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Glycemic response of coconut sugar, sucrose and brown sugar in healthy subjects

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ABSTRACT
Diabetes mellitus is a disease in which blood sugar (glucose) levels are abnormally high because the body doesn't produce enough insulin to meet its needs. It is estimated that the world population with diabetes mellitus is around 387 million and may reach 471 million by 2035. Diabetes is therefore considered the most common endocrine disease. There is significant evidence to support the idea of interventions to improve diabetes outcomes, one of which is glycemic control in the basic diet. Coconut sugar (Cocos nuciferas. L.), has been marketed with the promise of having a low glycemic index and recommended for diabetic patients. The aim of this study was to compare the glycemic response of 30 healthy volunteers fasting for 4 hours after ingesting coconut sugar, sucrose and brown sugar, ranging in age from 19 to 50 years, 73% female and 27% male, who were randomly divided into three different groups after ingesting 50g of the respective sugars. Capillary glycemia was measured at times 0, 15, 30, 45 and 60 minutes. The data was evaluated using analysis of variance and the Scott-Knott test was chosen to verify the differences in the results. It was concluded that the three types of sugar showed statistically the same behaviour ($p<0.05$) in terms of the increase in glycemia at times 15, 30 and 60 minutes compared to time zero, but there was a significant difference ($p<0.05$) at time 45 minutes, where there was a longer time for coconut sugar to decrease. However, it can be concluded that coconut sugar behaves in a similar way to other sugars and should be re-evaluated as a product with a low glycaemic index.

Keywords: Glycemic response, Coconut sugar, Diabetes mellitus, Capillary glycemia.

LIST OF ABBREVIATIONS AND ACRONYMS

BS	Brown sugar
CS	Coconut Sugar
DM	Diabetes Mellitus
GI	Glycemic Index
BMI	Body Mass Index
SUC	Sucrose
T0	Time zero

1 INTRODUCTION

Diabetes Mellitus (DM) is a pathology characterized by the elevation of blood glucose concentration due to the decrease or absence of insulin production by the pancreas, or by the ineffectiveness of the insulin produced on the target cells (AREAS; REYES, 1996).

Currently, it is estimated that the world population with diabetes is in the order of 387 million and that it may reach 471 million by 2035. About 80% of these individuals live in developing countries, where the epidemic is more intense and there is a growing proportion of people affected in younger age groups. Quantifying the current prevalence of DM and estimating the number of people with diabetes in the future is important, as it makes it possible to plan and allocate resources in a rational way (SBD, 2016).

Considered the most common of the endocrine diseases, diabetes is a complex and chronic disease that promotes a series of metabolic disorders and that requires continuous medical care with multifactorial risk reduction strategies, in addition to glycemic control. Ongoing patient education and self-management support are key to preventing acute complications and reducing the risk of long-term complications. There is significant evidence to support a range of interventions to improve diabetes outcomes (DIABETES CARE, 2015).

The Coconut (Cocos nuciferas, L.), is a tree that is cultivated for its multiple uses, mainly for its nutritional and medicinal values. The root of the coconut tree, in addition to being used for balaios, is used by native populations as a toothpaste (roasted and ground roots), for medicinal purposes and as an antiseptic in wounds, mouth wash and gargles. The tender shoots, when harvested when emerging from the ground, plus the apical gum, are consumed in salads, such as preserves (palm hearts, pickles, etc.). From the inflorescences, when they are still in the state of buso, that is, closed. A sap known as tódi (toddy in India and Siri Lanka, tuba in the Philippines, tuwak in Indonesia) is extracted from the inflorescences when they are still in their bushy state, i.e., closed, and is used as a refreshment drink in the regions where it is collected daily (RETEC, 2007).

The various coconut products in Brazil, as in most of the world, are raw material of relevance in the industry of many food products. From factories of biscuits, sweets, yogurts, ice cream, industrial restaurants and even small confectioneries and snack bars, stand out the products of greater demand in the Brazilian market as: whole coconut, water and green coconut pulp, coconut milk, grated coconut and ripe coconut almond (MORORÓ, 2007).

