EFFECT OF GRADED DOSES OF *COCOS NUCIFERA* EXTRACT ON BLOOD PRESSURE AND INTRAOCULAR PRESSURE IN NORMOTENSIVE SUBJECTS

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FACULTY OF LIFE SCIENCES

UNIVERSITY OF BENIN

FEBRUARY, 2025

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A PROJECT WORK SUBMITTED TO THE DEPARTMENT OF OPTOMETRY, FACULTY OF LIFE SCIENCES, UNIVERSITY OF BENIN, BENIN CITY, IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF DOCTOR OF OPTOMETRY (O.D) DEGREE

FEBRUARY, 2025.

CERTIFICATION

This is to certify that the project titled **EFFECT OF COCOS NUCIFERA EXTRACT ON BLOOD PRESSURE AND INTRAOCULAR PRESSURE IN NORMOTENSIVE SUBJECTS was** done by **ABDULLAHI SHERIFAT JOY** from the Department of Optometry Life Sciences, University of Benin, Benin City.

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DEDICATION

I dedicate this project work in loving memory of Late Mr Shaibu Abdullahi (my lovely Father) and to my family, The Abdullahis

ACKNOWLEDGEMENTS

My sincere gratitude goes to my creator, God Almighty for giving me the inspiration, wisdom, understanding and spiritual guidance to go through this phase of education successfully.

Special thanks and appreciation go to my amiable supervisor **Prof. (Mrs) G. O. George,** despite the time constraint, she gave me the necessary guidance, contributions, encouragement and support I needed.

I acknowledge the Head of Department, **Prof. (Mrs) J. A Ebeigbe** for her effort in management and coordinating of the affairs of the department.

I want to specially thank Doc M. Mutali, Doc G. N. Atuanya and Doc Cole, for holding me by the hand and walking me through the Optometry programme.

My sincere appreciation goes to my Mum, Mrs Comfort and siblings, Abigail, Emmanuel, Blessing, who supported me financially, morally and spiritually all through my stay in the university O.D programme.

Special thanks to my friends, Blessed, Emma DM, Ese, Ruth, Daniella, Abel, King, Martins, and other course mates and my junior colleagues who without their support and encouragement, this programme would not be smooth and fun. I say a very big thank you to the family optometry gave me.

To my Spiritual Father, Rev. Donald Osayande and his family, to Kragha Tare (Uncle T) and to my amiable Boss, Amb. Famous Ite, I want to say a big thank you for your prayers and support. A well-deserved applause to my senior colleagues who supported me with the necessary guidance; Dr Valentine, Dr Richmond and Dr Beulah.

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ABSTRACT

Background: Elevated intraocular pressure (IOP) and blood pressure are risk factors for various health conditions. Cocos nucifera (coconut) extract has been suggested to possess potential hypotensive and IOP-lowering properties. **Purpose:** This study investigated the effects of graded doses of Cocos nucifera extract on IOP, systolic blood pressure (SBP), and diastolic blood pressure (DBP) in normotensive subjects. **Methods:** Forty normotensive participants were divided into four groups (n=10 per group): three receiving different doses of Cocos nucifera extract (2.86 g/kg, 5.71 g/kg, and 8.57 g/kg body weight) and a control group receiving 300 ml of water. IOP and blood pressure were measured before and hourly for four hours after administration. Statistical analyses included independent sample t-tests to compare each extract group to the control and ANOVA to assess differences across the extract dosage groups. **Results:** Significant reductions in mean IOP were observed in all extract groups compared to the control ($p < 0.001$ for all comparisons). While all doses lowered IOP compared to control, differences between the extract doses were not statistically significant ($p = 0.308$). For DBP, all extract groups showed significant reductions compared to the control ($p < 0.01$ for the 2.86 g/kg group, $p < 0.001$ for the 5.71 g/kg and 8.57 g/kg groups), with a significant dose-dependent effect observed across the extract groups ($p < 0.001$). For SBP, only the 5.71 g/kg group showed a significant reduction compared to the control ($p < 0.001$), although the ANOVA showed a significant overall effect of the extract across the dosage groups ($p < 0.05$). **Conclusion:** Cocos nucifera extract demonstrates potential IOP-lowering and DBP-reducing effects in normotensive subjects. The effect on DBP appears to be dose dependent. Further research is warranted to elucidate the mechanisms of action and long-term effects.

***Key words*:** Cocos nucifera, intraocular pressure, blood pressure, systolic blood pressure, diastolic blood pressure, dose-response, normotensive.

CHAPTER ONE

1.0 INTRODUCTION

Cocos nucifera, commonly referred to as coconut, is a versatile tropical plant renowned for its diverse applications, including culinary, medicinal, and nutritional uses. The clear liquid extracted from young green coconuts, widely known as coconut water, has gained global recognition for its refreshing taste and purported health benefits. Rich in electrolytes such as potassium, sodium, magnesium, and calcium, along with bioactive compounds and antioxidants, coconut water has been embraced as a natural remedy for hydration, electrolyte balance, and overall health enhancement (Yong *et al.,* 2009). These properties have made it particularly popular among athletes and health-conscious individuals seeking natural alternatives for maintaining bodily function and recovery.

Emerging research highlights the potential of coconut water in addressing critical physiological markers like blood pressure (BP) and intraocular pressure (IOP). Blood pressure, an essential cardiovascular parameter, plays a pivotal role in maintaining proper circulation and organ perfusion, while intraocular pressure, crucial for ocular health, helps preserve the eye's shape and function (Farapti *et al.,* 2017). Elevated BP is a major risk factor for conditions such as hypertension, heart disease, and stroke, whereas increased IOP is closely linked to glaucoma, a leading cause of irreversible vision loss. Coconut water's high potassium content, known for promoting vasodilation and enhancing fluid regulation, has been associated with modest reductions in BP. Similarly, its potential role in influencing ocular fluid dynamics warrants further exploration, particularly for its effects on IOP regulation.

Despite its increasing popularity and potential health benefits, the impact of coconut water on BP and IOP remains underexplored, especially in normotensive individuals. While existing studies

suggest a connection between coconut water consumption and reduced BP in hypertensive subjects, the effects in healthy individuals and the possibility of a dose-dependent response remain uncertain. This study aims to fill this knowledge gap by investigating the effects of graded doses of Cocos nucifera extract on both BP and IOP in normotensive individuals. By focusing on these critical health parameters, the research seeks to provide insights into the potential therapeutic applications of coconut water, contributing to the broader understanding of natural interventions in health management.

1.1 BACKGROUND INFORMATION

Cocos nucifera, commonly known as the coconut, is widely recognized for its health-promoting properties, particularly through the consumption of coconut water. This clear liquid, found within young green coconuts, has gained popularity as a natural, refreshing beverage and is lauded for its rich nutritional content. Coconut water is an excellent source of electrolytes such as potassium, sodium, magnesium, and calcium, all essential for proper hydration, muscle function, and maintaining fluid balance in the body (Tuyekar *et al.,* 2021). In addition to these benefits, recent research has focused on its potential effects on systemic blood pressure (BP) and intraocular pressure (IOP), both critical indicators of overall health.

Coconut water contains a substantial amount of potassium, with approximately 250-300 mg per 100 ml (Markale *et al.,* 2023). Potassium is a vital nutrient that helps regulate BP by countering the effects of sodium, promoting vasodilation, and improving kidney function. Studies have shown that increased potassium intake can reduce systolic BP by 4-5 mmHg and diastolic BP by 3-4 mmHg (Rodrigues *et al.,* 2014). Furthermore, coconut water is rich in antioxidants and bioactive compounds, which help reduce oxidative stress and inflammation, key contributors to cardiovascular diseases (Prathanpan *et al.,* 2011).

The role of coconut water in managing IOP is also garnering attention. IOP, which refers to the fluid pressure inside the eye, is crucial for maintaining ocular structure and function. Elevated IOP is a significant risk factor for glaucoma, one of the leading causes of irreversible blindness worldwide. While studies on the relationship between coconut water and IOP are limited, early findings suggest that potassium, a primary component of coconut water, may play a role in regulating ocular fluid dynamics, potentially impacting IOP (Sherwin *et al.,* 2015). The fluid-regulating properties of potassium highlight its possible importance in maintaining healthy IOP levels.

Research into the effects of coconut water on BP has yielded promising results, particularly for hypertensive individuals. A study by Alleyne *et al*., (2005) demonstrated that regular consumption of coconut water resulted in a reduction of systolic BP by 12-15 mmHg and diastolic BP by 8-10 mmHg in hypertensive subjects. In normotensive individuals, the reduction was more modest, with systolic BP decreasing by 2-4 mmHg. However, concerns have been raised about the potential for hyperkalemia (elevated potassium levels) in individuals sensitive to potassium, particularly with high doses of coconut water (Patel & Moreau, 2021). Regarding IOP, Singh *et al*., (2019) found that consuming 200-400 ml of coconut water daily for six weeks led to a modest 3-7% reduction in IOP among potassium-sensitive individuals. While these results are encouraging, further research is required to determine the clinical significance of these effects.

This study aims to investigate the effect of graded doses of Cocos nucifera extract on BP and IOP in normotensive individuals. By administering doses of 2.86g/kg, 5.71g/kg, and 8.57g/kg body weight, the research seeks to assess whether there is a dose-dependent impact on these physiological parameters. Given potassium's established role in regulating both BP and IOP, this

study intends to explore whether incremental increases in coconut water extract consumption yield measurable effects on these critical health indicators.

Hypertension remains a major global health challenge, affecting approximately 1.13 billion people and serving as a leading cause of heart disease, stroke, and kidney failure (World Health Organization, 2021). In many regions, particularly those with limited access to pharmaceuticals, managing BP through natural interventions is a crucial area of interest. Elevated IOP, a key risk factor for glaucoma, affects an estimated 60 million people globally and is the second leading cause of blindness. Since glaucoma is often asymptomatic in its early stages, developing accessible strategies to manage IOP is essential for public health.

By investigating the therapeutic potential of *C.* nucifera extract, this study could offer insights into an affordable and natural means of managing BP and IOP. If proven effective, coconut water extract could provide a complementary or alternative approach to existing treatments, particularly in regions where healthcare resources are scarce. The findings of this research could also contribute to a broader understanding of dietary interventions for promoting cardiovascular and ocular health.

While existing research highlights the potential benefits of *C. nucifera*, significant gaps remain in understanding its precise effects, particularly regarding graded doses of its extract on BP and IOP in normotensive individuals. This study seeks to address these gaps, providing valuable insights into the health-promoting potential of coconut water and contributing to the development of accessible interventions for managing vital health parameters.

SYSTEMIC BLOOD PRESSURE

Systemic blood pressure, often simply referred to as blood pressure, is a crucial physiological parameter that reflects the force exerted by circulating blood against the walls of the large arteries within the systemic circulation (Saghiv *et al*., 2020). This pressure is essential for effective perfusion of tissues and organs throughout the body. Blood pressure is conventionally expressed as two distinct components: systolic blood pressure and diastolic blood pressure. These two values represent the dynamic changes in arterial pressure during the cardiac cycle (Schutte *et al*., 2022).

The traditional method for measuring blood pressure involves auscultation using a mercury-tube sphygmomanometer, a technique that has been a cornerstone of clinical practice for many years (Lacković, 2023). Blood pressure is quantified in millimeters of mercury (mmHg), a unit derived from the historical use of mercury manometers in early blood pressure measurement devices (Kumar *et al*., 2021). The blood pressure reading is typically presented as a ratio, with systolic pressure displayed over diastolic pressure (e.g., 120/80 mmHg).

