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# Comparison of Two Dark Chocolate and Their Effect on Blood Pressure

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Comparison of Two Dark Chocolate and Their Effect on Blood Pressure

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(TITLE)

BY

Melissa A. Foor

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**THESIS**

SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS  
FOR THE DEGREE OF

Master of Science in Dietetics

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IN THE GRADUATE SCHOOL, EASTERN ILLINOIS UNIVERSITY  
CHARLESTON, ILLINOIS

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### **Abstract**

This study was designed to determine if dark chocolate helps lower blood pressure and if the concentration of the dark chocolate varies the result. Currently, one in four Americans has high blood pressure. The recommended treatment may include medicine or a diet referred to as DASH or Dietary Approaches to Stop Hypertension. This study followed a within-subjects design having all participants receive each type of dark chocolate. Twenty-seven participants started the study to measure their blood pressure while consuming dark chocolate for a week at a time. Results showed that Hershey's Special Dark Chocolate did not lower blood pressure significantly over the span of a week. Ghirardelli's 60% Cacao Dark Chocolate was shown to statistically lower diastolic blood pressure after a week. The higher concentration of dark chocolate was the only one that had statistically significant results within the measure of blood pressure.

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## Chapter I: Introduction

### Introduction

High blood pressure is a problem that needs to be addressed as indicated by the large number of Americans who suffer from it. Hypertension is a modifiable risk factor for cardiovascular disease. While many people do not enjoy making big changes if any to their diet or exercise routines, many people do enjoy chocolate. There is some evidence that daily consumption of dark chocolate may have a positive impact on blood pressure (Davison, Berry, Misan, Coates, Buckley, & Howe, 2010). By changing the approach to lower high blood pressure from making major life changes to changing only a handful of problems, individuals will be likely to have success. Most people would be able to adhere to consuming only one piece of dark chocolate per day, if consumption of dark chocolate lowers blood pressure with minimal changes to the diet or exercise plans. Dark chocolate is usually considered a delicious treat. Some surveys say 4-14% of the population dislike chocolate, which is a relatively low number. While the United States does not have a definition for what truly defines dark chocolate, most experts say at least 40% must be cocoa solids (McShea, Ramiro-Puig, Munro, Casadesus, Castell, & Smith, 2008). Dark chocolate is unique in that it has either no or much less milk in it than milk chocolate. Semi-sweet chocolate is a type of dark chocolate. The Food and Drug Administration says that semi-sweet chocolate must contain 35% or greater chocolate liquor and less than 12% milk solids (Bennett Clark, 2001). People enjoy eating desserts and dark chocolate consumption has grown in recent years due to the number of health benefits being touted by the media.

High blood pressure has become common among the American population. Approximately one quarter of the population has high blood pressure (CDC, 2012). High blood pressure is defined as a systolic blood pressure of 140 mmHg or greater and/or a diastolic blood pressure of 90 mmHg or greater (CDC, 2012). Common treatments for high blood pressure include diet, exercise, and medication. A typical diet suggested for those with high blood pressure is the DASH diet or the Dietary Approach to Stop Hypertension (CDC, 2012). This diet includes increased fruits, vegetables, and low fat dairy, along with whole grains and minimal refined foods. The diet recommends avoiding foods with refined sugar, high fat, and high sodium.

### **Purpose of Study**

The purpose of this study was to examine the impact different percentages of dark chocolate have on blood pressure. There have been studies examining the differences between dark chocolate and white chocolate, including the study done with 6.3 g of dark chocolate per day over six months. This resulted in a small, but significant reduction in blood pressure for the dark chocolate eaters and no change for the white chocolate group (Taubert Roesen, Lehmann, et al. 2007). There have also been a handful of studies that have looked at dark chocolate and a placebo or dark chocolate and milk chocolate (Davison, Berry, Misan, Coates, Buckley, & Howe, 2010; Grassi, Desideri, Necozione, Lippi, Casale, Properzi, Blumberg, & Ferri, 2008). Even more research has been done on the comparison of cocoa and dark chocolate (Haber & Gallus, 2012). But there has been little research on comparing different percentages of dark chocolates. The two used in this study are Hershey's Special Dark Chocolate and Ghirardelli's 60% Cacao Dark Chocolate. These chocolates were chosen because they are mainstream brands, ranging

from just above milk chocolate up to a middle percentage dark chocolate. People who do not ordinarily consume dark chocolate may begin to do so if it provides health benefits.

### **Research Objectives**

The objectives of this study are:

- To determine if the consumption of dark chocolate lowers blood pressure in adults with hypertension.
- To determine if the percentage of the dark chocolate varies the results.

In the next chapter the literature explores the prevalence of high blood pressure, the DASH diet in reducing hypertension, and what is known about the impact of dark chocolate on blood pressure.

### **Definition of Terms & Nutritional Content of the 2 Chocolates**

- Flavonoids are phenolic phytochemicals that are in found in plant foods that have antioxidant properties which result in anti-inflammatory and cellular repair properties and are thought to influence normal biological responses (Denny & Buttriss 2007).
- Vasorelaxation is the reduction in vascular tension and pressure (Medical Dictionary, 2013).
- Hypertension is another term for high blood pressure which is diagnosed at 140 mm Hg or higher systolic and 90 mm Hg or higher diastolic (Gajewska, Niegowska, & Kurcharska, 2010).

- Monomeric flavanols, including epicatechins, are single molecule catechins (Heiss, Keen, & Kelm, 2011).
- Oligomeric flavanols, including procyanidins, are condensed flavanols (Heiss, Keen, & Kelm, 2011).

Nutritional values for the amount of Hershey's Special Dark Chocolate administered in this study as found on the product label are: 2 pieces or 0.7 ounces contains 84 calories, 5.2 g Total Fat – 2.8 g Saturated fat, 20 mg Sodium, 8.8 g Sugars, and 12 g Protein. Nutritional values for the amount of Ghirardelli's 60% Cacao Dark Chocolate administered in this study as found on the product label are: 2 pieces or 0.75 ounces contains 105 calories, 8 g Total Fat – 5 g Saturated fat, 0 mg Sodium, 8 g Sugars, and 1 g Protein.

## Chapter II: Literature Review

High blood pressure is a concern of many Americans with one in four having high blood pressure. High blood pressure is not just limited to those above a certain age anymore. Medications to lower blood pressure are used as treatments along with dietary plans, such as the DASH diet. Many people opt for the medication without any diet or physical activity adjustments. Dark chocolate and cocoa are looked at as sweets, which are typically advised to be used in moderation by doctors and dietitians. They are thought to contain high amounts of saturated fat, although only one third of the fat content in dark chocolate is thought to contribute to elevating LDL cholesterol levels (Chen, 2012). Recent studies have shown that even though these should be consumed in moderation, eating dark chocolate or cocoa every day can help lower blood pressure (Grassi et al, 2008). This literature review covers the prevalence of high blood pressure in the American population, the efficacy of the DASH diet in lowering blood pressure, the process of making dark chocolate, dark chocolate and blood pressure, the impact of consuming dark chocolate on the Kuna Indians, and flavanols.

### **Prevalence of High Blood Pressure**

In America, the population is around 311 million people. There are approximately 68 million people who have high blood pressure (Centers for Disease Control Prevention, 2012). This means that one in four have high blood pressure. Normal blood pressure is less than 120 mm Hg systolic and less than 80 mm Hg diastolic blood pressure. High blood pressure is defined as 140 mm Hg systolic blood pressure and 90 mm Hg diastolic blood pressure (Gajewska, Niegowska, & Kurcharska, 2010).

Pre-hypertension is defined as blood pressure at 120-139 mm Hg systolic and/or a diastolic blood pressure of 80-89 mm Hg. Around thirty percent of American adults have prehypertension (Centers for Disease Control Prevention, 2012) thereby increasing the number of adults that should be concerned with controlling high blood pressure. Of the adults who are hypertensive and treated with medicine only 30 percent manage to keep blood pressure controlled (Parati et al, 2013). High blood pressure is a risk factor for multiple diseases such as cardiovascular disease, stroke, and even kidney disease (Centers for Disease Control Prevention, 2012). Cardiovascular disease is the number one cause of death in the United States and cerebrovascular disease or stroke is the third cause (Centers for Disease Control Prevention, 2012). Both of these disease risks will lessen if high blood pressure is reduced and blood flow is increased. In treating high blood pressure, it is recommended that individuals monitor their blood pressure at home for better adherence to therapy (Parati et al, 2013). Research indicates that home blood pressure monitoring is the best diagnostic tool for hypertension. Individuals tend to be relaxed at home and their blood pressure monitoring should result in reliable readings (Imai, Hosaka, Elnagar, & Satoh, 2014).

There are two types of high blood pressure, primary and secondary (Mayo Clinic Staff, 2012). Primary hypertension is high blood pressure with no identifiable cause and secondary hypertension is caused by an underlying condition (Mayo Clinic Staff, 2012). Primary hypertension is also known as essential hypertension. This is the most commonly diagnosed type. Vasodilation, an increase in the interior of the blood vessels, contributes to whether individuals have hypertension or not and is mainly controlled by nitric oxide in the body (Raj, 2011). Decreased vasodilation is a contributing factor to

secondary hypertension. Vasodilation controlled by the endothelium is impaired in those with essential hypertension. Another risk factor that results from impaired vasodilation is arterial stiffness (Raj, 2011).