All its parts are used in some way or another in the daily life of people in the traditional areas of coconut cultivation. It is the only source of various natural products for the development of drugs against various diseases and for the development of industrial products. The parts of its fruit such as coconut seed and coconut water have numerous medicinal properties such as: antibacterial, antifungal, antiviral, antiparasitic, antidermatophytic, antioxidant, hypoglycemic, hepatoprotective and immunostimulant. Coconut water and coconut seed contain microminerals and nutrients, which are essential to human health, providing food for millions of people, especially in tropical and subtropical regions and with many uses, it is often called the "tree of life". A coconut tree has different harvest of nuts, from the opening of the flower to the ripe nuts. India is the third largest producer of coconut after Indonesia and the Philippines, with an area of around million hectares under cultivation (ENIG, 2000).

In Ayurvedic medicine, coconut oil, milk, cream and water are all used to treat hair loss, burns and heart problems. In India, the use of coconut for food, and its applications in Ayurvedic medicine were documented as early as 4000 years ago. Records show that in the United States, coconut oil was a major source of dietary fats, in addition to dairy and animal fats, before the advent of the American edible oil industry (soybeans and corn) in the mid-40s (DEBMANDAL; MANDAL, 2011).

According to information on the website of coconut sugar distributors in Brazil and Portugal, coconut sugar, which is extracted from the liquid of coconut palm flowers, has a high amount of potassium, magnesium, zinc, calcium and iron, as well as high amounts of antioxidant compounds such as flavonoids, anthocyanins and polyphenols, and its glycemic index is 35% (BIOSAMARA; COPRA, 2016).

The composition of the desiccated coconut has been documented by Bawalan and Chapman (2006); where some of its medicinal values have been documented as a powerful electrolyte, as it is highly rich in inorganic ions such as: potassium; sodium; calcium and magnesium. Coconut also has cardioprotective effect, due to coconut be composed of fatty acids called caprylic acid; capric acid; lauric acid; maristic acid; palmitic acid; stearic acid; oleic acid and linoeic acid, 65% of which are medium-chain saturated fatty acids, which allows them to be directly absorbed in the intestine and sent directly to the liver to be rapidly metabolized for energy production, not taking part in the biosynthesis and transport of cholesterol. It also has an antidiabetic effect due to the protein in the coconut kernel having a potent antidiabetic activity, reversing glycogen levels, carbohydrate metabolizing enzymes and damage to the pancreas to normal levels due to its effect on the regeneration of pancreatic cells through arginine (DEBMANDAL; MANDAL, 2011).

The role of nutrition today goes beyond the emphasis on the importance of a balanced diet, providing beyond basic nutrition the promotion of health (CARVALHO et al., 2006).

Functional foods are foods or beverages that, when consumed in everyday food, in addition to nourishing can bring specific physiological benefits, thanks to the presence of physiologically healthy ingredients (CANDIDO; FIELDS, 2005). These ingredients are not classic nutrients, but have beneficial functional properties, in addition to the traditional effects of nutrients (ANGELIS, 2001).

Recently, modern medicinal research has confirmed many health benefits of multiple coconut products in various forms, so extensive research is needed to explore their therapeutic utility to combat disease. The development of new products aimed at the promotion and/or maintenance of health is one of the main reasons for food research (CARVALHO, 2007).

In view of the above, this study aimed to compare the glycemic response of healthy subjects after ingesting coconut sugar with other sugars consumed more frequently by the population, namely refined sugar (sucrose) and brown sugar.

2 MATERIALS AND METHODS

This is a cross-sectional and descriptive study with 30 adult subjects of both sexes, carried out at the Skills Laboratory of the University Center of Volta Redonda in Rio de Janeiro.

This study had 30 volunteers with ages ranging from 19 to 50 years, 22 females and eight males.

The 30 participants were randomly divided into three distinct groups, each of which was given a different type of sugar, served in a disposable and coded cup. One BS group received 50g of brown sugar; the other group (SUC) 50g of sucrose and the last group (CS) 50g of coconut sugar. All sugars were diluted in 200 ml of filtered water.