Systolic pressure represents the peak arterial pressure attained during ventricular systole, the phase of the cardiac cycle when the heart muscle contracts forcefully to eject blood into the aorta and subsequently throughout the arterial system. This contraction generates the maximum pressure within the large arteries as blood is propelled through the body (Richter *et al*., 2021).

Diastolic pressure, conversely, reflects the minimum arterial pressure observed during ventricular diastole, the phase of the cardiac cycle when the heart muscle relaxes and the ventricles fill with blood (Arvidsson & Kovács, 2022). This relaxation period allows the arterial walls to recoil, maintaining a residual pressure within the arteries even between heartbeats. The diastolic pressure thus represents the baseline pressure within the large arteries during the

intervals between heart contractions. The difference between systolic and diastolic pressure is known as pulse pressure (Arvidsson & Kovács, 2022).

This value provides information about the elasticity of the arteries and the stroke volume of the heart. Maintaining blood pressure within a healthy range is essential for cardiovascular health. Both chronically elevated (hypertension) and chronically reduced (hypotension) blood pressure can have adverse health consequences (Kumar *et al*., 2021).

THE IMPORTANCE OF BLOOD PRESSURE REGULATION

The regulation of blood pressure is of paramount importance for overall health and well-being. Blood pressure, the force exerted by circulating blood against the walls of blood vessels, is a dynamic physiological parameter tightly controlled by a complex interplay of factors (Chen *et al*., 2023). These factors include cardiac output (the volume of blood pumped by the heart per minute), blood volume (the total amount of blood in the circulatory system), and vascular resistance (the resistance to blood flow within the blood vessels) (Kim, 2022). Maintaining blood pressure within a normal physiological range is vital for ensuring adequate blood flow and oxygen delivery to all organs and tissues throughout the body (Kim, 2022).

Optimal perfusion is essential for cellular function, tissue health, and overall organ system integrity. Deviations from the normal blood pressure range, whether in the form of chronically elevated blood pressure (hypertension) or chronically low blood pressure (hypotension), can have significant adverse health consequences (Schutte *et al*., 2022). Hypertension, in particular, is a major risk factor for a multitude of serious cardiovascular conditions, including stroke, myocardial infarction (heart attack), heart failure, kidney disease, and peripheral artery disease (Boehme *et al*., 2017). These conditions contribute substantially to global morbidity and mortality. A variety of lifestyle factors exert a considerable influence on blood pressure

regulation. These factors include dietary habits (such as sodium intake, consumption of fruits and vegetables, and overall dietary patterns), physical activity levels (regular exercise has a well-established blood pressure-lowering effect), stress levels (chronic stress can contribute to elevated blood pressure), alcohol consumption, and tobacco us (Boehme *et al*., 2017).

Given the significant impact of lifestyle on blood pressure, understanding natural dietary interventions that can effectively modulate blood pressure is of crucial importance. This knowledge is especially relevant in the context of hypertension, which remains a highly prevalent global health issue affecting a substantial proportion of the adult population worldwide. Identifying and promoting effective natural strategies for blood pressure management can play a vital role in preventing and mitigating the risks associated with hypertension and promoting cardiovascular health on a population level. Research into natural interventions offers the potential for complementary or adjunctive approaches to blood pressure management, potentially reducing reliance on pharmacological interventions and their associated side effects.

INTRAOCULAR PRESSURE

IOP refers to the fluid pressure inside the eye, which is essential for maintaining its shape and proper function (Kelly & Farrel, 2018). The spaces within the eye are filled with a clear fluid, the aqueous humour and a jelly-like substance, the vitreous humour. The aqueous humour is contained in the anterior and posterior chambers, while the vitreous body is contained in the large space between the lens and the retina (Mark, 2020).

Intraocular pressure is a function of the rate at which aqueous humour enters the eye (inflow) and the rate at which it leaves the eye (outflow) through the trabecular meshwork (Freddo *et al*., 2022).

When both inflow and outflow are equal, a steady state exists, and the intraocular pressure remains constant. Any factor which disrupts the relationship between the inflow and outflow of the aqueous humour will invariably affect the intraocular pressure (Starmer & Ethier, 2022). A disruption in favour of increased aqueous humour production (inflow) or decreased aqueous humour outflow will cause an increase in intraocular pressure, while a disruption in favour of decreased aqueous humour production and increased aqueous outflow will cause a decrease in the intraocular pressure (Starmer & Ethier, 2022).

The unit of measurement of intraocular pressure is millimeters of mercury (mmHg). Normal IOP ranges from 10 to 21 mmHg; however, elevated IOP can damage the optic nerve, leading to glaucoma (Zhang *et al*., 2022). The relationship between IOP and systemic health, particularly cardiovascular status, has garnered attention in recent years, emphasizing the interconnectedness of bodily systems. Effective management of IOP is vital not only for preserving vision but also for overall ocular health (Dada *et al*., 2022).

Blood pressure (BP) and intraocular pressure (IOP) are two critical physiological markers that provide insights into cardiovascular and ocular health, respectively (Farrah *et al*., 2020). Hypertension, characterized by consistently elevated BP, poses a significant risk factor for various cardiovascular diseases, including stroke, heart attack, and renal failure. Similarly, increased IOP is a primary risk factor for glaucoma, a disease that can lead to irreversible vision loss. Monitoring and managing these parameters are essential not only for disease prevention but also for enhancing the quality of life among individuals at risk (Farrah *et al*., 2020).

1.2 STATEMENT OF PROBLEM

Hypertension, characterized by persistently elevated blood pressure (BP), and elevated intraocular pressure (IOP) represent significant global health concerns, acting as major risk factors for a range of debilitating cardiovascular and ocular diseases. Hypertension is a well-established risk factor for conditions such as stroke, heart attack, heart failure, and kidney disease, contributing substantially to morbidity and mortality worldwide. Elevated IOP, on the other hand, is a primary risk factor for glaucoma, a progressive optic neuropathy that is a leading cause of irreversible blindness globally. The impact of glaucoma on vision and quality of life underscores the importance of effective IOP management.

Current conventional management strategies for both hypertension and elevated IOP frequently involve pharmacological interventions, including antihypertensive medications and IOP-lowering eye drops. While these pharmacological approaches can be effective in controlling BP and IOP, they are often associated with a spectrum of potential side effects, ranging from mild discomfort to more serious adverse reactions. Furthermore, these pharmacological treatments typically require long-term or even lifelong use, placing a significant burden on healthcare resources and potentially impacting patient adherence due to cost, inconvenience, or side effects. This reliance on pharmacological interventions, coupled with the potential for adverse effects and the associated healthcare costs, has spurred a growing interest in exploring natural alternatives that may offer complementary or adjunctive support in the regulation of BP and IOP. Natural products and dietary interventions have garnered increasing attention as potential strategies for managing various health conditions, including hypertension and ocular health. Therefore, this study aims to investigate the effect of graded doses of *Cocos nucifera* (coconut) extract on blood pressure and intraocular pressure in normotensive subjects. By examining the

potential of this natural extract to influence these key physiological parameters in individuals with normal baseline values, this research seeks to contribute to the growing body of knowledge on natural approaches to supporting cardiovascular and ocular health. The focus on normotensive subjects allows for the assessment of the extract's potential to maintain healthy BP and IOP levels, rather than focusing on a treatment effect in individuals with pre-existing conditions.

1.3 AIM AND OBJECTIVES

1.3.1 AIM

To investigate the effect of graded doses of Cocos nucifera extract on blood pressure and intraocular pressure in normotensive subjects.

1.3.2 OBJECTIVES

I. To determine the effect of graded doses of Cocos nucifera extract on intraocular pressure.

II. To determine the effect of graded doses of Cocos nucifera extract on systemic blood pressure.

III. To determine if the effect of graded doses of Cocos nucifera extract on intraocular pressure is dose dependent.

IV. To determine if the effect of graded doses of Cocos nucifera extract on systemic blood pressure is dose dependent.

1.4 HYPOTHESES

Null Hypothesis 1 (H_O1): There is no significant difference in IOP between Individuals administered 2.86g/kg of Cocos nucifera extract and the control group.

Null Hypothesis 2 (H_O2): There is no significant difference in IOP between Individuals administered 5.71g/kg of Cocos nucifera extract and the control group.

Null Hypothesis 3 (H_O3): There is no significant difference in IOP between Individuals administered 8.57g/kg of Cocos nucifera extract and the control group.

Null Hypothesis 4 (H_O4): There is no significant difference in SBP between Individuals administered 2.86g/kg of Cocos nucifera extract and the control group.

Null Hypothesis 5 (H_O5): There is no significant difference in SBP between Individuals administered 5.71g/kg of Cocos nucifera extract and the control group.

Null Hypothesis 6 (H_O6): There is no significant difference in SBP between Individuals administered 8.57g/kg of Cocos nucifera extract and the control group.

Null Hypothesis 7 (H_O7): There is no significant difference in DBP between Individuals administered 2.86g/kg of Cocos nucifera extract and the control group.

Null Hypothesis 8 (H_O8): There is no significant difference in DBP between Individuals administered 5.71g/kg of Cocos nucifera extract and the control group.

Null Hypothesis 9 (H_O9): There is no significant difference in DBP between Individuals administered 8.57g/kg of Cocos nucifera extract and the control group.

Null Hypothesis 10 (H_O10): There is no significant dose-response relationship between Cocos nucifera extract administration and Intraocular Pressure.

Null Hypothesis 11 (H_O11): There is no significant dose-response relationship between Cocos nucifera extract administration and Systolic Blood Pressure.

Null Hypothesis 12 (H_O12): There is no significant dose-response relationship between Cocos nucifera extract administration and Diastolic Blood Pressure.

1.5 SIGNIFICANCE OF STUDY

This study is significant for the following reasons:

I. This study will provide eye care practitioners with the knowledge of how Cocos nucifera extract affects intraocular pressure and systemic blood pressure.

II. This study will help determine the most effective dose of Cocos nucifera extract that has significant effect on IOP and BP.

III. This study is hoped to further contribute to the growing body of literature on dietary interventions for health promotion.

1.6 DEFINITION OF TERMS

- **Cocos nucifera (Coconut):** Cocos nucifera, commonly known as coconut, is a tropical tree species that produces the coconut fruit. The fruit, specifically its water (young coconut water), has various nutritional and health benefits. This study focuses on the extract from young coconuts, known for its high content of electrolytes such as potassium, magnesium, and calcium, which are believed to have potential effects on blood pressure and intraocular pressure.
- **Blood Pressure (BP):** Blood pressure refers to the force exerted by circulating blood on the walls of blood vessels. It is measured in millimeters of mercury (mmHg) and is represented as systolic over diastolic pressure. Systolic pressure is the maximum pressure when the heart contracts, while diastolic pressure is the lowest pressure during heart relaxation. Normal blood pressure is typically around 120/80 mmHg, and deviations from this range can indicate potential health issues like hypertension.