The risk factors associated with high blood pressure include age, race, family history, overweight/obesity, sedentary lifestyle, tobacco use, high-sodium diet, low potassium from diet, low vitamin D intake, large amounts of alcohol consumption, stress, and some chronic conditions (Mayo Foundation for Medical Education and Research, 2012). Advanced age increases the likelihood of developing high blood pressure. There were 7.6 million premature deaths related to hypertension in 2001 (Raj, 2011). In African-Americans high blood pressure is more common with more serious outcomes and complications (Mayo Foundation for Medical Education and Research, 2012). Five of these risk factors are specifically diet related, overweight/obesity, sedentary lifestyle, high-sodium diet, low potassium diet, and low vitamin D intake. This is why many people who have prehypertension are treated with the DASH diet.

### **DASH Diet**

The DASH diet was developed to help individuals lower their blood pressure. DASH is an acronym for Dietary Approaches to Stop Hypertension. This diet is high in magnesium, calcium, potassium, protein, and fiber (Gajewska, Niegowska, & Kurcharska, 2010). Research trials have indicated that while magnesium, calcium, and potassium are beneficial nutrients, it is more helpful to change food patterns (Malloy-McFall, Barkley, Gordon, Burzminski & Glickman, 2010). Recommendations in this diet include eating plenty of fruits, vegetables, low-fat dairy, whole grains, minimal foods

with refined sugar, low-sodium foods and foods low in saturated fat (Harnden, Frayn, & Hodson, 2010).

The DASH diet is the current national recommendation for dietary approaches to lower blood pressure (Malloy-McFall, Barkley, Gordon, Burzminski & Glickman, 2010). Other treatment suggestions for high blood pressure are to eat a balanced diet, lower sodium, and include exercise. One study found that the DASH diet decreased systolic blood pressure by 6.6 mm Hg. This same study found that although most study subjects complied with the lowered sodium intake and consumed the recommended amount of protein it was difficult for them to lower their fat intake, especially when it came to the percentage of saturated fat they consumed in calories (Gajewska, Niegowska, & Kurcharska, 2010). Their findings also revealed that it was challenging for the participants to consume adequate amounts of calcium and magnesium, fiber and potassium were also below the standard recommendations (Gajewska, Niegowska, & Kurcharska, 2010). Another study found the systolic blood pressure to be decreased by 4.6 mm Hg and 3.9 mm Hg when the DASH diet was followed for one month (Harnden, Frayn, & Hodson, 2010).

One study measured the compliance of participants with essential hypertension following the DASH diet. The results of this study showed that females were more likely than males to stay under the prescribed levels of intake for calories, fat, protein, saturated fat and carbohydrates. This also meant that they had less chance of reaching the recommended amount of iron, phosphorus, zinc, B vitamins, vitamin C, folate, and vitamin E (Gajewska, Niegowska, & Kucharska, 2010). Lower iron levels are typically consistent with low levels of protein and also lower B vitamins. When these participants

were compliant with following the DASH diet they were revealed to have adequate levels of protein consumed for both males and females (Gajewska, Niegowska, & Kucharska, 2010). In comparison, fat levels consumed, including saturated fat and cholesterol, were high in both genders on the control diet compared to the DASH diet. Sodium levels were within normal limits for males and lower than normal in the females. Carbohydrate, potassium, calcium, magnesium, and fiber intake were all low in the control group compared to the DASH diet standards (Gajewska, Niegowska, & Kucharska, 2010). All participants had the most difficulty with consuming the recommended amount of saturated fat, as shown by how compliant participants were. It was the one category in which all participants' intake was high. Not only is high saturated fat intake inconsistent with the DASH diet, it also contributes to an increased risk of cardiovascular disease. So if patients are having trouble with following the DASH diet, a main focus should be on reducing their total fat intake; specifically focusing on reducing saturated fat intake.

The DASH diet is more of a lifestyle change because individuals typically change their whole intake when they go on the DASH diet. Using dark chocolate as a way to reduce blood pressure is only asking them to change one thing, so if individuals have a difficult time trying to change their whole diet, they can start with the small step of including dark chocolate.

### **Dark Chocolate**

Chocolate is made from highly processed cacao beans. All manufacturers have the same beginning processes: fermentation, drying, and roasting (Clark, 2001). The beginning step of the processing is yeast to start the fermentation. A day later lactic acid bacteria takes over for the yeast in reacting with the cacao beans and ethanol is formed

from the sugary pulp that is around the bean. Oxygen and acetic acid bacteria help ferment this process even further, which causes the breakdown of the cacao bean as temperatures rise (McShea et al, 2008). The cacao beans are then dried, roasted, and broken to get to the meat of the bean that is ground into a paste.

A higher cocoa content means there is a higher percentage of cocoa solids in the chocolate, this limits the amount of sugar that can be added to make the dark chocolate. True chocolate lovers in America are moving towards preferring darker chocolates, up to 70% and 80% cocoa solids, which could have a positive health impact ( Clark, 2001). Flavanol composition changes during this chocolate-making process, under-fermented cacao beans have higher amounts of antioxidants than those with longer time to ferment. Higher antioxidants and flavanol amounts result in more flavanols being consumed per amount of chocolate eaten (McShea, Ramiro-Puig, Munro, Casadesus, Castell, and Smith, 2008).

Dark chocolate contains both monomeric and oligomeric flavanols. These flavanols are both beneficial in reducing blood pressure, especially the epicatechins (Allen, Carson, Kwik-Urbe, Evans, and Erdman, 2008). Epicatechins react with certain human genes; this may be one of the reasons why blood pressure is lowered when dark chocolate is consumed (Allen, Carson, Kwik-Urbe, Evans, and Erdman, 2008).

### **Flavanols**

Flavanols are phytochemicals that are commonly found in fruits and vegetables, but they are also found in chocolate and tea. They contribute to antioxidant activity. The flavanols are thought to help prevent low-density lipoprotein buildup (Chen, 2012). High

cholesterol can lead to plaque in the arteries which can raise blood pressure due to the heart having to work harder to pump the same amount of blood through a smaller space.

Research shows that flavanols reduce the risk of blood clots and improve blood circulation. This helps not only blood pressure but also helps decrease the stroke risk that is increased by high blood pressure. Flavanols are thought to provide positive benefits to the body's vascular system. Specifically by keeping arteries flexible, increasing circulation in small vessels, and reducing blood pressure (Pimentel, Nitzke, Klipel, Vogt de Jong, 2010). However, some studies have shown that the consumption of flavanols does not show sustained positive influence. This aspect is still being investigated to see if consuming flavanols will have a long-lasting effect or whether they need to be continuously consumed to see the health benefits.

One study compared the difference in flavonoid content between chocolate and wine. They used a dark chocolate with 71% cacao, one with 40%, a milk chocolate, and a white chocolate. These were compared with red wines made in Brazil by testing Pinot-Noir, Cabernet Sauvignon, Merlot, and Tannat. Flavanols were measured in micromoles of catechin equivalents per gram. Flavonoids found in the 71% dark chocolate were around 21.6  $\mu\text{mol}$ , for the 40% there were 17.2  $\mu\text{mol}$ , milk chocolate contained 8.4  $\mu\text{mol}$ , and white chocolate 3.4  $\mu\text{mol}$ . Tannat ranked highest with 5.4  $\mu\text{mol}$ , then the Cabernet Sauvignon with 4.8  $\mu\text{mol}$ , followed by Merlot at 4.6  $\mu\text{mol}$ , and Pinot-Noir at 4.0  $\mu\text{mol}$ . Polyphenols were also compared, and the dark chocolate with the highest cocoa content ranked highest and the polyphenol content decreased as the cocoa did. The same trend happened with the wines, the Tannat had the highest and they decreased as did their flavonoids (Pimentel, Nitzke, Klipel, Vogt de Jong, 2010). This suggests that the darker

the chocolate the higher the amount of flavonoids and polyphenols which would equate to the more health benefits. The majority of research has shown that the levels of flavanols cannot just be built up inside the body by eating a large amount at one time (Eat Right America, 2013). Flavanol consumption needs to be a continuous process for beneficial effects to take place, such as lowered blood pressure. Research shows that if the individual stops eating the dark chocolate, their blood pressure will begin to rise back up to where it was before they began eating the flavanol-rich dark chocolate (Haber & Gallus, 2012).

### **Dark Chocolate and Blood Pressure**

The amount of dark chocolate an individual should consume to have an effect on blood pressure is approximately one ounce per day (Allen, Carson, Kwik-Urbe, Evans, and Erdman, 2008). Although the DASH diet has been shown to have slightly higher reductions in blood pressure in most studies and trials, the difference is usually only 1-2 mm Hg (Harnden, Frayn, & Hodson, 2010). A study has shown that individuals are more likely to stick with a smaller change, especially when that change involves chocolate rather than changing their whole diet (Nordmoe, 2008).

