How Sweet?

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By

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Abstract

This project studied the effects of the classification of sweeteners (natural and artificial) of sweeteners on the blood glucose level in milligram per deciliter. Diabetes is a disease in which the pancreas produces little or no insulin, a hormone that helps the body’s tissues absorb glucose (sugars) so the glucose can be used as a source of energy. Diabetes was chosen for this project since a relative of the experimenter is recently combating diabetes. Blood was extracted from test subjects and placed into blood glucose meter. The fasting blood glucose level was recorded. A bottle of water with table sugar was ingested and the test subjects were allowed thirty minutes for the sweetener to enter the blood system. Blood was then again extracted from the test subjects and the blood glucose level for the water with table sugar was recorded. This process was repeated for water with stevia, and aspartame. The statistics applied to the data collected indicated there was a significant difference between the difference in table sugar and stevia, but there was not a statistical difference between the difference in table sugar and aspartame.
# Table of Contents

I  INTRODUCTION OF THE PROBLEM ............................................. 1-7  
   Introduction to Statement of Problem ......................... 1  
   Review of Literature .................................................. 2-9  
   Hypothesis ......................................................... 10  

II PROCEDURE .............................................................................. 11-13  
   Experimental Design .................................................... 11  
   Materials ................................................................. 12  
   Test Procedures ........................................................ 13  

III DISCUSSION OF DATA (RESULTS) .................................... 14-15  
   Results and Observations .......................................... 14  
   Dose Response Curve ................................................ 15  
   Mean Graph .............................................................. 15  

IV INTERPRETATION/CONCLUSION ........................................ 16-17  

V FUTURE STUDY ........................................................................... 18  

VI GLOSSARY OF TERMS ....................................................... 19-20  

VI ACKNOWLEDGEMENTS .................................................. 21  

VII WORKS CITED ........................................................................ 22-23
Introduction to Statement of Problem

An interest in blood glucose was established, when the experimenter observed a relative going through the required medical procedures of a diabetic. Diabetics must adjust the amount of insulin injected, the amount of physical exercise, and food intake to maintain the blood sugar at a normal level (Lodewick, 1998). People with diabetes must maintain their diet. This can be done by distributing meals and snacks throughout the day so that the insulin does not reach dangerous levels. Diabetics should eat foods that contain complex sugars, which break down slowly and cause a slower rise in the blood sugar levels. The experimenter wanted to help diabetics to be able to experience the sweetness of foods without having to deal with the rise in their blood glucose level. People with diabetes may use sweeteners because they make food taste sweet without raising blood sugar levels. The experimenters also wanted to see if natural sweeteners affect the blood glucose level the same as artificial. Some people prefer the taste of natural sweeteners as opposed to artificial ones. Some prefer the origin too. Natural sweeteners are natural and versatile, which makes them something everyone enjoys. This led the experimenter to the following problem:

Does the classification of sweetener (natural or artificial) affect the blood glucose level?
Review of Literature

Diabetes is a disease in which the pancreas produces little or no insulin, a hormone that helps the body’s tissues absorb glucose (sugar) so the glucose can be used as a source of energy (Diabetes Words and Phrases, 2008). The disease also causes improper use and storage of the glucose. The glucose will accumulate in the bloodstream-causing one’s glucose, blood sugar, level to rise. In the United States, it is estimated that approximately sixteen million people suffer from diabetes, although only half of these individuals have been diagnosed. Every year, about 650,000 people learn they have the disease. Diabetes is the sixth leading cause of all deaths known to be caused by disease (An Overview of Diabetes, 2008).

Diabetes is most common in adults over 45 years old of age; in people who are overweight or physically inactive; in individuals who have an immediate family member with diabetes; and in minority populations including African Americans, Hispanics, and Native Americans. The highest rate of diabetes in the world occurs in Native Americans. Also, more women then men are diagnosed with the diseases (Ingle, 2000).

In diabetes, without an appropriate level of insulin to help absorption, glucose collects in the blood because the glucose cannot enter the cells. When the blood passes through the kidneys, organs that remove impurities out of the blood, the kidneys cannot absorb all the excess glucose (Lodewick, 1998). This excess glucose spills into the urine, accompanied by water and electrolytes—ions needed by cells to regulate the electric charge and flow of water molecules across the cell membrane (Diabetic Words and Phrases, 2008). This causes frequent urination to get rid of the additional water drawn into the urine resulting in excessive thirst triggered to replace the loss of water,
and hunger to replace the glucose lost. Additional symptoms may include blurred vision, irritability, weakness and fatigue, tingling or numbness in the hands or feet, wounds that won’t heal, and nausea and vomiting (Lodewick, 1998).

