

DETERMINATION OF ACTIVE SWEET COMPONENTS OF COMMON
ARTIFICIAL SWEETENERS THAT ARE USED AS REPLACEMENT
FOR SUGAR

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ENUGU.

AUGUST, 2013

CERTIFICATION

This is to certify that this project research on ‘Determination of active sweet components of common artificial sweetener that are used as replacement for sugar’ was carried out by Offiong Miriam Essien under the supervision of Dr. Ikpe in the department of biochemistry Faculty of Natural Sciences Caritas University, Amorji-NikeEmeneEnugu.

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Head of department

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Supervisor

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Date

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External Examiner

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Date

DEDICATION

This work is dedicated to God Almighty and all aspiring biochemists striving to make a difference.

ACKNOWLEDGEMENT

My most profound gratitude is to Almighty God for the gift of life and intellect which has helped me through my stay in Caritas University.

Am immensely grateful to my parent Deacon and Deaconess Albert Essien Offiong for their unconditional support that has helped me weather the storms so far in life.

To the very Rev. Fr. Prof.E.M.P Edeh C.S.S.P the father chancellor of this Noble institution.

Special thanks to my H.O.D Mr. Moses Ezenwali and supervisor Dr. Ikpe who made sure this work was a reality and other lecturers of this noble department who have been helpful academically to me.

Finally, to my roommates, colleagues and all those who spiced my life during the period of this research I'm grateful.

ABSTRACT

This research investigated how the sweetness of sugar substitute compares to the sweetness of sugar. In this research different percentage solution of sugar, artificial sweetener and natural sweetener (10%, 1%, 0.1% and 0.01%) were prepared. Ten volunteers were gathered for the sensory evaluation in this case tasting of the solution, the volunteer's taste threshold of data was gotten. The artificial sweetener was found out to be the sweetest among the substances experimented and at the percentage of 0.1% and 0.01% saccharin an artificial sweetener was able to mimic the taste of sugar. Research prove that artificial sweetener are non-nutritive they have virtually no calories in contrast to sugar which contains 4 calories at each gram, a teaspoon of sugar is about 4 grams, for weight lose artificial sweetener may be an attractive option to sugar. Artificial sweetener may also be a good alternative for diabetic patient, unlike sugar; artificial sweeteners generally don't raise blood sugar levels because they are not carbohydrates.

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CHAPTER ONE

1.0 INTRODUCTION:

A sugar substitute is a food additive that duplicates the effect of sugar in taste, usually with less food energy. Some sugar substitutes are natural and some are synthetic. Those that are not natural are in general, called artificial sweeteners. Artificial sweeteners and other sugar substitutes are found in a variety of food and beverages marketed as sugar free or diet including soft drinks, chewing gum, jellies, baked goods, candy, fruit juice and ice-cream and yoghurt. [Whitney 2011]

People may not all like the same kind of baked treats but one thing we all agree on is that baked treats should be sweets usually, sugar is used to lend sweetness to foods but would cake taste just as good if the baker used a sugar substitutes instead of sugar? Many people prefer not to use sugar often due to health reasons and instead depend on sugar substitutes to sweeten their foods. But are sugar substitutes the same as sugar? What exactly are the differences between sugar and sugar substitutes?

Sugar also known as sucrose comes from plants like sugar cane and sugar beets and is a carbohydrate. Sugar adds bulk to cakes, cookies and all kinds of treats; sugar also causes browning and caramelizing in foods when it is

heated as when cookies turn golden brown in the oven sugar is a natural substance, something that our bodies can use for energy.

Sugar substitutes come in three categories; artificial sweeteners, sugar alcohols and natural sweeteners. Artificial sweeteners are attractive because they add almost no calories to foods and are sometimes a part of weight loss programs. Also they do not increase blood sugar levels which means that diabetics can use them. Many artificial sweeteners like sucralose were discovered by accident in the laboratory. In 1976, a scientist in England was studying different compounds made from sugar. The scientist asked a student to test the compounds but instead the student tested them. Another category of sugar substitutes is sugar alcohols. Sugar alcohols are not alcoholic beverages they do not contain ethanol which is found in alcoholic beverages. Sugar alcohols like sugar have calories and energy but not as much as sugar. Sugar alcohols like artificial sweeteners do not contribute to tooth decay and affect blood sugar levels slowly so diabetics can use them. Although sugar alcohols like xylitol, sorbitol and erythritol are manufactured products the sources are often natural.

The last category of sugar substitutes is called natural substitutes. The categories include maple syrup, agave nectar and honey. These substances

are absorbed by our digestive system and contain calories and nutrients that our bodies can use. [Michelle 2002]

The chart lists some popular sugar substitutes and how they're commonly categorized:

Artificial sweeteners	Sugar alcohols	Novel sweeteners	Natural sweeteners
Acesulfame potassium (sunett, sweet one)	Erythritol	Stevia extracts (pure via, truvia)	Agave nectar
Aspartame (Equal, Nutrasweet)	Hydrogenated starch hydrolysate.	Tegatose (Naturlose)	Date sugar
Neotame	Isomalt	Trehalose	Fruitjuice concentrate
Saccharin (sugartwin, sweet "N" low)	Lactitol		Honey
Sucralose (splenda)	Maltitol		Maple syrup
	Mannitol		Molasses
	Sorbitol		
	Xylitol		

1.1 AIM AND OBJECTIVES OF THE STUDY

AIM: To create an alternative to sugar by replicating the sweetness found in natural sugar.

Objectives:

- To determine how the sweetness of sugar substitutes compare to the sweetness of sugar. In this research sugar and sugar substitutes will be tested and the sweetness will be compare in relation to sugar.
- To compare the availability and affordability of the active components in the artificial sweetener and sugar
- To know the components of this artificial sweetener and what makes them taste sweet

1.2 SIGNIFICANCE OF STUDY

Artificial sweetener mimicking the taste of sugar will be a better alternative to people who are suffering from diabetics. Unlike sugar, artificial sweeteners generally don't raise blood sugar levels because they are not carbohydrates.

CHAPTER TWO

REVIEW OF LITERATURE

2.0 TABLE SUGAR (SUCROSE): Sugar was brought to the Americas by Christopher Columbus. At the time, sugar was processed by boiling the cane juice and then harvesting the crystals left behind after the water evaporated. These crystals contained protein, fiber, vitamins and minerals. Sugar is generally extracted from plants sugar beet and sugar cane or a main ingredient in many foods and recipes available as sucrose or saccharose (household sugar), lactose (milk sugar), fructose (fruit sugar), glucose (dextrose). [Abishak, 2009].

2.1 CLASSIFICATION OF SUGAR:

- Raw sugar: It is interesting to note that raw sugar is already refined. Only sugars from evaporated cane juice can be classified as truly raw or unrefined sugars. Sugars can come from other sources as well such as beets and fruit, once the cane juice crystals are harvested; they are washed, boiled, centrifuged, filtered and dried. The purpose of this is to remove all the original plant materials (stalk, fiber etc.) to produce pure sugar.

This process removes most of the fiber and nutrients that existed in the original crystals. The sugar then becomes refined and is now a food high in calories with little nutritional value.

- Refined sugar: several centuries ago, refined sugars were expensive to produce and were also taxed at a higher rate. Refined sugar is derived from cane juice but is extremely processed with many of the natural enzymes, vitamins, minerals and fiber removed.
- Natural sugar: natural sweeteners include; barley malt, evaporated cane juice before it is refined, fruit juice, rice, syrup honey and sugar alcohols. [Wikipedia 2013]

2.1.1 MECHANISM OF ACTION IN THE BODY

Sucrose is the organic compound commonly known as table sugar and sometimes called saccharose. A white, odorless, crystalline powder with a sweet taste. The molecule is a disaccharide composed of the monosaccharide, glucose and fructose. Glucose is a carbohydrate and is the most important simple sugar in human metabolism. In living organisms the oxidation of

glucose contributes to a series of complex biochemical reactions which provide the energy needed by cells. The first step in the breakdown of glucose in all cells is glycolysis, producing pyruvate which is the starting point for all other processes in cellular respiration. In cells where oxygen is present (aerobic respiration) these processes have been modeled in the TCA cycle. A major part of the use of the energy from glucose oxidation is the conversion of ADP to ATP with the energy rich molecule. ATP being subsequently used as the energy currency of the cell. [Jeremy, 2013].

2.1.2 SUGAR ALCOHOLS AND NOVEL SWEETENER

Sugar alcohols (polyols) are carbohydrates that occur naturally in certain fruits and vegetables, but they are also manufactured. They're not considered intense sweeteners, because they aren't sweeter than sugar. Infact, some are less sweet than sugar.

Sugar alcohols aren't considered non caloric or nonnutritive sweetener because they contain calories, but they're lower in calories. Despite their name sugar alcohols aren't alcoholic they don't contain ethanol which is found in alcoholic beverages.

Novel sweeteners are combinations of various types of sweeteners. Novel sweeteners such as stevia are hardtop fit into one particular category because of what they're made from and how they're made. Tegatose and Trehalose are considered novel sweeteners because of their chemical structure.

Tagatose is a low carbohydrate sweetener similar to fructose that occurs naturally but is also manufactured from lactose in dairy products.

[Mayo, 2012]

USES OF SUGAR ALCOHOL

Sugar alcohols generally aren't used when food is prepared at home, rather they are found in many processed foods and other product including chocolate, candy, baked goods etc. usually replacing sugar on an equal basis.

When added to foods sugar alcohols add sweetness, bulk and texture.

They also help food stay moist, prevent browning when heated and add a cooling sensation to products. Sugar alcohols are often combined with artificial sweeteners to enhance sweetness. [Mayo,2013].

2.1.3 ADVANTAGES AND DISADVANTAGES OF SUGAR

ADVANTAGES: Natural sugar is a direct form of glucose, which is required for the body to function. Insulin breaks down glucose or blood sugar and converts it into energy for the body to use, sugar in its natural or refined form is an easily digestible carbohydrate and a quick source of energy for the body.

DISADVANTAGES: There are many health concerns over sugar. Large amounts of sugar are required to make food sweet and because sugar contains a lot of calories, the body absorbs more calories and fat into its system. Similarly regularly eating food containing natural, refined or processed sugar increases the blood sugar intake and can result in type II diabetes, where the insulin in the body is inadequate to break up the amount of sugar in the bloodstream [Mayo, 2012].

2.2 ARTIFICIAL SWEETENERS

Artificial sweeteners are synthetic sugar substitutes but may be derived from naturally occurring substances including herbs or sugar itself. Artificial sweeteners are also known as intense sweeteners because they are many times sweeter than regular sugar. Artificial sweeteners are chemical compositions and are not naturally in foods or naturally produced or extracted. There are a variety of artificial sweeteners available such as aspartame, saccharin, sucralose, neotame which are sold under brand names but can be identified by the chemical name on food packages. All artificial sweeteners must be approved by the Food and Drug Administration. [Whitney *et al*, 2011].

2.2.1 ADVANTAGES AND DISADVANTAGES

ADVANTAGES: Artificial sweetener can be chemically composed to be low in calories. Natural, refined or processed sugar is generally full of calories and large amounts of sugar are required to sweeten food, artificial sweetener, however is much sweeter than sugar up to 400 times sweeter and low in calories therefore less artificial sweetener is needed to make food sweet.

DISADVANTAGES: Artificial sweetener is a chemical compound and there has been concern about the body's ability to digest chemical compounds to natural sugar. Artificial sweeteners despite being lower in calories also provide less energy for the body to use. There are also concerns of side effects from consuming artificial sweeteners; aspartame for example contains 50 percent phenylalanine, 40 percent aspartic acid and 10 percent methanol which are considered dangerous neurotoxins. [Mayo, 2011].

2.2.2 REASONS FOR USE

- To assist in weight loss: Some people chose to limit their food energy intake by replacing high energy. Sugar or corn syrup with other sweeteners having little or no food energy. This allows them to eat the same foods they normally would, while allowing them to lose weight and avoid other problems associated with excessive calorie intake.

- Dental care: Sugar substitutes are tooth friendly as they're are not fermented by the microflora of the dental plaque. An example of a sweetener that can benefit dental health is xylitol. Xylitol works to prevent bacteria from adhering to the tooth surface thus preventing plaque formation and eventually decay.
- Diabetes mellitus: People with diabetics have difficulty regulating their blood sugar levels. By limiting their sugar intake with artificial sweeteners they can enjoy their diet while closely controlling their sugar intake.
- Reactive hypoglycemia: Individuals with reactive hypoglycemia will produce excess insulin after quickly absorbing glucose into the blood stream. This causes their blood glucose levels to fall below the amount needed for proper body and brain function. As a result like diabetes they must avoid intake of high glycemic foods and often chose artificial sweeteners as an alternative.

- **Cost:** Many sugar substitutes are cheaper than sugar. Alternative sweeteners are often low in cost because of their long shelflife and high sweetening intensity. This allows alternative sweeteners to be used in products that will not perish after a short period of time.[Wikipedia,2013].

2.2.3 DIFFERENCES BETWEEN SUGAR AND ARTIFICIAL SWEETENER

Sugar is a natural form of energy for the body while artificial sweetener is a chemical compound. Sugar is edible crystalline substances extracted from sugarcane or sugar beet and is easily metabolized carbohydrate while the artificial sweeteners also known as sugar substitutes are additive used as alternative to sugar and are not naturally found in food. Artificial sweeteners are added to food for sweetness and are generally found in processed foods.[Victoria, 2012].

2.2.4 BIOCHEMICAL REACTION OF ARTIFICIAL SWEETENER

For an artificial sweetener to mimic the taste of sugar, it must first be soluble in water. In addition, the molecule must be able to bind to a specific receptor molecule that is located at the surface of the tongue. This receptor, known as G-protein coupled receptor, triggers a sequence of events resulting in nerve signals carried to the brain. The presence of these signals is interpreted as sweetness by the brain. G-protein coupled receptors however are not limited to the tongue, these receptors are also found in the intestinal tract, and also present signals to the brain. These nerves do not go to the brain for no reason at all. The nerve signals from the intestinal G-protein coupled receptors instruct the brain that a certain type of food is in the intestinal tract. Specifically the presence of the signals originating from the intestinal tract is telling the brain that sugar has been consumed and will be absorbed shortly. Expecting a rise in blood sugar levels the biochemistry of the body reacts accordingly. When an artificial sweetener is consumed, the brain receives signals but the cascade of neurological and a biochemical event occurs nevertheless. In faking out the body's neurological and biochemical mechanisms, the body has been prepared to receive nutrients specifically carbohydrates but the nutrients never show up in the

bloodstream. No evidence can be found indicating that sugar substitutes help people lose weight. In reality the opposite is true. Hunger is triggered by the hypothalamus, a gland in the brain. When a person gets hungry the hypothalamus is what initiates the hunger, causing the person to eat. If the person eats food containing an artificial sweetener the body's hunger mechanism is not satisfied, as a result the appetite is continuously stimulated until the nutritional demands of the body are finally satisfied. If other calories are found in the product containing the artificial sweetener these additional calories are most likely contributing to the body's fat reserves. [John, 2012].

2.3 ASPARTAME

Aspartame was discovered in 1965 by James M. Schlatter at the G.D Seale Company. Aspartame is a low calorie intense artificial sweetener. It is a white odorless powder, approximately 200 times sweeter than sugar. In Europe, it is authorized to be used as a food in foodstuffs such as drinks, desserts, sweets, chewing gum etc.

Two isolated amino acids, aspartic acid and phenyl alanine, are bonded or fused by a third chemical, methanol. Aspartame is metabolized in the body

back into its three components; aspartic acid, phenylalanine and methanol. Methanol is toxic to the body. Methanol is broken down in the liver, forming formic acid and formaldehyde. Methanol is known to cause retinal damage in the eye and interfere with DNA replication and is a known carcinogen. The body also must deal with the excess phenylalanine and aspartic acid, excess amounts of these amino acids must be broken down in the liver. A particular problem arises with aspartame because the transport of phenylalanine into the brain is mediated by a carrier mechanism shared with other amino acids in the same class. Among these other amino acids are tyrosine and tryptophan. Tyrosine is the precursor amino acid to both the neurotransmitters dopamine and norepinephrine. Tryptophan is the precursor to the neurotransmitter serotonin. Limiting the transport of tyrosine and tryptophan into the brain limits the conversion to the aforementioned neurotransmitters. This results in the associated enzymes that perform the conversion to become relatively unsaturated when tyrosine and tryptophan are again able to be transported by the carrier mechanism, the cascade of biochemical reactions involved in neurotransmitter synthesis will occur quite rapidly by the unsaturated enzyme. This can cause mood swings, seizures,

hyperactivity, emotional instability, depression and a host of other neurological and psychological issues. [Mercola, 2013].

2.4 SUCRALOSE

Sucralose is a chlorinated sugar that is about 600 times as sweet as sugar. It is produced from sucrose when three chlorine atoms replace three hydroxyl groups. It is used in beverages, frozen desserts, chewing gum, baked goods and other foods.

Sucralose incidentally is not a natural product; sucralose is prepared in the laboratory from sucrose by a chemical reaction that substitutes three chloride groups for three hydroxyl groups. This cannot be construed as natural, sucralose contains chlorine. The Material Safety Data Sheet for sucralose states that “Hazardous Decomposition of sucralose can occur, decomposing into carbon dioxide, carbon monoxide and minor amount of hydrogen chloride”. Chlorine is toxic to the body and known to cause cancer. The chemical sucralose, being synthetically chlorinated and unnatural in every respect has no business whatever being in the body.[Mercola,2013].

2.5 SACCHARIN

First artificial sweetener and was originally synthesized in 1879 by Remsen and Fahlberg. The basic substance, benzoic sulfonamide, has effectively no food energy and is much sweeter than sucrose but has a bitter or metallic aftertaste, especially at high concentrations. It is used to sweeten products such as drinks, candies, cookie, medicines and toothpaste. In the 1960s saccharin was proven to cause cancer by many research groups. In 1977, the Food and Drug Administration (FDA) proposed a ban on saccharin, but since saccharin was the only artificial sweetener in that era, the ban was met with great opposition. The U.S congress placed a moratorium on the ban; but required the product to display a warning label saying that the use of saccharin may be carcinogenic. Research has indicated that saccharin was not carcinogenic after all. As a result, in 1991 the Food Administration withdrew its proposed ban on saccharin. Saccharin however, is another synthetic chemical intended to fool the body into thinking it is consuming something that it has not. [Robert, 2011].

2.6 STEVIA

Stevia is another sweetener and is rapidly becoming popular; stevia unlike artificial sweeteners has a natural source. This source is plants in the asteraceae (sunflower) family. Extracts from the plant are reported to be 300 times the sweetness of sugar. Stevia as with the other artificial sweeteners has been the target of many controversies. Since stevia occurs naturally it does not require any patent or license to produce it. This causes a political controversy in addition to the standard controversies surrounding health issues. Nevertheless, the continuous use of any highly refined extract in concentrations far beyond what is found in nature is inadvisable. [Robert, 2011].

2.7 ERYTHRITOL

Erythritol, sorbitol and xylitol are natural sugar alcohols found in fruits and vegetables. They can be made commercially by catalytic hydrogenation from the corresponding sugars. Xylitol is produced from xylose, sorbitol also known as glucitol is produced from glucose. [Laura, 2011].

Erythritol is about 60-80% as sweet as sucrose and has a calorie value of 0.2 calories per gram. It is used primarily in chewing gum, baked

goods and beverage and occurs naturally in pears, soy sauce, watermelon and grapes. Infact, erythritol has even been found to exist naturally in human tissues and body fluids. Erythritol is a sugar alcohol that has been approved for used as a food. [Wikipedia, 2013].

Erythritol is produced commercially by fermentation of glucose. Xylitol is absorbed slowly and only partially utilized by the body; it contains 40% fewer calories than sugar. About 2.4 calories per gram. Sorbitol and xylitol are common ingredients in sugar free candies and chewing gum. Other sugar alcohols include mannitol, maltitol, and lactitol.

Sugar alcohols are not well absorbed in the intestinal tract, and they are fermented by micro flora that may produce bloating gas and diarrhea. Just 10grams of sorbitol may be enough to cause gastrointestinal distress. Xylitol appears to be safe for humans but it can cause seizures, liver failure and death in dogs in relatively small doses. Erythritol does not promote tooth decay and does not cause gastric side effects like other sugar alcohols. [Munro et al, 1998].

2.8 HONEY

Honey is a sweet food made by bees using nectar from flowers. Honey bees transform nectar into honey by a process of regurgitation and evaporation. They store it as a primary food source in wax honey combs inside the bee hive. Honey gets its sweetness from the monosaccharaides, fructose and glucose and has approximately the same relative sweetness as that of granulated sugar. Honey is a mixture of sugars and other compounds. With respect to carbohydrates honey is mainly fructose (about 38.5%) and glucose (about 31.0%) making it similar to the synthetically produced inverted sugar syrup which is approximately 48% fructose, 47% glucose and 5% sucrose. Honeys remaining carbohydrates include maltose, sucrose and other complex carbohydrates. As with all nutritive sweetness honey is mostly sugars and contains only trace amounts of vitamins or minerals. Honey also contains tiny amounts of several compounds thought to function as antioxidants including chrysin, pinobanksin, vitc, catalase and pinocembrin. [Wikipedia 2013].

CHAPTER THREE

3.0 MATERIALS AND METHOD

3.1 MATERIALS/APPARATUS USED:

The equipment and application and apparatus use for the research study include the following:

- Plastic cups: Afro- toastcup, clear, 12-ounce, disposable-product of AFRO-ASIA AUTOMOBILE AND PLASTICS LTD.
- Permanent marker
- 100ml graduated cylinder
- 10ml graduated cylinder
- Distilled water
- Sugar(10g)-Powder
- Plastic stirring sticks

- Weighing balance- Mettler, USA
- Sugar substitutes;
- Saccharin(10g)-Powder
- Honey(10ml)

3.2 METHODOLOGY

PREPARATION OF SOLUTIONS:

10g each of sugar powder and artificial sweetener (saccharin) was weighed, 10%, 1%, 0.1% and 0.01% solutions of sugar and each of the sugar substitutes were prepared. These solutions were used to find out the threshold of taste (sweetness) for each substance.

Mixing the sweetener solutions:

- Four plastic cups were labeled according to the solution that will be put into them. The first cup- sugar 10%, the second cup- sugar 1%, the third cup- sugar 0.1%, and the fourth cup -sugar 0.01%.
- 90ml of distilled water was measured into the 100ml graduated cylinder and poured into the cup labeled sugar10%.

- 10g of sugar powder was then poured into the cup labeled sugar 10% and using a stirring stick the solution was stirred until it completely dissolved and the sugar granules in the bottom can no longer be seen. This gives a 10% by weight (w/w) sugar solution then filled up to the 100ml mark.
- The 1% sugar solution was prepared: 90ml of distilled water was measured into the 100ml cylinder and poured into the cup labeled sugar 1% using the 10ml graduated cylinder, 10ml of the 10% sugar solution was carefully measured and poured into the cup labeled sugar 1% and stirred until the two liquids are completely mixed. This gives a 1% w/w solution.
- The 10ml graduated cylinder was thoroughly clean and dried to prevent cross- contaminations between the solutions.
- The 0.1% sugar solution was made by measuring 90ml of distilled water in the 100ml cylinder and poured into the cup labeled sugar 0.1%. Using the 10ml graduated cylinder 10ml of 1% sugar solution was carefully measured and poured into the cup labeled sugar 0.1% and stirred until the two liquids are completely mixed. The result is a

0.1% w/w solution; the 10ml graduated is thoroughly cleaned and dried.

- Finally the 0.01% sugar solution was made by measuring 90ml of distilled water in the 100ml cylinder and poured into the cup labeled sugar 0.01%. 10ml of the 0.1% sugar solution in the 10ml graduated cylinder was measured and poured into the cup labeled sugar 0.01% and the solution stirred until the two liquids are completely mixed. The result is a 0.01% w/w solution.
- The same steps were repeated using saccharin (for example saccharin 10%, saccharin 1% etc.).
- A serial dilution was made using honey. However honey is a liquid so the procedure to make the 10% solution was slightly different, because it was measured in milliliter and not in grams. The water was also warm in order to easily dissolve the honey.
- Four plastic cups were labeled the first cup honey 10%, the second honey 1%, the third honey 0.1%, the fourth 0.01%.
- 90ml of warmed distilled water in the 100ml graduated cylinder was measured and poured into the cup labeled honey 10%. 10ml of honey

was measured in the 10ml graduated cylinder and poured into the cup labeled honey 10% and stirred until the two liquids were completely mixed and the solution was a uniform light brown color. The result is a 10% by volume (v/v) honey solution.

- The 10ml graduated cylinder was thoroughly cleaned and dried.
- The steps that were used to prepare the 1%, 0.1% and 0.01% sugar solutions were repeated to make up the rest of the honey solutions.

SENSORY EVALUATION

Sensory evaluation concern itself with measuring responses of people to products in terms of all the attributes of the product that can be detected or evaluated using the sensory organs. The senses used in the analysis include: sense of sight and sense of taste.

3.3 TESTING THE SOLUTIONS

In taste testing the solutions, the change in taste is noted and not necessarily a change in sweetness.

- Ten volunteers were gathered
- A plastic cup was then filled with distilled water
- A clean cotton swab was dipped into the distilled water and smeared all over the first volunteers tongue. This gives the volunteer a baseline for comparing the different solutions
- Another clean cotton swab was dipped into the 0.01% sugar solution and smeared all over the volunteers tongue. The volunteer is then asked if he or she can detect a change in taste compared with the distilled water. If the volunteer can detect a change in taste then yes is written in the data table in the 0.01% solution box for sugar. If the volunteer cannot detect a change then no is written in the box.
- The steps were repeated for the 0.1%, 1% and 10% sugar solutions
- The solutions were tested from least concentrated to most concentrated
- The volunteers rinsed their mouths after tasting each solution
- The steps were repeated with each volunteer until all the volunteers tested the sugar solution. The same steps were followed for the

saccharin and honey solutions and the volunteers responses were recorded into the data table.

ANALYZING THE DATA

The data collected from the volunteers were reviewed. For each combination of sugar, sugar substitute and dilution percentage, the total number of volunteers who detected a change in taste, the degree of sweetness and the statistical analysis was calculated and recorded.

CHAPTER FOUR

4.0 RESULTS

4.1 Table 1: Baseline Taste Data with Distilled Water

No of volunteers	Result
1	No taste
2	No taste
3	No taste
4	No taste
5	No taste
6	No taste
7	No taste
8	No taste
9	No taste
10	No taste

4.2 TABLE 2: Volunteer's taste threshold data for sugar

No of volunteer	Substance	10% solution	1% solution	0.1% solution	0.01% solution
1	Sugar	YES	YES	NO	NO
2		YES	YES	NO	NO
3		YES	YES	NO	NO
4		YES	YES	NO	NO
5		YES	YES	NO	NO
6		YES	YES	NO	NO
7		YES	YES	NO	NO
8		YES	YES	NO	NO
9		YES	YES	NO	NO
10		YES	YES	NO	NO

4.3 TABLE 3: Volunteer's taste threshold data for saccharin

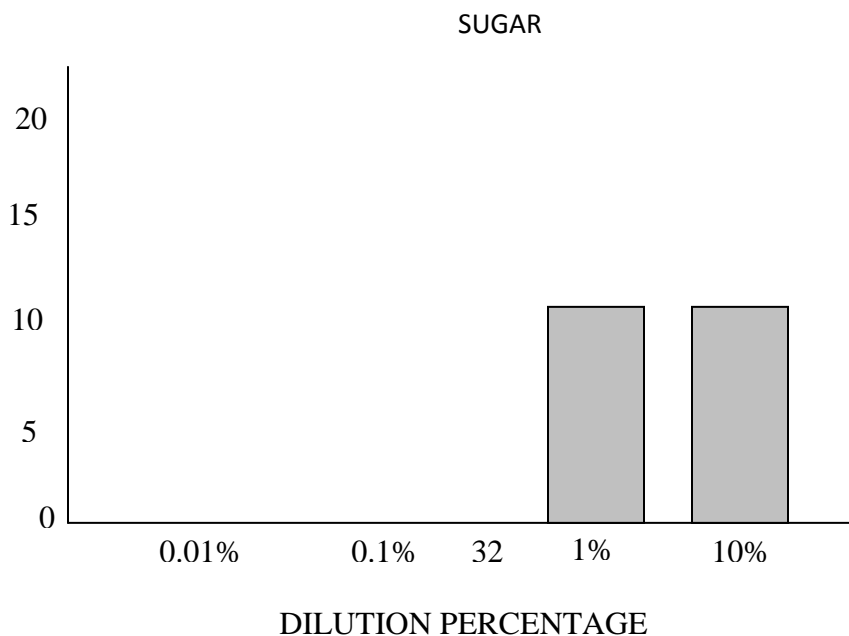
No of volunteers	Substance	10% solution	1% solution	0.1% solution	0.01% solution
1	Saccharin	YES	YES	YES	YES
2		YES	YES	YES	YES
3		YES	YES	YES	YES
4		YES	YES	YES	YES
5		YES	YES	YES	YES
6		YES	YES	YES	YES
7		YES	YES	YES	YES
8		YES	YES	YES	YES
9		YES	YES	YES	YES
10		YES	YES	YES	YES

4.4 TABLE 4: Volunteer's taste threshold data for honey

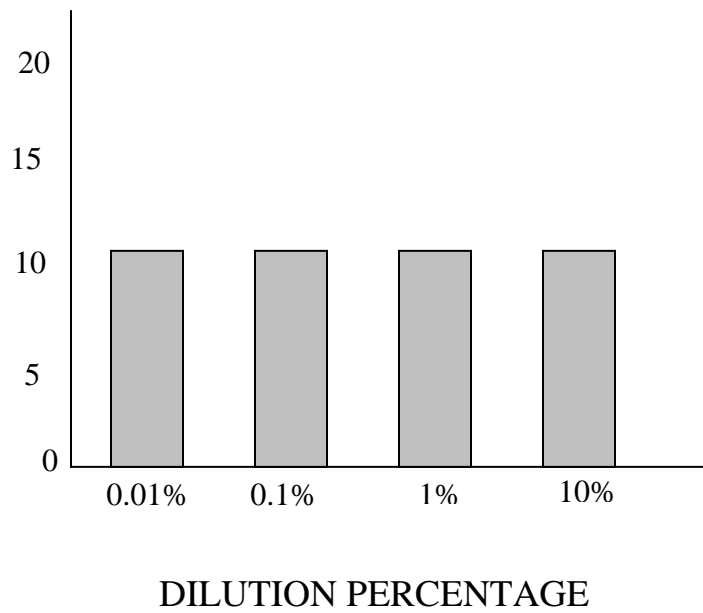
No of volunteers	Substance Honey	10% solution	1% Solution	0.1% solution	0.01% solution
1		YES	NO	NO	NO
2		YES	NO	NO	NO
3		YES	NO	NO	NO
4		YES	NO	NO	NO
5		YES	NO	NO	NO
6		YES	NO	NO	NO
7		YES	NO	NO	NO
8		YES	NO	NO	NO
9		YES	NO	NO	NO
10		YES	NO	NO	NO

Total number of volunteer's who detected a change in taste:

Substance and dilution	No of volunteer's who detected a change
Sugar 0.01%	-
Sugar 0.1%	-
Sugar 1%	10
Sugar 10%	10