It is important to remember that chocolate and cocoa are not the same things, but rather cocoa is the non-fat component of cocoa liquor, which is used to make chocolate (Cooper, Donovan, Waterhouse, & Williamson, 2008). Research findings have shown that the compounds responsible for the lowered blood pressure are flavanols and procyanidins (Davison, Berry, Misan, Coates, Buckley, & Howe, 2010). These are not found in white chocolate or milk chocolate because white chocolate is made up of only the cocoa butter and there is a dramatically lowered cacao component in milk chocolate

(Ried, Sullivan, Fakler, Frank, & Stocks, 2010). Milk chocolate should retain some of the flavanol properties since milk has not been shown to interfere with cacao components in studies, yet no research has found significantly lowered blood pressure (McShea et al, 2008). Meta-analyses report that flavonoid-rich diets reduce the risk of cardiovascular disease in patients. This is due to their antioxidant properties (Engler & Engler, 2006). Flavanols help with lowering the amount of free radicals in the body. It is thought that the dark chocolate provides nitric oxide which acts as a vasodilator (Engler & Engler, 2006). One study found that dark chocolate activated nitric oxide synthase in humans. The vasodilation is reversed by arginine analogs (Hollenberg, Fisher, & McCullough, 2009). So nitric oxide needs to be continuously supplied to have the vasodilation effect.

Other studies have found that dark chocolate may act as an ACE inhibitor which also has antioxidant properties (Engler & Engler, 2006). The dark chocolate was found to have vasorelaxation effects on not only those with coronary heart disease and hypertension but also healthy individuals. This is mainly because epicatechins are consumed and are important predictors of vasodilation (Grassi et al, 2008). One study concluded if an individual were to consume the same amount of flavonoids by consuming milk chocolate, they would have to eat 126 g compared to 49 g of the 71% cocoa content dark chocolate. This would increase their caloric intake by 250% compared to the 71% dark chocolate and taking up 35% of the daily calories of someone who consumed 2000 kcal/day. Looking at this from a health perspective, this is not conducive to a balanced diet, nor has milk chocolate been shown to provide the same antioxidant and blood pressure lowering effects (Pimentel, Nitzke, Klipel, Vogt de Jong, 2010).

In one review of multiple studies, chocolate intake ranged from 45 to 106 grams which provided 246-500 mg of flavanols per day (Davison, Berry, Misan, Coates, Buckley, & Howe, 2010). The serving size of dark chocolate ranged from 45 to 106 grams or 1.5 ounces to 3.75 ounces which was one to six pieces of dark chocolate. Even in studies that looked at consumption of low amounts of dark chocolate findings reveal that individual systolic blood pressure dropped by 6 mm Hg and diastolic blood pressure dropped by 3 mm Hg (Davison, Berry, Misan, Coates, Buckley, & Howe, 2010). One study found that the systolic blood pressure dropped by 5.8 mm Hg when consuming a flavanol-rich dark chocolate (Allen, Carson, Kwik-Urbe, Evans, and Erdman Jr, 2008). Individuals consuming dark chocolate also showed improved endothelial function. This impacts hypertension because when the veins are dilated vascular function improves which allows for blood to flow easier (Recio-Rodríguez, Gómez-Marcos, Patino-Alonso, Agudo-Conde, Rodríguez-Sánchez, & García-Ortiz, 2012).

Multiple trials reviewed for this study measured the effects that dark chocolate had on the study subjects for 15 days. This length of time was used in most of the studies that were reviewed showing that the effects can occur in a short period of time (Grassi, Desideri, Necozone, Lippi, Casale, Properzi, Blumberg, & Ferri, 2008). However since this specific study only looked at baseline and final blood pressures, it cannot identify if the effect was seen sooner. These research trials found a reduction in systolic blood pressure by an average of 5.4 mm Hg and a reduction in diastolic blood pressure by an average of 4.4 mm Hg (Grassi, Desideri, Necozone, Lippi, Casale, Properzi, Blumberg, & Ferri, 2008).

Although many trials studied the effects while participants consumed the dark chocolate, a few studies measured if the effects were long lasting. One study found that after as little as two days the blood pressure reduction was no longer apparent when they stopped administering the dark chocolate (Haber & Gallus, 2012). This is consistent with other research that the beneficial effects are only present with continuous consumption. The same can be true if individuals stopped following the DASH diet or a heart healthy diet. If they are suddenly starting to consume high-fat and unhealthy foods, their blood pressure will be affected (Malloy-McFall, Barkley, Gordon, Burzminski, & Glickman, 2010). More evidence is needed to show that individuals must be consistent in continuous consumption of dark chocolate to maintain its health benefits. The average reduction in blood pressure found when analyzing research in regards to dark chocolate consumption was approximately 5.8 mm Hg systolic and 3.5 mm Hg diastolic (Haber & Gallus, 2012).

When observing the cost of using dark chocolate as a treatment for hypertension, \$42 is the median amount spent to cover dark chocolate for the year (Zomer, Owen, Magliano, Liew, & Reid, 2012). Yet the United States spent \$93.5 billion dollars a year on high blood pressure-related healthcare in 2010 (Centers for Disease Control and Prevention, 2012). One meta-analysis revealed that patients with metabolic syndrome who consumed dark chocolate for ten years may have lowered their risk by 70 non-fatal cardiovascular problem chances and as many as 15 fatal cardiovascular problems (Zomer, Owen, Magliano, Liew, & Reid, 2012). Although consuming large amounts of dark chocolate can contribute high amounts of sugar, fat, and calories to the diet, the key is to

find the right amount to reduce high blood pressure without adding too much sugar, fat, and calories.

There is a distinction between consuming cocoa flavored drinks and consuming dark chocolate. A review of multiple studies found that cocoa flavored beverages had no significant blood pressure lowering effects (Haber & Gallus, 2012). These studies administered cocoa flavored beverages that contained multiple amounts of flavanols and found no impact on blood pressure (Davison, Berry, Misan, Coates, Buckley, & Howe, 2010). The only research found to result in lowered blood pressure from consuming cocoa flavored beverages was the one that followed the Kuna Indians (Hollenberg, Fisher, & McCullough, 2009).

### **The Kuna Indians**

The Kunas are a group of individuals living on a small, isolated island in Panama. They, as a group, have low blood pressure. Their death certificates were studied and normal leading causes of deaths were compared with those of Americans. They were found to have lower rates of death from cardiovascular disease or stroke causing researchers to question why their rates were lower (Hollenberg, Fisher, & McCullough, 2009). The Kunas' blood pressure was very low with a lifespan longer than other Panamanians (Hollenberg, Fisher, & McCullough, 2009). Observation of their diet revealed that they ate a relatively high sodium diet yet had low blood pressure, even into advanced years. The Kunas' also had a rather high sugar intake be due to their beverage intake. The only differentiating factor in their diet was they consumed on average five cups of cocoa per day. This was mainly due to their lack of refrigeration on the island so they were forced to boil their water supply (Hollenberg, Fisher, & McCullough, 2009).

Their water source was contaminated, and without boiling or a means to keep it cool enough the Kunas had non-potable water. The cocoa they consumed is not like the cup of cocoa that most Americans drink in that it has less milk and sugar. The Kunas' grow their own cocoa which has been shown to be especially high in flavanols and procyanidins (Hollenberg, Fisher, & McCullough, 2009).

### **Summary**

This review of literature has suggested that though the DASH diet may be effective in helping to lower high blood pressure in hypertensive individuals, it is not always easy to comply with. Specifically difficult to most individuals is finding a balance of foods that are high enough in micronutrients, iron, calcium, potassium, magnesium, fiber, and vitamins such as C, B1, B2, B6, & B12 and not too high in protein, calories, and fat, especially fat that is saturated. High blood pressure is a condition a large proportion of the American public faces and by identifying different, easier means of reducing their systolic and diastolic numbers they will be more likely to comply.

Dark chocolate has been shown to reduce blood pressure in various studies that were reviewed, yet cocoa flavored beverages did not have the same effect. Both were successful at improving endothelial function. The purpose of this study is to determine whether the type of dark chocolate will make a difference in the blood pressure of study subjects. Analyzing the impact of two readily available dark chocolates compared to more expensive, harder to find brands may provide the general public with an easy approach to blood pressure reduction. The following chapter describes the methodology of the comparison of two brands of dark chocolate and their effects on blood pressure.

## **Chapter III: Methodology**

### **Sample**

A convenience sample for this study was used by asking 25-30 to thirty staff and faculty members from St. Anthony's Hospital in Effingham and also staff from the Brickhouse Bar & Grill. A larger sample may have yielded more accurate results, but limitations due to product amount and data collection prevented a larger one from being used. Staff that was invited to participate was between the ages of 25-80. Potential participants were informed of the study and those interested were asked to meet for additional information. Participants who were hypotensive or had a blood pressure less than 95/60 were excluded from this study.

### **Design of Study**

Those who attended the informational meeting filled out a brief survey noting age, gender, and self-reported weight and height. The informed consent form was distributed and read aloud. Signed consent forms were collected and kept confidential in a file in the primary investigator's office. Participants set up appointments for the first day of the study, Tuesday, where initial blood pressures were recorded and participants were sent home with 14 pieces of their assigned brand dark chocolate. The initial blood pressure was read and recorded after the individual had been seated without excessive movement for five minutes. Individuals were instructed to consume 2 pieces of dark chocolate per day, which equated to roughly three-quarters of an ounce, and were instructed to make no changes to their diet or exercise routine.