It is important to note that before the ingestion of sugars, the blood glucose of all individuals who were fasting for at least four hours (T0) was measured. As a safety measure, individuals with glycemia above 140 mg/dL were excluded from the study. Subsequently, new blood glucose measurements were taken at the respective times: 15, 30, 45 and 60 minutes, respectively. The Accu Chek – Performa glucometer was used for these analyses.

Biosecurity measures were necessary in this process, such as the use of disposable gloves and lancets, as well as the use of 70% alcohol for disinfection of the blood collection site.

All the material was disposed of in a disposal box (Descarbox), sterilized in an autoclave and sent for proper disposal, in accordance with institutional biosafety procedures.

The study was approved by the Human Research Ethics Committee under the CAAE-Number (82145617.9.0000.5237), and all participants signed an Informed Consent Compliance Form explaining the objectives of the study.

For data analysis, analysis of variance was applied, and the Scott-knott test at 5% was chosen to verify the differences in the results.

3 RESULTS AND DISCUSSION

It can be seen in Table 1 and Figure 1 that the three sugars presented statistically equal behavior ($p<0.05$) with regard to the increase in blood glucose at times 15, 30 and 60 minutes compared to zero time after ingesting the sugars. However, there was a significant difference ($p<0.05$) at 45 minutes, with the glycemia of the participants who ingested sucrose being 44.4% lower than that of brown sugar and 61.1% lower than that of coconut sugar.

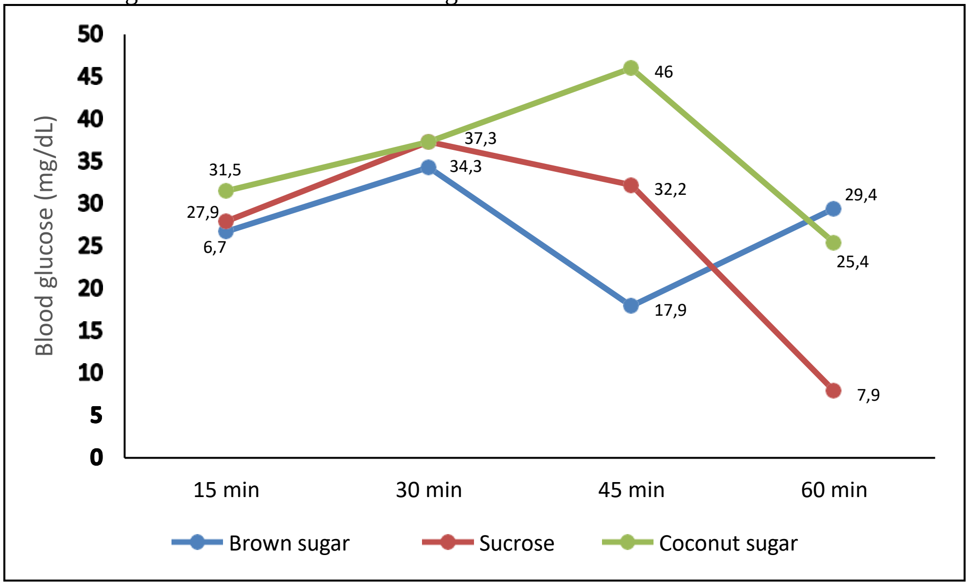
Table 1: Mean values of increased blood glucose (mg/dL) after ingestion of brown sugar, sucrose and coconut sugar

Sugar	Mean increase in blood glucose (mg/dL) *			
	15 minutes	30 minutes	45 minutes	60 minutes
Brown	26.7[a]	34.3[a]	17.9[a]	29.4[a]
Sucrose	27.9[a]	37.3[a]	32.2[b]	7.9[a]
Coconut	31.5[a]	37.3[a]	46.0[b]	25.4[a]
Coefficient of variation (%)	59,9	46,47	69,18	105,12

Source: The Authors (2018)

*Means followed by the same letter do not differ statistically by the Scott-Knott method ($p<0.05$)

Figure 1: Mean values of blood glucose increase in relation to time zero



Source: The Authors (2018)

Considering that the glycemic index of sucrose is 64%, and brown sugar 64%, (Powell et al 2002; 2008) it was expected a different behavior of coconut sugar, since the product's packaging promises a sugar with a glycemic index of 35%, which could induce diabetics to consume this food in the wrong way.