- **Intraocular Pressure (IOP):** Intraocular pressure refers to the pressure within the eye, primarily influenced by the production and drainage of aqueous humor. This fluid pressure is vital for maintaining the eye's shape and function. The normal range for intraocular pressure is between 10 and 21 mmHg. Elevated IOP is a major risk factor for glaucoma, a disease that can lead to irreversible vision loss if left unmanaged.
- **Normotensive:** Normotensive refers to individuals with normal blood pressure levels, typically defined as a systolic pressure below 120 mmHg and a diastolic pressure below 80 mmHg. These individuals do not suffer from hypertension, which is characterized by consistently elevated blood pressure readings.
- **Graded Doses:** Graded doses refer to different amounts or concentrations of a substance administered in increasing or decreasing quantities. In this study, graded doses of Cocos nucifera extract (2.86g/kg, 5.71g/kg, and 8.57g/kg body weight) are given to participants to assess the varying effects on blood pressure and intraocular pressure.
- **Hypertension:** Hypertension, also known as high blood pressure, is a medical condition in which the blood pressure in the arteries is persistently elevated. It is diagnosed when blood pressure readings consistently exceed 140/90 mmHg. Hypertension is a major risk factor for cardiovascular diseases, stroke, kidney failure, and other serious health conditions.
- **Glaucoma:** Glaucoma is a group of eye conditions that damage the optic nerve, often due to elevated intraocular pressure. It is one of the leading causes of blindness globally. Glaucoma can be either open-angle or angle-closure, with the primary risk factor being elevated intraocular pressure.

- **Electrolytes:** Electrolytes are minerals in the body that carry an electric charge and are essential for various bodily functions, including fluid balance, muscle contraction, and nerve signaling. Key electrolytes include sodium, potassium, magnesium, and calcium. Coconut water is rich in electrolytes, particularly potassium, which may contribute to its effects on blood pressure regulation.
- **Placebo:** A placebo is a substance or treatment with no therapeutic effect, used as a control in clinical trials. In this study, the placebo is represented by a group receiving water instead of Cocos nucifera extract. The purpose is to compare the effects of the extract with a non-active treatment to assess any observed changes in blood pressure and intraocular pressure.

CHAPTER TWO

2.0 LITERATURE REVIEW

Ocular Effect of Cocus nucifera Water

Poblete *et al.,* (1998) investigated the potential of coconut water to temporarily reduce intraocular pressure (IOP) in normotensive subjects. The study involved 25 participants whose baseline IOP was measured at 8 AM, 10 AM, and 12 noon. To evaluate the effects, the subjects consumed either plain water or coconut water on separate occasions, ensuring that the intake occurred on an empty bladder and at least one hour after meals. IOP measurements were then taken at 30, 90, and 120 minutes post-ingestion. This controlled approach allowed for a direct comparison of the effects of coconut water versus plain water.

The results revealed a significant reduction in IOP following coconut water consumption, with the effect lasting approximately 2.5 hours. In contrast, plain water did not produce the same IOP-lowering effect. Despite no significant difference in total urine output between the two groups, those who consumed coconut water experienced more frequent urination. The study concluded that coconut water could serve as a practical, easily accessible adjunct for the temporary management of elevated IOP, offering a non-pharmacological option for short-term ocular pressure control.

Effect of Cocos nucifera extract on Blood pressure

Alleyne *et al.,* (2005) studied the potential blood pressure-lowering effects of coconut water, focusing on its high electrolyte content (potassium, magnesium, and calcium). The study aimed to see if these electrolytes could help regulate blood pressure, particularly by reducing sodium levels and supporting fluid balance. Participants included both hypertensive and normotensive

individuals, who consumed coconut water, a control beverage, or no intervention. Blood pressure was measured at the start and throughout the study, with dietary and activity factors controlled. Results showed that hypertensive participants who drank coconut water experienced a significant drop in both systolic (12-15 mmHg) and diastolic (8-10 mmHg) blood pressure. This reduction was statistically significant, suggesting coconut water can help lower high blood pressure. In normotensive participants, the decrease was smaller, with systolic and diastolic pressures dropping by only 2-4 mmHg. This suggests coconut water may help maintain normal blood pressure but is less effective at lowering it in individuals with already healthy levels. The researcher concluded that coconut water could play a beneficial role in managing elevated blood pressure due to its high levels of potassium, magnesium, and other electrolytes, which are known to help regulate sodium balance and improve fluid distribution in the body. This is particularly beneficial for hypertensive individuals, as electrolyte-rich beverages can reduce sodium retention, a key factor in hypertension.

Faozi *et al.,* (2022) conducted a quasi-experimental study to evaluate the effect of young coconut water consumption on blood pressure among nursing students at Respati University Yogyakarta. The study involved 36 participants, selected using simple random sampling, who were divided into an experimental group and a control group. The experimental group consumed 30 ml of young coconut water, which contains 61 mg of potassium, 5.45 mg of sodium, and 1.3 mg of sugar, while the control group did not receive coconut water. The research utilized a pre-and-post-test design with paired T-tests and Wilcoxon tests to assess changes in systolic and diastolic blood pressure before and after the intervention.

The results indicated that coconut water consumption had a significant effect on systolic blood pressure in the experimental group, with a p-value of 0.030, suggesting a statistically significant

reduction. However, no significant changes were observed in diastolic blood pressure in the experimental group (p-value = 0.194). In the control group, no significant changes were observed in either systolic (p-value = 0.121) or diastolic blood pressure (p-value = 0.361). The post-test analysis revealed that the experimental group had a significant reduction in systolic blood pressure compared to the control group (p-value = 0.021), while no significant difference in diastolic blood pressure was found between the two groups (p-value = 0.371). These findings conclude that young coconut water consumption can positively affect systolic blood pressure in nursing students.

Tekade and Gullapalli (2013) investigated the impact of Tender Coconut Water (TCW) on blood pressure (BP) in 70 hypertensive individuals. The experimental group (n=40) consumed 300 ml of TCW daily for six weeks, while the control group (n=30) followed their usual routine.

Results showed a 7.2% reduction in systolic BP in the experimental group, from 145.8 mm Hg to 135.3 mm Hg, compared to a minimal drop in the control group (141 mm Hg to 140 mm Hg). Diastolic BP decreased by 7.3% in the experimental group (93.7 mm Hg to 86.9 mm Hg), while the control group experienced a slight decline from 90.9 mm Hg to 89.7 mm Hg.

The study concluded that TCW, rich in potassium, significantly reduces BP by promoting vasodilation and improving endothelial function, making it a beneficial intervention for managing hypertension.

Syafriani *et al.,* (2014) examined the effects of coconut water (Cocos nucifera L) and isotonic drinks on heart rate in hypertensive Wistar rats. The study divided rats into five groups, with hypertension induced by administering high-concentration NaCl for 14 days. Following this, treatments were applied for another 14 days. Heart rate measurements showed that during

hypertension induction, the coconut water and isotonic drink groups experienced significantly higher heart rates ($p<0.05$) than the control group. After treatment, the coconut water group exhibited a significant reduction in heart rate ($p<0.05$) compared to the control group, while the isotonic drink group showed a decrease, though not statistically significant. The study concluded that coconut water more effectively lowered heart rate than isotonic drinks in hypertensive rats.

Fadlilah and Sucipto (2021) investigated the effects of young coconut water and watermelon juice on blood pressure in nursing students at Respati University Yogyakarta. The study involved 54 participants divided into three groups: control, young coconut water (18 respondents), and watermelon juice (18 respondents). After intervention, the systolic blood pressure decreased by -3.1 mmHg in the coconut water group and -2.9 mmHg in the watermelon group, compared to -1.8 mmHg in the control group. Diastolic pressure changes were smaller, with reductions of -2.4 mmHg (coconut water), -1.5 mmHg (watermelon), and -1.0 mmHg (control). Statistically, systolic blood pressure significantly decreased in the coconut water ($p=0.030$) and watermelon groups ($p=0.032$), while diastolic changes were not significant. This study concluded that while both coconut water and watermelon juice lowered systolic blood pressure, their effect on diastolic pressure was not statistically significant.

Effect of Cocus nucifera on The Physiology

Pummer *et al.,* (2001) investigated the effects of coconut water (CNW) on plasma coagulation in vitro, exploring its potential as a short-term intravenous hydration and resuscitation fluid. The study involved citrated plasma samples from eight healthy volunteers, which were diluted with either CNW or physiological saline (PS). Thrombelastography (TEG) was used to assess coagulation, providing a comprehensive evaluation of clot formation, strength, and fibrinolysis. The study found that replacing up to 50% of citrated plasma with CNW or PS did not alter the

initiation of coagulation, as indicated by stable split points (SP) and reaction times (R). However, clot strength, measured by maximum amplitude (MA), decreased in a dose-dependent manner for both CNW and PS, with a 39% and 32% reduction in MA, respectively, when plasma was diluted by 50%.

The results suggest that CNW's effect on hemostasis is comparable to that of PS, indicating no significant difference in their influence on coagulation. The study also noted that while CNW has been previously recognized for its rehydration properties, concerns regarding its high potassium content have been highlighted, particularly when administered intravenously in large quantities. The study provided valuable insight into CNW's effect on clot formation, filling a gap in existing research. They concluded that CNW could be considered for intravenous use in emergency situations, but further investigation is needed to assess its full implications, particularly regarding electrolyte imbalances and long-term safety.

CT *et al.,* (2023) conducted a study to explore the therapeutic potential of coconut water (CW) and naturally fermented coconut water (FCW) in treating urolithiasis, a condition that leads to kidney stone formation. The study compared the anti-uropathogenic, antioxidant, and anti-urolithiasis properties of CW and FCW through various in vitro analyses. Initial physicochemical screening revealed that CW is rich in total phenolics, proteins, and minerals. The antioxidant potential was measured using the DPPH assay, showing that CW exhibited 48.33 ± 2.52% antioxidant activity, while FCW demonstrated a higher antioxidant capacity of 55.12 ± 2.99%. This suggests that fermentation enhances the antioxidant properties of coconut water. The study further examined the antimicrobial and anti-struvite properties of CW and FCW. FCW-treated cultures of selected uropathogens showed significant antimicrobial activity, whereas CW-treated cultures displayed negligible effects. Anti-struvite analysis conducted using the single gel

diffusion method demonstrated that increasing concentrations of both CW and FCW reduced the number and size of struvite crystals formed in the gel medium. However, FCW exhibited greater inhibitory effects on struvite crystallization compared to CW. The findings suggest that while CW offers antioxidant benefits and marginal inhibition of struvite formation, FCW possesses stronger antioxidant, anti-uropathogenic, and anti-struvite properties, highlighting its potential as a therapeutic agent for managing urolithiasis.

Muhammed and Luka (2013) investigated the effects of coconut oil, coconut water, and palm kernel oil on biochemical parameters in white albino rats. The study involved 20 rats divided into four groups of five, with one group serving as the control (receiving distilled water and feed only), while the other three groups received 400 mg/kg body weight of either coconut oil, coconut water, or palm kernel oil orally for seven days. The study analyzed lipid profiles, glucose, protein levels, and enzyme markers to assess potential toxicity. Results showed a significant ($p<0.05$) decrease in glucose and protein levels across the treatment groups. Additionally, coconut oil and coconut water led to a significant ($p<0.05$) reduction in triglycerides, total cholesterol, and low-density lipoprotein (LDL), whereas palm kernel oil increased these parameters. Conversely, high-density lipoprotein (HDL) levels significantly increased ($p<0.05$) with coconut oil and coconut water treatment but decreased with palm kernel oil. The study also evaluated enzyme activity to detect potential liver toxicity. Coconut oil, coconut water, and palm kernel oil treatments resulted in a significant ($p<0.05$) reduction in enzyme activity, except for alkaline phosphatase (ALP) in the palm kernel oil group and alanine aminotransferase (ALT) in the coconut oil group. These findings suggest that coconut oil and coconut water may have beneficial hypoglycemic and lipid-lowering effects, while palm kernel oil could negatively impact lipid profiles. Despite the biochemical changes observed, no toxic

effects on the liver were detected at the administered doses, indicating the relative safety of these natural products in short-term use.

CHAPTER THREE

3.0 METHODOLOGY

3.1 RESEARCH DESIGN

An experimental design was used to assess the effects of graded doses of Cocos nucifera extract on blood pressure and intraocular pressure in normotensive subjects. This design ensured controlled conditions, enabling the isolation of the extract's effects. Participants were randomly assigned to four groups, with three receiving different doses of the extract and one serving as a control. This facilitated dose-response analysis and ensured comparisons against the control group. The approach allowed for systematic observation of physiological changes, providing reliable and reproducible data on the influence of Cocos nucifera extract.

3.2 RESEARCH LOCATION

The study was conducted at the Optometry Clinic of the University of Benin, Benin City. This location was chosen due to its accessibility, availability of necessary equipment, and a controlled clinical environment that ensured accurate data collection. The clinic provided a suitable setting for conducting intraocular pressure and blood pressure measurements under standard operating procedures.

3.3 STUDY POPULATION

The study population consisted of healthy, normotensive individuals aged between 18 and 35 years. This age range was selected to minimize the influence of age-related changes in blood

pressure and intraocular pressure. Participants were recruited from the University of Benin community through voluntary enrollment. Inclusion criteria required participants to have normal intraocular pressure (10-21 mmHg) and no history of systemic hypertension or ocular disease. Pregnant women, individuals on medications affecting blood pressure or intraocular pressure, and those with allergies to Cocos nucifera were excluded to ensure the accuracy and safety of the study.

3.4 SAMPLING TECHNIQUE/SAMPLE SIZE DETERMINATION

3.4.1 SAMPLING TECHNIQUE

A convenience sampling technique was employed for participant recruitment in this study. This non-probability sampling method involved selecting individuals who fulfilled the pre-defined inclusion criteria and were readily accessible at the designated research location, which was the University of Benin community. Convenience sampling was deemed the most appropriate method given the practical constraints of the study, particularly the need to obtain the required sample size within the allocated timeframe and available resources. This method offers the advantage of efficiency and ease of implementation, as it relies on readily available participants, thereby streamlining the recruitment process and minimizing logistical complexities.

3.4.2 SAMPLE SIZE DETERMINATION

Using Fischer Formula

n= Z^2 × P (1-- P)/ d^2

Where n = sample size

Z= Statistical level of confidence of 95% (1.96)

P= maximum reported prevalence of 2.4%

d= confidence interval (margin of error) 5% (d= 0.05)

$n= 1.96^2 \times 0.024 (1- 0.024) / 0.05^2$

n= 0.090/ 0.0025

n= 36

Attrition factor is 10% of n

Which is 3.6~ 4

36+4 = 40

Therefore 40 participants will be used for this study.

3.5 MATERIALS

I. **Keeler non-contact tonometer:** A Keeler non-contact tonometer was employed for the measurement of intraocular pressure (IOP). This instrument uses a puff of air to applanate the cornea, providing a rapid and non-invasive method for IOP assessment. The non-contact nature of this device minimizes the risk of corneal abrasion and eliminates the need for topical anesthesia, enhancing participant comfort.

II. **Umec Sphygmomanometer:** An Umec sphygmomanometer, a manual blood pressure measuring device, was used to determine systolic and diastolic blood pressure. This instrument, consisting of an inflatable cuff, a manometer, and a bulb for inflation, is a standard tool for blood pressure measurement in clinical and research settings.

III. **Littmann Stethoscope:** A Littmann stethoscope, known for its acoustic quality and sensitivity, was used in conjunction with the sphygmomanometer for auscultation of Korotkoff sounds during blood pressure measurement. The stethoscope facilitated accurate identification of systolic and diastolic pressures.

IV. **Keeler Ophthalmoscope:** A Keeler ophthalmoscope was used for ophthalmoscopic examination of the participants' fundi. This instrument allowed for direct visualization of the optic disc, retina, and retinal vessels, enabling the exclusion of participants with pre-existing ocular pathologies.

V. **Body weight scale:** A calibrated body weight scale was used to measure each participant's weight in kilograms. This measurement was essential for calculating the appropriate dosage of *Cocos nucifera* extract, which was administered based on body weight (g/kg).

VI. **Kitchen scale:** A kitchen scale with appropriate precision was used to accurately weigh the *Cocos nucifera* extract to ensure accurate dosage preparation based on each participant's weight.

VII. **Penlight:** A penlight was used for basic examination of the ocular adnexa and anterior chamber angle. This allowed for a preliminary assessment of the external eye structures and the angle between the iris and cornea, helping to identify any gross abnormalities.

VIII. **Coconut water:** Fresh coconut water, serving as the source of the *Cocos nucifera* extract, was collected from young coconuts. The specific preparation methods for the extract are described elsewhere in the methodology.

IX. **Materials for recording data:** Pre-designed data collection forms and a mobile phone was used to document all measurements and observations.

X. **Stopwatch:** A stopwatch was used to accurately time the intervals between measurements, ensuring consistency in the data collection process. Specifically, it was used to time the one-hour intervals between measurements after the administration of the coconut water/extract.

XI. **Measuring/graded cups:** Measuring or graded cups were used to accurately measure the 300ml of water administered to the control group and likely for initial measurement of the coconut water before extract preparation.

XII. **Water:** Distilled or purified water was used as the control intervention, ensuring that the control group received a neutral fluid without any potential physiological effects on IOP or blood pressure.

3.6 INCLUSION/EXCLUSION CRITERIA

3.6.1 INCLUSION CRITERIA

I. Individuals who fell within the age range of 18-35 years.

II. Non hypertensive healthy individuals.

III. Individuals who had normal intraocular pressure, ranging from 11-21mmHg.

IV. Participants who gave consent to participate in this study.

3.6.2 EXCLUSION CRITERIA

I. Hypertensive and glaucomatous patients

II. Individuals who were taking medications that could affect IOP or BP.

III. Pregnant women.

IV. Individuals with known allergies or sensitivities to Cocos nucifera as this could lead to adverse reactions.

3.7 DESCRIPTION OF PROCEDURE

Cocos nucifera extract was collected from the same species of young coconut that has been cleaned and cut open, and served by standard operating procedures that have been made previously to obtain the various respective milliliter of young coconut water required per participants.

The following screening tests were carried out on each participant in order to select subjects that will be used for this study;

- Penlight examination to access the integrity of the ocular adnexa and the anterior chamber angle.
- Ophthalmoscopy to rule out ocular pathology in the fundus of each participant.
- Weight measurements.
- Tonometry for pre and post intraocular pressure measurements.
- Baseline blood pressure was measured using the mercurial sphygmomanometer and stethoscope and recorded.
- Baseline IOP measurement was taken using a non-contact tonometer.

Forty (40) subjects who met the inclusion criteria was selected and divided into four (4) groups, consisting of ten (10) subjects in each group.

Group A received 2.86g/kg body weight of Cocos nucifera extract

Group B received 5.71g/kg body weight of Cocos nucifera extract

Group C received 8.57g/kg body weight of Cocos nucifera extract

Group D received 300 ml of water.

Intraocular pressure and blood pressure readings were measured before and after every (1) hour for four (4) hours.

3.8 DATA ANALYSIS

Data collected during the study were analyzed using the Statistical Package for Social Sciences (SPSS) version 22.0. Descriptive statistics, including mean and standard deviation, were used to summarize baseline characteristics and post-intervention measurements.

Analysis of variance (ANOVA) was performed to compare the differences in intraocular pressure and blood pressure between the experimental and control groups. Post-hoc tests were conducted to determine which specific dose levels showed significant differences.

Graphical presentations such as bar charts and line graphs were utilized to visually represent the trends in intraocular pressure and blood pressure over time. This approach ensured a comprehensive understanding of the extract's effects and facilitated clear interpretation of the results.

3.9 ETHICAL CONSIDERATION

Ethical approval for this study was obtained from the Research and Ethics Committee of the Department of Optometry at the University of Benin. The committee's review ensured that all procedures complied with ethical standards and safeguarded participant welfare throughout the research process.

Informed consent was obtained from each participant prior to their involvement in the study. Participants were thoroughly informed about the study's purpose, procedures, and their rights,

including the right to withdraw from the study at any point without any consequences. This approach respected participants' autonomy and reinforced voluntary participation.

To protect participant anonymity, identifying information, such as names, was not collected, ensuring that all data remained confidential. Additionally, all data gathered were used exclusively for the purposes of this research. The study adhered to the principles of the Helsinki Declaration, maintaining ethical integrity by prioritizing participant welfare, data confidentiality, and transparency throughout the research process.

3.10 LIMITATIONS OF THE STUDY

I. **Sample Size**: The sample size for this study was limited to forty (40) normotensive subjects, which may not be large enough to fully represent the broader population. Although a power calculation was performed to determine an appropriate sample size, a larger cohort could provide more robust findings and enhance the generalizability of the results. Due to time and resource constraints, it was not possible to recruit more participants for the study.

II. **Short Duration of Study**: The study was conducted over a period of one month, with measurements taken only once, after a single administration of Cocos nucifera extract. The limited duration may not capture long-term effects or potential cumulative changes in blood pressure and intraocular pressure. Future studies with longer follow-up periods would be necessary to assess the lasting effects of Cocos nucifera on these parameters.

III. **Potential Bias in Participant Selection**: Convenience sampling was used to select participants, which might have introduced selection bias. Participants were drawn from a specific population at the University of Benin, which may not be representative of the

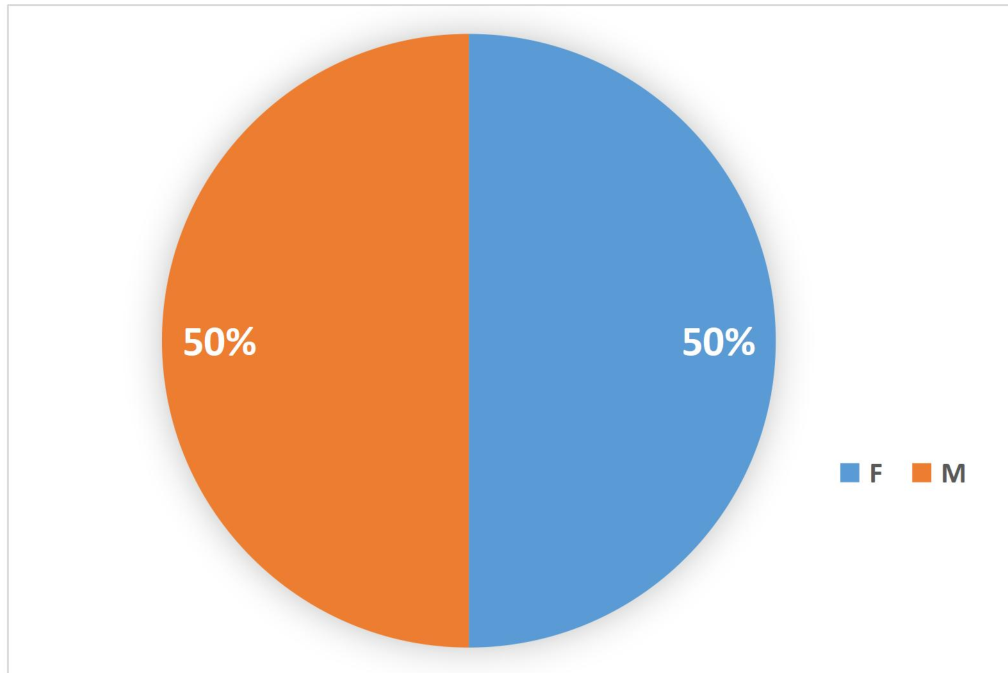
general population. This sampling method limits the ability to generalize the findings to other demographic groups or regions.

IV. **Control Group Limitations**: The control group in this study was administered 300 ml of water, which may not perfectly match the biological or placebo effects of coconut water. The lack of a more appropriate placebo or a broader control intervention could influence the interpretation of the results. Future studies could consider using a placebo that mimics the physical properties of coconut water to reduce potential bias in the control condition.

V. **Variability in Participant Responses**: Given the individual variability in responses to dietary interventions, it is possible that some participants may have experienced different physiological reactions to the coconut water extract based on factors such as underlying health conditions, lifestyle, or genetic predispositions. This variability could impact the consistency of results, making it harder to draw definitive conclusions about the extract's effects.

CHAPTER FOUR

4.0 RESULTS



F: Female; M: Male

Figure 4.1: Gender distribution of participants

In this study, 20 males and 20 females participated in all examinations including the IOP, systolic and diastolic pressure checks (figure 1).

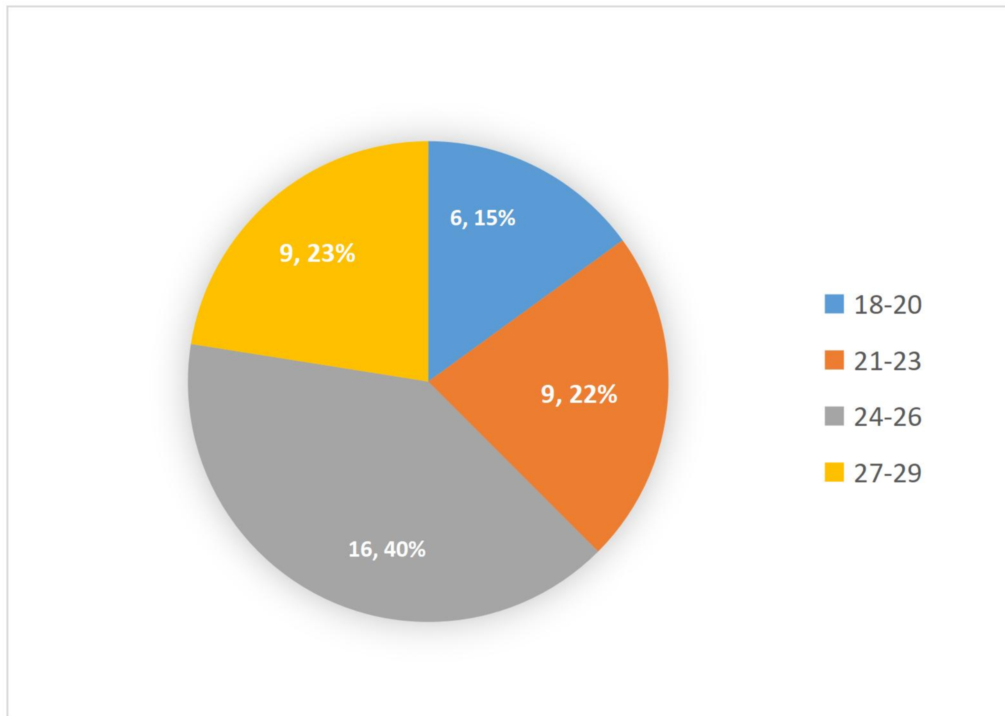


Figure 4.2: Age (years) distribution of the participants

The age group of the participants is represented in Figure 2. The majority (40%) of them were within the 24-26-year bracket, while those within 27-29 and 21-23 have just 9 (nine) participants each. The age group with the least number of participants was those in the range 18-20 years.

Table 4.1: Independent sample T-test comparing the mean *Oculus Dexter* intraocular pressure of the control group to those of Groups A, B and C.

Group of subjects	Mean IOP± SD (mmHg)	p-value
A	14.76 ±2.15	0.001
B	14.82 ± 2.43	0.001
C	14.14 ± 2.71	0.001
D	17.14 ± 2.19	

Subjects in the control group had the highest mean IOP (17.14 ± 2.19mmHg) compared to the groups with *C. nucifera* administration. Multiple T-tests showed significant differences ($p<0.001$) between IOP for each *C. nucifera* administered group and the control group (Table 1). It was observed that Group C, which had the highest dosage of *C. nucifera* [8.57g/Kg] was associated with the lowest mean IOP (14.14± 2.71mmHg) with a mean difference of 3.00± 0.52 mmHg. In contrast, those in Group B had the highest mean IOP (relative to other groups with *C. nucifera* administration.

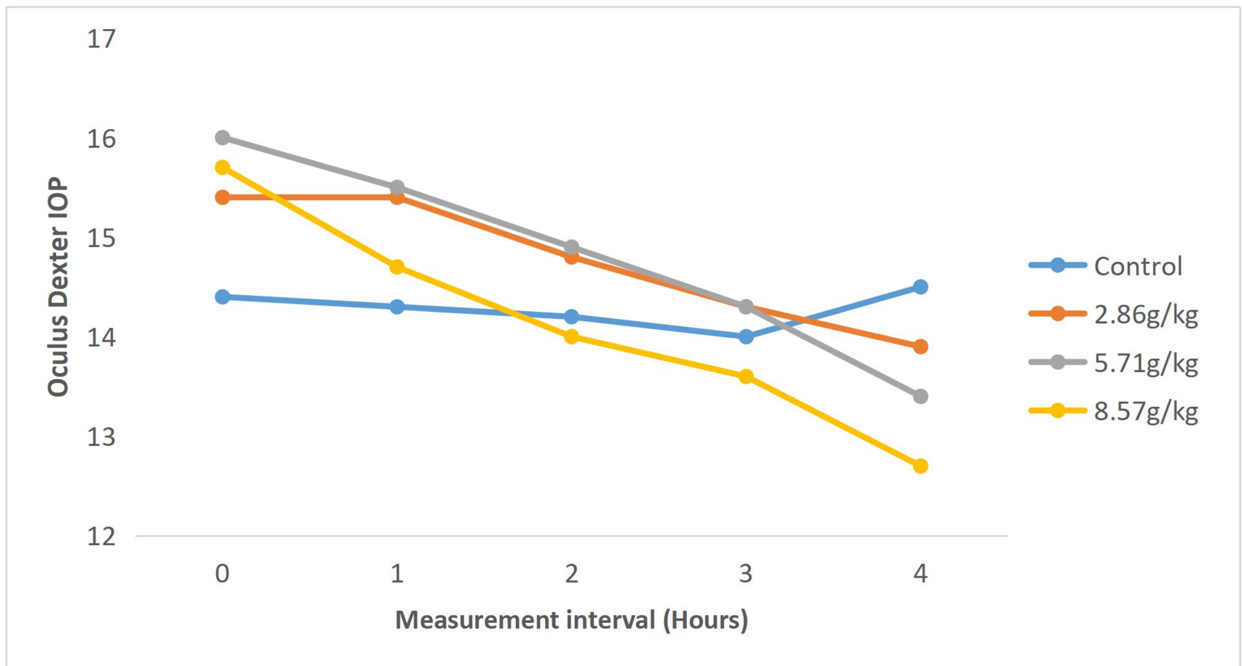


Figure 4.3: Multiple line chart representing temporal changes in mean IOP of all subjects

Multiple line chart representing temporal changes in mean Oculus Dexter Intraocular pressure measurement at hourly intervals beginning from 0 hours (the baseline) to four hours. Different coloured lines indicate *C. nucifera* solution dosage. Groups: D:300ml water; A: 2.86g/Kg; B: 5.71 g/Kg; C: 8.57 g/Kg

Table 4.2: Independent sample T-tests comparing the control group's systolic pressure to those of Groups A, B and C.

Group of subjects	Mean DBP± SD (mmHg)	p-value
A	120.22±10.72	0.01
B	108.50±9.52	0.001
C	117.76±8.58	0.001
D	124.12±4.36	

*** P values and T statistics are a result of statistical comparison with the control group's mean systolic blood pressure*

The mean systolic pressures of participants in this study were highest in the control group (Group D; mean DBP= 124.12±4.36mmHg). Likewise, independent T-tests show that there was a statistically significant difference ($p < 0.01$) in the mean systolic pressure levels between each *C. nucifera* group and the control group (Table 4.2). However, amongst the *C. nucifera* administered group, mean systolic pressure was lowest in Group B and highest in Group A, with a mean difference of 15.62± 5.16 mmHg.

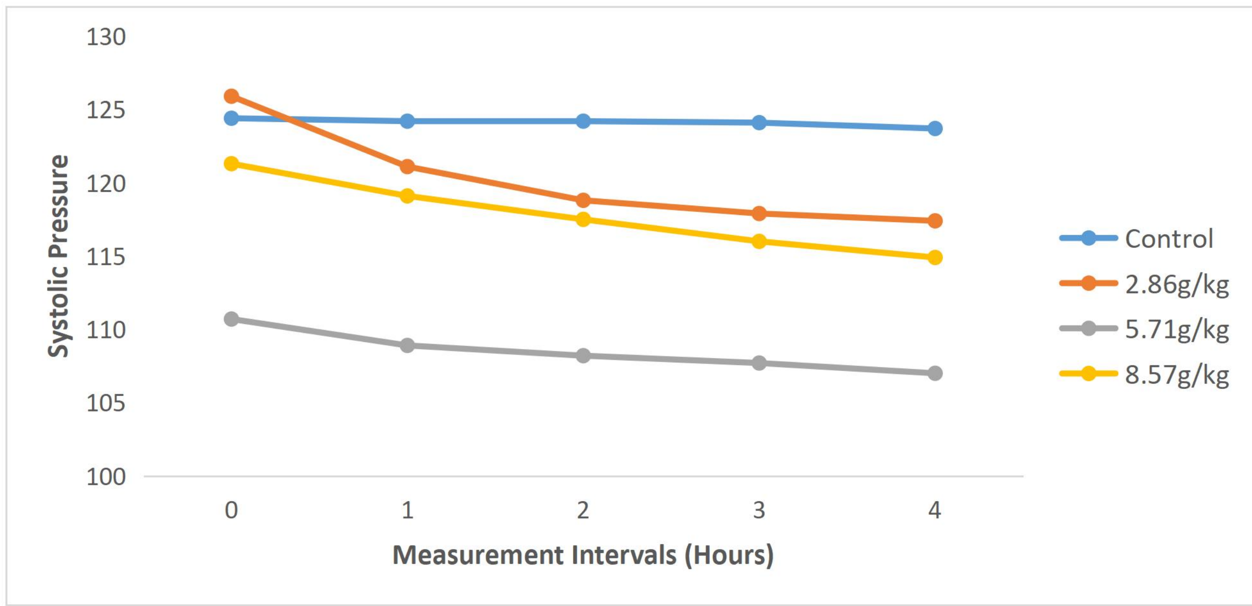


Figure 4.4: Multiple Line Chart Representing Temporal Changes in Systolic Pressure Measurement

Multiple line chart representing temporal changes in systolic pressure measurement at hourly intervals beginning from 0 hours (the baseline) to four hours. Different coloured lines indicate *C. nucifera* solution dosage. Groups: D (Control): 300ml water; A: 2.86g/Kg; B: 5.71 g/Kg; C: 8.57 g/Kg.

Table 4.3: Independent sample T-tests comparing the control group's diastolic pressure to those of Groups A, B and C.

Group of subjects	Mean ± SD (mmHg)	p-value
A	83.26±8.196	>0.05
B	78.88±7.116	<0.001
C	83.52±8.811	>0.05
D	85.22±6.75	

The mean diastolic pressures of participants in this study were highest in the control group (Group D; mean: 85.22±6.75 mmHg). Unlike for measures of systolic and IOP levels, only group B showed a significant difference (p<0.001) when compared to the control group (Table 3). This group had the lowest mean diastolic pressure, followed by Group C and Group A which had a mean diastolic pressure of 83.52±8.811mmHg and 83.26±8.196 mmHg, respectively.

Over time, there was an overall reduction in the mean diastolic pressure levels among the participants (Figure 5). However, relatively constant diastolic pressure was seen in the control group, while major regressions of diastolic pressure were seen in all *C. nucifera*-administered groups. An unusual spike in the systolic pressure was seen 1 hour after *C. nucifera* administration in Group A, however, this drops continuously over time. Relative to the baseline, this group had elevated systolic pressure levels.

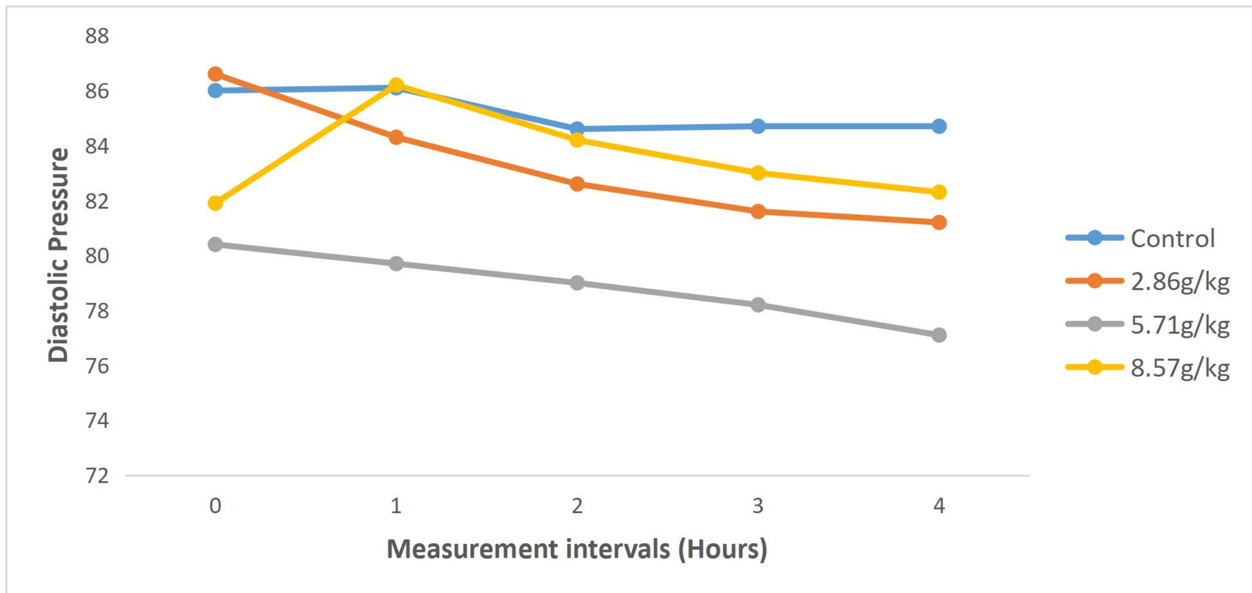


Figure 4.5: Multiple line chart representing temporal changes in diastolic pressure measurement

Multiple line chart representing temporal changes in diastolic pressure measurement at hourly intervals beginning from 0 hours (the baseline) to four hours. Different coloured lines indicate *C. nucifera* solution dosage. Groups: D (Control):300ml water; A: 2.86g/Kg; B: 5.71 g/Kg; C: 8.57 g/Kg.

Table 4.4: Anova summaries of comparisons of OD IOP, Systolic and diastolic blood pressure across the different *C. nucifera* dosed groups

Variables	df	F statistics	Sig.
OD IOP across different dosed groups	2	1.188	0.308
Diastolic blood pressure across different dosed groups	2	5.216	0.006
Systolic blood pressure across different dosed groups	2	20.508	<0.001

The differences in systolic blood pressure between groups were statistically significant (F= 20.51; p<0.001). Here, the mean systolic blood pressure was lowest in the group administered a 5.71g/Kg dose, followed by the 8.57g/Kg and 2.87g/Kg dosed group which had means of 117.76±8.58 and 120.22±10.72, respectively.

CHAPTER FIVE

5.0 DISCUSSION

This study sought to investigate the effects of graded doses of *Cocos nucifera* extract on intraocular pressure (IOP) and blood pressure in normotensive subjects. The findings provide valuable insights into the potential pharmacological and physiological properties of *Cocos nucifera* extract, particularly its effects on IOP and BP. The data revealed notable variations in the intraocular pressure and blood pressure readings across different dosage groups, highlighting dose-dependent trends in some instances and significant differences when compared to the control group.

The effect of *Cocos nucifera* extract on intraocular pressure (IOP) is one of the central findings of this study. Subjects in the control group consistently exhibited the highest mean intraocular pressure, with a mean value of 17.14 ± 2.19 mmHg. Conversely, subjects administered *Cocos nucifera* extract showed a reduction in IOP, with Group C, which received the highest dose (8.57 g/kg), demonstrating the lowest mean IOP at 14.14 ± 2.71 mmHg. This outcome suggests a clear IOP-lowering effect of *Cocos nucifera*, which is statistically significant across all dosage groups ($p < 0.001$). The significant differences between the control and experimental groups indicate that *Cocos nucifera* extract has active components capable of influencing ocular physiology. Interestingly, the dose-dependent relationship observed in this study, as evidenced by the progressive reduction in IOP with increasing doses, reinforces the hypothesis that higher concentrations of *Cocos nucifera* extract exert stronger effects. This finding aligns with previous studies that suggest natural plant-based substances can have hypotensive effects on ocular tissues, potentially by modulating aqueous humor dynamics or influencing vascular tone within the eye.

The implications of this IOP-lowering effect are noteworthy, particularly in the context of ocular hypertension and glaucoma management. Elevated intraocular pressure is a major risk factor for the development and progression of glaucoma, a leading cause of irreversible blindness globally. If further studies validate the efficacy and safety of *Cocos nucifera* extract, it could serve as a cost-effective, natural alternative or adjunctive therapy for lowering IOP. However, the exact mechanism of action remains unclear.

The significant reduction in IOP observed in our study aligns closely with the findings of Poblete *et al*., (1998), who reported that coconut water consumption temporarily lowered IOP in normotensive individuals. In our study, the control group exhibited the highest mean IOP (17.14 ± 2.19 mmHg), whereas the highest dose group (8.57 g/kg) demonstrated the lowest mean IOP (14.14 ± 2.71 mmHg). This dose-dependent reduction underscores a potential pharmacological role of *Cocos nucifera* in modulating ocular pressure, a conclusion consistent with Poblete *et al*.'(1998) s findings. However, our study expands on the earlier research by demonstrating a sustained effect over four hours, suggesting that graded doses of *Cocos nucifera* extract may have prolonged physiological effects.

While Poblete *et al*., (1998) emphasized the short-term utility of coconut water as a non-pharmacological option for reducing IOP, our findings suggest that the extract's impact may be more dose-sensitive and long-lasting. This distinction raises important questions about the bioactive components responsible for these effects. Poblete *et al*., (1998) did not isolate specific compounds or mechanisms, while our findings hypothesize that electrolytes, antioxidants, and phytochemicals in *Cocos nucifera* may play a role. The consistency of IOP reductions across all experimental groups further supports the notion of a biologically active component in the extract, potentially interacting with the trabecular meshwork or ciliary body to enhance aqueous humor

outflow or reduce production. Future studies could build on these insights by isolating these compounds and exploring their specific ocular effects.

Regarding systemic blood pressure, the findings reveal an intriguing pattern in the diastolic and systolic pressure measurements among the groups. Subjects in the control group consistently exhibited the highest mean systolic pressure (124.12 mmHg), while those in Group B, receiving 5.71 g/kg of *Cocos nucifera* extract, had the lowest mean systolic pressure (108.5 mmHg). Similarly, diastolic blood pressure (DBP) was significantly lower in the *Cocos nucifera*-treated groups compared to the control group, with a notable reduction in Group B. These results highlight the hypotensive effects of *Cocos nucifera* extract on systemic blood pressure. The dose-response relationship, however, appears less linear for systemic blood pressure compared to IOP, as Group A (2.86 g/kg) exhibited slightly higher mean systolic pressure compared to Group C (8.57 g/kg). This non-linear trend might indicate a threshold or optimal dose at which the hypotensive effects of *Cocos nucifera* extract are maximized.

The mechanism underlying the hypotensive effects of *Cocos nucifera* extract may involve multiple pathways. One plausible explanation is the presence of potassium and magnesium ions in coconut water, which are known to promote vasodilation by relaxing vascular smooth muscles. Additionally, the antioxidant properties of *Cocos nucifera* may reduce oxidative stress, which is implicated in endothelial dysfunction and hypertension. Moreover, the diuretic effects of coconut water, which facilitate the excretion of sodium and water, could contribute to the observed reduction in blood pressure. These findings align with prior research emphasizing the role of coconut water in cardiovascular health, particularly its ability to lower blood pressure in hypertensive subjects. However, the current study's focus on normotensive individuals

underscores the extract’s potential broader applications, suggesting that it may also aid in maintaining healthy blood pressure levels in non-hypertensive populations.

The findings on blood pressure reduction in our study also echo earlier research. Alleyne *et al*. (2005) demonstrated that coconut water could lower blood pressure due to its high potassium, magnesium, and calcium content, which promote vasodilation and diuresis. In our study, both diastolic and systolic blood pressures were significantly lower in the *Cocos nucifera*-treated groups compared to the control. Interestingly, Group B (5.71 g/kg) exhibited the lowest mean systolic pressure (108.5 mmHg), while the highest dose group (Group C, 8.57 g/kg) showed a less pronounced reduction. This non-linear trend deviates slightly from the dose-dependent effects observed in IOP, suggesting that the systemic hypotensive effects of *Cocos nucifera* extract may plateau or even diminish beyond an optimal dose.

These findings align with Alleyne *et al*., (2005) suggestion that the blood pressure-lowering effects of coconut water are mediated by its electrolyte composition. However, our study's focus on normotensive individuals highlights a broader potential application for maintaining cardiovascular health, rather than exclusively managing hypertension. The diuretic effects reported in prior studies are consistent with our observations, supporting the hypothesis that *Cocos nucifera* extract facilitates sodium and water excretion, thereby reducing blood pressure. However, the mechanisms underlying the non-linear dose-response relationship observed in our study warrant further exploration.

Temporal changes in both IOP and blood pressure provide further insights into the dynamics of *Cocos nucifera* extract’s effects. The multiple-line charts representing IOP and blood pressure changes over time reveal consistent reductions across the four-hour observation period. This sustained effect underscores the potential of *Cocos nucifera* extract to produce prolonged

physiological responses rather than transient changes. Such durability is crucial for therapeutic applications, as it indicates that the extract's bioactive compounds may have sufficient bioavailability and metabolic stability to exert long-lasting effects. Furthermore, the temporal data suggest that the onset of action occurs relatively quickly, with significant reductions observed within the first hour of administration. This rapid onset highlights the extract's potential for acute interventions, such as in situations requiring immediate IOP or blood pressure control.

It is worth noting the gender and age distribution of participants, which may influence the generalizability of these findings. The study achieved an equal gender distribution (20 males and 20 females), allowing for a balanced analysis of the extract's effects across sexes. Additionally, the majority of participants fell within the 24–26-year age bracket, representing a young adult population. While this demographic consistency enhances internal validity, it also limits the applicability of findings to older or pediatric populations, where physiological responses to *Cocos nucifera* extract may differ. Future studies should aim to include a broader age range to determine whether these effects are universal or age specific.

The statistical analyses employed in this study, including independent sample t-tests, provide robust evidence for the significant differences observed between groups. The low p-values (<0.001) reported for both IOP and blood pressure comparisons highlight the strong likelihood that the observed effects are not due to chance. These findings lend credibility to the hypothesis that *Cocos nucifera* extract exerts measurable physiological effects on ocular and systemic parameters. However, while the statistical significance is compelling, the clinical significance of these findings must also be considered. For instance, the reduction in mean IOP, though

statistically significant, may require further validation to assess whether it meets clinically relevant thresholds for therapeutic efficacy in glaucoma patients.

While our findings align with those of Poblete *et al*. and Alleyne *et al*., variations in study design and methodology must be considered. Poblete *et al*. focused on the short-term effects of coconut water ingestion, while our study examined graded doses of *Cocos nucifera* extract, providing a broader understanding of dose-response relationships. Additionally, the sample sizes in prior studies were smaller, limiting the statistical power and generalizability of their findings. Our sample size (n=40) enhances the reliability of the observed effects but remains relatively small for drawing definitive conclusions.

Despite the promising findings, certain limitations must be acknowledged. The study's sample size, though sufficient for preliminary analysis, remains relatively small (n=40). A larger sample size would enhance the power of statistical analyses and provide greater confidence in the generalizability of the results. Additionally, the study did not account for potential confounding factors such as dietary habits, hydration status, or physical activity levels, which could influence blood pressure and IOP. The absence of these controls may introduce variability into the data, potentially masking or exaggerating the true effects of *Cocos nucifera* extract.

Furthermore, the study's reliance on a single species and preparation of *Cocos nucifera* extract may limit its applicability to other varieties or formulations of coconut water. Differences in nutrient composition across coconut species or variations in preparation methods could influence the extract's efficacy. Future research should investigate whether similar effects are observed with other coconut varieties or commercially available coconut water products. Additionally, the bioactive components responsible for the observed effects remain unidentified. Isolating and

characterizing these compounds would provide critical insights into the mechanisms of action and facilitate the development of standardized therapeutic formulations.

In conclusion, this study demonstrates that graded doses of *Cocos nucifera* extract significantly reduce both intraocular pressure and systemic blood pressure in normotensive subjects, with evidence of dose-dependent effects on IOP. These findings highlight the potential of *Cocos nucifera* extract as a natural therapeutic agent for managing ocular hypertension and blood pressure. However, the non-linear dose-response relationship for systemic blood pressure and the lack of mechanistic insights underscore the need for further research. Larger-scale studies, including diverse populations and detailed biochemical analyses, are essential to validate these findings and elucidate the underlying mechanisms. Despite these limitations, the results provide a compelling basis for exploring the broader applications of *Cocos nucifera* extract in ocular and cardiovascular health.

CHAPTER SIX

6.0 CONCLUSION

In conclusion, this study provides valuable insights into the physiological effects of graded doses of *Cocos nucifera* extract on intraocular pressure (IOP) and systemic blood pressure in normotensive individuals. The findings demonstrate that *Cocos nucifera* extract has a significant IOP-lowering effect, with a clear dose-dependent trend observed across the experimental groups. The highest dose of *Cocos nucifera* extract (8.57 g/kg) resulted in the lowest mean IOP, highlighting its potential as a natural therapeutic agent for ocular hypertension and glaucoma management. Similarly, the extract exhibited a hypotensive effect on systemic blood pressure, reducing both systolic and diastolic pressures, though the relationship appeared less linear than with IOP.

This study shows the potential of *C. nucifera* extract in managing ocular and cardiovascular health, however, the exact mechanisms of action remain unclear and warrant further investigation. Future research should involve larger, more diverse populations and focus on isolating and characterizing the bioactive compounds responsible for the observed effects.

6.1 RECOMMENDATION

Based on the findings of this study, the following recommendations are proposed:

I. **Further Research on Mechanisms of Action:** Future studies should aim to identify and characterize the specific bioactive compounds in *Cocos nucifera* extract responsible for its IOP-lowering and hypotensive effects. Understanding these mechanisms will facilitate the development of standardized formulations for therapeutic use.

II. **Broader Population Studies:** Research involving larger and more diverse populations, including older adults, children, and individuals with pre-existing ocular or systemic conditions, should be conducted to determine the broader applicability and safety of *Cocos nucifera* extract.

III. **Dose Optimization Studies:** Investigations should explore the optimal dosage range of *Cocos nucifera* extract to maximize its therapeutic benefits while minimizing potential side effects.

IV. **Clinical Trials for Glaucoma and Hypertension Management:** Clinical trials assessing the efficacy of *Cocos nucifera* extract in patients with glaucoma and hypertension should be prioritized to evaluate its potential as a natural adjunct or alternative therapy.

V. **Development of Formulations:** Efforts should be made to develop standardized, easily administrable formulations of *Cocos nucifera* extract, such as capsules or eye drops, for targeted therapeutic use.

VI. **Public Awareness and Education:** Healthcare practitioners and the general public should be educated on the potential health benefits of *Cocos nucifera*, particularly its use in managing ocular and systemic conditions.

REFERENCES

Alleyne, T., Roache, S., Thomas, C., & Shirley, A. (2005). The control of hypertension by use of coconut water and mauby: Two tropical food drinks. *West Indian Medical Journal*, 54(1): 3–8.

Arvidsson, P. M., & Kovács, S. J. (2022). Systolic–diastolic coupling. In *Textbook of Arterial Stiffness and Pulsatile Hemodynamics in Health and Disease*. 227-240.

Boehme, A. K., Esenwa, C., & Elkind, M. S. (2017). Stroke risk factors, genetics, and prevention. *Circulation research*, *120*(3): 472-495.

Chen, Z., Zhu, L. T., & Luo, Z. H. (2023). Characterizing Flow and Transport in Biological Vascular Systems: A Review from Physiological and Chemical Engineering Perspectives. *Industrial & Engineering Chemistry Research*, *63*(1): 4-36.

Ct, D. R., Palaninathan, V., & James, R. A. (2023). Anti-uropathogenic, antioxidant and struvite crystallization inhibitory potential of fresh and fermented coconut water. *Biocatalysis and Agricultural Biotechnology*, *47*, 102555.

Dada, T., Verma, S., Gagrani, M., Bhartiya, S., Chauhan, N., Satpute, K., & Sharma, N. (2022). Ocular and systemic factors associated with glaucoma. *Journal of Current Glaucoma Practice*, *16*(3): 179-180.

Fadlilah, S., & Sucipto, A. (2021). The Effectiveness of Young Coconut Water and Watermelon Juice in Reducing Blood Pressure. *Pakistan J Med Heal Sci*, *15*(5), 1313-1322.

Faozi, E., Fadlilah, S., Syukur, B. A., & Susanto, R. (2022). EFFECTIVENESS OF COCONUT WATER CONSUMPTION ON BLOOD PRESSURE. *Jurnal Keperawatan Respati Yogyakarta*, *9*(1), 44-50.

Farapti, Sayogo, S., & Siregar, P. (2017). Plasma potassium levels in healthy prehypertension subjects and the role of a high potassium drink. *Current Hypertension Reviews*, *13*(1), 65-70.

Farrah, T. E., Dhillon, B., Keane, P. A., Webb, D. J., & Dhaun, N. (2020). The eye, the kidney, and cardiovascular disease: old concepts, better tools, and new horizons. *Kidney international*, *98*(2): 323-342.

Freddo, T. F., Civan, M., & Gong, H. (2022). Aqueous humor and the dynamics of its flow: mechanisms and routes of aqueous humor drainage. In *Albert and Jakobiec's Principles and Practice of Ophthalmology*. 1989-2033.

HS, G., Tekade, A. P., & Gullapalli, N. H. (2013). Effect of supplementation of tender coconut water on blood pressure of primary hypertensive subjects. *International Journal of Medical Research & Health Sciences*, *2*(2), 172-176.

Kelly, D. J., & Farrell, S. M. (2018). Physiology and role of intraocular pressure in contemporary anesthesia. *Anesthesia & Analgesia*, *126*(5): 1551-1562.

Kim, J. H. (2022). Heart and circulatory system. In *Recent Advancements in Microbial Diversity*. 229-254.

Kumar, R., Dubey, P. K., Zafer, A., Kumar, A., & Yadav, S. (2021). Past, present and future of blood pressure measuring instruments and their calibration. *Measurement*, *172*, 108-145.

Lacković, I. (2023). Inspection and Testing of Noninvasive Blood Pressure Measuring Devices. In *Inspection of Medical Devices: For Regulatory Purposes*. 173-211.

Mark, H. H. (2020). 13. Aqueous Humor Dynamics. *The History of Glaucoma*, 15-18.

Mohammed, A., & Luka, C. D. (2013). Effect of coconut oil, coconut water and palm kernel oil on some biochemical parameters in albino rats.

Poblete, G., Aquino, M., & Arroyo, M. (1998, December 31). *The effect of coconut water on intraocular pressure of normal subjects.* HERDIN. https://www.herdin.ph/index.php/herdin-journals?view=research&cid=32317

Pummer, S., Heil, P., Maleck, W., & Petroianu, G. (2001). Influence of coconut water on hemostasis. *The American journal of emergency medicine*, *19*(4), 287-289.

Richter, M. J., Hsu, S., Yogeswaran, A., Husain-Syed, F., Vadász, I., Ghofrani, H. A., & Tello, K. (2021). Right ventricular pressure-volume loop shape and systolic pressure change in pulmonary hypertension. *American Journal of Physiology-Lung Cellular and Molecular Physiology*, *320*(5): 715-725.

Rodrigues, S. L., Baldo, M. P., Machado, R. C., Forechi, L., Molina, M. D. C. B., & Mill, J. G. (2014). High potassium intake blunts the effect of elevated sodium intake on blood pressure levels. *Journal of the American Society of Hypertension*, *8*(4), 232-238.

Saghiv, M. S., Sagiv, M. S., Saghiv, M. S., & Sagiv, M. S. (2020). Blood Pressure. *Basic Exercise Physiology: Clinical and Laboratory Perspectives*, 251-284.

Schutte, A. E., Kollias, A., & Stergiou, G. S. (2022). Blood pressure and its variability: classic and novel measurement techniques. *Nature Reviews Cardiology*, *19*(10): 643-654.

Stamer, W. D., & Ethier, C. R. (2022). Cellular Mechanisms Regulating Conventional Outflow of Aqueous Humor. In *Albert and Jakobiec's Principles and Practice of Ophthalmology*. 2035-2062.

Syafriani, R., Sukandar, E. Y., Apriantono, T., & Sigit, J. I. (2014). The effect of coconut water (Cocos nucifera L.) and an isotonic drink on the change of heart rate frequency in the rats induced hypertension. *Procedia Chemistry*, *13*, 177-180.

Tuyekar, S. N., Tawade, B. S., Singh, K. S., Wagh, V. S., Vidhate, P. K., Yevale, R. P., ... & Kale, M. (2021). An overview on coconut water: As a multipurpose nutrition. *Int. J. Pharm. Sci. Rev. Res*, *68*(2), 63-70.

Yong, J. W., Ge, L., Ng, Y. F., & Tan, S. N. (2009). The chemical composition and biological properties of coconut (Cocos nucifera L.) water. *Molecules*, *14*(12), 5144-5164.

Zhang, D., Wang, L., Jin, L., Wen, Y., Zhang, X., Zhang, L. & Shen, Y. (2022). A review of intraocular pressure (IOP) and axial myopia. *Journal of Ophthalmology*, *2022*(1): 56-64.

APPENDIX

S/N	Group	Dosage	Sex	Age	WEIGHT	GRADED DOSES	Baseline iOP	IOP after 1 Hr	IOP after 2hr	IOP after 3hr	IOP after 4Hr	Baseline BP	BP after 1 Hr	BP after 2Hr	BP after 3Hr	BP after 4Hr
1	A	2.86 g/kg	M	22	72	205.92	OD: 13, OS: 15	OD:13, OS:14	OD:13, OS:13	OD :12, OS: 12	OD:12, OS:12	139/86	126/85	121/82	120/80	120/80
2	A	2.86 g/kg	F	20	53.35	15258	OD: 17, OS: 18	OD:17, OS:15	OD:14, OS:13	OD :13: OS: 13	OD:13, OS:14	110/76	95/68	97/68	97/68	97/68
3	A	2.86 g/kg	M	21	65.97	188.67	OD: 14, OS: 14	OD:14, OS:14	OD: 13, OS:13	OD :13: OS: 13	OD:12, OS:13	126/101	123/94	118/90	119/86	120/86
4	A	2.86 g/kg	F	19	64.55	184.61	OD: 18, OS: 16	OD:18, OS:16	OD:17, OS:15	OD :17, OS: 16	OD:16, OS: 15	127/100	126/99	120/95	120/96	120/94
5	A	2.86 g/kg	M	24	54.95	157.16	OD: 16, OS: 18	OD:16, OD:17	OD: 16, OS:15	OD :16, OS: 15	OD: 16, OS:15	123/83	119/80	118/81	118/80	116/80
6	A	2.86 g/kg	M	20	80.2	229.37	OD: 16, OS: 17	OD:16, OS:17	OD:16, OS:17	OD :15, OS: 16	OD:15, OS:15	120/90	120/90	116/88	116/87	115/86
7	A	2.86 g/kg	F	25	64.11	183.35	OD: 17, OS: 18	OD:17, OS:16	OD:17, OS:15	OD :17, OS: 16	OD:16, OS: 15	129/78	124/80	124/78	125/78	123/77
8	A	2.86 g/kg	M	20	54.9	157.01	OD: 14, OS: 14	OD:14, OS:14	OD:13, OS:13	OD :12, OS: 12	OD:12, OS:12	135/90	134/90	130/87	129/88	129/87
9	A	2.86 g/kg	F	20	50.35	144	OD: 18, OS: 16	OD:17, OS:15	OD:17, OS:15	OD :17, OS: 16	OD:16, OS:16	140/85	135/82	135/82	130/80	130/80
10	A	2.86 g/kg	M	21	60.89	174.15	OD: 11, OS: 13	OD:12, OS:13	OD:12, OS:12	OD :11, OS: 13	OD:11, OS:12	110/77	109/75	109/75	105/73	104/74
1	B	5.71 g/kg	F	25	77.3	441.38	OD: 19, OS: 18	OD:18, OS:18	OD:17, OS:17	OD : 16, OS: 17	OD:15, OS:16	118/74	118/72	120/72	118/72	118/70
2	B	5.71 g/kg	F	23	76	443.96	OD: 17, OS: 17	OD:17, OS:17	OD:15, OS: 16	OD :14, OS: 16	OD:14, OS:14	118/80	118/80	118/78	118/80	116/80

3	B	5.71 g/kg	M	20	89.28	509.79	OD: 12, OS: 13	OD:11, OS:13	OD:11, OS:12	OD :11, OS: 12	OD:10, OS:10	114/82	112/82	112/81	112/79	110/76
4	B	5.71 g/kg	F	25	66.15	377.72	OD: 18, OS: 18	OD:18, OS:17	OD:17, OS:17	OD :16, OS: 16	OD:16, OS:15	110/81	110/78	108/80	107/78	106/75
5	B	5.71 g/kg	M	26	81.8	467.08	OD: 14, OS: 16	OD:14, OS:15	OD:14, OS:14	OD :13, OS: 13	OD:12, OS:13	99/72	98/72	98/73	97/71	97/70
6	B	5.71 g/kg	M	24	80.04	457.03	OD: 18, OS: 17	OD:17, OS:17	OD:16, OS:14	OD :15, OS: 15	OD:15, OS:15	130/100	122/99	123/97	123/97	123/96
7	B	5.71 g/kg	F	21	68.14	389.08	OD: 17, OS: 17	OD:17, OS:16	OD:17, OS:15	OD :17, OS: 16	OD:16, OS: 15	110/78	108/79	105/78	104/78	104/78
8	B	5.71 g/kg	M	28	99.45	567.86	OD: 13, OS: 15	OD:13, OS:14	OD:13, OS:14	OD :12, OS: 12	OD:11, OS:12	109/77	108/76	108/76	108/75	107/75
9	B	5.71 g/kg	M	27	79.5	453.95	OD: 14, OS: 14	OD:13, OS:12	OD:12, OS:12	OD :12, OS: 12	OD:11, OS:12	100/80	100/80	95/79	95/76	95/76
10	B	5.71 g/kg	F	28	68.08	388.74	OD: 18, OS: 16	OD:17, OS:16	OD:17, OS:15	OD :17, OS: 16	OD:14, OS:14	99/80	95/79	95/76	95/76	94/75

1	C	8.57 g/kg	F	25	62.7	537.34	OD: 11, OS: 10	OD:11, OS:10	OD:10, OS:09	OD : 10, OS: 09	OD:10, OS:10	112/74	111/70	110/70	110/68	110/70
2	C	8.57 g/kg	F	28	70	599.9	OD: 20, OS: 18	OD:18, OS:17	OD:17, OS:15	OD :15, OS: 14	OD:14, OS:14	124/90	124/86	124/84	122/84	120/82
3	C	8.57 g/kg	M	28	100	857	OD: 13, OS: 13	OD:12, OS:13	OD:11, OS:13	OD :11, OS: 12	OD:11, OS:12	128/80	124/82	120/80	120/78	118/78
4	C	8.57 g/kg	F	24	94.24	807.64	OD: 16, OS: 18	OD:16, OD:17	OD: 16, OS:15	OD :15, OS: 15	OD: 13, OS:14	120/89	130/90	120/88	120/87	119/85
5	C	8.57 g/kg	M	21	50.1	429.36	OD: 17, OS: 18	OD:16, OS:17	OD:16, OS:16	OD :16, OS: 16	OD:15, OS:14	110/75	105/81	104/78	102/75	102/75
6	C	8.57 g/kg	F	28	82.03	703	OD: 12, OS: 13	OD:11, OS:10	OD:10, OS:10	OD :10, OS: 10	OD:10, OS:10	110/77	107/99	107/95	106/95	105/94
7	C	8.57 g/kg	M	25	51.35	440.07	OD: 19,	OD:16, OS:17	OD:15, OS:16	OD :15,	OD:14, OS:15	120/87	128/102	128/100	125/98	123/97

							OS: 17			OS: 15						
8	C	8.57 g/kg	M	26	99.25	850.57	OD: 15, OS: 15	OD:13, OS:14	OD:14, OS:14	OD :13, OS: 14	OD:13, OS:12	125/79	118/76	116/72	110/70	108/69
9	C	8.57 g/kg	F	24	84.49	724.08	OD: 18, OS: 20	OD:19, OS:19	OD:17, OS17	OD :17, OS: 16	OD:15, OS:14	135/87	124/86	130/87	129/88	129/87
10	C	8.57 g/kg	M	21	60.02	514.37	OD: 16, OS: 17	OD:15, OS:16	OD:14, OS:14	OD :14, OS: 13	OD:12, OS:12	129/81	120/90	116/88	116/87	115/86

1	D	300 ml	F	22	300 ml	0.3	OD: 11, OS: 11	OD:11, OS:11	OD:11, OS:11	OD :10, OS: 11	OD:11, OS:12	115/75	117/75	117/75	118/78	118/78
2	D	300 ml	M	25	300 ml	0.3	OD: 14, OS: 14	OD:14, OS:13	OD:14, OS:14	OD :13: OS: 13	OD:14: OS:14	130/98	130/98	128/85	128/85	128/85
3	D	300 ml	F	26	300 ml	0.3	OD: 14, OS: 13	OD:13, OS:13	OD:13, OS:13	OD :13, OS: 13	OD:13, OS:13	127/95	126/94	125/94	124/96	124/95
4	D	300 ml	M	26	300 ml	0.3	OD: 16, OS: 15	OD:16, OS:14	OD:15, OS:15	OD :15, OS: 15	OD:16, OS:16	133/83	130/84	130/83	129/82	129/82
5	D	300 ml	F	27	300 ml	0.3	OD: 14, OS: 15	OD:14, OS:15	OD:14, OS:14	OD :13, OS: 13	OD:13, OS:13	120/90	121/91	122/90	120/90	119/91
6	D	300 ml	F	25	300 ml	0.3	OD: 16, OS: 16	OD:16, OS:17	OD:15, OS:17	OD :16, OS: 16	OD:16, OS:17	129/78	128/78	128/77	128/77	128/77
7	D	300 ml	F	28	300 ml	0.3	OD: 14, OS: 16	OD:15, OS:17	OD:14, OS:15	OD :14, OS: 16	OD:14: OS:16	124/92	122/90	122/90	122/91	122/91
8	D	300 ml	M	29	300 ml	0.3	OD: 17, OS: 18	OD:16, OS:17	OD:18, OS:16	OD :18, OS: 16	OD:18, OS:17	128/80	126/80	127/80	127/80	126/79
9	D	300 ml	F	24	300 ml	0.3	OD: 14, OS: 15	OD:13, OS:13	OD:13, OS:12	OD :12, OS: 13	OD:14, OS:13	120/89	122/90	123/91	125/90	124/89
10	D	300 ml	M	21	300 ml	0.3	OD: 14, OS: 12	OD:15, OS:14	OD:15, OS:15	OD :16, OS: 14	OD:16, OS:14	118/80	120/81	120/81	120/78	119/80