The participants had their blood pressure measured on Friday two hours after they had consumed both pieces of their assigned dark chocolate following the same procedure of five minutes spent seated beforehand. On Monday participants returned to have their blood pressure measured, again two hours after they had consumed both pieces of the Hershey's dark chocolate. Once all measurements were recorded for the first week, the participants were instructed to return the following Tuesday. When participants arrived on Tuesday their blood pressure was recorded following the same procedure of being seated for five minutes prior. At this time the participants were given a bag of either Hershey's Special Dark Chocolate or Ghirardelli's Brand 60% Cacao Dark Chocolate, whichever they did not consume the first week. They were instructed to eat two pieces a day, which resulted in approximately three-quarters of an ounce of dark chocolate consumed per day. The same procedure was followed from the first stage; the participants arrived on Friday and Monday to have their blood pressure recorded two hours after they had consumed both pieces of dark chocolate for that day. Color-coded forms were kept for accuracy of distribution. Data was collected and analyzed. Participants that did not consume both pieces still had data collected and used, but notation is present to inform the reader. Both normal and hypertensive subjects were used.

### **Procedure for Data Collection**

Data collection was conducted at the initial meeting to obtain demographic information from the participants. The secondary initial blood pressure was also collected at the beginning of week three. To increase reliability, blood pressure readings were obtained on the same machine, by the same person, the principal investigator, who

had been trained how to properly use the machine by Jackie Brown, RN. All participants were invited to fill out a basic evaluation at each blood pressure reading, to control for outside influences to blood pressure. This questionnaire covered changes in stress, eating habits, and exercise habits.

A chart was given to the participants to mark off every day they consumed their two pieces of dark chocolate. The chart is listed under Appendix B for the handouts given to participants.

A follow-up survey was done with participants to see if it was easy to consume their two pieces of dark chocolate a day, and if this would be something they would enjoy continuing. This survey uses the Likert scale to examine how easy and enjoyable eating dark chocolate every day would be. These were used to assess if the participant actually complied with the daily consumption of dark chocolate and how willing they were to consume the chocolate. The survey is listed under Appendix B in the handouts that were given to participants.

### **Data Analysis**

Data was analyzed to compare initial blood pressures to the two follow up blood pressures for each percentage of chocolate by using data analysis software in Microsoft Excel. The data was analyzed to compare the results of the different percentages of dark chocolate.

The daily charts were also analyzed to examine whether participants were successful in following this diet. In this study the independent variable was dark chocolate, and the dependent variable was type of blood pressure. The test to be used was an ANOVA. Both systolic and diastolic blood pressure were compared separately to

see the differences between the systolic and diastolic, also to see if there is a general decline in blood pressure. Comparisons were charted between the two dark chocolates also to see if one was more successful than the other at lowering blood pressure.

### **Summary**

For this research the methods were chosen to assess the change in blood pressure of participants consuming two pieces of dark chocolate per day. The dependent factor studied was blood pressure and the independent factor was the type of dark chocolate they consumed, Hershey's Special Dark Chocolate or Ghirardelli's 60% Cacao Dark Chocolate. This study ran the length of three weeks, during which participants returned to meet with the primary investigator to check their blood pressure. Participant's data was analyzed after the experiment was conducted to measure differences. The next chapter discusses the results.

## **IV. Results and Discussion**

### **Research Objectives**

1. To determine if the consumption of dark chocolate lowers blood pressure in adults with hypertension.
2. To determine if the percentage of the dark chocolate varies the results.

### **Data Collection and Study Participants**

The study consisted of 27 participants that filled out informed consent forms and basic identifier information forms. The study was explained to the participants before signing and they were asked to fill out a basic questionnaire to determine if three factors had changed in their lifestyles within the past three days: their stress level, their eating habits, or their exercise habits. Participants' initial blood pressure was then recorded and they were given a bag of Hershey's Special Dark Chocolate or Ghirardelli's 60% Cacao Dark Chocolate. Odd numbered participants were given the Hershey's Special Dark Chocolate for the first week and even numbered participants were given the Ghirardelli's 60% Cacao Dark Chocolate. Instructions were printed on the bag of the dark chocolates to remind participants to consume two pieces of dark chocolate each day and when they would be meeting with the principal investigator. Of the 27 participants who began the study, 26 showed up at the midpoint of the week to have their blood pressure read and the basic questionnaire involving the three factors was filled out again. At the endpoint of the week, 24 of the participants showed up to have their final blood pressure of the first week read. The same procedure of filling out the basic questionnaire was completed. The participants had the wash-out period of a week to prevent the first dark chocolate from affecting their second week of dark chocolate consumption. The participants met

with the principal investigator on the first day of the third week to have their initial blood pressure noted and to fill out the basic questionnaire. The participants were switched to the other dark chocolate, odd numbered participants consumed the Ghirardelli's 60% Cacao Dark Chocolate and the even numbered participants consumed the Hershey's Special Dark Chocolate. The same procedure was repeated from the first week. At the end of the second week of data collection the participants were asked to complete a survey detailing if the task of consuming dark chocolate was easy and if it was something they would enjoy doing.

Participants in this study ranged from 25 to 63 years of age, the average age being 43.7. There were 10 males and 17 females that participated. The BMI range for the participants was 16.7 through 39.9, the mean being 26.1. Individual participants' blood pressure data is noted in Table 1.

Table 1

*Blood Pressure Results of Participants*

| Participant | Results from Hershey's<br>Special Dark |            |              | Results from<br>Ghirardelli's 60% Cacao |            |             |
|-------------|--|------------|--------------|---|------------|-------------|
|             | Initial                                | Mid        | Final        | Initial                                 | Mid        | Final       |
| 1           | <u>108</u>                             | <u>120</u> | <u>106</u>   | <u>107</u>                              | <u>107</u> | <u>113</u>  |
|             | 87                                     | 86         | 79           | 87                                      | 84         | 84          |
| 2           | <u>144</u>                             | <u>113</u> | <u>122</u>   | <u>141</u>                              | <u>151</u> | <u>126*</u> |
|             | 93                                     | 95         | 80           | 91                                      | 91         | 105         |
| 3           | <u>132</u>                             | <u>135</u> | <u>178*</u>  | <u>136</u>                              | <u>131</u> | <u>136</u>  |
|             | 88                                     | 94         | 106          | 102                                     | 83         | 76          |
| 4           | <u>114</u>                             | <u>112</u> | <u>116</u>   | <u>120</u>                              | <u>119</u> | <u>109*</u> |
|             | 88                                     | 81         | 70           | 77                                      | 92         | 74          |
| 5           | <u>141</u>                             | <u>142</u> | <u>170*</u>  | <u>156</u>                              | <u>134</u> | <u>141</u>  |
|             | 93                                     | 104        | 104          | 92                                      | 82         | 85          |
| 6           | <u>130</u>                             | <u>111</u> | <u>131</u>   | <u>138</u>                              | <u>130</u> | <u>134</u>  |
|             | 74                                     | 82         | 80           | 85                                      | 89         | 86          |
| 7           | <u>124</u>                             | <u>118</u> | * <u>110</u> | <u>136</u>                              | <u>117</u> | -           |
|             | 78                                     | 81         | 68           | 77                                      | 78         |             |

