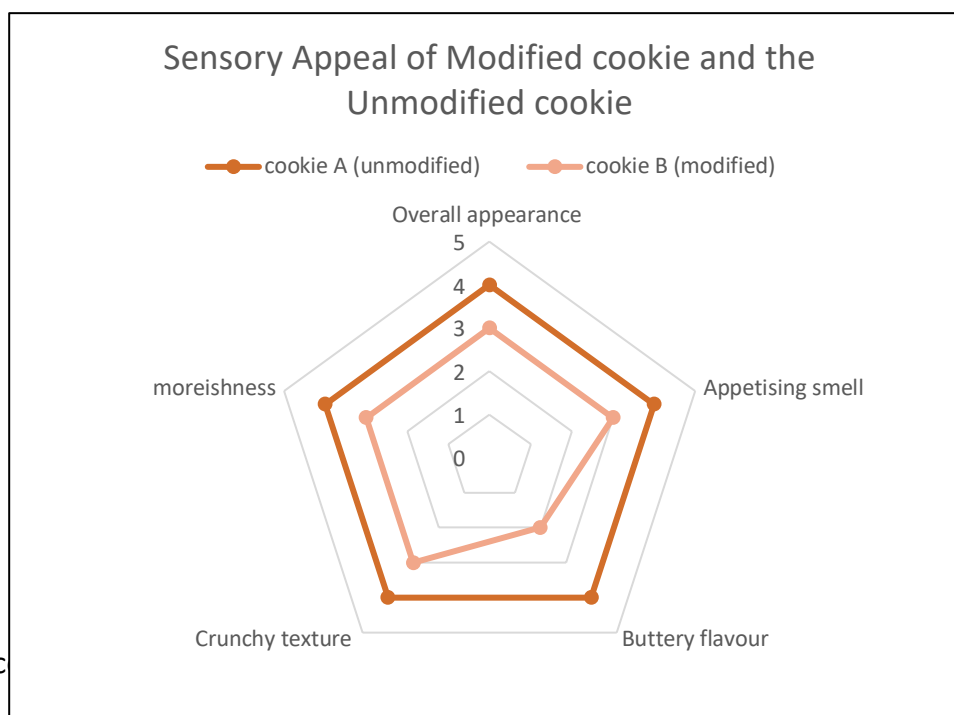
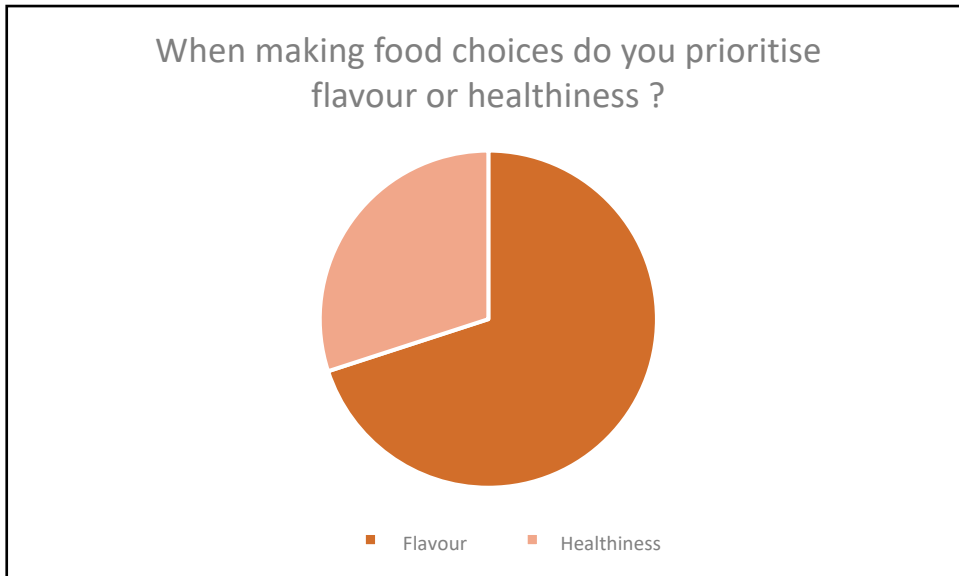
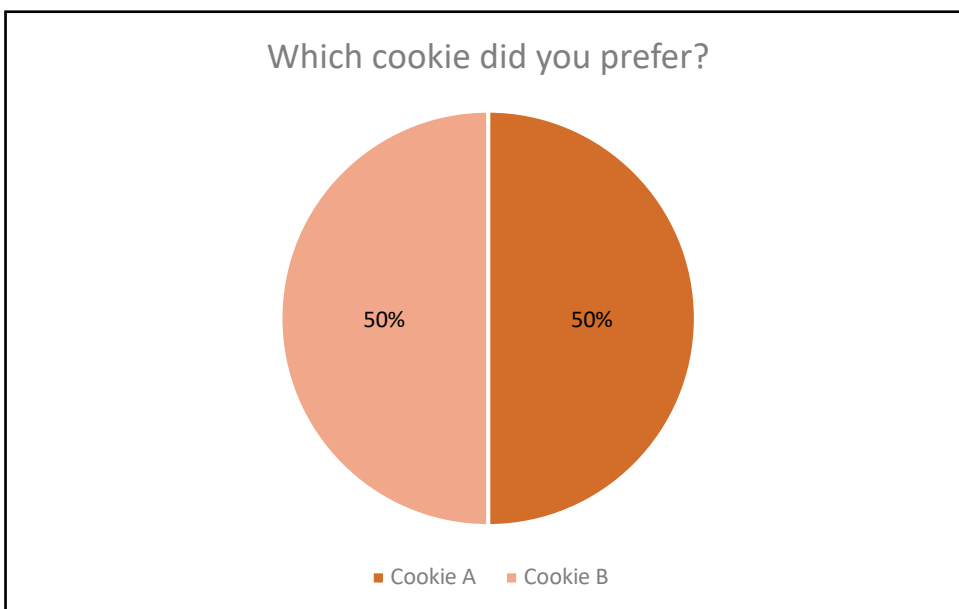
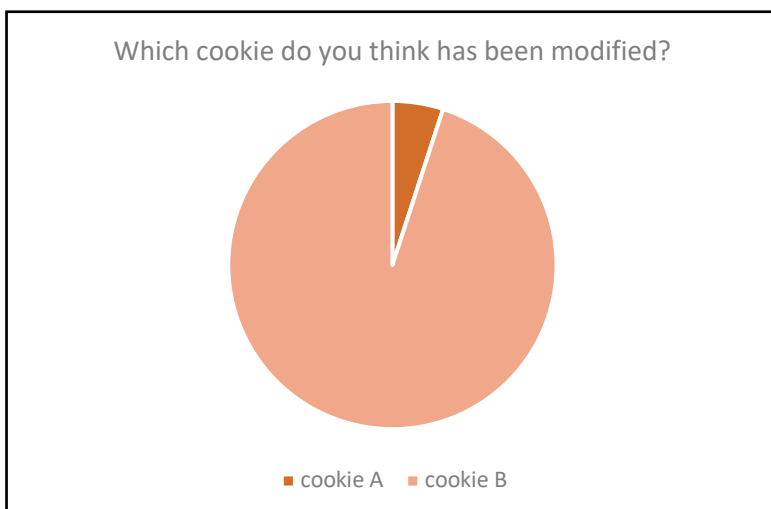
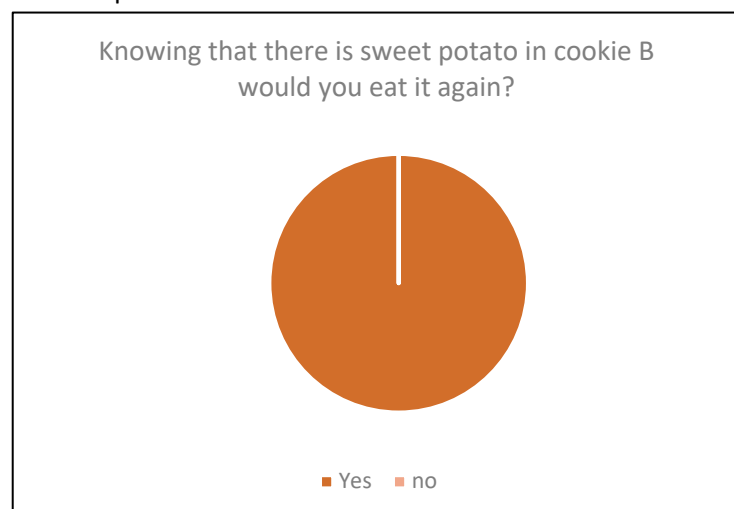
Chart 1. Sensory appeal of cookie A (unmodified TASTE.com cookie)**Chart 2.** Sensory appeal of cookie B (modified cookie)**Chart 3.** Sensory appeal of cookie A and B

Chart 4. Participants' priority for healthiness or flavour**Chart 5.** Participants' preference for cookie A (unmodified) vs cookie B (modified)**Chart 6.** Participants response to which cookie had been modified**Chart 7.** Participants response to the repeat consumption of cookie B

DISCUSSION

From the data in charts 1, 2 and 3 it can be noticed that overall, cookie A (unmodified cookie) had a superior sensory appeal when compared to cookie B (modified), outperforming cookie B in crunchy texture, appetising smell, buttery flavour and moreishness. The research hypothesis was therefore supported.

The modified cookie had average scores for buttery flavour and crunchy texture of 2 and 3, respectively. In contrast, the unmodified cookie had a score of 4 for both criteria. This result can be explained by the butter content of the original cookie, whereas the modified version contained sweet potato and margarine. Butter works very well as a flavour carrier for vanilla, sugar and other fat-soluble ingredients, therefore foods containing butter are often more flavourful and have a richer scent than those without.²⁶ Butterfat is also inherently tasty, and we are genetically programmed to seek out high-energy foods.²⁷ Butter not only affects the taste of the cookies but also generally has a low melting point of 32 °C.²⁸ This low melting point causes the cookies containing butter to spread easier during baking, so a cookie made with butter will be crunchier than the same cookie made with margarine, contributing to the textural appeal of the cookie.^{29,30} Furthermore, the inclusion of sweet potato added additional moisture to the modified cookies, affecting their crunchiness adversely. The sweet potato also further reduced the crunchiness of the cookie by binding with the gluten in the flour, inhibiting the cookie from spreading, resulting in a denser cookie.³¹

The modified cookie not only had a lesser textural and flavour appeal, but also less attractive appearance and lower moreishness than the original cookie. This could be attributed to the addition of oats and wholemeal flour in the modified cookies in place of the dark chocolate chips and plain flour. The oats masked the chocolate chips in the cookie, which are a major factor increasing visual appeal in the cookies. Chocolate has been shown to be strongly connected to emotions such as pleasure and indulgence.²³ These connections make us hardwired to be more visually attracted to cookies containing more chocolate chips.³² The extra amount of chocolate chips also increased the sweetness of the cookies which enhanced the moreishness, as sugar has a similar effect to cocaine, creating a craving for more.³³ The chocolate also releases endorphins, dopamine, serotonin and oxytocin promoting a feeling of happiness and increasing one's desire to eat more.³⁴ Furthermore, the addition of oats, due to their content of soluble fibre, increased the satiety of the modified cookie, reducing the desire to consume more.³⁵ The wholemeal flour had a similar affect, but also contributed to denser cookie, as it generally has a higher protein content than white refined flour.³⁶

Most of the population has grown up with butter, energy dense foods and an abundance of processed foods.³⁷ There is a constant bombardment and exploitation of the sensory appeal of food in marketing and through fast food where the basic biological sensory appeal of food is targeted to gain more consumers.³⁸ We are biologically wired to seek energy dense nutrition and various research reports show that there is a strong association between delicious food being unhealthy food.³⁹ This means more people prioritise flavour over health, which for much of the population means sacrificing nutrition for flavour and sensory appeal.⁴⁰ This can be noticed on chart 4, as less than one third of the participants prioritised healthiness of food over its flavour. Most of the participants also identified that cookie B was modified, with only 5% of participants stating that cookie A had been modified. Nevertheless, 50% of the participants specified that they preferred cookie B to cookie A, and 100% of the participants stated that they would consume cookie B again. This shows that the modifications to the recipe were not significant enough to affect the overall palatability and enjoyment of the cookie. Consequently, the modified cookie could be a suitable alternative for the prevention of diverticulitis.

²⁶ Lahne, J., 2016. Sensory science, the food industry, and the objectification of taste. *Anthropology of food*, (10).

²⁷ Lahne, J., 2016. Sensory science, the food industry, and the objectification of taste. *Anthropology of food*, (10).

²⁸ Peters, K. and Hervé Remaud, P., 2020. Factors influencing consumer menu-item selection in a restaurant context. *Food Quality and Preference*, 82, p.103887.

²⁹ Korver, O., 1993. Dietary fats: Determinants of preference, selection and consumption. *Trends in Food Science & Technology*, 4(4), p.122.

³⁰ Lahne, J., 2016. Sensory science, the food industry, and the objectification of taste. *Anthropology of food*, (10).

³¹ McCrickerd, K. and Forde, C., 2020. *Sensory Influences On Food Intake Control: Moving Beyond Palatability*.

³² Lahne, J., 2016. Sensory science, the food industry, and the objectification of taste. *Anthropology of food*, (10).

³³ McCrickerd, K. and Forde, C., 2020. *Sensory Influences On Food Intake Control: Moving Beyond Palatability*.

³⁴ McCrickerd, K. and Forde, C., 2020. *Sensory Influences On Food Intake Control: Moving Beyond Palatability*.

³⁵ Kemin. 2020. *Sensory Appeal Baked Goods* | Kemin Food Technologies Blog. [online] Available at: <<https://www.kemin.com/af/en/blog/food/sensory-appeal-baked-goods1>> [Accessed 5 June 2021].

³⁶ Korver, O., 1993. Dietary fats: Determinants of preference, selection and consumption. *Trends in Food Science & Technology*, 4(4), p.122.

³⁷ Kemin. 2020. *Sensory Appeal Baked Goods* | Kemin Food Technologies Blog. [online] Available at: <<https://www.kemin.com/af/en/blog/food/sensory-appeal-baked-goods1>> [Accessed 5 June 2021].

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⁴⁰ Kemin. 2020. *Sensory Appeal Baked Goods* | Kemin Food Technologies Blog. [online] Available at: <<https://www.kemin.com/af/en/blog/food/sensory-appeal-baked-goods1>> [Accessed 5 June 2021].