It is important to note that the Glycemic Index ranks foods based on the potential increase in blood glucose relative to a standard food. High-GI foods elicit a high glycemic response 15 to 20 minutes after ingestion, medium-GI foods elicit an average glycemic response 30-40 minutes, and low-GI foods elicit a low glycemic response 40 to 50 minutes after ingesting a certain food (Júnior, 2007). It should be noted that the increase in glycemia is determined by eating a food containing 50g of carbohydrates and comparing it over a period of 2 hours with a standard food (glucose) (Holt, 2004; Siqueira, Rodrigues and Frutuoso 2007).

A study conducted by Teixeira et. al (2009), in which one of the stages of the study aimed to assess the glycemic curve through the administration of two samples (orange juice and orange juice with the addition of yacon) carried out with 20 students aged between 20 and 40 (48% of whom were female), found that there was a significant difference between the standard juice and yacon-added juice samples, concluding that the individuals who ingested the standard sample had an increase in glycemia at post 1 and those who ingested the modified yacon juice had a gradual increase in blood glucose.

Machado and Costa (2009) verified the association of coffee intake with socio-behavioral aspects and risk of occurrence of DM2 in adult subjects, in order to better understand the effect of coffee on glycemic and insulinemic responses using the Oral Test of Meal Tolerance (MGTT). The study had 71 non-diabetic subjects, with and without family history of DM2, all were regular coffee drinkers, were given a breakfast with 75g of carbohydrates and blood was collected at times -10, 0, 10, 15, 30, 60, 120, 150 and 180 minutes, weight and height were also measured to calculate BMI. As a result, it can be verified that there was no significant difference between the groups of coffee consumption and age; practice of physical activity; smoking and alcohol intake. It can be verified in the insulin curves, according to the intake of coffee and BMI, that the highest average peaks were observed in participants with high coffee consumption and high body mass index, and the lowest peaks were observed in low coffee drinkers and normal BMI. Glucose values behaved similarly.

It can be seen in Table 2 and Figure 2 that the glycemic behavior of the three sugars were statistically equal between the groups in practically all the times observed, and the only time that there was a statistical difference was 45 minutes after the ingestion of the sugars. In this time the coconut sugar presented a higher result than the others, corroborating what has already been described in this study, i.e.: the glycemia of the participants who ingested this product took a longer time to decrease.

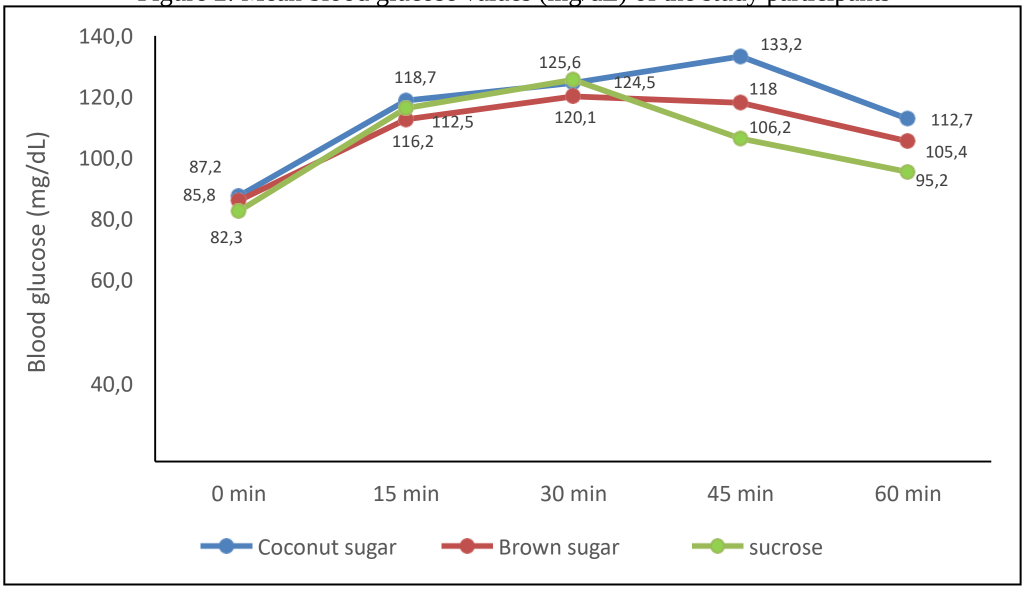
Table 2: Mean blood glucose values (mg/dL) after ingestion of brown sugar, sucrose and coconut sugar