|         |                   |                   |                    |                   |                   |                   |
|---------|-------------------|-------------------|--------------------|-------------------|-------------------|-------------------|
| 8       | <u>123</u><br>97  | <u>122</u><br>91  | -                  | <u>134</u><br>95  | <u>142</u><br>101 | <u>124*</u><br>90 |
| 9       | <u>140</u><br>96  | <u>138</u><br>105 | <u>164</u><br>102  | <u>136</u><br>98  | <u>142</u><br>100 | <u>141</u><br>102 |
| 10      | <u>109</u><br>74  | <u>123</u><br>84  | <u>138</u><br>76   | <u>114</u><br>83  | <u>116</u><br>78  | <u>131*</u><br>80 |
| 11      | <u>100</u><br>77  | <u>104</u><br>67  | <u>105</u><br>71   | <u>101</u><br>63  | <u>111</u><br>76  | <u>116</u><br>80  |
| 12      | <u>124</u><br>79  | <u>120</u><br>72  | <u>125</u><br>70   | <u>116</u><br>75  | <u>120</u><br>72  | <u>133</u><br>80  |
| 13      | <u>108</u><br>70  | <u>111</u><br>81  | <u>123</u><br>77   | <u>126</u><br>76  | <u>121</u><br>82  | <u>105</u><br>74  |
| 14      | -                 | -                 | -                  | <u>141</u><br>92  | <u>167</u><br>86  | <u>138*</u><br>78 |
| 15      | <u>122</u><br>75  | <u>136</u><br>80  | <u>140*</u><br>87  | <u>116</u><br>81  | <u>144</u><br>106 | <u>112</u><br>85  |
| 16      | <u>154</u><br>95  | <u>172</u><br>99  | <u>144</u><br>101  | <u>166</u><br>101 | <u>176</u><br>104 | <u>163</u><br>102 |
| 17      | <u>120</u><br>77  | <u>110</u><br>72  | -                  | <u>113</u><br>83  | <u>139</u><br>103 | -                 |
| 18      | -                 | -                 | -                  | <u>126</u><br>87  | -                 | -                 |
| 19      | <u>120</u><br>77  | <u>97</u><br>73   | -                  | <u>98</u><br>70   | <u>104</u><br>82  | -                 |
| 20      | -                 | -                 | -                  | <u>102</u><br>77  | <u>106</u><br>61  | <u>110</u><br>58  |
| 21      | <u>144</u><br>87  | <u>160</u><br>104 | <u>181*</u><br>92  | <u>143</u><br>104 | <u>139</u><br>80  | <u>148</u><br>100 |
| 22      | <u>142</u><br>83  | <u>122</u><br>82  | <u>141</u><br>98   | <u>140</u><br>105 | <u>130</u><br>92  | <u>122</u><br>89  |
| 23      | <u>169</u><br>106 | <u>136</u><br>75  | <u>140*</u><br>104 | <u>143</u><br>104 | <u>139</u><br>91  | <u>148</u><br>100 |
| 24      | <u>136</u><br>90  | <u>121</u><br>86  | <u>131</u><br>88   | <u>144</u><br>96  | <u>144</u><br>104 | <u>157</u><br>104 |
| 25      | <u>113</u><br>80  | <u>138</u><br>96  | <u>136</u><br>97   | <u>138</u><br>105 | <u>141</u><br>81  | <u>138</u><br>76  |
| 26      | <u>124</u><br>82  | <u>114</u><br>79  | <u>116</u><br>80   | <u>123</u><br>79  | <u>116</u><br>70  | <u>124</u><br>79  |
| 27      | <u>150</u><br>92  | <u>115</u><br>83  | <u>137</u><br>85   | <u>154</u><br>90  | <u>134</u><br>85  | <u>124</u><br>81  |
| Average | <u>129</u><br>85  | <u>125</u><br>97  | <u>136</u><br>86   | <u>130</u><br>88  | <u>131</u><br>87  | <u>130</u><br>86  |

Note: Blood pressures marked with an \* denote blood pressures that were dropped from the second analysis

### **First Analysis of Hershey's Special Dark Chocolate**

The difference between the average initial blood pressure and midpoint blood pressure for participants consuming the Hershey's Special Dark Chocolate was a decrease of 4.2 mmHg for systolic and an increase of 0.6 mmHg for diastolic. The difference between initial blood pressure and final blood pressure for participants consuming the Hershey's Special Dark Chocolate was an increase of 5.7 mmHg for systolic and an increase of 1.3 mmHg for diastolic.

After having their midpoint blood pressure read, 58% of participants that consumed Hershey's Special Dark Chocolate had a decrease in their systolic blood pressure from their initial blood pressure. The range of differences in their systolic blood pressure of initial to midpoint was a decrease of 33 mm Hg up to an increase of 25 mm Hg. At the midpoint, 50% of participants that consumed Hershey's Special Dark Chocolate had a decrease in their diastolic blood pressure from their initial blood pressure. The range of differences in the diastolic blood pressure of initial and midpoint was a decrease of 31 mm Hg up to an increase of 16 mm Hg.

After endpoint blood pressures were read and recorded, 43% of participants that consumed Hershey's Special Dark Chocolate had a decrease in their systolic blood pressure from their initial blood pressure. The range of differences in their systolic blood pressure of initial and final was a decrease of 29 mm Hg up to an increase of 46 mm Hg. At the endpoint, when blood pressure was read, 52% of participants that consumed Hershey's Special Dark Chocolate had a decrease in their diastolic blood pressure from initial to their final blood pressure. The range of differences in their diastolic blood pressure of initial and final was a decrease of 13 mm Hg up to an increase of 18 mm Hg.

An ANOVA was performed for the Hershey's Special Dark Chocolate detailing the initial, the midpoint, and endpoint systolic blood pressures for participants that had all three read and recorded. Results are recorded in Table 2.

Table 2

*Hershey's Special Dark Chocolate Systolic Blood Pressure Analysis*

|          | Mean     | Std.<br>Deviation | Shapiro-Wilk<br>Sig |
|----------|----------|-------------------|---------------------|
| Initial  | 129.9048 | 17.77612          | .792                |
| Midpoint | 126.7143 | 17.08257          | .021                |
| Final    | 135.9048 | 22.05426          | .117                |

*Mauchly's Test of Sphericity*

| Approx. Chi-Square | df | Sig. | Greenhouse-Geisser |
|--------------------|----|------|--------------------|
| 1.636              | 2  | .441 | .071               |

- a. Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.
- b. Greenhouse-Geisser is the corrected test.

Twenty-one participants were analyzed in the ANOVA. The data was normally distributed for the initial and final blood pressure readings, but not for the midpoint blood pressure readings. Mauchly's Test of Sphericity was shown to not be violated which reveals that the variation in blood pressures is not statistically significant by a Chi-square value of 1.636, 2 degrees of freedom,  $p=.441$ . Utilizing the Greenhouse-Geiser for correction, the findings are still not statistically significant as shown by a .071 p value.

Another ANOVA was performed, this time for the diastolic measure of participants consuming Hershey's Special Dark Chocolate detailing the initial, midpoint, and endpoint blood pressures. The ANOVA's values are listed in Table 3.

Table 3

*Hershey's Special Dark Chocolate Diastolic Blood Pressure Analysis*

|          | Mean    | Std.<br>Deviation | Shapiro-<br>Wilk Sig. |
|----------|---------|-------------------|-----------------------|
| Initial  | 85.0952 | 9.06590           | .739                  |
| Midpoint | 86.4762 | 10.72669          | .163                  |
| Final    | 86.4286 | 12.71051          | .091                  |

Mauchly's Test of Sphericity

| Approx. Chi-<br>Square | Df | Sig. | Greenhouse-Geisser |
|------------------------|----|------|--------------------|
| .107                   | 2  | .948 | .790               |

a. Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.

b. Greenhouse-Geisser is the corrected test.

There was normal distribution of the data for all three sets of blood pressure readings. Mauchly's Test of Sphericity shows that there is no statistical significance in the data with a Chi-square value of .107, 2 degrees of freedom, and .948 for a p value. The corrected Greenhouse-Geisser value of .790 also shows no statistical significance.

**First Analysis of Ghirardelli's 60% Cacao Dark Chocolate**

The difference between the mean initial blood pressure and midpoint blood pressure for participants consuming the Ghirardelli's 60% Cacao Dark Chocolate was an increase of 1.5 mmHg for systolic and a decrease of 1.0 mmHg for diastolic. The

difference between initial blood pressure and final blood pressure for participants consuming the Ghirardelli's 60% Cacao Dark Chocolate was a decrease of 1.4 mmHg for systolic and a decrease of 5.0 mmHg for diastolic.

After having their midpoint blood pressure read, 48% of participants that consumed Ghirardelli's 60% Cacao Dark Chocolate had a decrease in their systolic blood pressure of initial to midpoint. The range of differences in their systolic blood pressure between initial and midpoint was a decrease of 22 mm Hg up to an increase of 26 mm Hg. At the midpoint blood pressure reading, 48% of participants that consumed Ghirardelli's 60% Cacao Dark Chocolate had a decrease in their diastolic blood pressure of initial to midpoint. The range of differences in their diastolic blood pressure between initial and midpoint was a decrease of 24 mm Hg up to an increase of 25 mm Hg.

At the endpoint blood pressure reading, 55% of participants that consumed Ghirardelli's 60% Cacao Dark Chocolate had a decrease in their systolic blood pressure of initial to final. The range of differences in their systolic blood pressure between initial and final was a decrease of 30 mm Hg up to an increase of 17 mm Hg. After the endpoint blood pressure was read, 68% of participants that consumed Ghirardelli's 60% Cacao Dark Chocolate had a decrease in their diastolic blood pressure of initial to final. The range of differences in their systolic blood pressure between initial and final was a decrease of 32 mm Hg up to an increase of 17 mm Hg.

An ANOVA was performed for the Ghirardelli's 60% Cacao Dark Chocolate detailing the initial, the midpoint, and endpoint blood pressures for participants that had all three read and recorded. The ANOVA is detailed in Table 4.

Table 4

*Ghirardelli's 60% Cacao Dark Chocolate Systolic Blood Pressure Analysis*

|          | Mean     | Std.<br>Deviation | Shapiro-Wilk Sig. |
|----------|----------|-------------------|-------------------|
| Initial  | 131.5217 | 17.28602          | .556              |
| Midpoint | 133.0870 | 17.63755          | .329              |
| Final    | 130.3913 | 15.96798          | .661              |

## Mauchly's Test of Sphericity

| Approx. Chi-Square | df | Sig. | Greenhouse-Geisser |
|--------------------|----|------|--------------------|
| .730               | 2  | .694 | .606               |

a. Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.

b. Greenhouse-Geisser is the corrected test.

Twenty-three participants were analyzed in the ANOVA. There was a normal distribution for initial, midpoint, and final blood pressures taken for systolic. Mauchly's Test of Sphericity was not violated showing that the blood pressure values are not statistically significant, Chi-square value of .730, 2 degrees of freedom,  $p=.694$ . Utilizing the Greenhouse-Geisser for correction, the findings are still not statistically significant as shown by a .606 p value.