There are two major types of diabetes. In Type I, or insulin-dependent diabetes mellitus (IDDM), formerly known as juvenile-onset diabetes, the body does not produce insulin or produces in only in very small quantities. People with Type I diabetes must take daily insulin injections to survive. This form of diabetes usually occurs in individuals under twenty years old, but can occur at any age. In the United States, about five to ten percent of all diagnosed cases of diabetes, up to 800,000 people, suffer from Type I diabetes. About 30,000 new cases are diagnosed a year (Vinicor, 2001).

Type I diabetes is considered an autoimmune disease because the immune system attacks and destroys the cells in the pancreas, known as beta cells, that produce insulin. Scientists believe that genetic and environmental factors, such as viruses or food proteins, may somehow trigger the immune system to destroy these cells.

Also, if Type I diabetes goes untreated the metabolism of fat is affected because the body cannot convert glucose into energy. The body then begins to break down stored fat for fuel. This produces increased amounts of acidic compounds called ketone bodies in the blood, which will in turn interfere with respiration (Ingle, 2000).

In Type II, or non-insulin-dependent diabetes mellitus (NIDDM), formally known as adult-onset diabetes, the body either makes insufficient amounts of insulin or is unable to use it. Type II diabetes is the most common form of diabetes. Type II
diabetes accounts for 90 to 95 percent of all cases of diagnosed diabetes in the United States. Each year nearly 600,000 new cases are diagnosed. The onset of Type II diabetes usually occurs in adults over the age of forty. Also, scientists believe that in some people weight gain or obesity triggers diabetes - about 80 percent of diabetics with this form of the disease are overweight (Vinicor, 2001).

When Type II diabetes is left untreated in can result in a diabetic coma or death. In both Type I and Type II diabetes, blood sugar, blood pressure, and blood fats must be well-controlled to prevent possible development of blindness, kidney failure, and heart disease. Also, when left untreated tiny blood vessels in the body may become blocked causing damage (Lodewick, 1998). When the blood vessels of the eye are affected, a result can be retinopathy, the breakdown of the lining of the back of the eye (Diabetes Words and Phrases, 2008). Also, when the kidney is affected it is called nephropathy, the inability of the kidney to properly filter body toxins. Diabetes may also cause the loss of feeling, particularly in the lower legs. Also, blockage of large blood vessels in diabetic people can lead to many health problems such as, high blood pressure, heart attack, and stroke. Although these conditions can occur in nondiabetic individuals, these conditions are at a more prevalent and often occur at a younger age in people with diabetes (Lodewick, 1998).

Diabetes is detected by measuring the amount of glucose in the blood after the individual has fasted for several hours, usually overnight or several hours after breakfast. In some cases, a physician diagnoses diabetes by administering on oral glucose tolerance test, the measurement of glucose levels before and after a specific amount of sugar is ingested. Another test being developed for Type I diabetes looks
for specific antibodies present only in people with diabetes (An Overview of Diabetes, 2008).

Once diabetes is diagnosed, treatment consists of controlling the amount of glucose in the blood and preventing any complications that may occur. Depending on the type of diabetes, this can be accomplished through regular physical exercise, a carefully controlled diet, and medication (Vinicor, 2001).

Individuals with Type I diabetes requires insulin injections, often two to four times a day, to provide the body with the insulin the body does not produce. The amount of insulin depends on the person. Typically, several times a day, an individual with Type I diabetes measures the level of glucose in a drop of blood obtained by pricking a fingertip. To maintain normal blood sugar levels, the amount of insulin, physical exercise, or food intake may be changed. People with Type I diabetes must carefully control their diets by distributing meals and snacks throughout the day so that the insulin supply is not overwhelmed. Type I diabetics also work to maintain normal blood sugar levels by eating foods that contain complex sugars, which breakdown slowly and cause a slow rise in blood sugar levels. Although people with Type II diabetes strive to lower the amount of glucose in the blood, levels that are too low can also cause health problems (Laliberte, 2002).

For people with Type II diabetes, the basic treatments are diet control, weight reduction, and exercise. Weight reduction appears to partially reverse the body’s inability to use insulin. A person with Type II diabetes whose blood sugar level remains high may also require insulin injections (Laliberte, 2002).

Sugar is sucrose, a molecule composed of 12 atoms of carbon, 22 atoms of
hydrogen, and 11 atoms of oxygen \( (\text{C}_{12}\text{H}_{22}\text{O}_{11}) \). Sucrose can be broken down into simpler sugars, fructose and glucose. Like all compounds made from these three elements, sugar is a carbohydrate. Sugar is found naturally in most plants, but especially in sugarcane and sugar beets (What is Sugar, 2008).

All green plants manufacture sugar through photosynthesis, the process by which plants transform sunlight into food and energy supply. Once photosynthesis creates sugar, plants have the unique ability to change sugar to starch and starch to various sugars for storage. This diversity provides a wide variety of tasty fruits and vegetables, from the starchy potato to the sweet carrot. Sugar cane and sugar beet plants contain sucrose in large quantities; this is why these plants are used as commercial sources of sugar. A stalk of the cane plant contains about 14% sugar. Sugar beets contain about 16% sugar (What is Sugar, 2008).

The discovery of sugarcane, from which sugar, is known as today, is derived, dates back thousands of years, the actual date is unknown. Sugar is thought to have originated in New Guinea, and was spread along routes to Southeast Asia and India. The process known for creating sugar, pressing out the juice from the sugarcane and then boiling the sugar into crystals, is thought to have developed in India around 500 BC. The cultivation of sugar was not introduced into Europe until the middle-ages, when the sugar was brought to Spain by Arabs. Columbus took the plant to the West Indies, where it began to thrive in a most favorable climate (Sharpe, 2008).

It was not until the seventeenth century that sugarcane cultivation began in the United States. At this time sugarcane was planted near New Orleans due to the favorable southern climate. The very first refinery was built in New York City around
1690; the industry was established by the 1830s. Earlier attempts to create a successful industry in the United States did not fare well; from the late 1830s, when the first factory was built, until 1872, sugar factories closed down almost as quickly as they had opened. It was 1872 before a factory, built in California, was finally able to successfully produce sugar in a profitable manner. At the end of that century, more than thirty factories were in operation in the United States (Sharpe, 2008).

The average American consumes an astounding two to three pounds of sugar each week, which is not surprising considering that highly refined sugars in the forms of sucrose (table sugar), dextrose (corn sugar), and high-fructose corn syrup are being processed into so many foods. In the last 20 years, United States citizens have increased sugar consumption from 26 pounds to 135 pounds of sugar per person per year. Prior to the turn of this century (1887-1890), the average consumption was only 5 pounds per person per year.

One of sugar’s major drawbacks is that such an increase in the amount of sugar consumed causes an increased level of insulin, which inhibits the release of growth hormones, which in turn depresses the immune system. An influx of sugar into the bloodstream upsets the body’s blood-sugar balance, triggering the release of insulin, which the body uses to keep blood-sugar at a constant and safe level. Insulin also promotes the storage of fat, so that when sweets high in sugar are eaten, rapid weight gain and elevated triglyceride levels may be side affects, both of which have been linked to cardiovascular disease. Complex carbohydrates tend to be absorbed more slowly, lessening the impact on blood-sugar levels (What I need to know about Eating and Diabetes, 2008).
Aspartame is the name of an artificial, non-carbohydrate sweetener, with a sugar-like taste, but is approximately 200 times sweeter than sucrose. Aspartame is unique among the low-calorie sweeteners because the sweetener is completely broken down by the body into the original components, the amino acids, aspartic acid and phenylalanine, and a small amount of methanol. These components are also found in common foods such as meat, milk, fruit, and vegetables (Aspartame- Other Sweeteners, 2002).

The sweetener is marketed under a number of trademark names such as Equal, Nutrasweet, and Canderel, and is an ingredient in approximately 6,000 consumer foods and beverages sold worldwide. It is commonly used in diet soft drinks and is often provided as a table condiment. Aspartame is also used in some brands of chewable vitamin supplements and common in many sugar-free chewing gums. However, aspartame is not always suitable for baking, because the aspartame often breaks down when heated and loses much of the sweetness. In the European Union, aspartame is also known under the E number (additive code) E951. Aspartame is also one of the sugar substitutes used by diabetics.

Aspartame was discovered in 1965 by James M. Schlatter, a chemist working for G.D. Searle & Company. Schlatter had synthesized aspartame in the course of producing an anti-ulcer drug candidate. He discovered the sweet taste serendipitously when Schlatter licked his finger, which had accidentally become contaminated with aspartame (Food Additive Approval Process Followed for Aspartame, 1987).

Aspartame is one of the most thoroughly studied food ingredients that has ever reached the market shelves, with more than 200 scientific studies confirming the safety
of aspartame. In 1981 aspartame was approved for use in tabletop sweeteners and various foods and dry beverage mixes, making it the first low-calorie sweetener approved by the U.S. Food and Drug Administration (FDA) in more than 25 years. In 1983, FDA approved aspartame for use in carbonated beverages followed by a number of other product category approvals over the next 13 years, leading to a general use approval in foods and beverages in 1996. In addition to FDA, the Joint Expert Committee on Food Additives (JECFA) of the World Health Organization and Food and Agriculture Organization, the Scientific Committee on Food of the European Commission (SCF), and regulatory agencies in more than 100 countries have reviewed aspartame and found it to be safe for use.

Headache is the most common adverse side affect attributed to aspartame, but is seldom confirmed by a single-dose double-blind challenge. Up to eleven percent of patients with chronic migraine headaches reported headaches triggered by aspartame; however, a double-blind challenge with three doses of 10mg/kg given every two hours triggered no more headaches then did placebos in patients with vascular headaches believed to be exacerbated by aspartame. A small double-blind-four week trial showed an increase in frequency of headaches after ingestion of 1200 mg/d, indicating that a longer challenge period is needed (Aspartame- Other Sweeteners, 2002).

In anecdotal reports, aspartame had been linked to various neuropsychiatric disorders, including panic attacks, mood changes, visual hallucinations, manic episodes, and isolated dizziness. A small, double-blind crossover study of patients with major depression revealed a higher incidence of reactions in these patients compared with nondepressed volunteers after administration of 30mg/kg for seven days. This
crossover study reported symptoms that included headache, nervousness, dizziness, memory impairment, nausea, temper outbursts, and depression. None of these symptoms have been rigorously proven to be directly caused by aspartame, but carefully conducted double-blind challenges may suggest aspartame as a cause in patients with histories of neuropsychiatric tendencies. Patients with underlying affective disorders may be at increased risk for neuropsychiatric effects; several studies have shown that individuals without psychiatric or seizure disorders do not demonstrate these effects (Food Additive Approval Process Followed for Aspartame, 1987).

Stevia is a genus of about 240 species of herbs and shrubs in the sunflower family (Asteraceae), native to subtropical and tropical South America and Central America. The species *Stevia rebaudiana* Bertoni, commonly known as sweetleaf, sweet leaf, sugarleaf, or simply stevia, is widely grown for its sweet leaves. As a sugar substitute, stevia’s taste has a slower onset and longer duration than that of sugar, although some of stevia’s extracts may have a bitter or licorice-like aftertaste at high concentrations (Schardt, 2008).

With stevia’s extracts having up to 300 times the sweetness of sugar, stevia has garnered attention with the rise in demand for low-carbohydrate, low-sugar food alternatives. Medical research has also shown possible benefits of stevia in treating obesity and high blood pressure. Since stevia has a negligible effect on blood glucose, stevia is attractive as a natural sweetener to people on carbohydrate-controlled diets. However, health and political controversies have limited stevia’s availability in many countries; for example, the United States banned it in the early 1990s unless labeled as
a supplement. Stevia is widely used as a sweetener in Japan, and it is now available in Canada as a dietary supplement (Schart, 2008).

Stevia has some very interesting properties. It has no calories but has effects similar to several currently used medications. It stimulates the release of insulin and normalizes the response to glucose, especially in type 2 diabetes. It is used in Latin America as an inexpensive therapy for hyperglycemia. Studies conducted in South America indicated some positive results in regards to the effects of stevia on the blood glucose level (Massey, 2002).

In some medical studies, regular consumption of stevia also reduces high blood pressure without causing a change in normal blood pressure. Medical publications have shown that it affects calcium transport in a way that is similar to a class of drugs called calcium channel blockers (like verapamil), which commonly are used to treat high blood pressure. In laboratory animals, stevia also can induce diuresis or water release, similar to diuretics also used to treat high blood pressure.

Other studies have shown stevia improves insulin sensitivity in rats and may even promote additional insulin production, helping to reverse diabetes and metabolic syndrome. Preliminary human studies show stevia can help reduce hypertension although one study has shown it has no effect on hypertension. Indeed, millions of Japanese have been using stevia for over thirty years with no reported or known harmful effects. Similarly, stevia leaves have been used for centuries in South America spanning multiple generations as an ethnomedical tradition used for the treatment of Type II diabetes (Stevia Side Effects, 2008).
In 2006, the World Health Organization (WHO) performed a thorough evaluation of recent experimental studies of stevioside and steviol conducted on animals and humans, and concluded that "stevioside and rebaudioside A are not genotoxic in vitro or in vivo and that the genotoxicity of steviol and some of its oxidative derivatives in vitro is not expressed in vivo." The report also found no evidence of carcinogenic activity. Furthermore, the report noted that "stevioside has shown some evidence of pharmacological effects in patients with hypertension or with type-2 diabetes." However, in the report, the WHO concluded that further study was required to determine proper dosage (Schartt, 2008).

Although positive and encouraging reports have been published, many controversies have been brought up about Sevia as well. FDA has not actually permitted the stevia plant itself to be used as a food additive, but only as a dietary supplement. The FDA believes that the reference to stevia’s sweetness for use as a sugar substitute in baking or cooking implies use as a conventional food. There are sources that question this decision as being largely influenced by the sugar industry. The non-patentable, natural stevia could be a major competitor for a multi-billion dollar sweetener industry which could cause them to lose money if the FDA was to allow the stevia as a food additive (Food Safely, 2008).
Hypothesis

As the classification of sweetener (artificial or natural) changes, then the blood glucose level will change. According to Mayo Clinic endocrinologist, Maria Collazo-Calvell, MD and colleagues sucrose (table sugar) will affect the blood glucose level. Foods containing sweeteners can affect the blood glucose level due to other ingredients such as carbohydrates and proteins. Therefore, the blood glucose level will be higher for the table sugar.

Null Hypothesis

As the classification of sweetener (artificial or natural) changes, then the blood glucose level will not change.
Experimental Design

Does the type of classification of sweetener affect the blood glucose level?

**Independent variable** - classification of sweetener

**Dependent variable** - blood glucose level

**Retests** - 10 retests for each classification of sweetener

**Control Group** - undefined; true comparison

**Constant**

- Same testing device
- Same brand of testing strips
- Same amount of sweetener
- Same time of day tested
- Same source of water
- Same amount between each consumption and test
- Same test subjects
- Same amount of fasting period
- Same age group of test subjects
Materials

1. Blood glucose meter
2. Blood glucose testing strips
3. Cotton swabs
4. Bottle of alcohol
5. Lancing device
6. Lancets
7. 250 grams of pure sugar
8. 250 grams of stevia sweetener
9. 250 grams of aspartame sweetener
10. Water
11. 30 Styrofoam cups
Procedure

1. Have test subjects fast from midnight until time of control blood glucose testing.
2. Place test strip into meter.
3. Place lancet into lancing device.
4. Clean selected finger with alcohol.
5. Cock the lancing device and prick the finger.
6. Allow testing strip to absorb the blood.
7. Record reading into data table.
8. Repeat steps 2-7 for each test subject.
9. Place 25 grams of pure sugar into a Styrofoam cup for each test subject.
10. Have each test subject ingest the pure sugar.
11. Wait 30 minutes for the sugar to get into the blood stream.
12. Repeat steps 2-9 to record each test subject’s blood glucose level after the 30 minutes
13. Repeat steps 1-12 for stevia sweetener and aspartame sweetener.
Results and Observations

The average blood glucose for the difference in table sugar was 35.7 mg/dL. The average for difference in stevia was 8.4 mg/dL. Finally, the average for the difference in aspartame was 42.4 mg/dL.

The median blood glucose for the difference in table sugar was 41.5 mg/dL. The median for the difference in stevia was 12 mg/dL. Finally, the median for the difference in aspartame was 40 mg/dL.

The experimenter observed that the test subjects did not like the taste of the stevia. Also, observations were made that the stevia was much less dense than the table sugar or the aspartame. The consistence of the stevia was that like powdered sugar. Observations were made that the test subjects were temperamental when not fed. It seemed that the females were more temperamental than the males. The experimenter also noticed that drawing blood was harder when the test subject’s hands were cold. Also, when observing the ingredients in the aspartame sweetener it was found that dextrose was a key ingredient.
Individual Graph
The Effects of the Classification of Sweeteners on the Blood Glucose Level in Milligrams per Deciliter.

Mean Graph
The Effects of the Classification of Sweeteners on the Blood Glucose Level in Milligrams per Deciliter.
Conclusion

Prior to conducting the experiment, the hypothesis stated that as the classification of sweeteners changes, then the blood glucose level will change. The hypothesis has been accepted when the table sugar was compared to the stevia, but not accepted when compared to the aspartame based on the statistics applied to the data collected. There was a significant difference between the table sugar and the stevia, but there was no significant difference between the table sugar and the aspartame.

The research indicated foods containing sweeteners can affect the blood glucose level due to other ingredients such as carbohydrates and proteins. "When it comes to these artificial sweeteners, the calorie count is an artificial definition," said Dr. Sheldon S. Hendler, co-editor of the PDR for Nutritional Supplements. If a product for example Equal or Splenda contains less than five calories per serving, the Food and Drug Administration allows the label to state that it contains zero calories. Actually, Splenda and Equal both contain one gram of dextrose, or four calories per serving, and so four packets would be equivalent in caloric value to one teaspoonful of sugar. An excessive amount of sweetener containing the dextrose could have caused the high rise in the blood glucose level.

Since sugars raise the blood glucose levels, diagnosis of diabetes was once a sentence to a dessert free life. No cake. No pie. No hot fudge sundaes. One option for allowing a person to enjoy more sweet foods is the use of sugar substitutes. However, some sugar substitutes do contain calories and
carbohydrates. When choosing products with sugar substitutes, read the label. A natural sweetener, such as stevia, can be a viable alternative to other sugar substitutes. Some people prefer the taste of natural sweeteners as opposed to artificial ones. Some prefer the origin too. For example, stevia natural sweetener is natural and versatile, which makes it something everyone can enjoy.
Future Study

The experimenter would like to expand this project by reforming more retests to see if the stevia would be a viable alternative to pure sugar and even artificial sweeteners. Also, the experimenter would like to test on other natural sweeteners, other than stevia, to see if they would have the same affect.

Another possible way to expand this project is to actually perform the tests on diabetic people.
Glossary of Terms

1. **Aerotolerant** - Able to survive in the presence of oxygen. This term especially applies to facultative anaerobes, which don’t actually require oxygen to live but are not harmed by its presence.

2. **Anaerobic** - (of an organism or tissue) living in the absence of air or free oxygen.

3. **Arcbaebacteria** - A group of microorganisms, including the methanogens and certain halophiles and thermoacidophiles, which have RNA sequences, coenzymes, and a cell wall composition that are different from all other organisms: considered to be an ancient form of life that evolved separately from the bacteria and blue-green algae and sometimes classified as a kingdom.

4. **Diabetic blisters (bullosis diabeticorum)** - These blisters are rare and resemble burn blisters. They usually appear on the fingers, hands, toes, feet, or forearms. They tend to be painless and heal on their own. They will heal faster if you get your blood glucose levels in the normal range. They are thought to be caused by diabetic neuropathy.

5. **Diabetic dermopathy** - A skin disorder most commonly occurring on the shins of people with diabetes mellitus, characterized by discolored patches and small papules that often become pigmented and ulcerated and result in scars.
6. **Eruptive xanthomatosis**- consists of firm, yellow, pea-like enlargements in the skin. Each bump has a red halo and may itch. This condition occurs most often on the backs of hands, feet, arms, legs, and buttocks.

7. **In situ**- in place or position; undisturbed.

8. **Microaerophilic**- requiring very little free oxygen

9. **Necrobiosis lipoidica diabeticorum**- refers to a skin rash that most commonly affects the shins and is seen more often in women. More than fifty per cent of sufferers are also found to have diabetes mellitus.
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Work Cited


