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Article

Comparing the reducing sugars in avocados, soybeans, and cinnamon: A Benedict's test experiment

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SUMMARY

America's growing obesity rates are putting millions of individuals at risk for developing Type II diabetes, which increases the likelihood that these people will develop serious illnesses later in life. In the past few decades, studies have shown the importance of a diet rich in nutrients, low in fat, and low in calories in managing Type II diabetes. Since consumption of reducing sugars like glucose affects diabetes and blood glucose levels, this study aimed to test if Hass avocados (*Persea americana*), dried yellow soybeans (*Glycine max*), and Ceylon cinnamon (*Cinnamomum verum*) contain a low amount of reducing sugars. Benedict's Test uses a reagent that detects the amount of reducing sugars in a sample. Using this test to determine the presence of reducing sugars in Hass avocados, soybeans, and Ceylon cinnamon, we concluded that the three foods contained only a trace of reducing sugars. Our finding that Hass avocados, soybeans, and Ceylon cinnamon contain low amounts of reducing sugars suggests that a diet containing these foods may help individuals better manage Type II diabetes.

INTRODUCTION

The rates of people diagnosed with Type II diabetes, which is affected by lifestyle factors more than genetics, are accelerating at a higher rate than those with Type I diabetes (1). Type II diabetes primarily affects the younger generation, with as many as 5,700 adolescents ages 10 to 19 diagnosed annually (2). Diabetes predominantly affects those transitioning between developmental stages and adolescents, though it can affect people of any age (2). This research project focused on Type II diabetes as it has the possibility of remission. While Type II diabetes may not have a cure yet, its severity can be reduced (3).

A healthy dietary plan is essential in managing Type II diabetes. Consuming fiber generally reduces fasting blood glucose, thus benefiting individuals living with Type II diabetes (4). One source of fiber is avocados. They are rich in vitamins, fatty acids, magnesium, and potassium, accounting for over a tenth of the recommended daily fiber intake value (5). Specifically, Hass avocados rank highly in tree nut qualified health claims with the most dietary fibers (6). Soybeans are another source of fiber. Consuming soybeans is linked to various health benefits as they are high in antioxidants and proteins (7).

Fibrous foods with low glycemic indexes regulate blood sugar and insulin levels (8). Simple carbohydrates can vary in glycemic indexes, and carbohydrates with a higher glycemic index measurement tend to decompose quicker during digestion and thus affect blood levels faster than carbohydrates with a lower glycemic index. Foods with low glycemic indexes contain carbohydrates that inhibit the speed at which the body processes foods and score below 55 on the glycemic index scale (9). Hass avocados and yellow soybeans are categorized as low glycemic index foods, with a glycemic index of 15 for Hass avocados and between 14 and 20 for soybeans (9, 10). Furthermore, Hass avocados are considered one of the lowest carbohydrate fruits (11). Additionally, the World Health Organization imposed a new guideline that recommends adults and children limit their daily intake of free sugars to less than a tenth of their total energy consumption (12). This guideline can help people with Type II diabetes manage their diets and sugar consumption.

Cinnamon is a widely known spice used in various home remedies. In a recent study, scientists tested Ceylon cinnamon in rats with diabetes and found that the cinnamon raised insulin levels in the rats to near-standard levels (13). Ceylon cinnamon may act as an alternative treatment in managing Type II diabetes to reduce blood sugar levels and regulate insulin levels in the body. Like Hass avocados and soybeans, Ceylon cinnamon is categorized as having a low glycemic index of 5, which is lower compared to avocados and soybeans (14).

Given the potential of these three foods for improving the diets of those with Type II diabetes, we sought to evaluate the health benefits and nutritional values of Hass avocados, yellow soybeans, and Ceylon cinnamon. Due to their low glycemic indexes and high nutritional values, we determined that Hass avocados, soybeans, and Ceylon cinnamon are ideal variables for this experiment. While researching Type II diabetes, we hypothesized that these three foods would yield a presence of reducing sugars when tested with Benedict's Test. This test is designed to measure reducing sugars in a sample, relating to managing a diet specific to diabetes. After collecting data from five food sources to test our hypothesis, we determined that the final results supported the hypothesis and that a diet managing diabetes could benefit from including the tested foods. Yellow soybeans and Ceylon cinnamon resulted in 0.1% reducing sugars, and Hass avocados

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resulted in 0.5%. Our data suggest that Hass avocados, yellow soybeans, and Ceylon cinnamon may be beneficial dietary choices for people with Type II diabetes.

RESULTS

The objective of our experiment was to determine the amount of reducing sugars in nutritional foods like avocados, soybeans, and cinnamon. Our goal was to analyze this information to provide a recommendation of foods that people with Type II diabetes should or should not consume. We used Benedict's Test to collect data from three foods of varying nutritional values (Hass avocados, dried yellow soybeans, and Ceylon cinnamon) and two controls (water and organic banana). Benedict's Test used a solution that changed color over time from blue to red to monitor the amount of reducing sugars in a sample (15). We included a positive control and negative control in our experiment to ensure that Benedict's Test was working as expected under standard experimental conditions. The organic banana was the positive control of our experiment, intending to produce a positive result of orange as its final color that would suggest a moderate presence of reducing sugars. Moreover, we used water as a negative control, and its final blue color change indicated that it had no reducing sugars.

We collected data on the amount of reducing sugars in the three experimental components to test our hypothesis. We incubated the foods in boiling water for an uninterrupted two minutes. Using Benedict's Test, we determined that Hass avocados contained 0.5 +/- 0% reducing sugars, soybeans contained 0.1 +/- 1.70e17%, and cinnamon contained 0.1 +/- 0.06% (**Table 1-3**). Our positive (banana) and negative (water) controls showed at least 1.5% and no reducing sugars, respectively (**Table 4 and 5**). All five foods, except for water, yielded a positive result with reducing sugars detected. The standard error of the mean for each of the five foods indicated how likely it would be that the same mean would be calculated if the experiment were to be repeated. The five foods tested had significantly different overall reducing sugar content (ANOVA, $p < 0.01$).

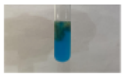
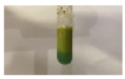
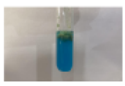
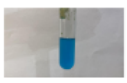
Hass avocados	Incubation Time	Percentage of Reducing Sugars Present	Mixture Photographed at Interval
Trial 1	0 seconds	0.0%	
Trial 1	120 seconds	>0.5%	
Trial 2	0 seconds	0.0%	
Trial 2	120 seconds	0.5%	
Trial 3	0 seconds	0.0%	
Trial 3	120 seconds	0.5%	

Table 1: Analysis of 3 trials of Benedict's reagent and Hass avocados with qualitative data. Hass avocados were tested with Benedict's Test, and the amount of reducing sugars was measured before and after the uninterrupted 2-minute incubation time.

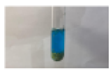
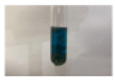
Soybeans	Incubation Time	Percentage of Reducing Sugars Present	Mixture Photographed at Interval
Trial 1	0 seconds	0.0%	
Trial 1	120 seconds	0.1%	
Trial 2	0 seconds	0.0%	
Trial 2	120 seconds	0.1%	
Trial 3	0 seconds	0.0%	
Trial 3	120 seconds	0.1%	

Table 2: Analysis of 3 trials of Benedict's reagent and yellow soybeans with qualitative data. Soybeans were tested with Benedict's Test, and the amount of reducing sugars was measured before and after the uninterrupted 2-minute incubation time.

In the first twenty seconds of the experiment, the constant percentages of reducing sugars in Hass avocados and yellow soybeans were 0.1%, suggesting a similar relationship between the two foods in the early stages of experimentation (**Figure 1**). However, Hass avocados rose to 0.5% reducing sugars present after the two minutes concluded, while yellow soybeans remained at a constant 0.1%. Like the yellow soybeans, Ceylon cinnamon rose to 0.1% reducing sugars present after the two minutes, suggesting a similar end relationship between the two foods.

Lastly, the results of the experiments supported the hypothesis and were not anomalous to the hypothesized results. In summary, our results indicated that yellow soybeans and Ceylon cinnamon might be more beneficial than Hass avocados when added to the Type II diabetes diet management since the average reducing sugar percentages in the soybeans and cinnamon were less than that of Hass avocados.

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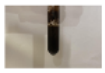
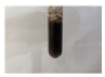
Ceylon Cinnamon	Incubation Time	Percentage of Reducing Sugars Present	Mixture Photographed at Interval
Trial 1	0 seconds	0.0%	
Trial 1	120 seconds	0.0%	
Trial 2	0 seconds	0.0%	
Trial 2	120 seconds	0.1%	
Trial 3	0 seconds	0.0%	
Trial 3	120 seconds	0.0%	

Table 3: Analysis of 3 trials of Benedict's reagent and Ceylon cinnamon with qualitative data. Ceylon cinnamon was tested with Benedict's Test, and the amount of reducing sugars was measured before and after the uninterrupted 2-minute incubation time.

DISCUSSION

Our experiment aimed to determine the presence of reducing sugars in Hass avocados, yellow soybeans, and Ceylon cinnamon. The results supported the initial hypothesis as the experiment yielded a positive result with reducing sugars in the foods. Our data suggest that Hass avocados, yellow soybeans, and Ceylon cinnamon are low-sugar foods that may be part of the Type II diabetes food management system. Consequently, we recommend consuming yellow soybeans and Ceylon cinnamon more than Hass avocados as the soybeans and cinnamon contain a lower percentage of reducing sugars. By spreading awareness of the nutritional values of Hass avocados, yellow soybeans, and Ceylon cinnamon, our data may aid individuals with Type II diabetes in searching for foods with low glycemic indexes. For those who would like to add or keep Hass avocados in their diets, scientists have researched how adding Hass avocados to lunchtime meals may increase satisfaction from eating and decrease the desire to eat in the hours following the meal (16). The satisfaction resulting from this decision could temporarily improve the health of people with Type II diabetes as a suggestion for the time of day most beneficial for consuming Hass avocados.

In future experiments, we could perform Fehling's Test to further test the hypothesis by detecting the presence of glucose in a sample with an alternate solvent. Similar to Benedict's Test, Fehling's Test samples the reaction of carbohydrates in solutions containing glucose and fructose. Like Benedict's Test, Fehling's Test changes color depending on the type of carbohydrates present in a sample. In contrast, the two tests differ as Benedict's Test contains sodium citrate while Fehling's Test contains sodium tartrate (17). Fehling's Test can be used to check for the presence of glucose in urine to detect diabetes, like Benedict's Test; however, a positive result in Benedict's Test does not necessarily suggest that one has diabetes, whereas Fehling's Test is evaluated primarily for this purpose (17).

Because we tested our experiment with a positive and negative control, we determined that Benedict's Test was working as designed at the time. Therefore, these results were satisfactory and supported the hypothesis by going within the specifications of Benedict's Test. Our data encourage the consumption of Hass avocados, yellow soybeans, and Ceylon cinnamon as part of the Type II diabetes food management system. While the three foods are nutritious, our data propose that Hass avocados may cause blood glucose levels to rise faster than soybeans and cinnamon, as Hass avocados had the highest average of reducing sugars out of these three foods. Nonetheless, these food components have many nutritional benefits that could help people with Type II diabetes in general.

MATERIALS AND METHODS

Benedict's Test, a scientific experiment used to detect and measure the presence of reducing sugars in a sample, was used to test the hypothesis. The test consisted of Benedict's reagent mixture and a sample. First, a positive and negative control were sampled to test if Benedict's Test was working as expected under standard experimental conditions. A

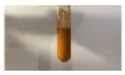
Banana	Incubation Time	Percentage of Reducing Sugars Present	Mixture Photographed at Interval
Trial 1	0 seconds	0.0%	
Trial 1	120 seconds	>1.5%	
Trial 2	0 seconds	0.0%	
Trial 2	120 seconds	>1.5%	
Trial 3	0 seconds	0.0%	
Trial 3	120 seconds	>1.5%	

Table 4: Analysis of 3 trials of Benedict's reagent and a banana with qualitative data. An organic banana was tested with Benedict's Test, and the amount of reducing sugars was measured before and after the uninterrupted 2-minute incubation time.

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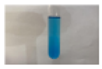
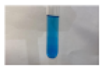
Water	Incubation Time	Percentage of Reducing Sugars Present	Mixture Photographed at Interval
Trial 1	0 seconds	0.0%	
Trial 1	120 seconds	0.0%	

Table 5: Analysis of 1 trial of Benedict's reagent and water with qualitative data. Water was tested with Benedict's Test, and the amount of reducing sugars was measured before and after the uninterrupted 2-minute incubation time.

measurement of 0.5 g of a Chiquita Brands International banana was tested as the positive control, and 8 drops of tap water were tested as the negative control. The 8 drops of water weighed approximately 0.25 g. Instead of 0.5 g of water, 8 drops were used to follow the procedure of testing liquids with Benedict's reagent. Furthermore, 0.5 g of the smashed mesocarp of a Del Monte Foods Hass avocado, 0.5 g dried yellow mashed soybeans from Laura Soybeans, and 0.5 g of Simply Organic Ceylon cinnamon were used for this experiment.

First, 5 mL of the room-temperature Benedict's reagent were poured into a clean test tube. Afterward, 0.5 g of a food item was added to the test tube and then mixed to create a uniform solution. Next, the test tube was submerged in a boiling water bath (100.9°C) and continuously shaken for two minutes while ensuring the open end of the test tube remained above the waterline. Water was tested with only one trial, while the other foods had three trials for more precise measurements. The statistical comparisons in this experiment were calculated through DataClassroom, an online application. When the data was calculated, the quantitation limit of the percentage of reducing sugars present was 0.5. Since there were more than two experimental groups, a one-way ANOVA was used to calculate the p-value at an alpha level of 0.05.

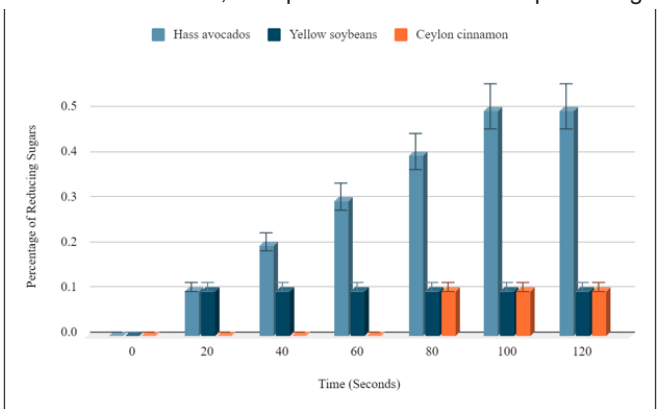


Figure 1: Percentage of reducing sugars. Reducing sugars in Hass avocados (light blue), yellow soybeans (dark blue), and Ceylon cinnamon (orange) after being boiled in a water bath for two minutes. The three foods were tested by Benedict's Test, and the amount of reducing sugars was measured over 2 minutes. Ceylon cinnamon had no percentage of reducing sugars present from 0 to 60 seconds. The error bars represent standard error at each time interval. The upper limit of quantitation for the percentage of reducing sugars is 0.5.

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