An ANOVA was performed to study the diastolic findings for the Ghirardelli's 60% Cacao Dark Chocolate. The ANOVA is detailed in Table 5.

Table 5

*Ghirardelli's 60% Cacao Dark Chocolate Diastolic Blood Pressure Analysis*

|          | Mean    | Std.<br>Deviation | Shapiro-Wilk Sig. |
|----------|---------|-------------------|-------------------|
| Initial  | 89.4783 | 11.69254          | .244              |
| Midpoint | 86.9565 | 11.17415          | .471              |
| Final    | 84.0435 | 11.92201          | .078              |

## Mauchly's Test of Sphericity

| Approx. Chi-Square | df | Sig. | Greenhouse-Geisser |
|--------------------|----|------|--------------------|
| 5.741              | 2  | .057 | .095               |

a. Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.

b. Greenhouse-Geisser is the corrected test.

Twenty-three participants were analyzed. A normal distribution for initial, midpoint, and final blood pressures was found. Mauchly's Test of Sphericity was shown to not be violated which tells that the differences are not statistically significant, Chi-square value of 5.741, 2 degrees of freedom,  $p=.057$ . Utilizing the Greenhouse-Geisser for correction, the findings are still not statistically significant as shown by a .095 p value.

**Re-Analyzing Data**

Participants who did not consume all of their dark chocolate, who had changes in diet, changes in exercise, or changes in stress level were removed from the second analysis. There were five participants removed from the Ghirardelli's 60% Cacao Dark

Chocolate analysis and five participants removed from the Hershey's Special Dark Chocolate analysis.

Three participants had worsening stress levels throughout the experiment and were removed from the second analysis. One of the participants noted that their stress level was high due to disagreements at home with their significant other. The other two participants noted that their stress was high due to increases in their workload. The one participant also noted their child's wedding had caused increased stress.

There were a total of three participants removed from the second analysis due to changes in diet. Participants mainly referred to having consumed nothing by three in the afternoon on the day of blood pressure readings as their main change in diet. Two of the participants noted that the only thing they had consumed by three in the afternoon was their dark chocolate along with two and five cups of coffee, respectively.

There was one participant that noted a change in exercise before their blood pressure reading. They were currently involved in nutrition and exercise education classes for children; as a result they had just participated in some cardiovascular exercise an hour before the blood pressure reading. The participant did not exercise before their readings the rest of the meetings.

Three of the participants did not consume their full amount of dark chocolate for the week. Two participants had just not remembered to consume their second piece of dark chocolate in time for the blood pressure reading. A third participant had forgotten their dark chocolate at their work place and other staff members consumed part of their bag.

## **Second Analysis of Hershey's Special Dark Chocolate**

After excluding the data for participants that had not consumed all of their dark chocolate, had changes in stress level, changes in eating habits, or changes in exercise a second analysis was performed. There were 16 participants for the second analysis of Hershey's Special Dark Chocolate. The difference between initial blood pressure and midpoint blood pressure for participants consuming the Hershey's Special Dark Chocolate was a decrease of 6.1 mmHg for systolic and a decrease of 1.3 mmHg for diastolic. The difference between initial blood pressure and final blood pressure for participants consuming the Hershey's Special Dark Chocolate was a decrease in 0.2 mmHg for systolic and a decrease of 1.9 mmHg for diastolic.

After applying the new exclusions, the mean initial blood pressure compared to the midpoint showed 73% of participants that consumed Hershey's Special Dark Chocolate had a decrease in their systolic blood pressure. The range of differences in their systolic blood pressure of initial and midpoint was a decrease of 33 mm Hg up to an increase of 25 mm Hg. The initial blood pressure compared to the midpoint showed 58% of participants that consumed Hershey's Special Dark Chocolate had a decrease in their diastolic blood pressure. The range of differences in their diastolic blood pressure with initial and midpoint was a decrease of 31 mm Hg up to an increase of 16 mm Hg.

The initial blood pressure compared to the final showed that 50% of participants that consumed Hershey's Special Dark Chocolate had a decrease in their systolic blood pressure. The range of differences in their systolic blood pressure with initial and final was a decrease of 29 mm Hg up to an increase of 29 mm Hg. For diastolic, the initial blood pressure compared to the final showed that 62% of participants that consumed

Hershey's Special Dark Chocolate had a decrease. The range of differences in their diastolic blood pressure with initial and final was a decrease of 18 mm Hg up to an increase of 17 mm Hg.

An ANOVA was performed for the Hershey's Special Dark Chocolate detailing the initial, the midpoint, and endpoint systolic blood pressures for the participants that had all three read and recorded. Five participants were excluded leaving 16 participants for the second analysis. The ANOVA is detailed in Table 6.

Table 6

*Hershey's Special Dark Chocolate Systolic Blood Pressure Second Analysis*

|          | Mean     | Std.<br>Deviation | Shapiro-<br>Wilk Sig. |
|----------|----------|-------------------|-----------------------|
| Initial  | 127.4375 | 19.02619          | .555                  |
| Midpoint | 123.3125 | 16.36549          | .004                  |
| Final    | 128.0000 | 15.79451          | .691                  |

Mauchly's Test of Sphericity

| Approx. Chi-<br>Square | Df | Sig. | Greenhouse-Geisser |
|------------------------|----|------|--------------------|
| .900                   | 2  | .638 | .426               |

a. Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.

b. Greenhouse-Geisser is the corrected test.

There was normal distribution for initial and final blood pressure values, but not the midpoint. Mauchly's Test of Sphericity was not violated, therefore the values were not statistically significant as shown by Chi-square value of .900, 2 degrees of freedom,

and  $p=.638$ . The corrected value of Greenhouse-Geisser shows .426 which is not statistically significant.

The ANOVA performed for Hershey's Special Dark Chocolate following the diastolic blood pressures had normal distribution of data for the initial and final blood pressure readings but not for the midpoint blood pressure readings. This is shown in Table 7.

Table 7

*Hershey's Special Dark Chocolate Diastolic Blood Pressure Second Analysis*

|          | Mean    | Std.<br>Deviation | Shapiro-Wilk<br>Sig. |
|----------|---------|-------------------|----------------------|
| Initial  | 85.0625 | 9.87569           | .722                 |
| Midpoint | 84.5000 | 10.01998          | .565                 |
| Final    | 83.0000 | 12.07201          | .062                 |

Mauchly's Test of Sphericity

| Approx. Chi-Square | Df | Sig. | Greenhouse-Geisser |
|--------------------|----|------|--------------------|
| .995               | 2  | .608 | .691               |

a. Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.

b. Greenhouse-Geisser is the corrected test.

Mauchly's Test of Sphericity was not violated, the variation is not statistically significant, Chi-square value of .995, 2 degrees of freedom,  $p=.608$ . Utilizing the Greenhouse-Geisser for correction, the findings are still not statistically significant as shown by a .691 p value.

## **Second Analysis of Ghirardelli's 60% Cacao Dark Chocolate**

After excluding the data for participants that had not consumed all of their dark chocolate, had changes in stress level, changes in eating habits, or changes in exercise a second analysis was performed for Ghirardelli's 60% Cacao Dark Chocolate as well. There were 18 participants for the second analysis. The difference between the mean initial blood pressure and midpoint blood pressure for participants consuming the Ghirardelli's 60% Cacao Dark Chocolate was a decrease of 0.3 mmHg for systolic and a decrease of 1.7 mmHg for diastolic. The difference between initial blood pressure and final blood pressure for participants consuming the Ghirardelli's 60% Cacao Dark Chocolate was a decrease in 0.7 mmHg for systolic and a decrease of 5.7 mmHg for diastolic.

The initial blood pressure compared to the midpoint showed that 52% of participants that consumed Ghirardelli's 60% Cacao Dark Chocolate had a decrease in their systolic blood pressure. The range of differences in their systolic blood pressure of initial and midpoint was a decrease of 22 mm Hg up to an increase of 28 mm Hg. Comparing the initial blood pressure to the midpoint showed that 48% of participants that consumed Ghirardelli's 60% Cacao Dark Chocolate had a decrease in their diastolic blood pressure. The range of differences in their diastolic blood pressure of initial and midpoint was a decrease of 24 mm Hg up to an increase of 25 mm Hg.

The initial blood pressure compared to the final showed that 50% of participants that consumed Ghirardelli's 60% Cacao Dark Chocolate had a decrease in their systolic blood pressure. The range of differences in their systolic blood pressure of initial and final was a decrease of 30 mm Hg up to an increase of 17 mm Hg. The initial diastolic

blood pressure compared to the final showed that 61% of participants that consumed Ghirardelli's 60% Cacao Dark Chocolate had a decrease. The range of differences in their diastolic blood pressure of initial and final was a decrease of 32 mm Hg up to an increase of 17 mm Hg.

An ANOVA was performed for the Ghirardelli's 60% Cacao Dark Chocolate detailing the initial, the midpoint, and endpoint systolic blood pressures for participants that had all three read and recorded. This is detailed in Table 8.