EVALUATION OF METHODS

SAMPLE SIZE

The cookies were assessed by 20 individuals and the sample size of this experiment was therefore 20. This increased the reliability of the results as an average could be calculated, reducing the effect of random errors, outliers within the results and differences in personal preferences. It is essential to have large sample sizes to account for differences in past experiences and personal preference among individual participants. To further increase the reliability of the results a greater sample size should be used in future investigations with a greater variety in participants.

REPETITION

The investigation was not repeated and there is no plan to do this due to the amount of fresh ingredients and time required. However, the investigation should be repeated, so that potential systematic errors can be identified and eliminated. This should be done until the results become consistent.

LIMITATIONS

A major limitation of the sensory testing is that data is generated from participants' responses which are highly variable and subjective. This is common for all sensory evaluations and are explained by an individual's past experience, personal preference, values, beliefs, attitudes and family habits. To gain more reliable data from sensory evaluations, a reasonable number of tasters must be used to reduce the impact of random errors and outliers. Another limitation of the investigation is the fact that only female participants were tested, reducing the reliability and validity of the investigation. All participants were also of a high socioeconomic standpoint, contributing to a selection bias of the study.

RANDOM ERRORS

Inconsistent number of chocolate chips per cookie – Inconstancies may have occurred in the distribution of the chocolate chips in the cookies which may have caused some cookies to have more chocolate chips and thus giving the cookie a greater sensory appeal as chocolate is linked to a greater sensory appeal due to a sweeter taste. This reduced the reliability of the investigation.

Position in the oven - The cookies were placed on different positions on the baking tray thus being exposed to different levels of heat in the oven, consequently causing some cookies to be browner and more baked than others. Thus, there were inconsistencies in the visual and textural appeal of the cookies which created variations in results, reducing the precision and reliability of the investigation.

Variations in participants – Though cookies from the same batch were evaluated using the same evaluation score card, variation in results were received due to natural differences in personal preference, upbringing and past experience. For example, cookie B in trial 6 for appetising smell only received a 1 which could have just been caused by the tester disliking the scent sweet potato because of past experience.

Positioning of the chocolate chips - In some of the cookies the chocolate chips were at the bottom which caused the chocolate to be exposed to more heat of the baking tray and to become caramelised or even burnt, reducing or increasing the sensory appeal of the cookie and creating inconsistencies in the flavour appeal of the cookies among the batches. This resulted in inconsistencies in results as well as reduced reliability of results.

SYSTEMATIC ERRORS

Volume of egg – One egg was used for each of the batches of cookies, but there was a difference in the size of the eggs. Eggs act as binding agent within the cookie providing moisture which allows the bonding of the protein in the flour thus increasing the firmness and crunchiness of the cookies.⁴¹ This could have caused differences in the textural appeal of the cookies because of inconsistencies in the volume of the egg between the batches. Consequently, reducing the accuracy of the results regarding the influence of the selected modifications on the textural appeal of the cookies.

Inconsistencies in the mixing of the ingredients – There were differences in the mixing of the cookie doughs as they were mixed by different group members. This could have caused inconsistencies in the texture of the batch cookies, as over mixing the dough can cause cookies to become tough as the gluten becomes overly activated producing a harder cookie, therefore decreasing the sensory appeal of the batch of cookies and reducing the accuracy of the results.⁴²

Parallax error when measuring vanilla – Parallax error may have occurred when measuring the teaspoon of vanilla extract, potentially resulting in variations of vanilla extract concentration between the 2 batches of cookies. Consequently, the tester may have been influenced by the differences in the volume of vanilla extract used rather than the allocated modifications reducing the validity of the investigation.

Packing of the sugar - The brown sugar was packed into the cup by the same person, however, differences in the amount of force applied when packing the sugar could have caused a variation in sugar content in the dough of cookie batches, potentially influencing the sensory appeal. Therefore, sensory differences between cookie A and cookie B may have been affected by the amount of sugar rather than the allocated modifications reducing the accuracy of the comparisons made regarding the effect of the chosen modifications on the sensory appeal of the cookies.

IMPROVEMENTS

If the investigation was to be repeated, certain improvements should be made to the methodology of the investigation to improve the quality of the data. One of the main limitations of the investigation was the narrow scope of participants, therefore, to improve the validity and data received, a broader scope of participants should be included in the investigation, i.e. also male participants and individuals of lower socioeconomic standpoint. In particular a greater age range should be tested, as diverticular disease is more common in the older population. Next time the chocolate chips should be placed into the cookies to ensure that the chocolate chips are placed in the same positions among the cookies and that there is an equal quantity of chocolate chips per cookie to ensure that testers are not influenced by discrepancies in the number of chocolate chips but only the designated modifications. Water should also be provided to allow the participants to cleanse the palate, so that the prior sample does not influence the subsequent. A larger sample size could also be included, i.e. 100 participants, to reduce the effect of random error and past experience, producing more reliable results.

⁴¹ McCrickerd, K. and Forde, C., 2020. *Sensory Influences On Food Intake Control: Moving Beyond Palatability*.

⁴² Lahne, J., 2016. *Sensory science, the food industry, and the objectification of taste. Anthropology of food, (10)*.

CONCLUSIONS

The research showed that the unmodified chocolate chip cookie had a greater sensory appeal than the cookie modified for diverticular disease in the categories of overall appearance, crunchy texture, buttery flavour, moreishness and appetising smell. Therefore, the hypothesis of the investigation was supported. While the unmodified cookie had an overall greater sensory appeal, 50% of the 20 participants still stated that they preferred cookie B and 100% that they would eat the modified cookie again. This indicated that modifications to the cookie did not adversely affect the overall palatability and enjoyment of the cookie. The modified cookie could therefore be a suitable healthier alternative for individuals suffering from diverticular disease, incorporating more fibre into their diet, reducing saturated fat and positively affecting cholesterol levels. It would also be a suitable alternative for individuals at risk or suffering from obesity and/or cardiovascular disease. While the investigation had a reasonable reliability due the inclusion of a large sample size, before this cookie recipe can be recommended, it should be offered and evaluated by older consumers with potentially different sensory taste preferences. It should also be evaluated if the cookie is economically affordable for consumers of lower socioeconomic standing where diverticulitis is more prevalent. Overall, the investigation demonstrated that if food is modified to become healthier, it does not necessarily have a negative impact on its tastiness. Thus, it can be recommended that more foods with high fibre content and sensory appeal, such as the recipe tested in this research, should be developed to reduce the prevalence of diverticular disease within populations.

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Appendix 1.

LOGBOOK

| Date | Discussion/tasks completed/idea development |
|---|---|
| 18 th May | <ul style="list-style-type: none"> - Research was undertaken into different dietary disorders including <ul style="list-style-type: none"> - diabetes - diverticular disease - obesity - cardiovascular disease - Diverticular disease was selected as the focus for the investigation due to that it is not very well known in society and due to that its prevalence is increasing with the increase in processed food |
| 19 th May | <ul style="list-style-type: none"> - Following research and reading into diverticular disease a clear trend between decreasing fibre intake and increases in diverticular disease was noticed. Therefore, it was decided that there would be a focus on why the fibre consumption is decreasing. For this it was noticed that due to the increase in process food consumption there is a decreased consumption of fibre. Therefore, it was decided to complete an investigation on the modification of a recipe to make it more suitable for diverticular disease. A chocolate chip cookie was selected as the base recipe due to the ease of modification and production. - During recipe modification it was realised that the effect of the cookie modification on the sensory appeal of the cookie must be considered to ensure that the cookie remains palatable. Therefore, it was decided to investigate the effect of recipe modification for diverticular disease on the sensory appeal. |
| 25 th May | <ul style="list-style-type: none"> - Research was undertaken to develop the research question and to modify the recipe to have a higher fibre content and a lower saturated fat content as these are dietary factors attributed with increasing the risk of diverticular disease - Sensory evaluation table was made incorporating all of the sensory factors aimed to be evaluated - Procedure for the sensory evaluation was developed |
| 28 th May | <ul style="list-style-type: none"> - Approval was received for the proposed recipe and ingredients for the recipe were ordered |
| 2 nd June | <ul style="list-style-type: none"> - All of the required documents including the sensory evaluation cards were printed to ensure that everything was prepared for the following day |
| 3 rd June – SET UP and PREPERATION | <ul style="list-style-type: none"> - Both the taste.com cookies and the modified cookies were baked and prepared according to the recipes (appendix 2) - The cookies were set up according to the practical design and the evaluation layout was set up - Evaluators were briefed on what to say to the participants and made aware of all of the information regarding the investigation |
| 3 rd June – SENSORY EVALUATION | <ul style="list-style-type: none"> - The participants were guided into the room and given the sensory evaluation cards and the sensory evaluation was completed of both cookies (appendix 3) - All sensory evaluation cards were collected, and the evaluation area was cleaned |
| 5 th June | <ul style="list-style-type: none"> - All the data from the evaluation cards was collated and put into Microsoft excel (see tables 8 and 9) - From the data graphs were generated |
| 9 th June | <ul style="list-style-type: none"> - All of the data was evaluated, and conclusions were developed from analysing the received data |

METHODS FOR COOKIE PRODUCTION – Appendix 2

INGREDIENTS

All ingredients required for both types of cookies:

- | | |
|---|--|
| - 1 cup brown sugar | - 1 cup caster sugar |
| - 2 tsp baking soda | - Salt |
| - 1 $\frac{3}{4}$ cup whole grain flour | - 1 $\frac{3}{4}$ cup flour |
| - 150 grams butter | - 50 grams margarine |
| - 2 eggs | - 100 grams sweet potato cooked and mashed |
| - 1 cup plain chocolate chips | - $\frac{3}{4}$ wholegrain oats |
| - Vanilla extract | - $\frac{1}{2}$ cup dark chocolate bits |

*note apparatus was not included as it is assumed that the cookies are being made in a standard kitchen with a standard conventional oven and with all the apparatus required for the cookie production

PRODUCTION METHOD

1. Preheat the oven to 180°C and line 2 baking trays with baking paper
2. Using an electric mixer beat the 150g butter (100 grams sweet potato + 50 grams polyunsaturated spread) with $\frac{1}{2}$ cup of each of the 2 sugars until smooth and well mixed. Beat in an egg and 1 tsp vanilla extract
3. Stir in 1 $\frac{3}{4}$ cup flour. Stir in $\frac{1}{2}$ cup dark and $\frac{1}{2}$ cup milk chocolate pieces.
4. Measure out 15 grams of cookie dough and roll it into a ball, placing the ball onto a pre lined baking tray (see image 1 and 2).
5. Repeat step 4 with the remaining cookie dough, placing the balls 3 cm apart, allowing room for spreading.
6. Bake the cookies for 12 minutes and transfer to cool onto a wire rack
7. Repeat steps 1-7 substituting the flour for wholemeal flour, the butter for sweet potato and margarine and the dark chocolate chips for $\frac{3}{4}$ cup wholegrain oats
8. Place the unmodified cookies on a white plate labelled cookie A and put the modified cookies on a black plate labelled cookie B (see image 3)
9. Wash all equipment and put it away, disinfect kitchen and wash hands.



Image 1. Weighing the cookies prior to baking



Image 2. Cookies on baking tray prior to baking



Image 3. Final cookies on plates for sampling

Sample size

The sample size for this investigation is 20, as each of the cookies is tasted by 20 people. A large sample size minimizes random errors due to personal preference of individual participants and allows an average to be calculated.

Repetition

This experiment is not planned to be repeated but should be repeated so that results can be compared, and any potential systematic errors be removed. The experiment should be repeated until the results become constant.

SENSORY EVALUATION PROCEDURE – Appendix 3

Time frame - the testing will occur on the 3rd of June, following production from 1.05pm until 1.45pm

SET UP (see figure 3)

1. Four desks will be lined up in a row. 25 sensory evaluation cards will be placed on the first table, the samples on the middle tables and an evaluation card drop off on the last table
2. The first table will also have signs saying, “stop here” and “contains eggs, lactose, butter and flours” and “unsuitable for vegans”. There will also be a hand sanitiser.
3. The second desk will have cookie A arranged on a white plate with a label stating cookie A.
4. The third desk will have cookie B samples arranged on black plates with a label stating cookie B.
5. The last table will have a sign “thank you for your participation” and “sensory evaluation card drop-off”

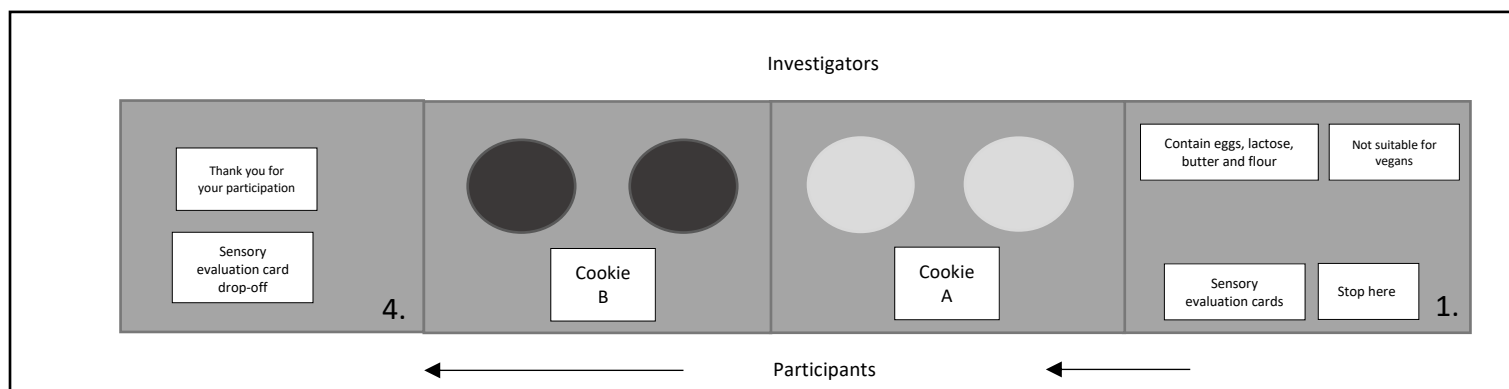


Figure 3. Sensory evaluation desk set up

DESIGN – procedure

1. Investigators will be located behind each of the desks and the participants will be asked to line up 1.5 metres apart at table 1.
2. Participants will move through the tables 1-4 one by one.
3. At the first table the investigator will inform the participant to take a sensory evaluation card, to read it and to proceed once finished.
4. When the participant moves to the second table (cookie A) the investigator 2 will ask the participant to take only one sample and take into consideration the scent and appearance prior to consumption. After the cookie has been consumed and the cookie has been evaluated, the investigator will ask the participant to advance to table 3 (cookie B).
5. Once the participant moves to the third table (cookie B) the participant will be informed by the investigator to only take one sample and to take into consideration the scent and appearance prior consumption. After the cookie has been consumed and evaluated, the participant will be asked to move to the final table.
6. At the final table the investigator will ask participants to put their completed evaluation card in the drop off and thank them for their participation. The run through can also be visualised in figure 4.
7. Once the participants have left, the desks will be wiped and disinfected. Hands will be washed. The data will be collected on Friday the 5th of June and the sensory appeal of the cookies will hence be determined

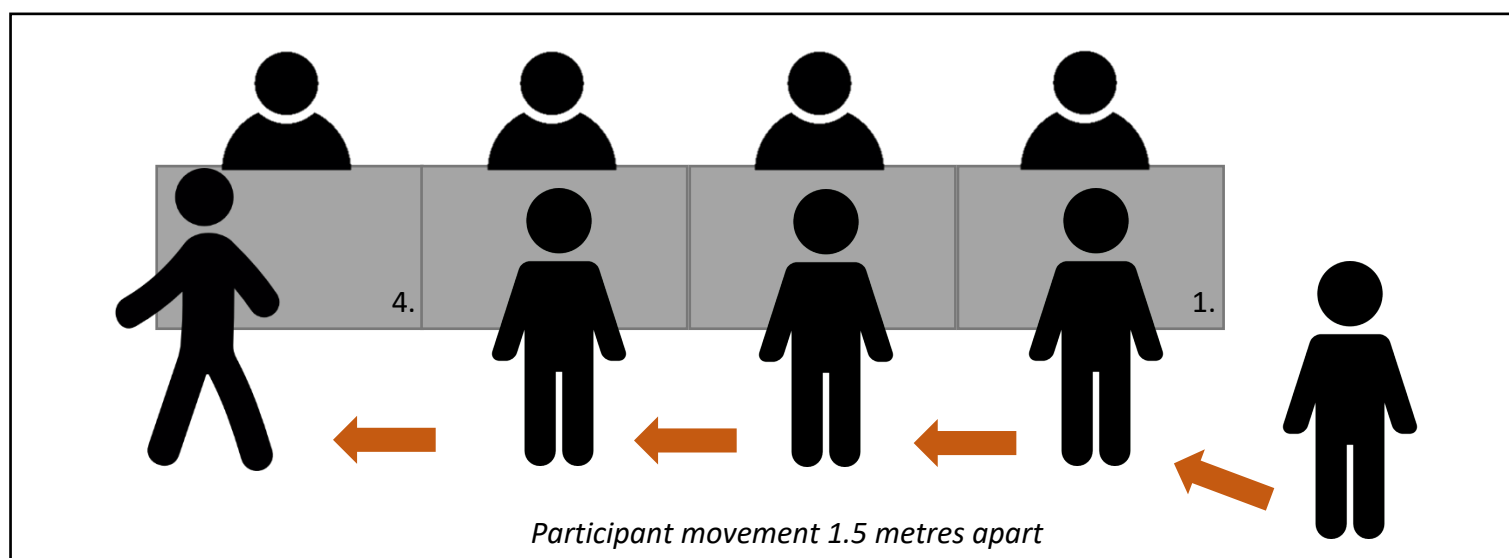


Figure 4. Sensory evaluation run through

METHODS FOR SENSORY EVALUATION – Appendix 4

Individuals will be asked to read the following sensory evaluation cards prior to the investigation, so that they are aware of the questions and assessed cookie-qualities

Thank you for participating in this investigation. Please read through the sensory evaluation cards for cookie A and cookie B. If you have done so, please take one sample of both cookie A and cookie B and evaluate.

Sensory Evaluation Score Card**BEWARE - NOT SUITABLE FOR VEGANS, CONTAINS FLOUR, EGGS AND DAIRY*****Table 6: Evaluation of Cookie A***

| Product | Characteristic | Rating | | | | |
|----------|--|--------|---|--------|---|------|
| | | Low | | Medium | | High |
| Cookie A | Overall Appearance | 1 | 2 | 3 | 4 | 5 |
| | Appetising Smell | 1 | 2 | 3 | 4 | 5 |
| | Buttery Flavour | 1 | 2 | 3 | 4 | 5 |
| | Crunchiness | 1 | 2 | 3 | 4 | 5 |
| | Moreishness (your desire to eat more) | 1 | 2 | 3 | 4 | 5 |

Table 7: Evaluation of Cookie B

| Product | Characteristic | Rating | | | | |
|----------|--|--------|---|--------|---|------|
| | | Low | | Medium | | High |
| Cookie B | Overall Appearance | 1 | 2 | 3 | 4 | 5 |
| | Appetising Smell | 1 | 2 | 3 | 4 | 5 |
| | Buttery Flavour | 1 | 2 | 3 | 4 | 5 |
| | Crunchiness | 1 | 2 | 3 | 4 | 5 |
| | Moreishness (your desire to eat more) | 1 | 2 | 3 | 4 | 5 |

TURN OVER FOR FURTHER QUESTIONS ON THE BACK

- Do you generally enjoy chocolate chip cookies? Yes/no
- Do you prioritise healthiness or flavour when it comes to selecting food? Healthiness / Flavour
- What cookie do you prefer? Cookie A / Cookie B
- Which cookie do you think is modified? Cookie A / Cookie B
- Which cookie do you think is healthier? Cookie A / Cookie B
- Knowing that there is sweet potato in cookie A would you eat it again? Yes /No

Appendix 5. RAW RESULTS AND SAMPLE CALCULATIONS

Table 8. Raw data obtained from the sensory evaluation of cookie A (unmodified)

| Sensory factor | Cookie A - unmodified taste chocolate chip recipe | | | | | | | | | | | | | | | | | | | | | |
|--------------------|---|---------|---------|---------|---------|---------|---------|---------|---------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|-------|---------|
| | Trial 1 | Trial 2 | Trial 3 | Trial 4 | Trial 5 | Trial 6 | Trial 7 | Trial 8 | Trial 9 | Trial 10 | Trial 11 | Trial 12 | Trial 13 | Trial 14 | Trial 15 | Trial 16 | Trial 17 | Trial 18 | Trial 19 | Trial 20 | Range | Average |
| Overall appearance | 4 | 4 | 4 | 3 | 4 | 4 | 4 | 4 | 3 | 3 | 4 | 3 | 4 | 3 | 3 | 5 | 4 | 5 | 4 | 4 | 2 | 4 |
| Appetising smell | 4 | 5 | 4 | 5 | 5 | 3 | 4 | 3 | 4 | 4 | 5 | 2 | 3 | 4 | 3 | 3 | 5 | 4 | 3 | 5 | 3 | 4 |
| Buttery flavour | 5 | 5 | 3 | 5 | 4 | 5 | 3 | 5 | 3 | 3 | 4 | 4 | 5 | 2 | 4 | 4 | 5 | 4 | 3 | 5 | 3 | 4 |
| Crunchy texture | 4 | 4 | 4 | 4 | 5 | 2 | 2 | 3 | 3 | 3 | 3 | 2 | 4 | 5 | 4 | 3 | 4 | 4 | 4 | 4 | 3 | 4 |
| Moreishness | 4 | 5 | 5 | 5 | 5 | 4 | 5 | 4 | 3 | 4 | 3 | 3 | 4 | 3 | 5 | 4 | 4 | 5 | 4 | 4 | 2 | 4 |

Note all values in the above table have been rounded to a whole number due to the scale provided on the sensory evaluation card

Table 9. Raw data obtained from the sensory evaluation of cookie B (modified)

| Sensory factor | Cookie B - modified sweet potato cookie | | | | | | | | | | | | | | | | | | | | | |
|--------------------|---|---------|---------|---------|---------|---------|---------|---------|---------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|-------|---------|
| | Trial 1 | Trial 2 | Trial 3 | Trial 4 | Trial 5 | Trial 6 | Trial 7 | Trial 8 | Trial 9 | Trial 10 | Trial 11 | Trial 12 | Trial 13 | Trial 14 | Trial 15 | Trial 16 | Trial 17 | Trial 18 | Trial 19 | Trial 20 | Range | Average |
| Overall appearance | 3 | 3 | 3 | 2 | 2 | 4 | 3 | 3 | 2 | 2 | 3 | 1 | 2 | 2 | 3 | 3 | 2 | 3 | 2 | 3 | 3 | 3 |
| Appetising smell | 3 | 4 | 4 | 4 | 4 | 1 | 2 | 3 | 1 | 3 | 4 | 2 | 2 | 4 | 3 | 4 | 3 | 4 | 4 | 3 | 3 | 3 |
| Buttery flavour | 2 | 4 | 4 | 2 | 3 | 2 | 2 | 4 | 2 | 1 | 2 | 2 | 2 | 2 | 1 | 3 | 2 | 3 | 2 | 1 | 3 | 2 |
| Crunchy texture | 2 | 5 | 3 | 4 | 3 | 1 | 3 | 2 | 1 | 1 | 4 | 1 | 2 | 5 | 2 | 2 | 4 | 4 | 1 | 2 | 4 | 3 |
| Moreishness | 2 | 5 | 3 | 2 | 3 | 3 | 2 | 4 | 3 | 3 | 2 | 4 | 3 | 5 | 2 | 3 | 5 | 4 | 2 | 2 | 3 | 3 |

Note all values in the above table have been rounded to a whole number due to the scale provided on the sensory evaluation card

Table 10. Sample calculations of the average and range

| Sample calculations | Sample | Buttery flavour for cookie A |
|---------------------|---|--|
| Average | $\frac{\text{sum of all trials}}{\text{number of trials}} = \text{average}$ | $\frac{5 + 5 + 3 + 5 + 4 + 5 + 3 + 5 + 3 + 3 + 4 + 4 + 5 + 2 + 4 + 4 + 5 + 4 + 3 + 5}{20} = 3$ |
| Range | $\text{maximum} - \text{minimum} = \text{range}$ | $5 - 3 = 2$ |