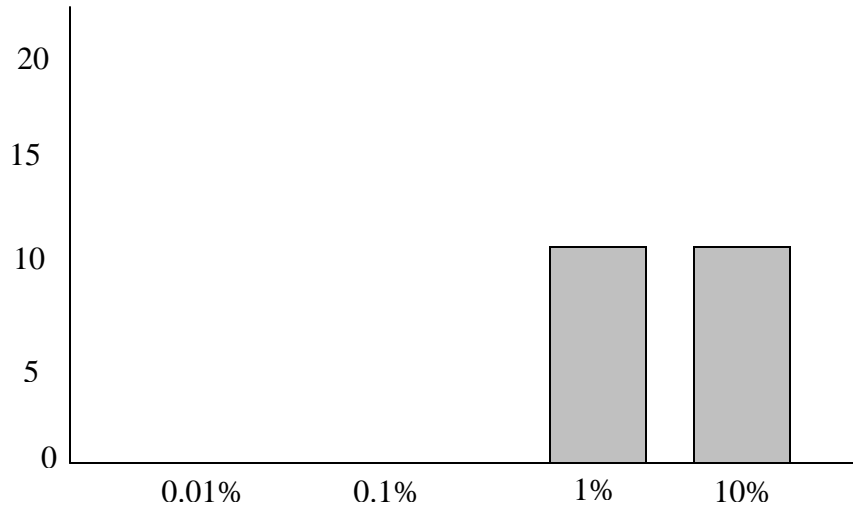


Substance and dilution	No of volunteer's who detected a change
Saccharin 0.01%	10
Saccharin 0.1%	10
Saccharin 1%	10
Saccharin 10%	10



Substance and dilution	No of volunteer's who detected a change
Honey 0.01%	-
Honey 0.1%	-
Honey 1%	10
Honey 10%	10

HONEY



4.5 DEGREE OF SWEETNESS

5- Very high

4- High

3- Moderate

2- Slight

1 - No taste

Panelist	Sugar	10%	1%	0.1%	0.01%
1		4	3	1	1
2		4	3	1	1
3		4	3	1	1
4		4	4	1	1
5		4	3	1	1
6		4	3	1	1
7		4	4	1	1
8		4	3	1	1
9		4	3	1	1
10		4	3	1	1

Panelist	Saccharin	10%	1%	0.1%	0.01%
1		5	5	4	3
2		5	5	4	3
3		5	5	5	3
4		5	5	4	3
5		5	5	4	3
6		5	5	4	3
7		5	5	4	3
8		5	5	4	3
9		5	5	4	3
10		5	5	4	3

Panelist	Honey	10%	1%	0.1%	0.01%
1		4	3	1	1
2		4	3	1	1
3		4	3	1	1
4		4	4	1	1
5		4	3	1	1
6		4	3	1	1
7		4	4	1	1
8		4	3	1	1
9		4	3	1	1
10		4	3	1	1

CHAPTER FIVE

DISCUSSION AND CONCLUSION

DISCUSSION: Table 1 is the baseline taste data with distilled water which is used as the control.

In Table 2 there is a change in taste in the 10% and 1% dilution percentage of sugar, no change of taste was observed in the 0.1% and 0.01% dilution percentage this means that it requires much servings of sugar to produce sweetness and since sugar increases the blood sugar intake it is not good for diabetic patients especially the type 2 diabetes, where the insulin in the body is inadequate to break up the amount of sugar in the bloodstream.

In Table 3 saccharin an artificial sweetener has a change in taste in all the percentage dilutions but at different degree this means that it requires less servings of saccharin to produce sweetness. Saccharin at dilution percentage 0.01% and 0.1% produces the same degree of sweetness as that of the 10% and 1% table sugar and can be used at this concentration as a replacement for sugar since saccharin does not increase blood sugar level they are recommended for diabetes patients. At 10% and 1% saccharin dilution percentage the taste is higher than that of sugar and honey. According to the

statistical analysis (Anova) there is significant difference between the samples at different dilution percentage. In Saccharin the 10% and 1% concentration can be recommended for the young children and hypoglycemia patients, it can also be used to produce sweets, candies and other sugary substances but the adult can use it at the 0.1% and 0.01% concentration.

In Table 4 honey a natural sweetener produces the same degree of sweetness as that of sugar in the different dilution percentage, it can be a better choice to be used since honey is a natural sweetener made by bees and contains trace amounts of vitamins and minerals and can also function as antioxidants. It is recommended for both young and adult.

Taste durability: In regular sugar and honey the sweet taste hits quickly and dissipates quickly but the taste of saccharin last longer than that of sugar with a bitter or metallic feeling after taste especially at high concentrations.

CONCLUSION

Following the experimental analysis and results the artificial sweetener has high degree of sweetness than the table sugar and the natural sweetener honey. At the percentage of 0.1% and 0.01% artificial sweetener completely mimics the taste of sugar and can be used as a replacement at this percentage for sugar. Further researches are hence encouraged using other types of artificial sweeteners and natural sweeteners.

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APPENDIX

Panelist	Sugar	10%	1%	0.1%	0.01%	T.
1		4	3	1	1	9
2		4	3	1	1	9
3		4	4	1	1	10
4		4	3	1	1	9
5		4	3	1	1	9
6		4	4	1	1	10
7		4	3	1	1	9
8		4	3	1	1	9
9		4	4	1	1	10
10		4	3	1	1	9
Ex		40	33	10	10	93T..
Mean x		4	3.3	1	1	
Ex2		1600	1089	100	100	2889T...

$$\text{Correctionfactor (cf)} = \frac{T_{..}^2}{N} = \frac{93^2}{40} = 216.23$$

N40

$$SS_{\text{Sample}} = T_{...} - cf$$

No of panelist **105**

NO. OF PEOPLE

$$= \frac{2889}{10} - 216.23 = 72.67$$

10

$$SS_{\text{panelist}} = \frac{E T_{.}^2}{N} - cf$$

No of samples

$$= \frac{867}{4} - 216.2 = 0.52$$

4

$$SS_{\text{total}} = E (\text{every observation})^2 - cf$$

$$= 291 - 216.23 = 74.77$$

ANOVA TABLE

Sample	Sugar	Df 4-1=3	SS 72.67	MS 72.67/3 =24.2	Fcal MSS/MSE =24.2/0.059 =410.2	Ftab 2.96
Panelist		10-1 =9	0.52	0.52/9 =0.057		
Error		39-12 =27	1.58	1.58/27 =0.059		
Total		40-1 =39	27.97			

$F_{cal} > F_{tab}$ the null hypothesis (H_0) is rejected therefore there is significant difference ($p < 0.05$) between the samples.

	Saccharin	10%	1%	0.1%	0.01%	T.
1		5	5	4	3	17
2		5	4	5	3	17
3		5	5	5	3	18
4		5	5	4	3	17
5		5	5	4	3	17
6		5	5	4	3	17
7		5	5	4	3	17
8		5	5	4	3	17
9		5	5	4	3	17
10		5	5	4	3	17
EX		50	49	42	30	171T..
Mean x		5	4.9	4.2	3	
EX ²		2500	2401	1764	900	7565T...

$$\text{Correction factor (cf)} = \frac{\underline{T..}^2}{N} = \frac{171^2}{40} = 731.03$$

$$\text{SSsample} = \underline{T...} - \text{cf}$$

No of panelist

$$= \frac{7565}{10} - 731.03$$

$$= 25.47$$

$$\text{SSpanelist} = \underline{ET..} - \text{cf}$$

No of samples

$$= \frac{2925}{4} - 731.03$$

$$= 0.22$$

$$\text{SStotal} = E (\text{every observation})^2 - \text{cf}$$

$$= 759 - 731.03$$

$$= 27.97$$

ANOVA TABLE

Source of variance	Df	SS	MS	Fcal	Ftab
Sample	4-1=3	25.47	25.47/3 =8.49	MSS/MSE =106.1	2.96
Panelist	10-9=9	0.22	0.22/9 =0.024		
Error	39-12=27	2.28	2.28/27 =0.08		
Total	40-1 =39	27.97			

Since $F_{cal} > F_{tab}$ the null hypothesis (H_0) is rejected, therefore there is significant difference ($p < 0.05$) between the samples.

LSD

From A_7 the value under 4 samples and 27df for error

$$LSD = 0.28 \times 3.84 = 1.0752$$

$$= 0.28 \times 3.90 = 1.0752$$

Any two sample means differing by LSD or more (\geq LSD)

$$A-B \quad 5 - 4.9 = 0.1$$

$$A-C \quad 5 - 4.2 = 0.8$$

$$A-D \quad 5 - 3 = 2 \text{ Difference exists}$$

$$B-C \quad 4.9 - 4.2 = 0.7$$

$$B-D \quad 4.9 - 3 = 1.9 \text{ Difference exists}$$

$$C-D \quad 4.2 - 3 = 1.2 \text{ Difference exists}$$

X of scores

A 5 ^a	B 4.9 ^a	C 4.2 ^a	D 3 ^b
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Any two means bearing different superscripts are significantly different.(p<0.05).

Panelist	Honey	10%	1%	0.1%	0.01%	T.
1		4	3	1	1	9
2		4	3	1	1	9
3		4	4	1	1	10
4		4	3	1	1	9
5		4	3	1	1	9
6		4	4	1	1	10
7		4	3	1	1	9
8		4	3	1	1	9
9		4	4	1	1	10
10		4	3	1	1	9
Ex		40	33	10	10	93T..
Mean x		4	3.3	1	1	
Ex2		1600	1089	100	100	2889T...

Correctionfactor (cf) = $\frac{T_{..}^2}{N} = \frac{93^2}{40} = 216.23$

N40

SS Sample= $\frac{T_{...}}{N}$ - cf

No of panelist

105

NO. OF PEOPLE

= $\frac{2889}{40} - 216.23 = 72.67$

$$SS_{\text{panelist}} = \frac{ET.^2}{n} - cf$$

No of samples

$$= \frac{867}{4} - 216.2 = 0.52$$

4

$$SS_{\text{total}} = E(\text{every observation})^2 - cf$$

$$= 291 - 216.23 = 74.77$$

ANOVA TABLE

	Honey	Df	SS	MS	Fcal	Ftab
Sample		4-1=3	72.67	72.67/3 =24.2	MSS/MSE =24.2/0.059 =410.2	2.96
Panelist		10-1 =9	0.52	0.52/9 =0.057		
Error		39-12 =27	1.58	1.58/27 =0.059		
Total		40-1 =39	27.97			

Fcal > Ftab the null hypothesis (H0) is rejected therefore there is significant difference (p < 0.05) between the samples.