Table 8

*Ghirardelli's 60% Cacao Dark Chocolate Systolic Blood Pressure Second Analysis*

|          | Mean     | Std. Deviation | Shapiro-Wilk<br>Sig. |
|----------|----------|----------------|----------------------|
| Initial  | 132.5000 | 18.59870       | .525                 |
| Midpoint | 131.4444 | 16.72343       | .148                 |
| Final    | 131.7222 | 17.15262       | .694                 |

*Mauchly's Test of Sphericity*

| Approx. Chi-Square | df | Sig. | Greenhouse-Geisser |
|--------------------|----|------|--------------------|
| .360               | 2  | .835 | .927               |

a. Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.

b. Greenhouse-Geisser is the corrected test.

There was normal distribution of the initial, midpoint, and final systolic blood pressure values. The Chi-square value of .360, 2 degrees of freedom, and a p value of .835 show no statistical significance. The corrected value of .927 for Greenhouse-Geisser showed no statistical significance.

In the ANOVA that was performed for the diastolic blood pressure for those who consumed Ghirardelli's 60% Cacao Dark Chocolate there was normal distribution of initial, midpoint, and final diastolic blood pressure values. Table 9 shows the ANOVA. Mauchly's Test showed a Chi-Square value of 8.707, 2 degrees of freedom and a p value of .013 suggesting that the values were statistically significant.

Table 9

*Ghirardelli's 60% Cacao Dark Chocolate Diastolic Blood Pressure Second Analysis*

|          | Mean    | Std.<br>Deviation | Shapiro-Wilk<br>Sig. |
|----------|---------|-------------------|----------------------|
| Initial  | 90.0000 | 12.75562          | .142                 |
| Midpoint | 86.2222 | 11.92405          | .366                 |
| Final    | 83.6667 | 12.11708          | .184                 |

## Mauchly's Test of Sphericity

| Approx. Chi-Square | df | Sig. | Greenhouse-Geisser |
|--------------------|----|------|--------------------|
| 8.707              | 2  | .013 | .104               |

a. Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.

b. Greenhouse-Geisser is the corrected test.

**Survey Findings**

Participants filled out the survey in Appendix B at the conclusion of the study.

Individual responses are presented in Table 10.

Table 10  
*Survey Results*

| How easy was it for you to consume your dark chocolate each day? | Would eating dark chocolate every day be something you would enjoy doing? |
|--|---|
| 4  | 2   |
| 5  | 4   |
| 4  | 5   |
| 5  | 5   |
| 5  | 5   |
| 4  | 5   |
| 5  | 5   |
| 5  | 5   |
| 4  | 4   |
| 5  | 5   |
| 5  | 5   |
| 5  | 5   |
| 4  | 4   |
| 5  | 5   |
| 5  | 3   |
| 5  | 5   |
| 4  | 5   |
| 4  | 3   |

Additional Comments: 1) Was too dark 2) Yum!

The average rating participants gave for ease of consuming the dark chocolate each day was 4.6 out of 5, with 18 responses. The average rating participants answered for enjoyment of the dark chocolate consumption was 4.4 out of 5. Two additional comments were written; one stated “Yum!” the participant had enjoyed being part of this study a lot, noted verbally. The other comment detailed that the Ghirardelli’s brand chocolate was too dark for the participant, having been 60% compared to 45% for the Hershey’s Special Dark.

### **Discussion**

Participants were easy to find when it came to eating dark chocolate. As noted in the survey many participants found it easy and enjoyable to consume dark chocolate

daily. In the first analysis of the two different dark chocolate groups between 43 and 68% of participants showed some signs of reduction in blood pressure during the week of recorded blood pressures, although this did not account for participants that did not adhere to attempting to keep their diet, exercise, and stress levels consistent. Most participants were able to remember to eat their dark chocolate each day, but the first analysis did include some participants that had only consumed one piece.

In the second analysis those participants that had changes to diet, exercise, and stress levels were excluded from the statistical analysis. Also excluded were those participants that had not consumed both pieces of dark chocolate by the time blood pressure was read and recorded. In the second analysis of the two different dark chocolate groups between 48 and 72% of participants showed some signs of reduction in blood pressure during the week of recorded blood pressures.

There were two participants in the Ghirardelli's group that had no difference in their systolic initial-to-midpoint blood pressure. Also in the Ghirardelli's group there were two participants that had no difference in their systolic initial-to final blood pressure as well as another participant that had no difference in their diastolic endpoint-from-initial blood pressure.

After looking at the ANOVAs that were executed for the first analysis for systolic and diastolic for both Hershey's Special Dark Chocolate and Ghirardelli's 60% Cacao Dark Chocolate, there was no statistical significance between the data for the original set of 21 and 23 participants, respectively.

Removing the participants that fit the exclusion criteria of changes in stress level, changes in diet, changes in exercise, and not consuming all the dark chocolate dropped the numbers down to 16 and 18 for Hershey's Special Dark Chocolate and Ghirardelli's 60% Cacao Dark Chocolate, respectively. The ANOVAs performed on these analyses of systolic and diastolic blood pressure at initial, midpoint, and endpoint showed that the only value with statistical significance was the second analysis of diastolic blood pressure taken from those who consumed Ghirardelli's 60% Cacao Dark Chocolate. This analysis excluded values from those who did not consume all their chocolate, had changes in diet, stress level, and exercise level.

Participants that fit the hypertensive category, with their initial blood pressure reading, were a small portion of the participants. Five of those participants were from Hershey's Special Dark Chocolate's group and seven from Ghirardelli's 60% Cacao Dark Chocolate. For systolic blood pressure when consuming Hershey's Special Dark Chocolate, there was no statistically significant difference as shown by a Chi-square of .063, p value of .969, and Greenhouse-Geisser corrected value of .304. The diastolic blood pressure comparison for Hershey's Special Dark Chocolate showed no statistically significant difference revealed by a Chi-square of 1.485, p value of .476, and Greenhouse-Geisser corrected value of .472. In the Ghirardelli's 60% Cacao Dark Chocolate, systolic blood pressure comparison showed no statistically significant difference, 1.405 Chi-square, .495 p value, and .359 Greenhouse-Geisser corrected value. For Ghirardelli's 60% Cacao Dark Chocolate's diastolic blood pressure comparison, no statistically significant difference was shown with a 4.377 Chi-square, .112 p value, and a

corrected value from Greenhouse-Geisser of .123. The next chapter will focus on conclusions, implications, and limitations in this study.

## V. Conclusions, Implications, and Limitations

This study was designed to investigate if dark chocolate consumption lowers blood pressure in adults with hypertension and to see if the percentage of cacao varies the result. The results showed that there was no statistically significant lowering effect during the first analysis that included all patients for Hershey's Special Dark Chocolate. The results for Ghirardelli's 60% Cacao Dark Chocolate also showed no statistically significant lowering effect. These analyses included both systolic and diastolic blood pressure. When removing participants from analysis due to changes in their lifestyle, dark chocolate was found to decrease blood pressure on average. In the second analysis, there was a statistically significant impact on lowering diastolic blood pressure for those consuming the Ghirardelli's 60% Cacao Dark Chocolate in this study. This indicated that the product used was ineffective at lowering both systolic and diastolic blood pressure when it came to consuming Hershey's Special Dark Chocolate, and also systolic blood pressure when consuming Ghirardelli's 60% Cacao Dark Chocolate.

All individual's blood pressures did not drop from initial to midpoint to final blood pressure in the first analysis, but the majority of the participants' did. This happened more frequently when excluding some participants in the second analysis. As noted on the survey findings most participants enjoyed eating the dark chocolate, and indicated they would continue to do so if it were proven to have a beneficial effect on their health.

### **Answering Research Objectives**

1. To determine if the consumption of dark chocolate lowers blood pressure in adults with hypertension.
2. To determine if the percentage of the dark chocolate varies the results.

As shown by this research, Ghirardelli's 60% Cacao may reduce diastolic blood pressure with a greater probability than the Hershey's Special Dark Chocolate. This result supports similar research findings that darker chocolate is shown to lower blood pressure better than other dark chocolates with lower cacao percentage. The darker the chocolate, the better the health benefit for participants hoping to lower blood pressure. The research objective of the percentage of cacao in dark chocolate varying the results of blood pressure lowering showed support for one aspect. Findings of the second analysis of this study indicate that diastolic blood pressure may be lowered with consumption of a higher percentage dark chocolate.

Only a small portion of participants from this research study had blood pressure taken at the initial blood pressure readings of each week qualified as hypertensive. Five participants were from Hershey's Special Dark Chocolate and seven participants from Ghirardelli's 60% Cacao Dark Chocolate consumption. ANOVAs were run and none of the analyses showed a statistically significant change in reduction of blood pressure. This was likely due to such small sample numbers for the analysis. The research objective of dark chocolate lowering blood pressure for those with hypertension was not indicated by this study.

Despite the poor results, there remains research supporting the concept that consuming dark chocolate is beneficial for lowering blood pressure. To verify that diastolic blood pressure can be lowered, this study should be repeated by other researchers for a longer run time with additional participants to provide for the best possible collection of data. Controlling measures such as having participants follow the same diet as provided by the researchers will help the validity of the results. Along with having participants follow the same exercise measure and consume the dark chocolate like medication, at the same time every morning. Continued research into easy ways to help improve cardiovascular health may help improve lives.