Sugars	**Mean Blood Glucose Values (mg/dL) ***				
	Time 0	**15 min**	**30 min**	**45 min**	**60 min**
Coconut	87.2[a]	118.7[a]	124.5[a]	133.2[b]	112.7[a]
Sucrose	82.3[a]	116.2[a]	125.6[a]	106.2[a]	95.2[a]
Brown	85.8[a]	112.5[a]	120.1[a]	118.0[a]	105.4[a]
Coefficient of variation (%)	8,2	14,9	14,1	18,12	19,9

Source: The Authors (2018)

*Means followed by the same letter do not differ statistically by the Scott-Knott method ($p<0.05$).

Figure 2: Mean blood glucose values (mg/dL) of the study participants



Source: The Authors (2018)

A study conducted by Musa and Marangon (2012), which aimed to study blood glucose in seven subjects after the consumption of different sources of carbohydrates (dextrose, cassava, sweet potato and yams), found that there was no significant difference between the mean glycemic of sweet potatoes when compared to the standard carbohydrate source (dextrose). However, there was a significant difference between the glycemic means of Cassava and Yams.

It is observed in the International Table of glycemic index and glycemic load that, in general, traditional foods such as whole grains and minimally processed vegetables cause lower glycemic responses. This is because they have higher amounts of slowly digestible and non-digestible carbohydrates, since starch and sugars are protected by botanical structures, such as the cell wall and other barriers that decrease the speed of gelatinization, and digestion and absorption of these carbohydrates. On the contrary, foods with a high degree of processing, which were submitted to grinding, at high pressures and temperatures, present destruction of these barriers and a high degree of starch gelatinization and, consequently, a greater glycemic response (CAPRILES; MATIAS; ARÊAS, 2009).

Coast et. al (2017) evaluated the effect of the addition of fiber-rich foods (oats and flaxseed) and an isolated soluble fiber supplement on the glycemic index (GI) and glycemic response of a cornstarch porridge in six healthy subjects, based on a corn porridge added to different fiber-rich foods. In conclusion, the preparation added with flaxseed resulted in a lower glycemic response at times of 45 to 90 minutes and the preparation with the addition of oats showed better results at times 60 and 90 minutes.

4 CONCLUSIONS

This study demonstrated that coconut sugar increases blood glucose in the same way as brown sugars and sucrose, but it was observed the need for a longer time (over 45 minutes) for its reduction to occur.

In the literature there is a lack of proven information about coconut sugar, which is a product without scientific proof about its glycemic index and glycemic load.

Further studies using coconut sugar are still needed, focusing mainly on the correct determination of the glycemic index, its chemical composition and its real functional activity for the human organism.

Foods with a low glycemic index and glycemic load are associated with reduced risk of chronic diseases. For this reason, there is a growing interest in the application of these concepts to the evaluation and prescription of diets. Thus, professionals and students in the areas of Food and Nutrition should be prepared to select, interpret and use these data. With this it will be possible a better knowledge, even if estimated, of the effects of the carbohydrates of food for human health, providing additional subsidies for a dietary prescription of better quality and safer, especially for patients who need to control blood glucose in their treatment.

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