### **Limitations**

The original size of the study was planned to be 25-30 participants. At the first week 27 participants showed up for initial blood pressure to be read and received their dark chocolate. Unfortunately, not all of these participants returned each meeting to have their blood pressure read. This dropped the study numbers down to 21 and 23 for the two dark chocolate on the first analysis which was below the initial planned number. After applying exclusions, the second analysis dropped the numbers down to 16 and 18.

Additional limitations in this study include errors with the blood pressure monitor, on 10 occasions the machine reported an error and those participants were allowed to remain seated for an extra 30 seconds before having their blood pressure re-read. This may have helped lower the blood pressure for some, but others worried that it meant that they had problems with their blood pressure and their blood pressure increased.

Unreported changes in stress level, eating habits, and exercise habits are also limitations in this study. Some participants may still have felt uncomfortable writing down reasons for why their stress level was raised. Others asked not to be judged on their eating habits, such as consuming a large amount of caffeine for the day. A lot of participants remarked at the initial survey that they do not have a normal diet at all and they did not do any exercise.

There were a small number of participants unable to meet for one or more blood pressure readings due to being out of town, getting sick, or not answering their phone. All possible ways to meet with participants were attempted, but some participants did not understand the importance of keeping appointments to obtain all blood pressure recordings. Additional limitations are the sample size of the study and the lack of resources for extending the study into 2 week consumptions of both dark chocolates.

### **Implications**

Even though the sample size ended up being smaller than planned, this study did have some positive implications. Participants were overall very good at consuming their dark chocolate each day. The Ghirardelli's 60% Cacao Dark Chocolate did show that with consumption diastolic blood pressure decreased after a week. If participants continued to consume this dark chocolate, they could help lower their blood pressure. Although participants were left to follow their own diets and exercise plans, many noted that they had no set diet. This shows that in future studies a prescribed diet may help increase the validity of the research by having all participants following the exact same protocols.

As previously noted, in the second analysis where all participants kept their stress levels, diet, and exercise the same, average systolic and diastolic blood pressures decreased at both the midpoint and final analyses. This may indicate that blood pressure could be reduced, but more research needs to be conducted. Participants noted the ease and how enjoyable it was to consume the dark chocolate. This shows that adding dark chocolate to their day was a simple addition that a high majority enjoyed doing. Other studies have shown that dark chocolate helps lower blood pressure, even though only diastolic blood pressure was shown to be lowered with the darker concentration chocolate in this study. It appears that dark chocolate with a concentration of at least 60% cacao might be recommended to be added to the DASH diet for the best chance at lowering blood pressure, although additional research needs to be completed before firm recommendations can be made.

Research to be completed to monitor the effect of dark chocolate on blood pressure in additional studies includes having participants follow a control diet and consume their dark chocolate at the same time of day. Another study can follow participants for a month-long study having them consume the same amount and type of dark chocolate every day with blood pressure readings taken weekly. Future studies can also determine if the cocoa content of the dark chocolate indicates whether a decrease in blood pressure will occur.

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## Appendix A

### CONSENT TO PARTICIPATE IN RESEARCH

#### Dark Chocolate and Blood Pressure

You are invited to participate in a research study conducted by Melissa Foor, from the Dietetics major inside the Family and Consumer Sciences department at Eastern Illinois University.

Your participation in this study is entirely voluntary. Please ask questions about anything you do not understand, before deciding whether or not to participate.

You have been asked to participate in this study because you fit the criteria of being over the age of 25 and do not have low blood pressure. This study is not intended to diagnose or treat any health condition you may have. You may want to check with your doctor before making any changes to your diet.

- **PURPOSE OF THE STUDY**

The purpose of this study is to determine the effects of dark chocolate on blood pressure. Previous research done on this topic has pointed to positive results on blood pressure reduction in participants. This study will study whether there is a difference between consuming three different concentrations of dark chocolate.

- **PROCEDURES**

If you volunteer to participate in this study, you will be asked to:

Fill out the form detailing date of birth and last known height and weight.

Your initial blood pressure will be taken and you will be given 14 pieces of one concentration of dark chocolate.

You are to consume 2 pieces of dark chocolate each day.

You will be asked to arrange a meeting with Melissa 3 days later where your blood pressure will be read again.

You will be asked to eat your 2 pieces of dark chocolate at least 2 hours before this meeting.

You will then arrange another meeting with Melissa 3 days later again to read your blood pressure, following the same procedure.

After this you will have a week without any dark chocolate to ensure results will not be affected by overlapping dark chocolate concentrations in your body.

After two weeks you will meet back up with Melissa to receive your 14 pieces of another concentration of dark chocolate and have your blood pressure taken.

You will then consume 2 pieces of this dark chocolate each day.

You will arrange meetings with Melissa again 3 and 6 day later where your blood pressure will be read.

You will follow the same procedure by eating your 2 pieces of dark chocolate at least 2 hours before this meeting.

If you are interested in the results, you can get a copy and discuss them with Melissa at the last day.

During this study you are advised not to change your diet or your exercise habits.

- **POTENTIAL RISKS AND DISCOMFORTS**

The discomforts associated with this study include the face to face meeting with the principal investigator. Melissa will make all possible adjustments to meet with you with the least inconvenience.

- **POTENTIAL BENEFITS TO SUBJECTS AND/OR TO SOCIETY**

Potential benefits to you include lowered blood pressure.

Potential benefits to science include a better understanding of whether mainstream brands of dark chocolate have positive effects on blood pressure. If so, it is more readily accessible to all people interested in lowering their blood pressure.

- **CONFIDENTIALITY**

Any information that is obtained in connection with this study and that can be identified with you will remain confidential and will be disclosed only with your permission or as required by law. Confidentiality will be maintained by means of keeping names only on the original forms for the collection of data. You will be assigned a number after this data is collected, and the forms with the names will be destroyed to remain confidential.

- **PARTICIPATION AND WITHDRAWAL**

Participation in this research study is voluntary and not a requirement or a condition for being the recipient of benefits or services from Eastern Illinois University or any other organization sponsoring the research project. If you volunteer to be in this study, you may withdraw at any time without consequences of any kind or loss of benefits or services to which you are otherwise entitled.

There is no penalty if you withdraw from the study and you will not lose any benefits to which you are otherwise entitled.

You may also refuse to answer any questions you do not want to answer.

- **IDENTIFICATION OF INVESTIGATORS**

If you have any questions or concerns about this research, please contact:

Melissa Foor by email: [mafoor@eiu.edu](mailto:mafoor@eiu.edu) or phone: 517-605-2650

Or

Dr. Carla Honselman RD by email: [cshonselman@eiu.edu](mailto:cshonselman@eiu.edu) or phone: 217-581-6676

- **RIGHTS OF RESEARCH SUBJECTS**

If you have any questions or concerns about the treatment of human participants in this study, you may call or write:

Institutional Review Board

Eastern Illinois University

600 Lincoln Ave.

Charleston, IL 61920

Telephone: (217) 581-8576

E-mail: [eiuirb@www.eiu.edu](mailto:eiuirb@www.eiu.edu)

You will be given the opportunity to discuss any questions about your rights as a research subject with a member of the IRB. The IRB is an independent committee composed of members of the University community, as well as lay members of the community not connected with EIU. The IRB has reviewed and approved this study.

---

I voluntarily agree to participate in this study. I understand that I am free to withdraw my consent and discontinue my participation at any time. I have been given a copy of this form.

---

Printed Name of Participant

---

Signature of Participant

---

Date

I, the undersigned, have defined and fully explained the investigation to the above subject.

---

Signature of Investigator

---

Date

**Appendix B****Initial Handout****Dark Chocolate and You**

For this study, I would like you to consume 2 pieces of dark chocolate per day. You will be given 14 pieces for the duration of the week. I have recorded your initial blood pressure and will need to meet with you to have your blood pressure taken and recorded in 4 days and again in 7 days. After this you will have a week off and then I will need to meet with you again. The same procedure will happen, I will record your blood pressure that day and then you will be given 14 pieces of dark chocolate for the week, 2 pieces/day. You will meet with me in 4 days and then again at 7 days. Enclosed is a chart for you to mark off every time you consume your 2 pieces/day.

Name \_\_\_\_\_ Birthdate \_\_\_\_\_  
Height \_\_\_\_\_ Weight \_\_\_\_\_ Gender Male / Female

**Chart for Dark Chocolate Consumption**

Week 1

| Tues | Wed | Thurs | Fri | Sat | Sun | Mon |
|------|-----|-------|-----|-----|-----|-----|
|      |     |       |     |     |     |     |

Week 3

| Tues | Wed | Thurs | Fri | Sat | Sun | Mon |
|------|-----|-------|-----|-----|-----|-----|
|      |     |       |     |     |     |     |

Blood Pressure Values:

Week 1

Week 3

|  |  |  |  |  |  |  |
|--|--|--|--|--|--|--|
|  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |

**Final Dark Chocolate Survey**

Survey

How easy was it for you to consume your dark chocolate each day?

- 1- Not easy Easy      2- Rarely easy      3-Somewhat      4-Fairly easy      5-

Would eating dark chocolate every day be something you would enjoy doing?

- 2- Not at all Enjoy a lot      2- Rarely enjoy      3- Somewhat      4-Slightly      5-

Any Additional Comments:

