CONSUMPTION PATTERNS OF ENERGY DRINKS AT LORRY STATIONS IN ACCRA AND CONCENTRATION OF THEIR MAIN CONSTITUENTS

THIS THESIS IS SUBMITTED TO THE DEPARTMENT OF NUTRITION AND FOOD SCIENCE, UNIVERSITY OF GHANA, LEGON

BY

NANA YANKSON CHRIS OSCAR

(ID: 10701373)

IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE AWARD OF A MASTER OF PHILOSOPHY DEGREE IN FOOD SCIENCE

AUGUST, 2022

DECLARATION

This is to certify that this thesis is the result of research undertaken by Nana Yankson Chris Oscar towards the award of the MPhil Food Science Degree in the Department of Nutrition and Food Science, University of Ghana, under the supervision of Prof. Firibu K. Saalia and Dr. Joycelyn K. Quansah, both of the Department of Nutrition and Food Science. All references cited have been duly acknowledged.

.....

Nana Yankson Chris Oscar

(STUDENT)

.....

Prof. Firibu K. Saalia

(PRINCIPAL SUPERVISOR)

.....

Dr. Joycelyn K. Quansah

(CO-SUPERVISOR)

ABSTRACT

Energy drinks are beverages that are rich in caffeine and sugars and contain other constituents. Energy drink consumption has become popular in Ghana in the last five years, and are mostly retailed at lorry stations in Accra. In spite of this, there is little information on the consumption patterns or reasons for consumption among consumers. There is also poor data on the concentrations of the main constituents (sugar and caffeine) of energy drinks in Ghana. Therefore, the objective of the study was to determine the consumption patterns of energy drinks at lorry stations in Accra, and the concentrations of the main constituents of energy drink.

This was a combined cross sectional survey done at three lorry stations in Accra and laboratory analysis of main constituents (sugar and caffeine) of energy drink samples. The energy drinks that were analyzed were; Local (Rush, Storm, Run, BigBoss and 5Star energy drink) and imported (Red Bull, Xploza, Bullet, Lucozade). A total of 360 participants were surveyed in the study.

Most of the participants (78.3 %) were consumers of energy drink and males were dominant. The dominant age for the consumers was (21-30 years, 39.4 %), with JHS (33 %) and SHS (30.5 %) being the dominant level of education. Commercial drivers (25.5 %) and traders (25.2 %) were the top occupations amongst the consumers. Most of the consumers drank 1-2 bottles of energy drinks in a week (29.7%), and the energy drinks were mostly drunk in the afternoons (55.3 %). The foreign energy drinks had higher caffeine concentrations than the local ones. The caffeine concentrations of imported energy drinks were above 300mg/L except for Lucozade that was below 150 mg/L whereas the local energy drinks were below 300 mg/L except Rush, which was above 320

mg/L. The sugar concentrations of the energy drinks were within similar ranges; majority of them were above 100 g/L and less than 120 g/L. The sugar concentrations of the energy drinks were within similar ranges; majority of them were above 100 g/L and less than 120 g/L. The local energy drinks were mostly consumed by the participants in the study than the foreign ones due to their cheaper price, and also they were very accessible because they were sold by hawkers at lorry stations but the foreign ones were mostly sold at marts and big malls.

Energy drink consumption is highly prevalent at lorry stations in Accra. In spite of the consumption rate being excessive, few experienced adverse health effects. Some of the adverse effects were insomnia, accelerated heartbeat and sexual weakness. Most consumers of energy drink perceived it to be helpful whiles most non-consumers perceived them to be harmful.

DEDICATION

I dedicate this thesis to the Almighty God, the Alpha and Omega and the Giver of life for His guidance and protection throughout my academic career, to my beloved family; Mr. and Mrs. Nana Yankson, Edinam, Dan-Joel, Erica and Margaret Awusu for their immense support throughout my study.

ACKNOWLEDGEMENT

I would express my biggest gratitude to my supervisors; Prof. Firibu Saalia and Dr. Joycelyn Quansah for their immense help and relentless contributions to the completion of my work.

I would also say a big thank you to Mr. Owusu Ansah Leslie, of the Food Drugs Authority of Ghana (FDA), for helping me with my laboratory analysis, and also thank you to Richard Ansong for helping me with my statistical analysis.

To Mr. Owusu Aboagye (Quality Assurance Officer at Kasapreko Company Limited) for his immense contribution on the analytical part of my work.

Last but not the least, special thanks to my family for their encouragement and support throughout my study and above all thanks be to God who, by His mercies, has seen me through till the successful completion of this program.

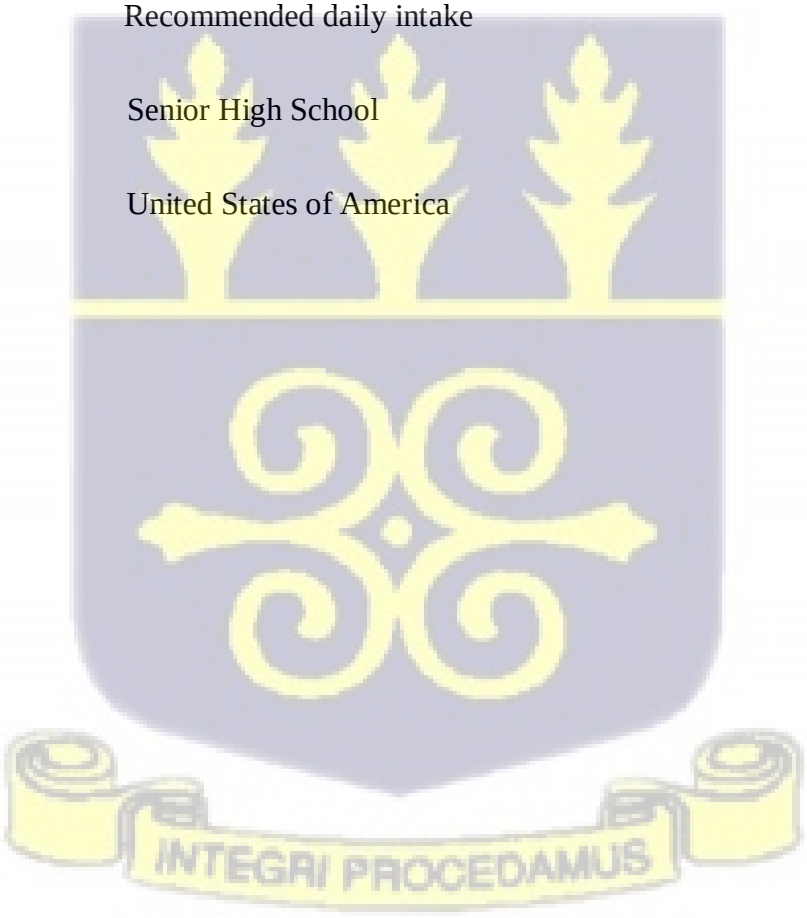
TABLE OF CONTENT

LIST OF FIGURES

LIST OF TABLES

LIST OF ACRONYMS AND ABBREVIATIONS

EFSA	The European Food Safety Authority
FDA	Food and Drugs Administration
GSA	Ghana Standards Authority
JHS	Junior High School
GIJ	Ghana Institute of Journalism
RDI	Recommended daily intake
SHS	Senior High School
USA/US	United States of America



CHAPTER ONE

INTRODUCTION

1.0 Background to study

Energy drinks are soft drinks that are popularly drunk as stimulants to boost mental and physical performance. Energy drinks contain sugars and other presumed performance enhancement ingredients like; caffeine, taurine, sugars, herbal extracts (guarana, ginseng) and vitamins (Khan et al., 2016). Energy drinks are types of new beverages that fall under the category of soft drinks but contain higher levels of caffeine compared to those soft drinks which contain smaller amounts of caffeine.

These drinks are marketed to enhance the abilities of the consumer to stay sharp, very attentive and increase their capacity to undertake physical and mental works. The target for promoters and marketers of energy drinks are the youth and adults involved in manual or physical activities (Hoyte et al., 2013). Energy drinks are different from sports drinks in the sense that sports drinks contain electrolytes that replaces lost fluid during exercise, but energy drinks do not replace lost fluids but rather make the consumer dehydrate due to its diuretic nature (Riesenhuber et al., 2006).

Caffeine intake from energy drinks consumption has increased in recent years; it was previously at 120 mg per day but currently at 165 mg per day (Mitchell et al., 2014). The needs of people to stay alert and work for longer hours can account for this increase in consumption of energy drinks (Mitchell et al., 2014). Athletes are frequent consumers of energy drinks, and they consume them usually before sporting competitions with the belief that it will improve their performance and also allow them endure pain without any sign of fatigue for long periods of exercise. This claim was

backed by a scientific study which proved that an energy drink consumer as compared to a placebo, had energizing effects which lasted between 30-90 minutes after consumption (Buxton and Hagan, 2012). Caffeine is the predominant component of energy drinks. Caffeine in energy drinks stimulates the central nervous system, thereby making the consumer alert (Temple, 2009).

Energy drinks regulations are lenient in most countries thereby most consumers are uninformed about the dangers associated with excessive consumption. The USA Food and Drugs Authority, allows a maximum of 300 mg per litre of caffeine in energy drinks whereas the limits in Ghana are 320mg per litre. In USA, Spain and developing countries like Ghana, it is not mandatory to state the amount of caffeine on the labels of energy drinks. In Canada, energy drink labels must indicate if the caffeine contents are high and a recommended daily intake (Rosenfeld et al., 2014).

Excessive intake of energy drinks causes health problems like insomnia, irritability, increased heartbeat rate, increased blood pressure and sometimes death due to the presence of caffeine. These effects are manifested when the caffeine intake exceeds 400 mg per day (Temple, 2009). Due to the dangers associated with energy drinks some countries have regulations in place to help regulate its intake. In Turkey, France and Denmark, energy drinks containing taurine and high amounts of caffeine have been banned from the market. Sweden also, allows energy drinks to be sold in pharmacies as medicinal product. Despite the influx of energy drinks globally, developing countries like Ghana, have not taken measures to reduce the dangers associated with excessive consumption of energy drinks (Reynolds, 2010). Energy drinks are soft drinks hence contain large amounts of sugars that can be harmful to the consumer's health.

There has been massive leap in energy drinks production worldwide due to readiness of the market for an extra source of power. Energy drink production represented around 6.7 billion dollars of the industry in 2010, with about 90 % of the consumers being the youth and adults under 40 years

(McLellan and Lieberman, 2012). Also, the consumption rate in countries like USA, Canada and other European countries has doubled between the years 2006 to 2012 (Reid et al., 2017). Red Bull is the biggest brand of energy drink in the US, Canada and most European countries, and it holds majority of the market share. Most people consume energy drinks together with alcohol to reduce the levels of intoxication and also increase their ability to consume more alcohol (Marczinski, 2011). Students consume energy drinks to stay alert so as to learn for longer hours without sleeping and to improve their mental performance, the rate of consumption increases during examination periods. Student athletes are known to consume more energy drinks than students who do not participate in sports (Paddock, 2008).

1.1 Problem statement

Energy drinks consumption in Ghana, was previously associated with athletes and persons involved in gymnastics (Buxton and Hagan, 2012). However presently energy drinks are sold at lorry stations by hawkers making them ubiquitous and accessible to the Ghanaian consumer.

In recent years, energy drink production has been on the rise in Ghana due to demands of people to work for longer hours without being fatigued. The abundance of energy drinks on the Ghanaian market is evident from the number of commercials on energy drinks being aired in the media. However, consumers have little knowledge on concentration of constituents and dangers involved with excessive consumption. From interactions with vendors around lorry stations, fuel mart attendants, wholesale shop owners and retail stores, energy drinks are the most sought-after soft drinks currently. Examples of popular brands of energy drinks in Ghana are; *Rush, 5star, Run, Storm, Dr. Caesar Lina energy tea, Bigboss and Special energy drink, Red Bull energy drink,*

Bullet energy drink, Xploza energy drink, Blue Jeans energy drink and Lucozade energy.

1.2.1 Justification

Despite the influx of energy drinks on the Ghanaian markets (imported and locally produced ones), there has been little knowledge on the consumption patterns among consumers, the motive behind their consumption, and consumer's knowledge on the risks associated with excessive consumption of energy drinks. Up till date, there has not been much studies that assesses the consumption practices among the Ghanaian consumers other than student-athletes, which was a study done by; Buxton and Hagan in 2012 on '*the consumption patterns of energy drinks among student-athletes'* and concentrations of the main constituents (sugar and caffeine) of energy drinks. The other study that was done in Ghana on energy drinks was done by Saku et al., `*on consumption prevalence, and awareness of its potential health implications among commercial drivers in Ho municipality of Ghana*`. Therefore, there is a need to embark on a study that will determine the consumption patterns of energy drinks at major sale points like lorry stations in Accra, and also the concentrations of the main constituents.

1.3 Objective of the Study

1.3.1 Main objective

To determine the consumption patterns, composition and concentrations of energy drinks consumed at lorry stations in Accra.

1.3.2 Specific objectives

1. To determine the consumption patterns and reasons for consumption of energy drinks from consumers.
2. To assess the consumers` perceptions of the benefits and experiences with drinking energy drinks.
3. To determine the caffeine and total sugar concentration of selected energy drinks.

CHAPTER TWO

2.0 Literature review

2.1 Energy drinks

Energy drinks are novel and popular beverages, that fall under the category of soft drinks believed to improve cognitive performances and reduce fatigue during manual or physical activities (McLellan and Lieberman, 2012). Energy drinks are non-alcoholic beverages which consist of ingredients like vitamins, sugars, herbal extracts (ginseng, guarana, yerba mate), taurine and at least 120 mg of caffeine per litre. Caffeine is found in some soda drinks but these amounts are minimal compared to the amounts in energy drinks (Reid et al., 2015). Also, energy drinks come in several forms; powder, ready-to-drink or shots (Bruzell, Granum, and Rohloff, 2018).

Energy drink was first introduced into the markets in the early 1960s. It was first manufactured by Taisho pharmaceuticals, a company in Japan. In 1962, Lipovitan D was launched into the markets as the first ever energy drink. Lipovitan D contained ginseng, B vitamins and taurine, and it was produced as a result of consumers demands for a dietary supplement that would increase their abilities to do physical work (Heckman et al., 2010). Lipovitan D was the only energy drink during the 1960s until 1997 when Red Bull energy drink was produced. Red Bull energy drink was manufactured by Dietrich Mateschitz, an Austrian in 1987 but was launched in the United States in 1997. At the moment, Red Bull is leading the energy drinks industry in terms of market share and second in terms of the beverage industry after bottled water (Heckman et al., 2010).

Most countries' regulatory bodies do not require the producers of energy drinks to label the amount of caffeine in the beverages (Wilson et al., 2018).

Energy drink production represented around 6.7 billion dollars of the beverage industry in 2010, with about 90% of the consumers being the youth and adults under 40 years (McLellan and Lieberman, 2012). The reason for the rise is due to different options in which the manufacturers present the energy drinks. Some of these options are; sugar-free, larger containers and diverse fruit flavours that make the energy drinks tastier (Heckman et al., 2010).

In the United States and few other countries, energy drinks are marketed as dietary supplements so as to erase any fears from the consumer (McLellan and Lieberman, 2012). Energy drinks are categorized under functional beverages with sports and nutraceutical drinks. Energy drinks are different from sports drinks in the sense that that sports drinks contain electrolytes that replaces lost fluid during exercises. Also, nutraceutical beverages contain vitamins, minerals, and some antioxidants like polyphenols (Heckman et al., 2010). Despite this difference, energy drinks are marketed to athletes with the catchy phrase, 'energy drink'. This sends a message to the athlete that it can improve physical activities (Buxton and Hagan, 2012). Energy drinks can sometimes fall under the category of nutraceutical beverages with respect to their constituents (Heckman et al., 2010).

Studies have been done to prove the effectiveness of energy drinks in providing energy. A consumer of energy drink had more energy compared to a placebo. The energy drink consumer had an increased amount of energy and very alert for about 30 to 90 minutes (Buxton and Hagan, 2012).

2.2 Constituents of energy drinks

For a drink to be considered as an energy drink, it must contain at least 150 mg of caffeine per litre. Most energy drinks have similar constituents but vary in their concentrations. Total amount of caffeine in energy drinks, must be from all ingredients, because some constituents like guarana contain little amounts of the caffeine compound. Examples of these constituents or active ingredients found on energy drinks are; taurine, caffeine (most active ingredient in energy drinks), sugars, B vitamins, herbal extracts; ginseng, gingko, guarana, yerba mate (Alsunni, 2015).

Table 2. 1: Energy drink brands and their constituents

Energy drink	**Active Ingredients**	**Manufacturing Company**
Red Bull	Taurine (1000mg), caffeine (80mg), glucuronolactone, sucrose, B vitamins.	Red Bull GmbH
Monster	Caffeine (80mg), glucose, inositol, L-carnitine, guarana.	Monster Beverage Co.
Burn	Caffeine, B vitamins, guarana, ginseng, sugars.	Coca-Cola Company; Monster Beverage
Storm	Inositol, caffeine, sugars, B vitamins, taurine.	Kasapreko Company Limited
Rush	Caffeine, sugars, taurine, inositol, B vitamins.	Twellium Industrial Company Ghana
Run	Taurine, caffeine, inositol, sugars.	Twellium Industrial Company Ghana

Source: Information of products were from product labels and manufacturer's website

2.2.1 Caffeine

Caffeine (1,3,7-trimethylxanthine) is a xanthine, a central nervous system stimulant found in most human diets, and is one of the most popularly consumed pharmacologically active compound. Caffeine is wholly and quickly absorbed after oral ingestion and naturally occurs in cocoa beans, tea and coffee (Srdjenovic et al., 2008). Of all the sources of caffeine, the highest concentrations of caffeine are found in cocoa, guarana berries, yerba mate, kola nut, tea and the leaves and beans of the coffee plant (Garcia, 2013).

Ingested caffeine reaches the blood plasma within 20 to 120 minutes after its intake. Caffeine is largely metabolized in the liver by the cytochrome P-450 isozyme CYP 1A2 (Babu et al., 2008). The liver releases extra sugar into the blood stream that provides energy to the consumer. It takes about 3 to 6 hours for ingested caffeine to be eliminated from the consumer's system and that depends on several factors like the sex, health state of the consumer, age and level of caffeine exposure. As soon as caffeine is ingested, it blocks the action of adenosine, which is a brain chemical involved in sleep, thereby making the body to act as if it was in an emergency. Signals are then sent to the pituitary glands to release the flight or fight hormone (adrenaline) which makes the heart beat faster and the eyes dilate. Caffeine is able to attach itself to adenosine because it has the same chemical structure as adenosine. Caffeine also stimulates the action of dopamine (the brain's pleasure center), making the consumer feel rejuvenated because it improves the mood of the consumer and makes them alert (Babu et al., 2008).

Caffeine used to be included only in products for athletes but recently it is being added to a variety of products like energy drinks, alcoholic beverages, drugs and supplementary diets (Graham and Graham, 2014). For people who do not drink tea or coffee, the main source of caffeine is through consumption of caffeine-containing soft drinks (energy drinks and sodas). Caffeine has also been

added to products such as beer, confectionaries and bread in recent years. The main source of caffeine consumption in recent years is from the introduction of energy drinks (Garcia, 2013).

The US Food and Drugs Authority allows up to 300 mg of caffeine per litre of energy drink, whereas in Ghana, the standard for caffeine in energy drinks is 320 mg per litre, by the Ghana Standards Authority (GSA) (Buxton and Hagan, 2012).

2.2.1.1 Effects of caffeine on the consumer

Caffeine present in energy drinks have both beneficial and negative effects to the consumer. However, the negative effects outweigh the benefits derived from caffeine in energy drinks. Some of the benefits are;

1. **Weight Loss** – Caffeine is very effective in fat oxidation and reduces the rate of glycogen breakdown in the body of the consumer (Hoffman, 2010). In combination with other ingredients like yerba mate extracts in energy drinks, its role in weight loss increases by a faster rate of metabolism and also fat loss stimulation (Diepvens et al., 2007). A study by Boozer et al. (2002), showed that prolonged consumption of caffeine proved effective in the reduction in body mass and body fat with positive change in the lipid profile of the consumer. It was proven by Hackman et al. (2006), that a drink made up of several vitamins and caffeine administered to females for nine months showed an improvement in various metabolic rates, decrement in body mass and fat, and also, an enhancement in lipid profile and insulin sensitivity.

2. **Athletic Performance –** the potency of caffeine is highly manifested during endurance or athletic activities. These activities are normally done within a time frame; hence exhaustion time or fatigue is very important (Doherty and Smith, 2004). Caffeine is able to slow down fatigue through its potential to disrupt exercise metabolism by enhancing oxidization of fat and consequently, preserve the glycogen contents of the muscle (Hoffman, 2010). Caffeine in conjunction with other ingredients like taurine in energy drinks forms a synergistic effect which increases the consumer's endurance ability or athletic performance (Ratamess et al., 2007). Another study by Hoffman et al., (2009), sought to determine the effects an energy drink containing caffeine and taurine had on an athlete who consumed it ten minutes before exercise. They observed an improvement in performance time by the athlete. The caffeine and taurine present in the energy drink enhanced the anaerobic response and also the insulin response of the athlete, thereby delaying fatigue. Caffeine with glucose also promote cognitive performance. In a study by Smith and Roger (2002), the behaviours of the participants were observed after they took an energy drink made up of glucose, caffeine and treated water. From the study, the participants who consumed the energy drinks in comparison to those who consumed the treated water had a faster reaction time and also an energetic arousal.

Caffeine consumption is safe in small doses but becomes detrimental when a daily intake exceeds 400mg for an adult and 100mg for an adolescent. Thus, caffeine present in a single serving of an energy drink is difficult to evoke an adverse health effect to the consumer (Buxton and Hagan, 2012). No death was associated with caffeine intake until after 2005, when one death was recorded of a person from consumption of caffeinated-energy drink (Babu et al., 2008). Some of the negative effects of caffeine consumption are;

1. **Cardiovascular Effects** – large doses of caffeine consumption have been proved to have some negative effects on the heart and its functions. Some of the symptoms are accelerated heart rate and an increase in blood pressure (Buxton and Hagan, 2012). Over consumption of caffeine reduces the function of the endothelial cells (cells that line the interior surface of the heart and blood vessels) and initiates platelet aggregation (Pommerening et al., 2015). A man from the United States died from cardiac arrest after consuming three cans of 250ml of energy drink. He played basketball after, consumption of the energy drinks rendering him unconscious and died three days after (Breda et al., 2014).

2. **Effects on the Central Nervous System** – consumers who take in large doses of caffeine experience certain symptoms like insomnia, irritability, anxiety and muscle twitching (Bedi et al, 2014). The consumer may experience chronic headaches which leads to pains in the nostrils and visual distortions at times (Espinosa and Sobrino, 2015). These malfunctions portrayed by the consumer are due the blocking of adenosine by caffeine and also release of dopamine. Also, caffeine induces cortisol (stress hormone) stimulation in high levels and cortisol enhances the effects of stress (Crowe et al., 2011). A study conducted on teenagers between the ages of 15 to 16 years showed that violent behaviors and other social misconduct were related to caffeine intake (Kristjansson et al., 2013).

3. **Renal effects and fluid imbalance –** continual consumption of caffeine leads to diuresis (loss of water through urine), which consequently leads to electrolyte loss and a reduction in plasma volume. Despite caffeine being diuretic, it takes many hours for a mild change in the renal system to occur (Graham and Graham, 2014). It is therefore not advisable to consume caffeine when exercising under high temperatures and for a long time, since it

can lead to increased micturition rate and sweating which can lead to fluid loss from the body (Alsunni, 2015). Intake of caffeine over long periods can cause natriuresis (presence of sodium in the urine). This however, in turn alters the plasma volume. A work done by Greene et al. (2014) showed how a 40-year-old man who consumed caffeinated-energy drink daily for two (2) weeks developed an acute renal injury.

2.2.2 Taurine

Taurine also known as 2-aminoethanesulfonic acid, is the most abundant amino acid used in energy drinks. It is manufactured in the body by metabolic action of cysteine or methionine (Brosnan and Brosnan, 2006). Taurine is a non-essential or conditional amino acid that can be produced by healthy adults from other amino acids however, ill-health adults and infants must obtain taurine from supplements and or their diet (Hendler and Rorvik, 2001).

Taurine naturally occurs in mammals, fish, meat and dairy products. In humans it is found in the retina, cardiac and skeletal muscles (Heckman et al., 2010). The highest concentrations of taurine in humans are found in the brain and heart. Taurine can be also given as supplements and it possesses antioxidant properties, aids in glycolysis and osmoregulation, and also, increases the plasma concentration in males after physical works (McLellan and Lieberman, 2012). Taurine helps in the prevention of apoptosis (death of cells normally ocurring in multicellular organisms), it reduces cytokine-induced apoptosis, thereby preventing abnormal growth in the pancreas.

Abundance of taurine in the pancreas gives it the ability to act on the insulin and thus reduces glucose levels in the blood (hyperglycemia). Taurine prevents DNA damage in the leukocytes from exercise fatigue and induced oxidative damages.

Typically, a quantity of 20 to 200 mg of taurine is found in most diets consumed. Ingested taurine forms part of bile salts and further degrades to sulfate, thus when taurine intake is above the required levels, the excess are excreted through the urine unchanged (Munro and Renwick, 2006). Due to the efficacy of taurine in infant development, it was previously formulated in infant diets (Heird, 2004).

The concentrations of taurine present in energy drinks are minimal to provide the benefits derived from taurine and likewise any adverse health effects generated from consuming them in energy drinks. Taurine is known to promote cognitive performance but in conjunction with caffeine (McCusker et al., 2006). Taurine is usually safe on its own but can be lethal when combined with caffeine in high concentrations (Nordqvist, 2007).

2.2.3 B Vitamins

These are water-soluble vitamins present in most energy drinks. B vitamins are a group of eight of vitamins; Niacin, thiamine, pantothenic acid, riboflavin, inositol, biotin, cyanocobalamin and pyridoxine hydrochloride. When they work together, they are referred to as vitamins B complex. B vitamins are present in our daily diets like potatoes, bananas and tuna fish.

Each of the B vitamins have their specific function; Thiamine (B_1) acts as a coenzyme precursor for most carbohydrate metabolism enzymes (Ba, 2008). Riboflavin (B_2) helps in the respiratory chain and promotes energy catabolism involving proteins, fats and carbohydrates (Lakshimi, 1998). Niacin (B_3) helps in energy production in cells and also, stimulates the secretion of some neurotransmitters like serotonin, dopamine and L-dopa (Sauve, 2008). Pantothenic acid (B_5), plays

a role in fatty acid oxidization (Depeint et al., 2006). Pyridoxine hydrochloride (B_6) helps in DNA and RNA synthesis, metabolism of lipid and glucose, and acts a coenzyme in the metabolism of cysteine and amino acid (Spinneker et al., 2007). Biotin (B_7), also helps in fatty acid oxidization (Depeint et al., 2006). Inositol was formerly vitamin B_8, but no longer considered a vitamin because the human body can synthesize it. It is now replaced by folate (B_9). Inositol is most popular vitamin present in energy drinks. Inositol helps in processing of fats in the liver. Cyanocobalamin (B_{12}) promotes erythrocytes formation and vital in DNA production (Balla, 2009).

Vitamins present in energy drinks provide energy through mitochondrial functions (Depeint et al, 2006). Due to the large amounts of sugars present in energy drinks, the B vitamins are believed to facilitate the conversion of the available sugars to energy (Depeint et al., 2006). Most energy drinks have minimal amounts of vitamins except few ones which contain large quantities of vitamins. B vitamins are water soluble, therefore excess vitamins are eliminated through the urine. Large doses of B vitamins do not evoke any adverse health effects (Wardlaw and Smith, 2009).

2.2.4 Herbal extracts

The popular herbal extracts added to energy drinks. These are; guarana and ginseng (Bahrke et al., 2009).

2.2.4.1 Ginseng

Ginseng, also known as panax ginseng is a herb found in the eastern part of Asia. The root is the most potent part; other parts are also of medicinal importance. It is believed to improve memory and stamina (Coon and Ernst, 2002).

Ginseng is also one of the most popular herbal extracts added to energy drinks, and it helps in stress relief by the stimulation of pituitary glands to secrete adrenocorticotropin (Bahrke et al., 2009). Panax ginseng is used by athletes due to its ergogenic abilities. Despite its huge benefits, there are adverse health effects associated with consumption of ginseng in large doses. Some of these are; headache, loss of appetite, insomnia, vaginal bleeding and fever, however, the ginseng present in energy drinks are minute to cause any harm to the consumer (Clauson et al., 2008).

Reay et al. (2005) reported that an administration of 200 mg of panax ginseng improved cognitive performance and also reduced blood glucose levels in healthy adults.

2.2.4.2 Guarana

Guarana (*Paullinia cupana)*, is a rainforest vine found in the Amazon basin in Brazil. The seeds contain caffeine and are the only edible part of the guarana plant (Scholey and Haskell, 2008). The seeds contain other xanthines but at lower levels compared to caffeine. Of all plants in the world containing caffeine, guarana contains the highest concentrations. For every 1g of guarana seed, there is about 40 mg of caffeine present (Finnegan, 2003). The caffeine in guarana is released at a steady rate compared to pure caffeine in energy drinks, thereby has a much greater stimulatory effect. Caffeine from guarana is insoluble in water, which accounts for the slower release rate of the caffeine present in guarana (Scholey and Haskell, 2008).

The stimulatory effects of guarana is also as a result of the presence of the stimulants theophylline and theobromine (Smith and Altroch, 2007). Research shows guarana improves physical and cognitive performance and also slows down fatigue time. It also contains tannins and saponins which gives guarana its antioxidant properties (Mattei et al, 1998). The effects of guarana are experienced when they are in high concentrations, however guarana poses no danger to the

consumer when consumption is low. Nevertheless, the amount of guarana in energy drinks are minimal to exert the benefits such as the energy rush derived from the plant (Lima et al., 2005).

2.2.5 Sugars

Energy drink is marketed to provide energy, therefore the addition of sugar to this beverage is highly important. This is because sugar is the main source of energy for the body. The commonly used sugars in energy drinks are glucose, fructose corn syrup and sucrose (Higgins et al., 2010).

Energy drinks are soft drinks and do contain large quantities of sugar. Energy drinks contain about thirteen teaspoons of sugar. (Feely, 2011). Consumption of large quantities of sugar poses a lot of adverse problems. Obesity and insulin resistance are few of the effects of overconsumption of sugar. With time the consumers can suffer from diabetes because they are not able to produce the required insulin to maintain the blood glucose levels (Tappy et al., 2010). Excessive consumption of added sugars from soft drinks is becoming a global menace and the American Heart Asscociation recommends a daily intake 150 calories or 37 g or 9 teaspoons of added sugars per day for men whereas 100 calories or 25 g or 6 teaspoons for women. Daily added sugar consumption within the recommended intakes prevents or minimizes the chances of a consumer suffering from effects of excessive consumption of added sugars (Feely, 2012).

Sweeteners are also added to energy drinks to improve their taste and flavor, sweeteners are chemical compounds which are mostly found nature or artificially made (Hsieh et al., 2003). Sweeteners do not only improve a product`s taste but can be provide health benefits, that is they reduce the amount of added sugars present in a product whiles making the product still taste acceptable (Hsieh et al., 2003). Energy drinks like other soft drinks contain sweeteners such as

Acesulfame K, Aspartame, Rebiana which help gives them a nice taste whiles reducing the amount of added sugars so as to avert any health issues like diabetes and obesity as a result of excessive consumption of added sugars. Energy drink products like Lucozade that had a small amount of added sugar compensated its taste with the additions of sweeteners: Acesulfame K and Aspartame.

The interactions between sugars and caffeine was studied by Huston and Jeukendrup (2008), since these two ingredients were reported to improve cognitive and athletic performance by provision of energy. From their findings, sugars were ingested faster than caffeine and cognitive performance was increased by the action of caffeine alone not in conjunction with the sugar. This was further buttressed by a study, where sugars together with caffeine were administered to athletes before exercise. This combination increased the rates of resynthesis of muscle glycogen therefore slowing down fatigue by reducing the rates of muscle glycogen depletion (Pedersen et al., 2008).

2.3 Consumption patterns of energy drinks

Energy drinks are becoming the leading beverage with a market share of about 12 million dollars worldwide (Reissig et al., 2009). Energy drinks have now become very popular for its use as a supplement to improve cognitive performance and being an ergogenic aid (Zucconi et al., 2013).

Energy drink is usually consumed by adults and adolescents (10-19 years). The European Food Safety Authority (EFSA) investigated the consumption patterns of energy drinks within sixteen (16) European countries in 2011 and found out that 68 % of adolescents, 18 % of children (below 10 years) and 30 % of adults consumed energy drinks.

The consumption patterns of energy drink differ among individuals; some use it as a stimulant for academic excellence, mixed with alcohol to reduce the intoxication rate, as an ergogenic aid for sporting activities and even for stamina for sexual intercourse. People who mix alcohol with energy

drinks feel sober and still attentive despite being drunk. Alsunni and Badar (2011) reported that two males in Sweden died from the consumption of alcohol mixed with energy drinks due to dehydration because energy drinks and alcohols reduce body fluids.

Due to adverse health problems from energy drinks consumption, regulatory bodies of some countries have developed stringent measures on the usage of energy drinks. Denmark, France, Norway, Turkey and Uruguay have issued a ban on the sale of caffeinated energy drinks on their markets. In Sweden, energy drinks are sold only in pharmacies as medicinal products. Also, in Canada warning labels have to be placed on the containers of energy drinks warning consumers against consumption with alcohol, consuming large quantities, avoidance of use by children and pregnant women (Buxton and Hagan, 2012).

Reid et al. (2015) researched on the consumption patterns of energy drinks among university students in the Caribbean. From their survey, the prevalence among students was 86 %. Most of the student consumers began to use energy drinks before 20 years old, and the reasons for their use were out of curiosity, peer pressure, for sporting activities and from energy drinks advertisements. The main factors influencing use among the current users (thus the youth) were recommendations by friends, sexual stamina, to treat hangovers, to control their weight, taste of most energy drinks and the energy rush they felt after consuming the energy drink. Male consumers were attracted to energy drinks by brand names whiles females by energy rush of the energy drinks. About 61%, of the students attested to attain the energizing effects from consuming energy drinks and intended to keep using them. About 51 %, of the student consumers, didn't see any change after consuming the energy drinks so decided to stop its usage. On adverse effects, 62 % revealed they experienced adverse effects after consumption of energy drinks such as restlessness (being the commonest),

increased heartbeat rate, jolt and crash effect. More than half knew there were adverse effects related to continual intake of energy drinks.

In Canada, Reid et al. (2017) embarked on a research on the consumption patterns of energy drinks among adult and youth. The prevalence for consumption was 74 %, out of which the mean age for commencement of energy drink use was 14 years old. Most consumers drank more than two cans in a day, males consumed energy drinks slightly more than females. The Caucasians consumed it more than the mixed race. Locations where energy drinks were consumed mostly, were; at school, at home, someone else' house, at bars/pubs/night clubs and lastly at the gyms or sporting centers. The reasons for consumption of energy drinks were; for concentration during learning or work, out of curiosity, to mix with alcohol, to deal with hangover, for weight loss and maintenance, for the taste and recommendations by friend.

In Ghana, Buxton and Hagan (2012) conducted a study on the consumption patterns of energy drinks among student-athletes in Ghana. The study area was an inter-university sporting event. The prevalence rate was 62.2 %, out of which male student-athletes consumed more energy drinks than females. The reasons of consumption by the student-athletes were; provides energy and replenish body fluids, improves performance, slows down fatigue and replaces lost energy after training and sporting activities.

2.4 Determination of Caffeine

Various methods can be used to determine the caffeine concentration in energy drinks or colas, some of these methods are: UV/VIS Spectrometry, mass spectrometry and HPLC. However, the HPLC is the latest technology used to determine caffeine due to its

convenience and how quick results are obtained. High performance liquid chromatography (HPLC) is a type of chromatographic method used to separate different components of a liquid, depending on their size and shape in a rapid manner. HPLC can be used to determine the caffeine component in a substance in a pharmaceutical drug or matrix of food. (Patil, 2012). It is made up of six (6) components; *mobile phase, stationary phase, injection chamber, detector, pump and a computer system*. The mobile phase, pumps the liquid to be analyzed through the stationary phase (Dooling et al., 2013). A small part of the sample to be analyzed is injected and moved by the mobile phase into the column, where the separation occurs. The smallest particles elute first and are recorded by a detector as a peak and shown in the chromatogram on the computer screen. The area covered by the peaks is proportional to the concentration of the sample. In determining the concentration of caffeine in drinks, a standard caffeine concentration is used to determine the total caffeine concentration of the drink (Leacock et al., 2011).

2.5 Determination of sugar content

The amount of sugars in a soft drink is measured using various method: HPLC, mass spectrometry or refractometry. Using the refractometer to determine the sugar content is the fastest and easy-to-use method. Refractometer is a device that is used to determine the sugar concentration of soft drinks, syrups or even sugar cane. It is rapid and only requires little drops of the sample to determine its sugar content in percentage. A refractometer works by shining a beam of light through the sample (which should be a liquid) and the amount of light refracted through the sample is measured. The refraction angle is then taken and

correlated to an already existing refractive, which then calculates the concentration of the sugar in the sample (Sella, 2008).

CHAPTER THREE

MATERIALS AND METHODOLOGY

3.1 Experimental design

The study was a combined cross-sectional survey of the consumption patterns of energy drinks at lorry stations in Accra and laboratory analysis of the main composition of energy drinks (caffeine and sugar). The energy drink samples were categorized into two; imported energy drinks and local energy drinks.

3.2 Samples

Local energy drinks (*Rush, Storm, Run, BigBoss and 5star*) and imported energy drinks *(Red Bull, Xploza, Lucozade, and Bullet*). The samples were purchased from Achimota retail center and Madina market, for the laboratory analysis.

3.3 Cross Sectional Survey

Semi-structured questionnaires were developed and used to obtain information such as: demographics, socio-economic background, consumption patterns, perception, knowledge and adverse health effects from consumption of energy drinks from the participants willing to take part in the study.

According to Buxton and Hagan (2012), the prevalence of energy drink consumption among student-athletes in Ghana was **62.2 %,** therefore using the binomial model; $N=z^2.p$**$(1-p)/d^2$, where**;

N= sample size,

z= confidence interval (1.96 for 95% confidence interval),

d= margin of error at 5% (0.05),

p= estimate prevalence of energy drink consumption among student athletes in Ghana.

$N= 1.96^2 *62.2(1-62.2)/0.05^2 = 362$

This was approximated to give a sample size of 360.

The survey was undertaken at lorry stations because they are the dominant places where energy drinks are sold or retailed in Accra. From the Ghana Population Census in 2010, Accra Metropolis was the most populated municipality in the Greater Accra Region, hence the stations to be used were selected from this municipality. Information from Ghana Private Road Transport Union (G.P.R.T.U.) on the various stations in Accra Metropolis showed the three (3) largest in terms of size and busiest stations in terms of activities in Accra were;

1. *Lapaz Southside and Northside stations,*
2. *Arena Station, Fearon Road, Accra Central*
3. *Circle Stations (Circle Ayawaso, Circle Blow Up, Odorna, Ministries).*

An approval was obtained from the Ethics Committee for Basic and Applied Sciences**,** University of Ghana. Inclusion criteria were consumers and non-consumers of energy drinks willing to participate in the study and the exclusion criteria were people below 18 years of age.

The questionnaires were administered to participants randomly sampled from people present in the selected lorry stations and willing to participate in the study.

3.4 Laboratory Analysis

3.4.1 Caffeine content determination by HPLC (Koerner, 2013)

The energy drinks were poured into labelled beakers, and degassed using a sonicator, (Hielscher Ultrasonics UP200S, Hielscher Ultrasonics, Germany), until no air bubbles could be seen in the beakers. The degassed samples were filtered with a #42 filter paper and then transferred into vials using a syringe.

A 0.3 mg/ml caffeine (Sigma-Aldrich company, USA) standard was prepared, filtered using the #42 filter paper then transferred into vials using a syringe.

A mixture of degassed HPLC grade water and methanol (70:30, v/v) was used as the mobile phase. The stationary phase was a reverse phase 25 cm C_{18} column. The vials containing the dissolved caffeine and energy drinks were placed in the injection chamber of HPLC (Agilent 1220 Infinity LC, Agilent Technology, USA). The analysis was run using the following parameters; temperature was set between 21-29 ^{0}C, 275 nm wavelength, at flow rate of 1.5 mL/min and a run time of 17 minutes. Analysis was repeated thrice for each sample. The laboratory analysis were done at FDA, Ghana.

The total caffeine concentration was estimated using the formula below:

$$\text{Concentration of sample} = \frac{area\ of\ sample}{area\ of\ caffeine\ standard} * concentration\ of\ caffeine\ standard$$

Where,

Concentration of the caffeine standard = 0.3 mg/ml.

Area of the sample is obtained from the chromatogram of the samples.

Area of the caffeine standard is obtained from the chromatogram of the caffeine standard (Naik, 2001).

3.4.2 Total Sugars Determination with Refractometer.

The energy drinks were poured into labelled beakers and degassed using a sonicator, (Hielscher Ultrasonics UP200S, Hielscher Ultrasonics, Germany). Distilled or deionized water was poured into the sample well of the refractometer (Digital Abbe Refractometer, Shanghai Jiuran Instrument Equipment Co. Limited). The zero button was then pressed and the water was removed from the prism. The samples were then poured into the sample well. The reading of the refractometer was then taken (Agbazue et al., 2014).

$$\text{Total sugars} = \frac{\text{mass from refractometer x net volume of energy drink}}{100}$$

3.5 Recommended Daily Intake of Caffeine and Sugar

The daily intake of caffeine should not exceed 40 mg and maximum amount of added sugars that is considered safe to consume daily by men are 37 g or 9 teaspoons and 25 g or 6 teaspoons for females (Feely, 2011). Therefore, using the volumes of the selected energy drinks, the number of bottles or cans of a particular energy that could meet the recommended daily intake of caffeine and sugar was determined.

3.6 Statistical Analysis

Using Statistical Package for the Social Scientist (IBM SPSS, Statistics for Windows, Version 26.0, Armonk, NY: IBM Corp), logistic regression was used to determine the relationship between energy drinks usage among consumers and factors that influenced its use. Analysis of variance (ANOVA), was used to determine the differences between the concentrations of the caffeine and sugar of the energy drink samples.

CHAPTER 4

RESULTS AND DISCUSSION

4.0 Consumers and Non Consumers of Energy Drinks at The Lorry Stations

A total of 360 participants were interviewed in this study, with 120 participants from each lorry station. Out of the total number of participants, **282 (78.3 %)** were energy drink consumers whereas **78 (21.7 %)** did not consume energy drinks (Table 4.1). The prevalence for energy drink consumption in this study from the three selected lorry stations was **78.3 %,** which is high compared to the **62.2 %** prevalence rate reported by Buxton and Hagan (2012), among student-athletes at universities in Ghana. The increased prevalence for energy drink consumption observed in this study could be due to the current accessibility of energy drinks as compared to five years ago. Formerly energy drinks were sold only at malls, fuel marts and pharmacies but in recent years it is sold by hawkers at lorry stations making them ubiquitous and accessible to many consumers.

4.1 Demography of energy drink consumers

A majority of the energy drink consumers were male (74.8 %), whiles females were 25.2 % as shown in Table 4.1. The kind of occupations in and around the lorry stations were more suited to males than females (Overå, 2007), which may have attributed to the male dominance among the consumers in this study.

Most of the consumers were between the ages of 21-30 years (39.4 %) with the remaining respondents between the ages of 18 to 20 years (16.3 %), 31 to 40 years (25.9 %), 41 to 50 years (10.3 %), with the least age groups between 51 to 60 years (6.4 %) and above 60 years (1.8 %)

(Table 4.1). Most activities at lorry stations were physical and required physical strength, thus it was not surprising that most of the participants in such an environment were less than 40 years reflecting the active working age group in Ghana (above 20 years and below 40 years) (Ntewusu, 2012). Also, less elderly men or women were found in the sampling area because they will be fatigued easily after driving for about six hours in a day or sitting to sell under the sun for five hours.

Commercial drivers (25.5 %) and traders (25.2 %) were the dominant occupations among the consumers (Table 4.1). This observation was not surprising because the lorry stations thus were converging points for commercial drivers to off load and pick passengers and the traders provided services to the passengers at the lorry stations (Grieco et al, 1995). Also due to the tiring nature of these two occupations (commercial drivers and traders), it was logical that these two groups would consume more. Commercial drivers who worked at night or went for long journeys took energy drinks to be alert and reduce fatigue likewise traders who sold under the sun mostly standing or chasing after customers passing through the lorry stations needed to replenish their lost energy with energy drinks. Other consumers were students (22.0 %), and conductors (14.2 %) as shown in (Table 4.1). One of the lorry stations; Circle lorry station (Odorna taxi rank), was close to a tertiary institution (IPMC) and could account for the high number of students in this study, also this same station was a means by which students of Ghana Institute of Journalism (GIJ) got to their campus. The relatively small number of conductors among the consumers compared to drivers was because most of the commercial drivers at these lorry stations operated cabs and did not require them unlike those who were mini-bus operators.

Most of the consumers were JHS (33.0 %), SHS (30.5 %) or tertiary (26.6 %) graduates. However,

2.5 % of the consumers did not have any formal education (Table 4.1). JHS and SHS were the dominant levels of education among the respondents. The inabilities of some respondents with JHS and SHS education level to attain tertiary education could make it difficult for them to secure white collar jobs and therefore may resort to occupations present at lorry stations (Ntewusu, 2012).

Table 4. 1: Demography of Consumers

Variable	Frequency	Percentage
Gender		
Male	211	74.8
Female	71	25.2
Age groups		
18-20	46	16.3
21-30	111	39.4
31-40	73	25.9
41-50	29	10.3
51-60	18	6.4
>60	5	1.8
Occupation		
Commercial drivers	72	25.5
Conductors	40	14.2
Traders	71	25.2
Students	62	22.0
Others	37	13.1
Educational background		
None	7	2.5
Primary	21	7.4
JHS	93	33.0
SHS	86	30.5

Tertiary	75	26.6

Others represented occupations like electrician, dressmaker, welder, pastor, nurse, journalist and auto mechanic.

4.2 Consumption Patterns of Energy Drink by consumers

Most of the consumers have been consuming energy drinks for more than five years (34.8 %), while others have been consuming it for two years (18.8 %), three years (17.7 %), four years (12.1 %) and less than a year (16.7 %) (Table 4.2).

Red Bull, Lucozade, other imported brands and Rush energy drink were the first energy drink consumed by participants who begun to consume it more than five years ago. Those who begun consuming energy drink within the last five years, mostly consumed the energy drinks that were produced in Ghana, because they were usually retailed at lorry stations by hawkers.

A majority of the consumers drank about two bottles of energy drink in a week (23.0 %), and other consumers also drank about two bottles in a day (10.0 %), one bottle in a day (9.2 %), five or more bottles in a day (7.5 %) and four bottles in a day (3.5 %) (Table 4.2). Due to the dangers associated with excessive consumption of energy drinks, in some European countries like Sweden, energy drinks are sold only in pharmaceutical shops and hence its purchase could be regulated (Buxton and Hagan, 2012). However, in developing countries like Ghana, anyone can buy it and take it without any regulations, because energy drinks are very accessible.

The consumers take energy drinks in the afternoons (55.3 %), mornings (25.5 %) or evenings (19.2 %) (Table 4.2). This observation could be because it is during the afternoons that most commercial drivers and conductors get the opportunity to rest and eat after busy morning rush hours of

transporting persons to their workplaces. Traders on the other hand, were mostly busy in the afternoons, and most of the times are stationary or standing in plying their trade, therefore consumed energy drinks to stay sharp and reduce fatigue (Fouracre et al., 1994). Also, due to the quest for a cool sensation to alleviate the stress caused by the scorchy sun made most of the consumers consume energy drinks mostly at noon (Kjellstorm et al., 2015). A few consumers drank them in the evening and were mostly commercial drivers who drove long distances at night and didn't want to feel tired and doze off while driving, or persons who used it to enhance their sexual prowess because they believed energy drinks helps boost one's sexual stamina.

The consumers had various reason for consuming energy drinks. Most consumers took energy drinks to work (50.4 %), to stay awake (36.2 %), to study (4.0 %), for sexual intercourse (1.4 %) and others also had no reason (8.2 %) why they took them (Table 4.2). Due to some of the jobs the consumers undertook at the lorry stations, they had to always be sharp and alert so as not to be left out in attracting passengers or customers (Yeboah, 2000). There were consumers who believed that in order not to feel fatigued or fall asleep whiles driving, they needed to take energy drinks. There were consumers, who also claimed because it provided energy to work for longer hours it could improve their sexual stamina when they met their partners. The consumers who had no motive as to why they consumed energy drinks, were people who had the knack to try new stuff on the market and will take anything so far as it tastes nice and was trending.

It was observed that most of the consumers took energy drinks with no accompaniment (71.7 %) and others consumed it with snacks such as bread, pie or biscuit (14.2 %), or mixed it with water (8.5 %) or alcohol (5.7 %), as shown in Table 4.2. The few consumers that took energy drinks with either biscuit, bread or meat pie claimed energy drinks were similar to sodas. Those consumers who mixed the energy drinks with water, believed it will reduce the caffeine content and the

consumers that mixed energy drinks with alcohol, believed it made them drink for longer hours and to also prevent hangovers in the mornings. Majority of the consumers who took the energy drink with no accompaniment were of the opinion that energy drinks were not similar to refreshing drinks like sodas and need to be taken with nothing.

Table 4. 2: Consumption Patterns of Energy Drinks

Variables	Frequency	Percentage
When consumer started consuming energy drinks		
Less than or equal to a year (≤1year)	47	16.7
Two years (2years)	53	18.8
Three years (3years)	50	17.7
Four years (4years)	34	12.1
Five years or more (≥5years)	98	34.8
Average number of bottles/cans consumed		
One - two in a day	54	19.2
Three - four in a day	24	8.6
Five or more in a day (≥5)	21	7.5
One - two in a week	84	29.7
Five or more in a week (≥5)	37	13.1
One - two in a month	43	15.2
Five or more in a month (≥5)	19	6.7
Time of the day energy drink was consumed		
Morning	72	25.5
Afternoon	156	55.3
Evening	54	19.2
Reason for energy drink consumption		
Energy to work	142	50.4

To stay awake	102	36.2
To study	11	4.0
For sexual intercourse	4	1.4
No reason	23	8.2
What energy drink was being consumed with		
Nothing	202	71.7
Bread, Biscuit or Pie	40	14.2
Alcohol	16	5.7
Water	24	8.5

4.3 Most patronized energy drink at the study sites

Despite the influx of many energy drinks at lorry stations, some definitely stood out and appealed more to consumers than others. Among the types of energy drinks available at lorry stations, the most patronized energy drinks by the consumers were 5Star energy drink (28 %), closely followed by Rush energy drink (24 %), Storm (21 %), Lucozade (9 %) and the least patronized was Red Bull energy drink (3 %), as shown in figure 4.1.

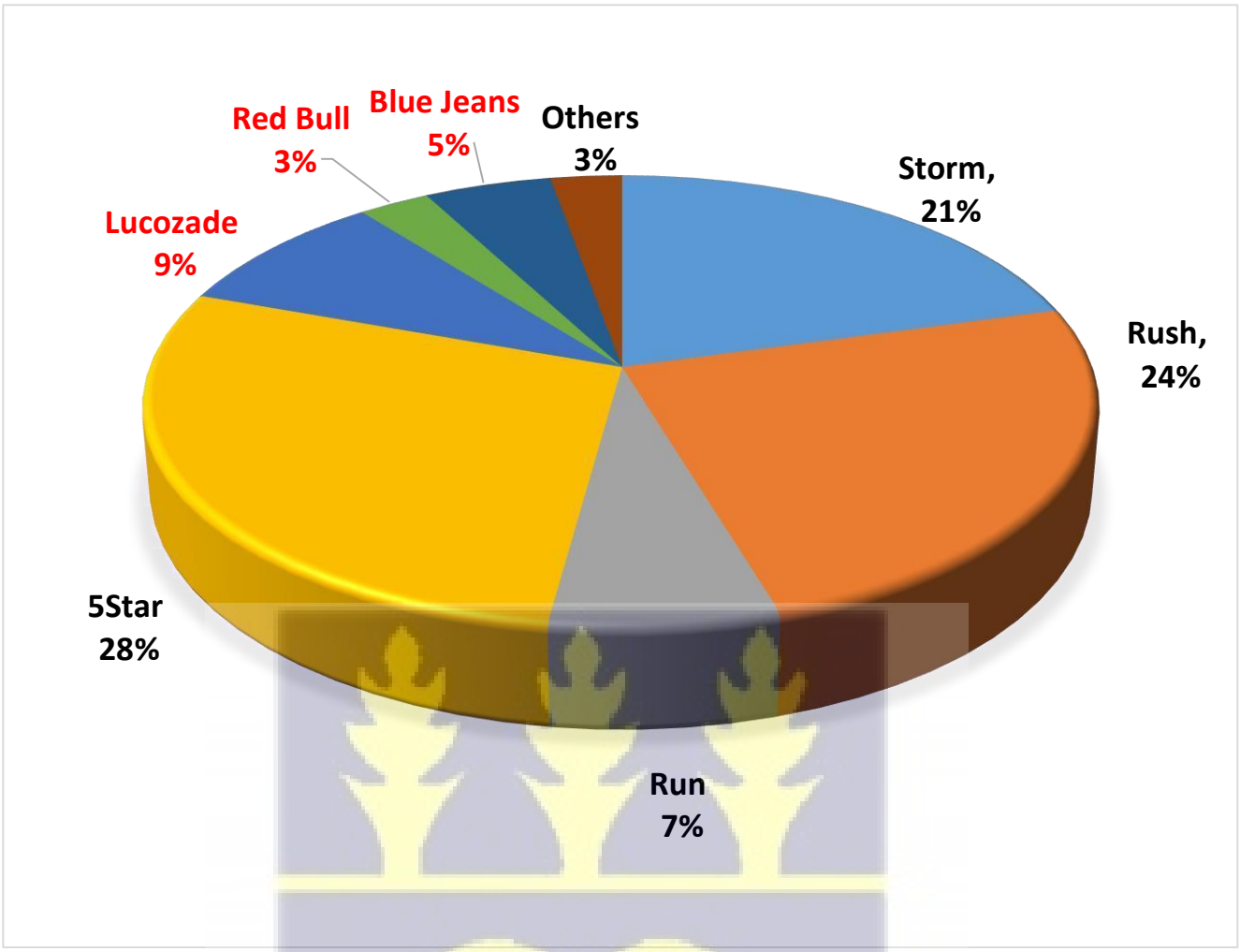


Figure 4. 1: Most patronized energy drinks at lorry stations in Accra

4.4 Consumers reasons for Consuming Preferred Energy Drinks

Most of the consumers indicated that they preferred particular energy drink brands due to their potency (52.5 %), followed by their taste (18.1 %), cost (17.7 %) whereas advertisement (9.6 %) and flavour (2.1 %) were the least of their reasons (Table 4.3). The consumers preferred some brands of energy drinks because of how they felt revitalized and could work for longer hours without signs of tiredness for a long time. The consumers who drank energy drinks because of cost explained that Rush and 5Star are 2gh, thus cost less than the other drinks available. Also, although those energy drinks cost less, they provided them with what they sought for in an energy drink. Advertisements had less influence on the consumer's choice and most consumers claimed they barely had time to pay attention to the commercials on energy drinks. The consumers that preferred energy drinks because of their taste claimed some of the energy drinks had nicer taste and others had this sharp and sour after taste.

Most consumers took the energy drink alone (75.5 %) whiles few shared or took it with people (24.5 %) (Table 4.3). The busy nature of lorry stations doesn't provide room for groups to sit together and enjoy drinks unlike people at home or on campuses (Yeboah, 2000). Majority of the consumers at the lorry stations consumed energy drinks alone whiles on the go, and the remaining who didn't consume it alone, mostly gave their leftovers to their friends.

Table 4. 3: Consumer Reasons for Consuming Preferred Energy Drinks

Variable	Frequency	Percentage
Reason for consuming energy drinks		
Cost	50	17.7

Potency	148	52.5
Taste	51	18.1
Advertisement	27	9.6
Flavour	6	2.1
Do you consume energy drinks alone		
Yes	213	75.5
No	69	24.5

4.5 Consumer's Knowledge on Energy Drink and Adverse Health Effects

About 88 % of the energy drink consumers in this study had no idea that there was a difference between energy and sports drinks (Table 4.4). Most energy drink consumers thought they were both similar and used to replenish lost energy while about 50 % of those who didn't know the difference, had not heard of sports drinks before. Majority of the consumers (72.0 %) knew about caffeinated beverages (Table 4.4).

It was observed that most of the consumers (83.3 %) are aware that over consumption of energy drinks could trigger some health complications to the consumer (Table 4.4). Although over 35 % of the consumers were not aware of any of such health problems associated with drinking too much energy drinks, others stated heart problems (16.1 %), sexual weakness (18.4 %) and insomnia (13.0 %) as some associated health problems (Table 4.4). Almost all of these speculated health problems associated with energy drink usage were similar to results on energy drink usage in a Caribbean university by Reid et al., (2014).

Some energy drink consumers in this study have experienced adverse effects such as insomnia (35.4 %), accelerated heartbeat (20.5 %), sexual weakness (8.7 %), and nausea (4.0 %) after

consumption of energy drinks. (Table 4.4). About 62.2 % of energy drink consumers in the Caribbean university experienced after effect, which is higher compared to the 33.7 % consumers with similar issues in this study (Reid et al., 2014). Most consumers said when they take the energy drink during late afternoons, they find it very difficult to sleep at night when they get home, and some who took it in the mornings too had this same experience. Some consumers experienced accelerated heartbeat when they took energy drinks mostly at nights, while others felt very uneasy and restless after consuming energy drinks late afternoons or before going to bed. Some men claimed of experiencing sexual weakness after consuming energy drinks. From the trend of the adverse effects experienced by the consumers, it shows a pattern where those who were idle after consuming energy drinks experienced these effects or people who took it in the evenings prior to their bedtime.

Table 4. 4: Knowledge on adverse health effects from energy dinks consumption

Variable	Frequency	Percentage
Is energy drink different from sports drink		
Yes	35	12.4
No	247	87.6
Knowledge on adverse health effects from excessive consumption		
Yes	235	83.3
No	47	16.7
Knowledge on caffeinated beverages		
Yes	203	72.0
No	79	28.0

Knowledge of some adverse health effects		
None	122	35.1
Heart problem	56	16.1
Kidney problem	10	2.9
Liver problem	9	2.6
Sexual weakness	64	18.4
Insomnia	45	13.0
Restlessness	21	6.0
Irritability/Headache	5	1.4
Cancer	10	2.9
Others[a]	6	1.7
Experienced any after effect		
Yes	95	33.7
No	187	66.3
After effect experienced		
Insomnia	45	35.4
nausea	5	4.5
accelerated heartbeat	26	20.5
Irritability/Headache	12	9.5
Restlessness	21	16.5
Sexual weakness	11	8.7
Others[b]	7	5.5

Others[a] represent adverse health effects such as ulcer, sleepiness, high blood sugar, fever and weight loss.

Others[b] represented after effects such as: fever, sleepiness. dizziness and eye pains.

4.6 Logistic Regression of Energy Drinks Usage and Factors That Determines It Among Consumers

It was observed that out of all the factors examined, only gender and educational background of consumers influenced energy drinks consumption, this was because from the statistical table only these two consumer factors had a p-value less than 0.05 (Table 4.5). Male consumers were six times more to consume energy drinks than females and this was obvious with the dominance of male amongst the consumers of energy drink. Consumers with SHS level of education were most likely to consume energy drinks compared to the other levels of education (none, primary, JHS and Tertiary). The odds at which the SHS graduates would consume energy drinks with respect to tertiary graduates was four times more.

Table 4. 5: Logistic regression of energy drink usage against potential covariates

Covariant	O.R.	C.I	P- value
Age			
18-20	1.189	0.323-4.377	0.795
21-30	0.74	0.233-2.352	0.609
31-40	1.763	0.529-5.869	0.356
41-50	2.219	0.534-9.219	0.273
≥51	1	1	
Gender			
Male	6.56	2.856-15.068	0.001*
Female	1	1	
Occupation			
Commercial. driver	0.494	0.139-1.752	0.275
Conductor	0.549	0.141-2.137	0.387

Trader	1.799	0.551-5.870	0.33
Student	2.821	0.861-9.244	0.087
Other	1	1	
Educational background			
Primary	4.763	0.825-27.508	0.081
JHS	3.664	0.762-17.615	0.105
SHS	4.676	1.033-21.182	0.045**
Tertiary	1	1	

*is the significant difference for gender and **is the significant difference for educational background.

O.R is the odds ratio and **C.I** is the confidence interval set at 95%.

4.7 Non-Consumers of Energy Drink Demographics

Among the participants that were non-consumers of energy drinks, the males (59.0 %) were still more than the females (41.0 %) (Table 4.6). The age range of 21 to 30 years (52.6 %) was the dominant age amongst the non-consumers of energy drinks, followed by 18 to 20 years (19.2 %) whiles least age groups were that of 41 to 50 years (10.3 %) and 51 to 60 years (5.1 %) and there was no non-consumer participant above 60 years (Table 4.6). Both, the consumers of energy drink, and the non-consumers also fell within the active working age for most Ghanaians, thus 20 – 40 years (Ntewusu, 2012). Moreover, the lorry stations settings were not suited to the elderly hence the absence of non-consumers above sixty years.

Commercial drivers (29.5 %) and students (27.0 %) were the two predominant occupations among the non-consumers. It was logical to have commercial drivers as the most participants' occupation

due to the study location (a lorry station) (Ntewusu, 2012). Conductors (10.3 %) were fewer since most of the commercial drivers were cab drivers and did not need a conductor to operate.

Traders (20.5 %) being another dominant occupation of the participants was constituted mostly by females (Grieco et al., 1995). (Table 4.6).

Tertiary (33.3 %) and JHS (32.1 %) were the dominant levels of education whiles Primary (14.1 %) was the least among the non-consumers of energy drink as shown in Table 4.6. The greater number of students among the non-consumers in the survey, was due to Circle lorry station being close to IPMC and also being a transport means to get to GIJ. The high number of students was the reason for the high number of non-consumers with tertiary education (33.3 %). (Table 4.6). The number of participants who had a formal education of JHS and above were more than those who do not have any formal education or ended at primary. Among the non-consumers, there were other professions like nurses, journalist and auto mechanics as seen among the consumers of energy drink.

Table 4. 6: Non-consumer demographics

Variable	Frequency	Percentage
Gender		
Male	46	59.0
Female	32	41.0
Age groups		
18-20	15	19.2
21-30	41	52.6
31-40	10	12.8
41-50	8	10.3
51-60	4	5.1

>60	0	0.0
Occupation		
Commercial driver	23	29.5
Conductor	8	10.3
Traders	16	20.5
Students	21	27.0
Others	10	12.8
Educational background		
None	1	1.3
Primary	11	14.1
JHS	25	32.1
SHS	15	19.2
Tertiary	26	33.3

Others represent occupations like electrician, dressmaker, welder, pastor, nurse, journalist and auto mechanic.

4.8 Non-Consumer's Knowledge on Adverse Health Effects of excessive consumption of Energy Drinks

It was observed that about 80% of the non-consumers of energy drinks had no idea on the difference between an energy and sports drink (Table 4.7). Most participants (79.5%) had an idea of the health complications that arises from over consumption of energy drinks, with majority listing insomnia (26.5 %), heart problems (22.6 %), sexual weakness (11.8 %), restlessness (6.9 %), cancer (5.9 %), kidney problems (3.0%), headache (3%) or liver problem (1 %) as some associated health complication. (Table 4.7). Even though, they were not consumers of energy drinks, they knew of the dangers associated with over consumption of energy drinks. The health effects they listed were

similar to what consumers also gave, which meant most of the participants were informed about some adverse effects associated with energy drinks.

Table 4. 7: Adverse health effects of excessive consumption of energy drinks

Variables	Frequency	Percentage
Is energy drink different from sports drink		
Yes	15	19.2
No	63	80.8
Knowledge on adverse health effects from excessive consumption		
Yes	62	79.5
No	16	20.5
Knowledge on caffeinated beverages		
Yes	59	75.7
No	19	24.4
Knowledge of some adverse health effects		
None	19	18.6
Heart problem	23	22.6
Kidney problem	3	3.0
Liver problem	1	1.0
Sexual weakness	12	11.8
Insomnia	27	26.5
Restlessness	7	6.9
Irritability/Headache	3	3.0
Cancer	6	5.9

Others	1	1.0

Others represented adverse health effects such as ulcer, sleepiness, high blood sugar, fever and weight loss

4.9 Non-consumers Awareness of Energy Drink Brands on the market

Even though the non-consumer did not patronize energy drinks, they surely knew of the popular brands available on the Ghanaian markets. From Figure 4.2, Rush energy drink (26 %) was the most popular, followed by 5Star energy drink (15 %), Lucozade (14 %), Storm (14 %), whiles the least were Red Bull energy drink (7 %) and Run energy drink (5 %). Others represented energy drinks such as Rox, Big Boss and Special energy drinks.

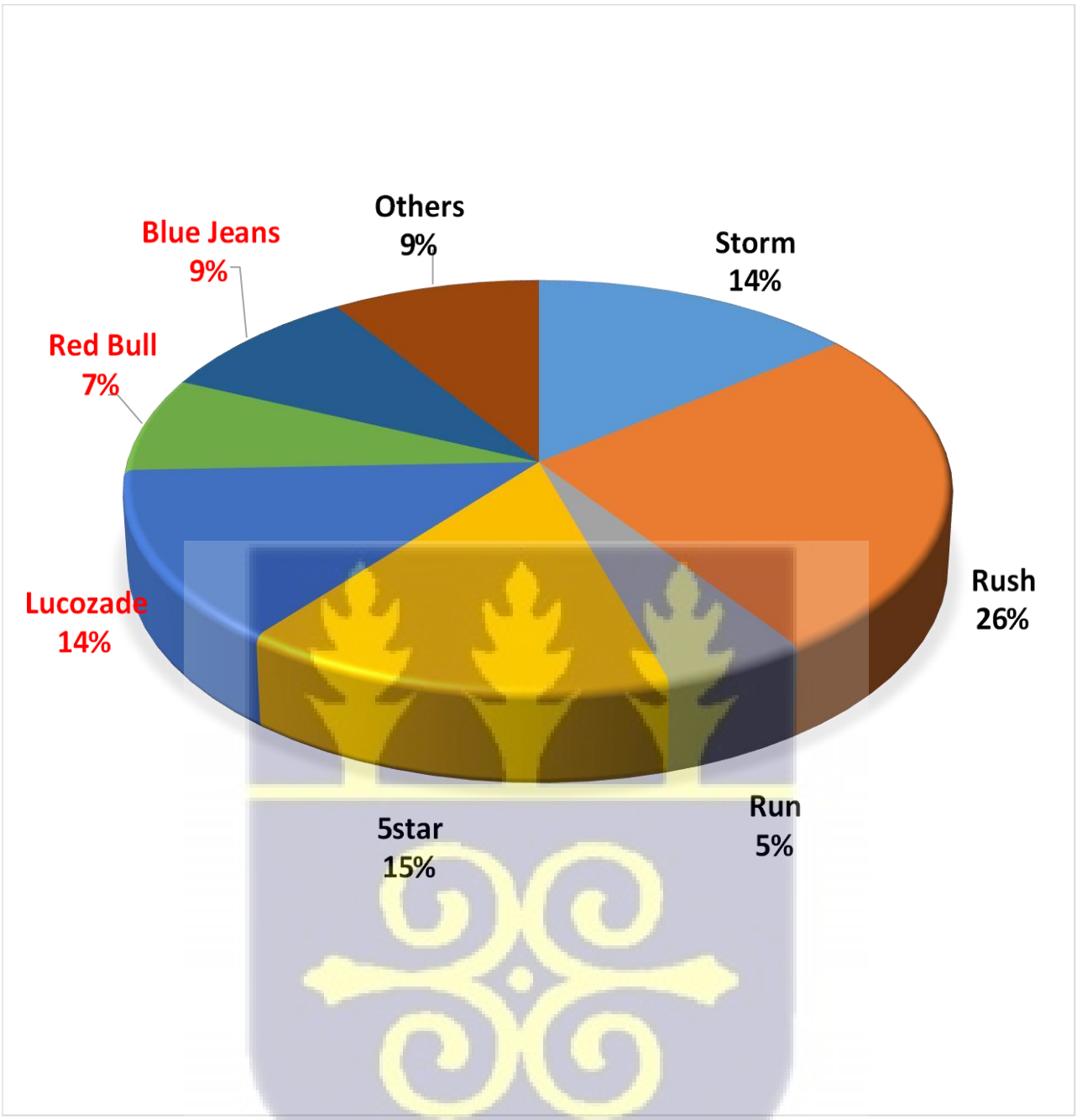


Figure 4. 2: Non-consumers awareness of energy drink brands on the market

4.10 Perception on effects of energy drink between consumers and non-consumers

It was not surprising that consumers were of the opinion that energy drinks were helpful (67.7 %) whereas many non-consumers also perceived energy drinks to be harmful (68.0 %) (Table 4.8). Ideally, no one consumes what they fear or feel could be detrimental to their well-being.

Table 4. 8: Perception on energy drink

	Helpful	Harmful	Indifferent
Consumer	67.7 %	18.8 %	13.5 %
Non consumer	7.7 %	68.0 %	24.4 %

4. 11 Total caffeine per net volume of energy drinks

Caffeine was the most important constituent of the energy drink and the ingredient that provided the consumer with the energy rush found in the drink (Babu et al., 2008). Rush energy drink (340.54 mg/L) had the highest caffeine concentration, followed by Red Bull (314.24 mg/L), Bullet (311.2 mg/L) whiles Lucozade had the least concentration (121.15 mg/L), as shown in Table 4.9. The amount of caffeine in an energy drink is regulated in every country. In Ghana, the Ghana Standards Authority, GSA has set the caffeine standard to be 320 mg/L

Lucozade energy, was the most consumed imported energy drink brand in Ghana among the consumers at lorry stations. Lucozade energy has a long history with Ghanaians prior to the introduction of Rush and other energy drinks produced locally. It had the least caffeine concentration in comparison to the other energy drink brands.

On the basis of conforming to the caffeine concentration standard, all the energy drinks conformed to the 320 mg/L standard set by GSA, except Rush energy drink which was 340.54 mg/L. This observation was worrying because it was the most consumed energy drink at lorry stations in Accra. Generally, the imported energy drinks had higher caffeine concentrations than the local ones. Their caffeine concentrations were above 300 mg/L except Lucozade which was below 150 mg/L.

The local energy drinks were popular and more patronized than the foreign ones because of their price, availability and accessibility. The foreign energy drinks are quite expensive with the least being about GH6 (1.05 $), whereas the local energy drinks were as low as GH2 (0.35 $), which makes them affordable by the average Ghanaian. The local energy drinks are readily sold by hawkers at lorry stations and can be purchased by anyone at any time but the imported energy drinks are sold mostly in big marts and malls, hence their low patronage. People who visited malls and big marts in Ghana are less as compared to those who visit lorry stations and the local markets.

The labels of most of the foreign energy drinks (Red Bull, Bullet and Xploza) had an estimate of the amounts of caffeine present therefore, the consumer knows the amount of caffeine he/she is taking into their system but the labels of the local energy drinks just listed the constituents without an estimate of the amount of caffeine present. Also, messages about the risks and potential undesirable effects associated with energy drink use are rarely embossed on their labels or mentioned in the ads promoting local energy drinks.

The caffeine concentrations of the energy drinks were significantly different ($p<0.05$) from each other except Xploza and Storm, which were not. Rush had the highest ($p<0.05$) caffeine content of 340.54 mg/L while Lucozade had the least caffeine content ($p<0.05$) of 121.15 mg/L.

Table 4. 9: Caffeine concentration of energy drinks

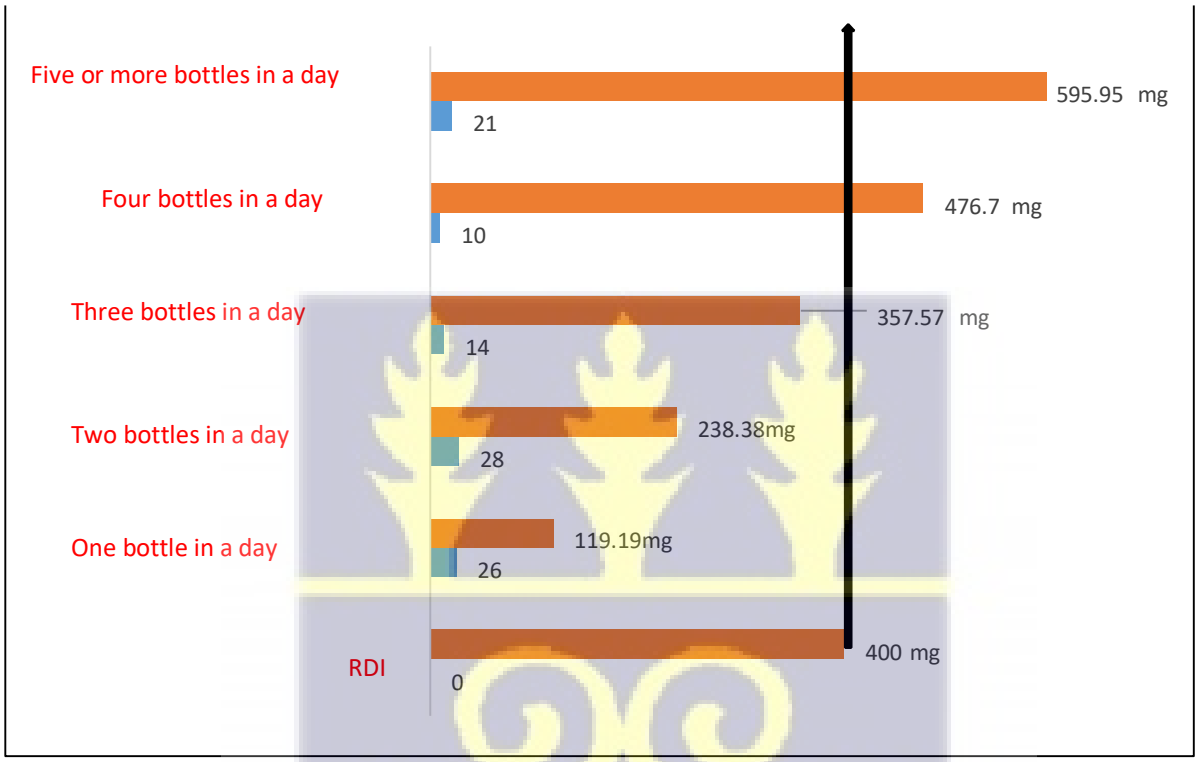
Energy drink	Net volume (ml)	Total caffeine concentration (mg/L)
Red Bull	250	314.24 ± 0.72^{B}
Bullet	250	311.20 ± 0.81^{C}
Xploza	250	308.88 ± 0.90^{D}
Lucozade	330	121.15 ± 0.62^{H}
Storm	500	308.94 ± 0.25^{D}
Rush	350	340.54 ± 0.70^{A}
Run	500	292.50 ± 0.48^{F}
5Star	350	241.03 ± 0.22^{G}
BigBoss	350	296.56 ± 1.49^{E}

Means with different letters are significantly different at the level of $p \leq 0.05$.

4.12 Recommended Daily Intake Versus Daily Consumption of Energy Drinks (Caffeine)

The daily intake of caffeine that is considered safe should not exceed 400 mg (Reissig et al., 2009)). The figures below (figure 4.3, 4.4, 4.5 & 4.6), represented average number of bottles consumed in relation to the recommended daily intake, so as to assess how many bottles a consumer will consume to be at risk of experiencing adverse health effects from excessive consumption of caffeine in energy drinks. The four most consumed energy drinks from the survey were: Rush, Storm, 5Star and Lucozade energy.

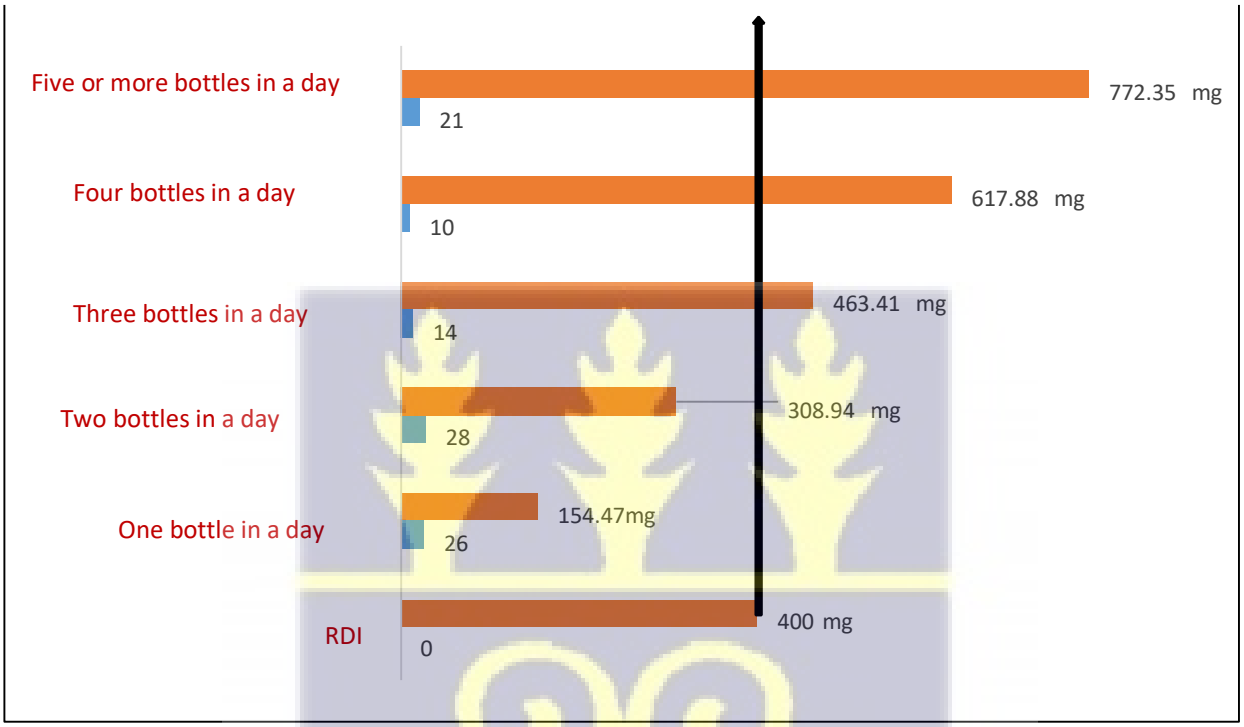
For Rush energy drink, consumers who took four bottles or more in a day were at risk but those who took three bottles or less were not with respect to the recommended daily intake of caffeine.



The daily intake of the consumers were the orange bars and the blue bars represented the number of consumers who took that amount of bottles in a day.

Figure 4. 3: Daily consumption of Rush energy drink (caffeine)

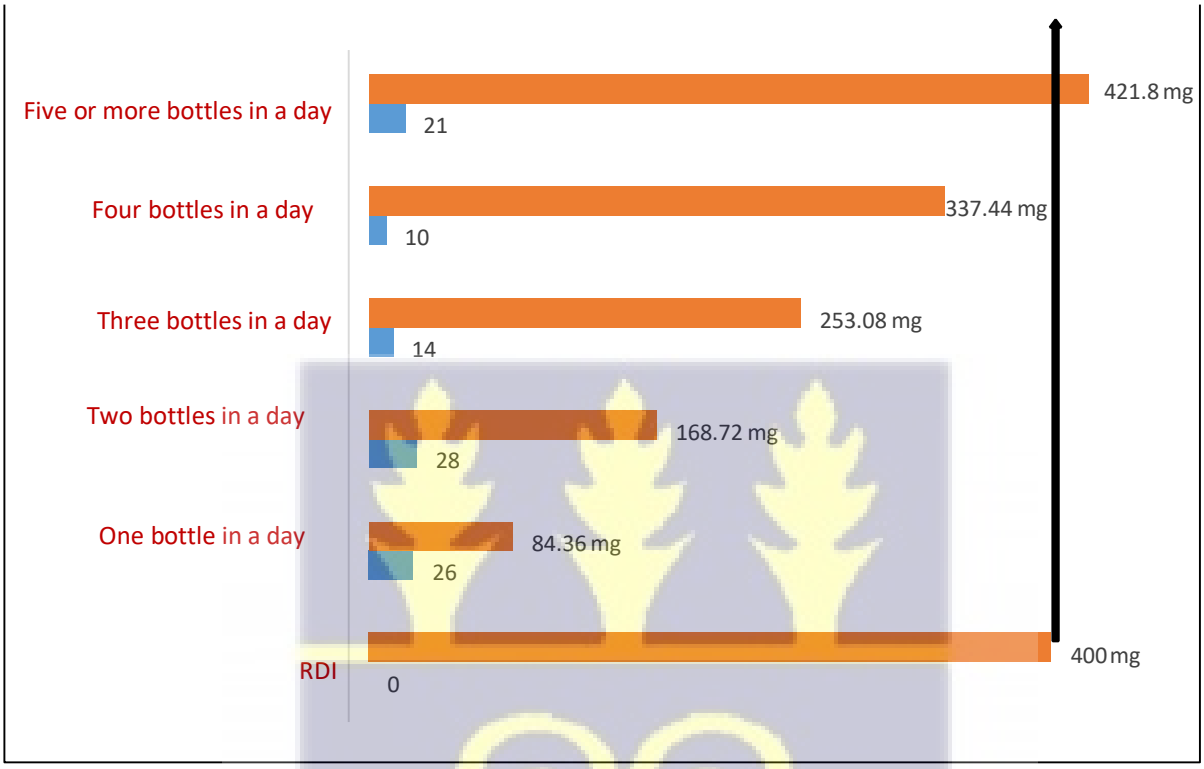
For Storm energy drink, consumers who took three bottles or more in a day were at risk of experiencing adverse effects from caffeine consumption whereas those who took two bottles or less were not.



The daily intake of the consumers were the orange bars and the blue bars represented the number of consumers who took that amount of bottles in a day.

Figure 4. 4: Daily consumption of Storm energy drink (caffeine)

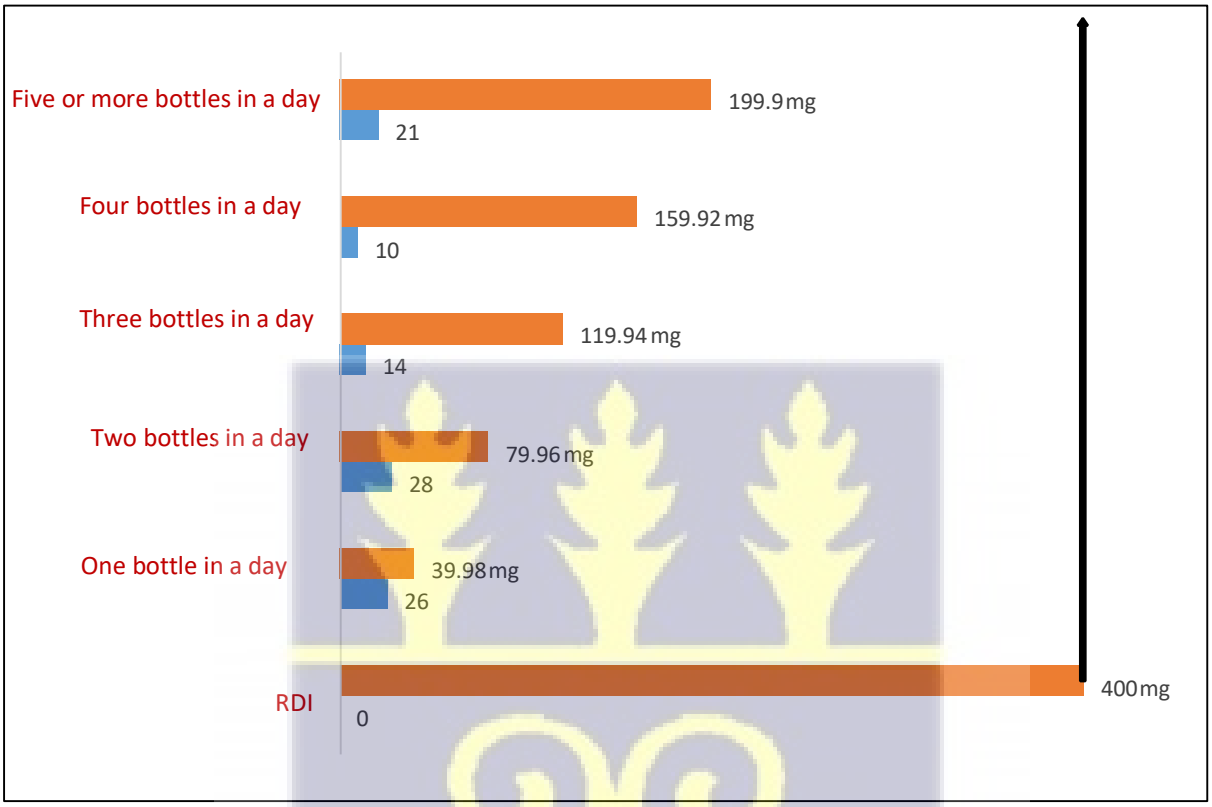
For those who took 5Star energy drink, the consumer would not be at risk unless he takes five or more bottles in a day.



The daily intake of the consumers were the orange bars and the blue bars represented the number of consumers who took that amount of bottles in a day.

Figure 4. 5: Daily consumption of 5star energy drink (caffeine)

In the case of Lucozade energy consumers would be at risk should he/she take ten cans or more in a day. However, from the survey no consumer took ten bottles or cans in a day.



The daily intake of the consumers were the orange bars and the blue bars represented the number of consumers who took that amount of bottles in a day.

Figure 4. 6: Daily consumption of Lucozade energy (caffeine)

4.13 Total sugar content of energy drinks

Energy drinks fall under the category of soft drinks; therefore, they contain added sugars and sweeteners. Rush energy drink (114 g/L) had the highest sugar concentration, followed by Bullet (113 g/L), Run (112 g/L) whilst Storm (75 g/L) had the least, as seen in Table 4.10.

There is no regulation on the sugar content of soft drinks, therefore a manufacturer is not restricted to the amount of sugar to be added into a soft drink. The energy drinks produced here in Ghana, had relatively higher sugar concentrations in comparison to the imported energy drinks. the American Heart Association recommends a daily intake 150 calories or 37 g or 9 teaspoons of added sugars per day for men whereas 100 calories or 25 g or 6 teaspoons for women. Daily added sugar consumption within the recommended intakes prevents or minimizes the chances of a consumer suffering from effects of excessive consumption of added sugars (Feely, 2012). The imported energy drinks were rarely patronized by the consumers at lorry stations, therefore the high sugar concentrations of the local energy drinks were a concern since most of the energy drinks exceeded the safe daily sugar concentration of 37 g, with the exception of 5Star energy drink (Feely, 2012).

Rush energy drink was the most patronized energy drink among the consumers at the lorry stations and also contained high amounts of sugar. In spite of Storm energy drink having a bigger net volume than Rush, Rush energy drink contained more sugar than Storm energy drink which is a bit of a safety concern. The only local energy drink with a sugar concentration below the added sugar safety limit for men is 5Star energy drink, but some consumers even took three or four bottles in a day which could make them experience certain adverse effects like diabetes type 2 and high blood pressure.

Lucozade energy had a smaller concentration of sugar despite its larger volume. Among the imported energy drinks Lucozade was the most consumed and its sugar content been within the safe daily levels meant consumers might not experience adverse health effects associated with excessive sugar consumption.

The sugar concentrations of the energy drinks were significantly different from each other as shown in Table 4.10 below. The sugar concentrations of Red bull, Bullet, Rush and Run were significantly higher than that of the other energy drinks analysed in the study while Storm had the lowest sugar content ($p \leq 0.05$).

Table 4. 10: Total sugar concentration of energy drinks

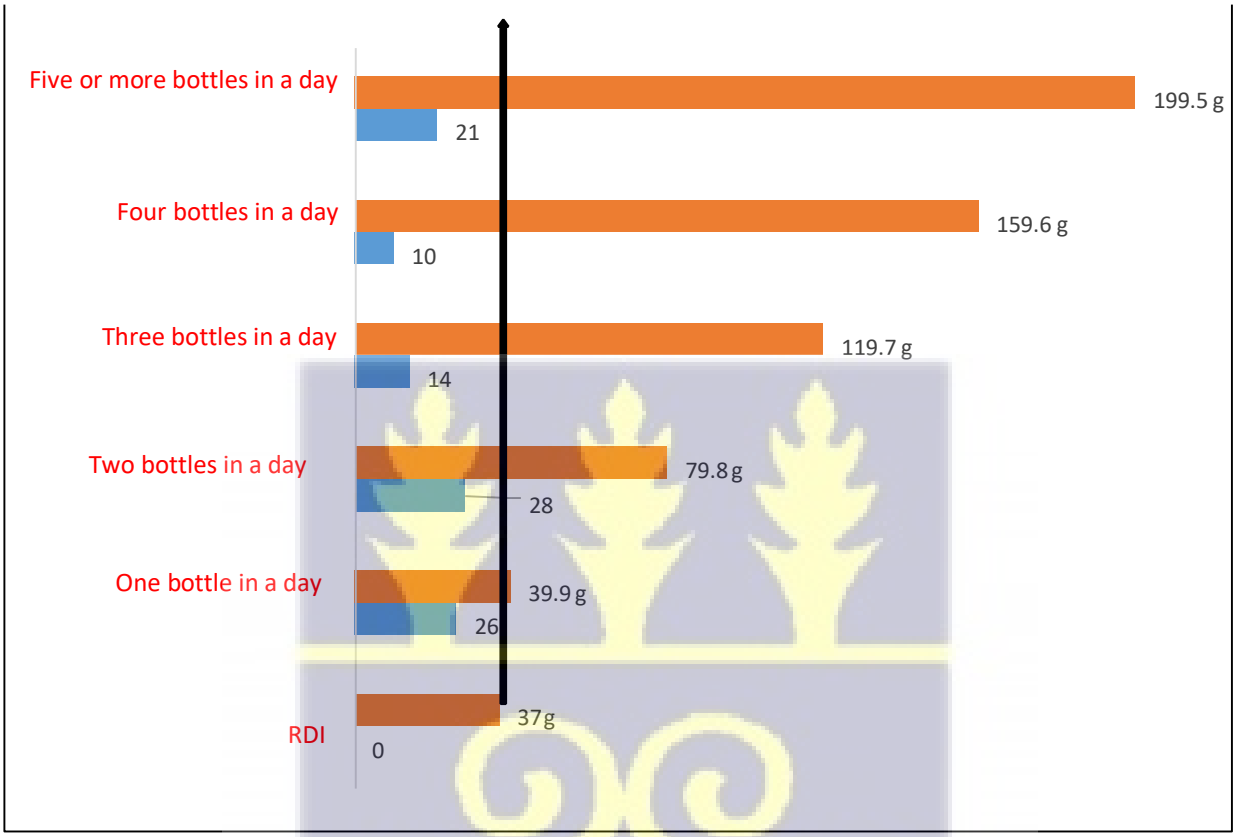
Energy drink sample	Net volume of energy drink (ml)	Total sugar concentration(g/L)
Red bull	250	111.00 ± 1.00^{AB}
Bullet	250	113.00 ± 2.55^{AB}
Xploza	250	110.00 ± 0.95^{B}
Lucozade	330	89.00 ± 1.58^{D}
Storm	500	75.00 ± 2.12^{E}
Rush	350	114.00 ± 1.94^{A}
Run	500	112.00 ± 2.07^{AB}
5Star	350	100.00 ± 2.08^{C}
BigBoss	350	110.00 ± 2.05^{B}

Means with different letters are significantly different at the level of $p \leq 0.05$

4.14 Recommended Daily Intake Versus Daily Consumption of Energy Drinks (Sugar)

The maximum amount of added sugars that is considered safe to consume daily by men are 37 g or 9 teaspoons and 25 g or 6 teaspoons for females by American Heart Association (AHA). From the added sugar consumption limit for a day, most of the consumers of energy drinks are at risk of adverse health effects from excessive consumption of added sugars. Figures (4.7, 4.8, 4.9 & 4.10) represented the recommended daily intake of sugar against the daily consumption of energy drinks by consumers at lorry stations that can evoke health issues such as type 2 diabetes, high blood pressure and inflammation with relation to the sugars present in them. The four most consumed brands were used.

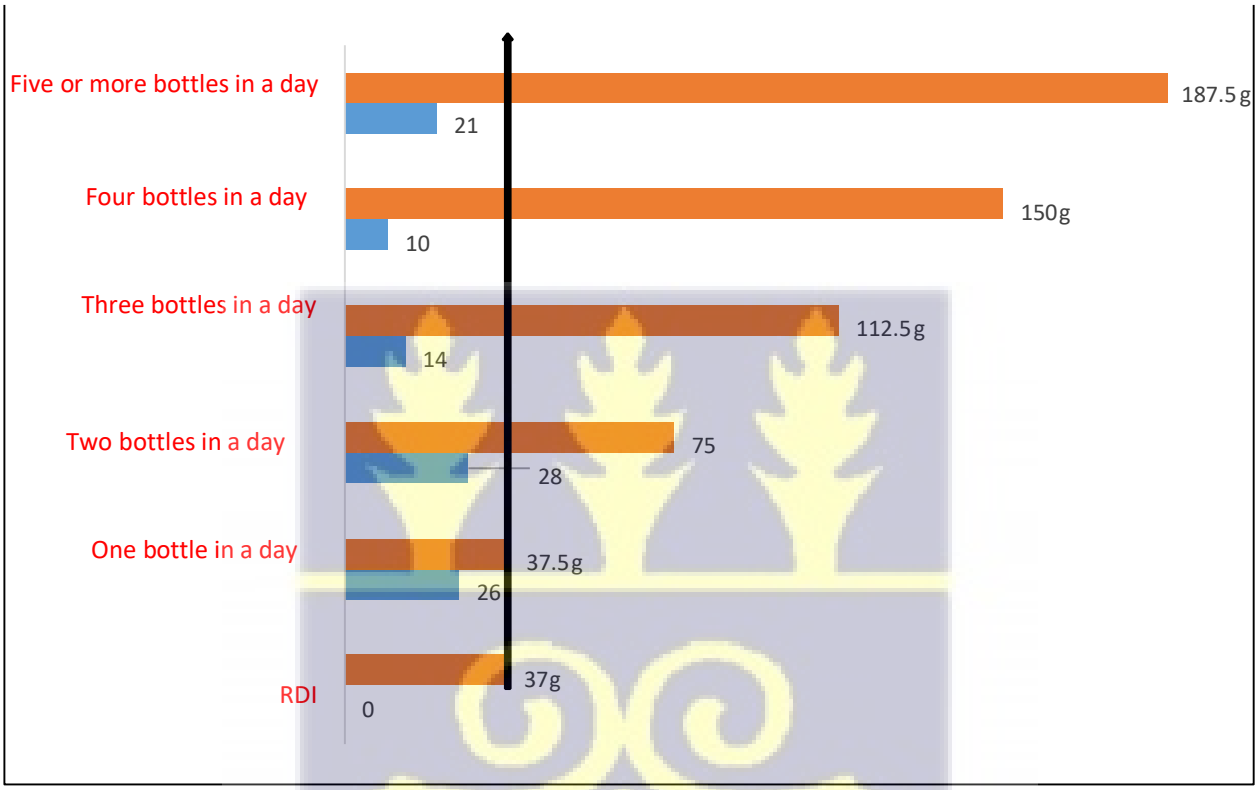
Consumers of Rush energy drink who drank just one bottle or more in a day were at risk of experiencing health issues related to excessive sugar consumption.



The daily intake of the consumers were the orange bars and the blue bars represented the number of consumers who took that amount of bottles in a day.

Figure 4. 7: Daily consumption of Rush energy drink (sugar)

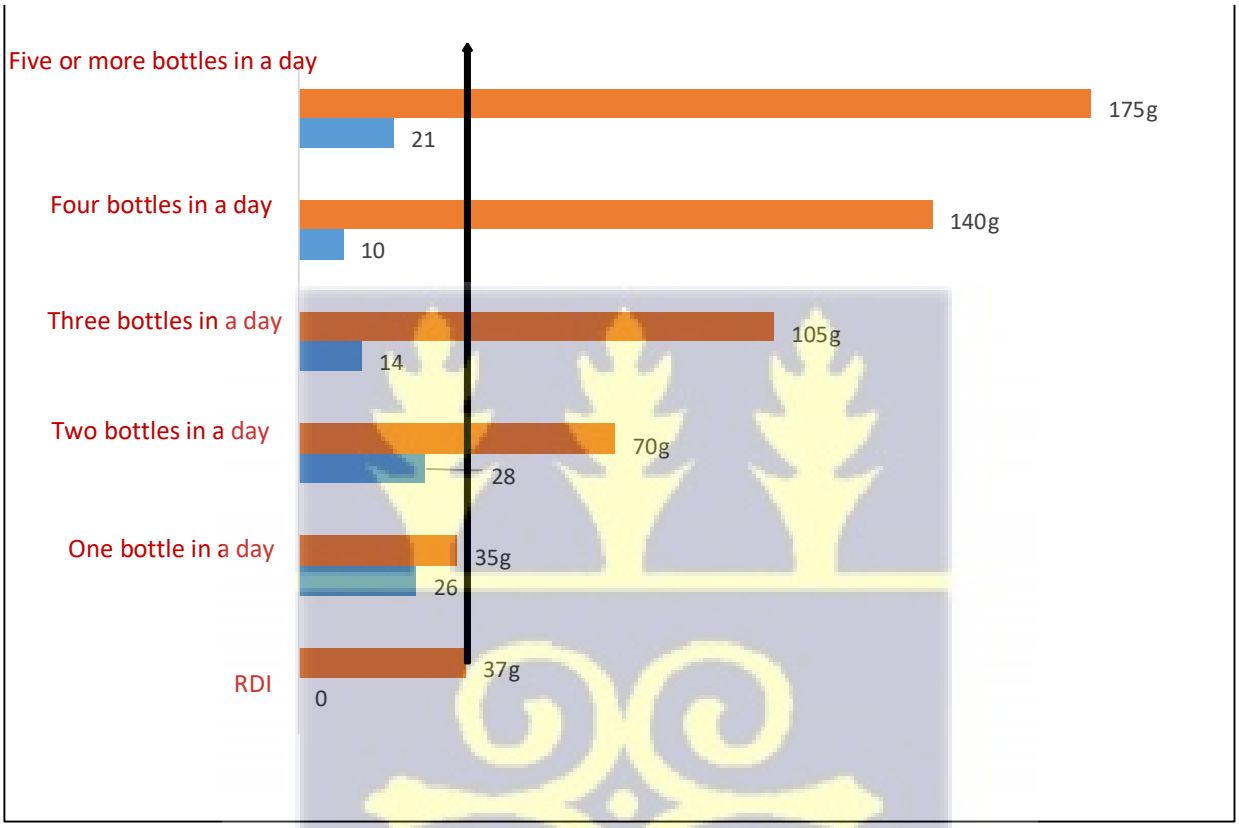
For Storm energy, a consumer could experience adverse health effects in terms of the sugar concentration after consumption of more than one bottle.



The daily intake of the consumers were the orange bars and the blue bars represented the number of consumers who took that amount of bottles in a day.

Figure 4. 8: Daily consumption of Storm energy drink (sugar)

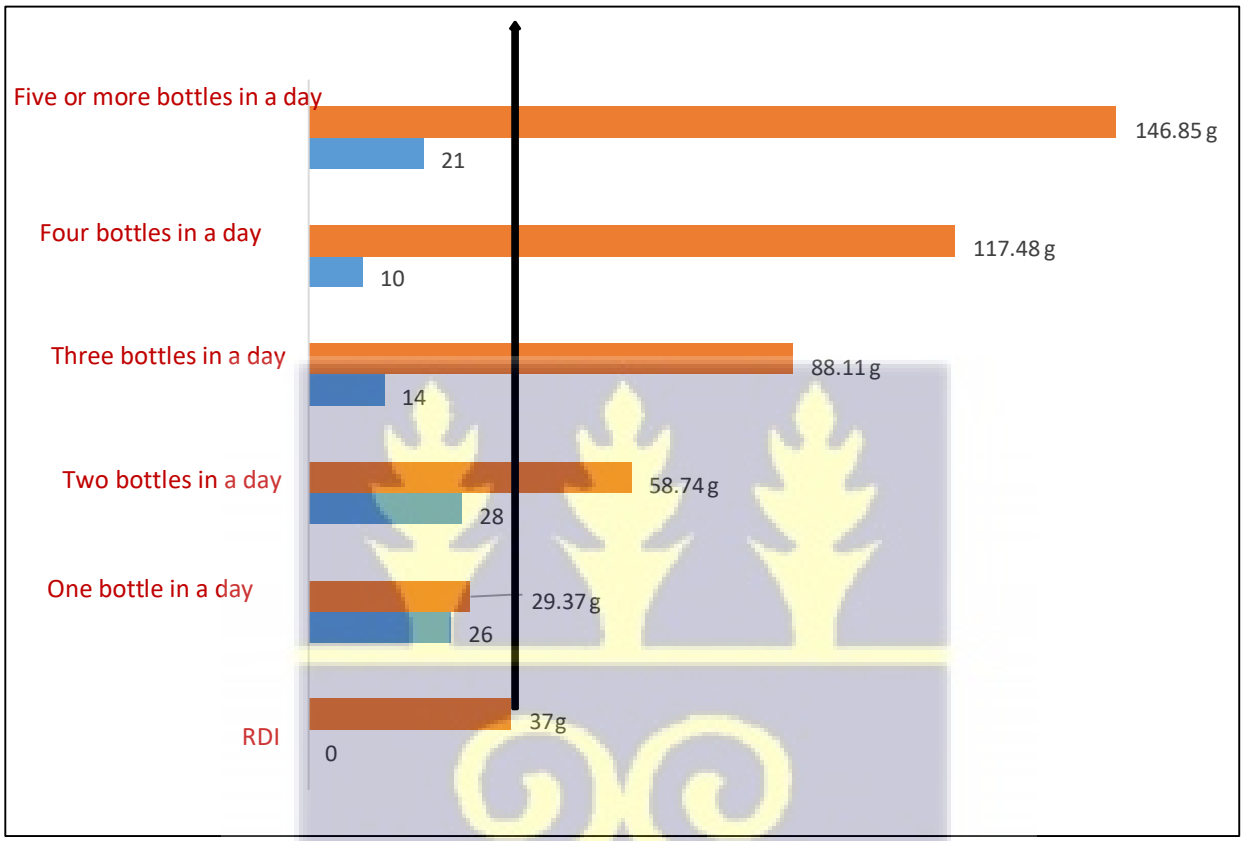
For 5Star energy drink, consumers who did not exceed a bottle per day were not at risk but those who took more than one bottle were at risk of health issues relating to excessive consumption of sugar.



The daily intake of the consumers were the orange bars and the blue bars represented the number of consumers who took that amount of bottles in a day.

Figure 4. 9: Daily consumption of 5Star energy drink (sugar)

Consumers who took two cans or more of Lucozade energy were all at risk of evoking adverse health effects relating from excessive consumption of sugar.



The daily intake of the consumers were the orange bars and the blue bars represented the number of consumers who took that amount of bottles in a day.

Figure 4. 10: Daily consumption of Lucozade energy (sugar)

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.0 Conclusion

Energy drink consumption is highly prevalent at lorry stations in Accra and majority of the consumers drunk energy drinks to work for longer hours to prevent being fatigued easily.

Most of the consumers took averagely one to two bottles in a week, majority took them in the afternoons and few of them mixed it with alcohol or water. Most of the consumers at the lorry stations consumed the energy drinks alone.

The consumers of energy drinks, perceived them to be helpful due to how they benefited from them whereas the non-consumers who have heard of complications associated with consumption of energy drinks perceived them to be harmful to their health.

In spite of the consumption rate of energy drinks being excessive by consumers at the lorry stations, there were few consumers who experienced an after effect and most of them experienced insomnia and accelerated heartbeat.

The caffeine content of the local energy drinks was more than that of the imported ones. The local energy drinks also contained much sugars than the imported energy drinks.

5.1 Recommendation

1. Local manufacturers of energy drinks should decrease the sugar and caffeine content in the drinks since they are relatively high and its consumed a lot especially by the youth.

2. Regulatory agencies in Ghana, must make it mandatory for caffeine content and indications of possible risk from excessive consumption to be printed on labels of energy drinks produced locally.
3. The Ghana FDA should conduct regular checks to make sure the energy drinks contain the required amount of caffeine permitted by GSA.
4. An awareness should be created among energy drink consumers at lorry stations on the negative effects of excessive consumption of energy drinks.
5. Energy drink consumers especially the youth, should be educated on the dangers associated with mixing energy drinks with alcohol.

REFERENCES

Abourashed, E. A., Mossa, J. S. (2004). HPTLC determination of caffeine in stimulant herbal products and power drinks. J Pharm Biomed Anal. 36:617–620.

Agbazue, V. E., Ibezim, A. and Ekere, N. R. (2014). Assessment of sugar levels in different soft drinks, *Int. J. Chem. Sci.:* 12(2), 327-334.

Agriculture and Agri-Food Canada. (2008). The Energy Drink Segment in North America. Available from: <http://www.ats.agr.gc.ca/us/4387_e.html. (17th july, 2022)

Alsunni, A. A. (2015). Energy drink consumption: Beneficial and adverse health effects. International Journal of Health Science, Vol .9, pp .468 –474 https://doi.org/10.12816/0031237.

Alsunnsi, A. A., and Badar, A. (2011). Energy drinks consumption patterns, perceived benefits and associated adverse effects amongst students of University of Dammam, Saudi Arab J Ayub Med Coll Abottabad. 23(3): 3-9.

Ba, A. (2008). Metabolic and structural role of thiamine in nervous tissues. Cell Mol Neurobiol. 28(7):923-931.

Babu, K. M., Church, R. J., & Lewander, W. (2008). Energy Drinks: The New Eye-Opener for Adolescents. Clinical Pediatric Emergency Medicine, 9(1), 35–42. https://doi.org/10.1016/j.cpem.2007.12.002.

Bahrke, M.S., Morgan, W.P., Stegner, A. (2009). Is ginseng an ergogenic aid? Int J Sport Nutr Exerc Metab. 19(3):298-322.Balla, T. (2009). Regulation of Ca2+ entry by inositol lipids in mammalian cells by multiple mechanisms. Cell Calcium. 45(6):527-534.

Ballard, S.L., Wellborn-Kim J.J., Clauson, K.A. (2010). Effects of Commercial Energy Drink Consumption on Athletic Performance and Body Composition. Phys Sportsmed. 38(1):107-117.

Breda, J. J., Whiting, S. H., Encarnação, R., Norberg, S., Jones, R., Reinap, M., & Jewell, J. (2014). Energy drink consumption in Europe: A review of the risks, adverse health effects, and policy options to respond. Frontiers in Public Health, Vol. 2, pp. 1–5. https://doi.org/10.3389/fpubh.2014.00134.

Brosnan, J.T., and Brosnan, M.E. (2006). The sulfur-containing amino acids:an overview.J Nutr 136 (6 Suppl):1636S–40S.

Bruzell, E. M., Granum, B., & Rohloff, J. (2018). Protocol for the risk assessment of energy drinks and caffeine. Nordic Institute of Dental Material.

Buxton, C., & Hagan, J. E. (2012). A survey of energy drinks consumption practices among student -athletes in Ghana: Lessons for developing health education intervention programmes. Journal of the International Society of Sports Nutrition, 9(1), 9. ttps://doi.org/10.1186/1550-2783-9-9.

Clauson, K.A., Shields, K.M., McQueen, C.E., Persad, N. (2008). Safety issues associated with commercially available energy drinks. J Am Pharm Assoc. 48(3): e55-e63.

Coon, J.T., Ernst, E. (2002). Panax ginseng: a systematic review of adverse effects and drug interactions. Drug Saf. 25:323-44.

Crowe, S., Barot, J., Caldow, S., d'Aspromonte, J., Dell'Orso, J, Di Clemente, A. (2011). The effect of caffeine and stress on auditory hallucinations in a non-clinical sample. Personality and Individual Differences. 2011;50(5):626-630.

Depeint, F., Bruce, W.R., Shangari, N., Mehta, R., and O'Brien, P.J. (2006). Mitochondrial function and toxicity: role of the B vitamin family on mitochondrial energy metabolism. Chem BBiol Interact. 163(1-2):94-112.

Diepvens, K., Westerterp, K.R., and Westerterp-Plantenga, M.S. (2007). Obesity and thermogenesis related to the consumption of caffeine, ephedrine, capsaicin, and green tea. AmJ Physiol Regul Integr Comp Physiol 292: R77–R85.

Doherty, M. and Smith, P.M. (2004). Effects of caffeine ingestion on exercise testing: A meta-analysis. Int J Sport Nutr Exerc Metab 14: 626–646.

el-Sayed, M.S., MacLaren, D., Rattu, A.J. (1997). Exogenous Carbohydrate Utilisation: Effects on Metabolism and Exercise Performance. Comp Biochem Physiol Physiol. 1118(3):789-803.

Espinosa, J.C., Sobrino, M.F. (2015). Caffeine and headache: specific remarks. Neurologia (Barcelona, Spain). Current neuropharmacology 13 (1), 71-88.

Feely, M. (2011). The Health Dangers of Energy Drinks. Irish medical news 20, Retrieved from: www.imn.ie/clinical/clinical-focus/3691-the-health-dangers-of-energy-drinks

Finnegan, D. (2003). The health effects of stimulant drinks. Br Nutr Found Nut Bull 28:147–55.

Fouracre, P., Kwakye, E., Okyere, J. and Silcock, D. (1994). Public transport in Ghanaian cities a case of union power. Transport Reviews, 14(1) pp 45-61.

Garcia, M. (2013). caffeine risk assessment on nordic children. In Journal of Chemical Information and Modeling (Vol. 53). https://doi.org/10.1017/CBO9781107415324.004

Graham, T., and Graham, T. E. (2014). Caffeine and Exercise Metabolism, Endurance and Performance. (November). Journal of Applied Physiology.

Greene, E., Oman, K., Lefler, M. (2014). Energy Drink– Induced Acute Kidney Injury. Annals of Pharmacotherapy. 48(10):1366-1370.

Greenwood, D.C., Alwan, N., Boylan, S., Cade, J.E., Charvill, J., Chipps, K.C. (2010). Caffeine intake during pregnancy, late miscarriage and stillbirth. Eur J Epidemiol. 25(4):275–80. doi:10.1007/s10654-010-9443-7

Hackman, R.M., Havel, P.J., Schwartz, H.J., Rutledge, J.C., Watnik, M.R., Noceti, E.M., Stohs, S.J., Stern, J.S., and Keen, C.L. (2006). Multinutrient supplement containing ephedra and caffeine causes weight loss and improves metabolic risk factors in obese women: A randomized controlled trial. Int J Obes (Lond) 30: 1545–1556.

Heckman, M. A., Sherry, K., and de Mejia, E. G. (2010). Energy drinks: An assessment of their market size, consumer demographics, ingredient profile, functionality, and regulations in the United States. Comprehensive Reviews in Food Science and Food Safety, 9(3), 303–317. https://doi.org/10.1111/j.1541-4337.2010.00111.x.

Higgins, J. P., Ms, T. D. T., Higgins, C. L., & Exsc, B. (2010). Energy Beverages: Content and Safety. Mayo Clinic Proceedings, 85(11), 1033–1041. https://doi.org/10.4065/mcp.2010.0381

Heird, W.C. (2004). Taurine in neonatal nutrition-revisited. Arch Dis Child Fetal Neonatal Ed. 84: F473-4.

Hendler, S.S., Rorvik, D. (2001). PDR for nutritional supplements. Montvale, N.J.: Medical Economics Company:442–5.

Hoffman, J.R., Kang, J., Ratamess, N.A., Rashti, S.L., and Faigenbaum, A.D. (2008). Thermogenic effect of a high energy, pre-exercise supplement. Kinesiology 40: 207–213.

Hoffman, J.R., Kang, J., Ratamess, N.A., Hoffman, M.W., Tranchina, C.P., and Faigenbaum, A.D. (2009). Examination of a high energy, pre-exercise supplement on exercise performance. J Int Soc Sports Nutr 6:2.

Hoffman, J. R. (2010). Caffeine and energy drinks. Strength and Conditioning Journal, 32(1), 15–20. https://doi.org/10.1519/SSC.0b013e3181bdafa0.

Hoyte, C.O., Albert, D., Heard, K.J. (2013). The Use of Energy Drinks, Dietary Supplements and Prescription Medications by United States College Students to Enhance Athletic Performance. J Commun Health. 38(3):575-80.

Hulston, C.J., and Jeukendrup A.E. (2008). Substrate metabolism and exercise performance with caffeine and carbohydrate intake. Med Sci Sports Exerc. 40:2096– 2104.

Jiang, W., Wu, Y., and Jiang, X. (2013). Coffee and Caffeine Intake and Breast Cancer Risk: An Updated Dose-Response Meta-Analysis of 37published studies. Gynecol Oncol 129:620–629.

Khan, S.R., Cottler, L.B., Striley, C.W. (2016). Correlates of Use of Alcohol Mixed with Energy Drinks Among Youth Across 10 US Metropolitan Areas. Drug Alcohol Depend. 163, 236–241.

Kjellstorm T, Holmer I, Lemke, B. (2015). Workshop heat stress, Health and Productivity: Increasing challenge for low- and middle-income countries during climate change.

Kristjansson, A.L., Sigfusdottir, I.D., Frost, S.S. & James, J.E. (2013). Adolescent caffeine consumption and self-reported violence and conduct disorder. Journal of youth and adolescence. 42(7):1053-1062.

Lakshmi, A.V. (1998). Riboflavin metabolism–relevance to human nutrition. Indian J Med Res. 108(1):182-190.

Lima, W.P., Carnevali, L.C., Eder, R., Fernando, L., Costa Rosa, B.P., Bacchi, E.M., Seelaender, M.C.L. (2005). Lipid metabolism in trained rats: effect of guarana (Paullinia cupana Mart) supplementation. Clin Nutr 24:1019–28.

Loureiro, M.L, Gracia, A., and Nayga, Jr. R.M. (2006). Do Consumers Value Nutritional Labels? European Review of Agricultural Economics Vol 33 (2) (2006) pp. 249–268.

Mattei, R., Dias, R.F., Espinola, E.B. (1998). Guarana (Paullinia cupana): Toxicbehavioral effects in laboratory animals and antioxidant activity in vitro. J Ethnopharmacol. 60:111–116.

McCusker, R.R., Goldberger, B.A. & Cone, E.J. (2006). Caffeine content of energy drinks, carbonated sodas, and other beverages. J Anal Toxicol. 30:112–4.

McLellan, T. M., & Lieberman, H. R. (2012). Do energy drinks contain active components other than caffeine? Nutrition Reviews, 70(12), 730–744. https://doi.org/10.1111/j.1753 4887.2012.00525 .x.

Miura, K., Hughes, M.C., Green, A.C., van der Pols, J.C. (2014). Caffeine Intake and Risk of Basal Cell and Squamous Cell Carcinomas of the Skin in an 11-Year Prospective Study. Eur J Nutr 53:511–520.

Munro, I.C., Renwick, A.G. (2006). The 5th workshop on the assessment of adequate intake of dietary amino acids: general discussion 2. J Nutr 136:1755S–7S.

Naik, J. P. (2001). Imporoved high-performance liquid chromatography method to determine theobromine and caffeine in cocoa and cocoa products. *J. Agric. Food Chem.* **49:** 6579–83.

Nordqvist, C. (2007). French ban on Red Bull (drink) upheld by European Court. Accessed at www.medicalnewstoday.com/ articles/5753.php. (27th July, 2022).

Ntewusu, Samuel A. 2012. Settling in and Holding On: a socio-economic history of northern traders and transporters in Accra's Tudu: 1908–2008. Leiden: African Studies Center.

Overå, Ragnhild. (2007). "When men do women's work: structural adjustment, unemployment and changing gender relations in the informal economy of Accra, Ghana." Journal of Modern African Studies 45 (4): 539–563.

Patil, P. N (2012). Caffeine in various samples and their analysis with HPLC—a review. Int J Pharm Sci Rev Res 16(2):76–83

Pedersen, D.J., Lessard, S.J., Coffey, V.G. (2008). High rates of muscle glycogen resynthesis after exhaustive exercise when carbohydrate is co-ingested with caffeine. J Appl Physiol. 105:7–13.

Pommerening, M.J., Cardenas, J.C., Radwan, Z.A., Wade, C.E., Holcomb, J.B., Cotton, B.A. (2015). Hypercoagulability after energy drink consumption. Journal of Surgical Research. 199 (2), 635-640.

Ratamess, N.A., Hoffman J.R., Ross R., Shanklin M., Faigenbaum A.D., and Kang J. (2007). Effects of an amino acid/creatine/energy supplement on performance and the acute hormonal response to resistance exercise. Int J Sport Nutr Exerc Metab 17: 608–623.

Reay, J.L., Kennedy, D.O., and Scholey, A.B. (2005). Single doses of Panax ginseng (G115) reduce blood glucose levels and improve cognitive performance during sustained mental activity. J Psychopharmacol 19:357–65.

Reid, J. L., McCrory, C., White, C. M., Martineau, C., Vanderkooy, P., Fenton, N., & Hammond, D. (2017). Consumption of Caffeinated Energy Drinks Among Youth and Young Adults in Canada. In Preventive Medicine Reports (Vol. 5). https://doi.org/10.1016/j.pmedr.2016.11.012

Reid, S. D., Ramsarran, J., Brathwaite, R., Lyman, S., Baker, A., Cornish, D. C., & Thapelo, C. K. (2015). Energy drink usage among university students in a Caribbean country: Patterns of use and adverse effects. In Journal of Epidemiology and Global Health (Vol. 5). https://doi.org/10.1016/j.jegh.2014.05.004.

Reissig, C.J.,Strain, E.C.,Griffiths, R.R. (2009). Caffeinated energy drinks – a growing problem. Drug Alcohol Depend. 99(1–3):1–10.doi: 10.1016/j.drugalcdep.2008. 08.001.

Riesenhuber, A., Boehm, M., Posch, M., and Aufricht, C. (2006). Diuretic Potential of Energy Drinks. Amino Acids. 31(1):81-3.

Reynolds, G. (2010).: Phys Ed: Do Energy Drinks Improve Athletic Performance? The New York Times. Retrieved fromhttp://well.blogs.nytimes.com/2010/12/08/phys-ed-do-energy-drinks improve-athletic-performance/.(8th, October, 2022).

Sauve, A.A. (2008). NAD+ and vitamin B3: from metabolism to therapies. J Pharmacol Exp Ther. 324(3):883-893.

Scholey, A., and Haskell, C. (2008). Neurocognitive effects of guarana plant extract. Drugs Future 33:869–74.

Schuller- Levis, G.B., and Park, E. (2003). Taurine: New Implications for an Old Amino Acid. FEMS Microbiol Lett. 226:195-202.

Shao, A., Hathcock, J.N. (2008). Risk assessment for the amino acids taurine, L-glutamine and L-arginine. Regul Toxicol Pharmacol 50:376–99.

Smit, H.J., & Rogers, P.J. (2002). Effects of 'energy'drinks on mood and mental performance: critical methodology. Food quality and preference. 13(5):317326.

Smith, N., Atroch, A.L. (2007). Guaraná's journey from regional tonic to aphrodisiac and global energy drink. Evid Based Complement Alternat Med. 5(10):5.

Spinneker, A., Sola, R., Lemmen, V., Castillo, M.J., Pietrzik, K., GonzalezGross, M. (2007). Vitamin B6 status, deficiency and its consequences—an overview. Nutr Hosp. 22(1):7-2 4.

Srdjenovic, B., Djordjevic-Milic, V., Grujic, N., Injac, R., & Lepojevic, Z. (2008). Simultaneous HPLC determination of caffeine, theobromine, and theophylline in food, drinks, and herbal products. In Journal of Chromatographic Science (Vol. 46). https://doi.org/10.1093/chromsci/46.2.144,

Tappy, L., Lê K.A., Tran C., Paquot, N. (2010). Fructose and metabolic diseases: new findings, new questions. Nutrition. doi: 10.1016/j.nut.

Wardlaw, G.M., Smith, A.M. (2009). Contemporary nutrition a functional approach. New York: McGraw-Hill.

Wilson, M. N., Cumming, T., Burkhalter, R., Langille, D. B., Ogilvie, R., & Asbridge, M. (2018). Driving under the influence behaviours among high school students who mix alcohol with energy drinks. In Preventive Medicine (Vol. 111). https://doi.org/10.1016/j.ypmed.2017.11.035.

Yeboah, Ian E. A. 2000. "Structural adjustment and emerging urban form in Accra, Ghana." Africa Today 47 (2): 61–89.

Zucconi, S., Volpato, C., Adinolfi, F., Gandini, E., Gentile, E., Loi, A. (2013). Gathering Consumption Data on Specific Consumer Groups of Energy Drinks. EFSA Supporting Publications 10 (3), 394E.

APPENDIX I

CONSENT FORM

Title: Energy Drinks Consumption Patterns at Lorry Stations in Accra and Concentration of their Main Constituents

Student Investigator: Nana Yankson Chris Oscar, MPhil Food Science (Part II).

Address: Department of Nutrition and Food Science, University of Ghana, Legon Tel: 0273964122, Email; conana_yankson@st.ug.edu.gh

Supervisor: Prof. Firibu Kwesi Saalia, Department of Nutrition and Food Science, University of Ghana, Legon,0243125566, fsaalia@ug.edu.gh

Section B– CONSENT TO PARTICIPATE IN RESEARCH

General Information about Research

Energy drinks are soft drinks that contain certain ingredients that are believed to improve physical and mental performance. Energy drinks make the consumer stay sharp and alert to work for many hours without feeling tired. Energy drinks are composed of caffeine, taurine, sugars, vitamins and herbal extracts. Caffeine is the main ingredient in energy drinks which provides the consumer with the energetic benefits derived from this drink. When consumption of energy drinks become too much, there are health problems that come along with this practice, some of these health problems are high blood pressure, obesity, insomnia and headaches. The popularity and consumption of energy drinks has been on a fast rise globally. Developed countries like Canada, Sweden, and France have taken measures to reduce the dangers associated with excessive consumption of energy drinks. In developing countries, like Ghana energy drink production and consumption has been on the rise but there is little knowledge on the consumption patterns among consumers, what consumers think of energy drinks, why they take it, what they take energy drinks with and what influences their favorite choice of brand. Due to these uncertainties, I chose to embark on a study to determine the consumption patterns of energy drinks at lorry stations in Accra, consumer perception about energy drinks and determine the concentrations of the major constituents (caffeine and sugars) of energy drinks.

The study will comprise of a field and laboratory work. The concentrations of the major constituents of the energy drinks to be used will be measured. The brands of energy drinks to be used will be; Red Bull, Bullet, Xploza, Lucozade, Rush, Storm, Run, 5star and BigBoss energy drinks. Lorry station will be chosen as the research area for the field component because it is a dominant place where energy drinks are sold and much retailing is done. 1.*Lapaz Southside and Northside station, 2. Arena Station, Fearon Road, Accra Central and 3. Circle Stations (Circle Ayawaso, Circle Blow Up, Odorna, Ministries)* are the targeted lorry stations in Accra that will be used due to their large size and busy nature. Interviews in local dialect (twi or Ga or Ewe), English and questionnaires will be used to obtain information on your age, occupation, number of energy drinks you consume in a day or week, if you have experienced any adverse health effect from consuming energy drinks and why you consume energy drinks.

Participation in this study is by your will and not for people below 18years old. The duration for the interview will not exceed twenty (20) minutes and will be recorded without the names of the participant.

Benefits of the study

There is no immediate benefit to any participant but information on consumption patterns will help regulate the intake of energy drinks in Accra so as to reduce any risks like high blood pressure, insomnia and headaches, involved in excessive consumption of energy drinks.

Risk of the study

No risk is anticipated in this study

Confidentiality

Any and all information given out by participants will be kept highly confidential, that is no name will be attached or reference that might relate to any participant will be used. The information given out will be only accessible by just me.

Compensation

All participants in this field survey will receive a piece of chocolate as compensation for participating in the study.

Withdrawal from Study

Any participant is free to opt out at any point time during the interview since participation is voluntarily. You are not forced to answer all questions and are free to ask questions concerning the study at any point during the study. A copy of this consent form will be given to you.

If you have any issues on your rights as a participant, you can contact the address below:
Administrator, Ethics Committee for Basic and Applied Sciences, College of Basic and Applied Sciences, University of Ghana. P. O. Box LG 68, Legon – Accra, IP No.: 3014, Email:ethicscbas@ug.edu.gh

Section C- VOLUNTEER AGREEMENT

"I have read or have had someone read all of the above, asked questions, received answers regarding participation in this study, and I am willing to give consent for me, my child/ward to participate in this study. I have not waived any of my rights by signing this consent form. Upon signing this consent form, I will receive a copy for my personal records."

_____

Name of Volunteer

_____

_____

Signature or mark of volunteer Date

If volunteers cannot read the form themselves, a witness must sign here:
I was present while the benefits, risks and procedures were read to the volunteer. All questions were answered and the volunteer has agreed to take part in the research.

_____

Name of witness

_____

_____

Signature of witness Date

I certify that the nature and purpose, the potential benefits, and possible risks associated with participating in this research have been explained to the above individual.

_____

Name of Person who obtained Consent

_____

_____

Signature of Person who obtained Consent Date

APPENDIX II

DEPARTMENT OF NUTRITION AND FOOD SCIENCE

UNIVERSITY OF GHANA, LEGON

QUESTIONNAIRE

Quality assessment and consumption patterns of energy drinks in Accra.

Dear respondent, this questionnaire seeks to solicit some information on consumption patterns of energy drinks in Accra, as part of MPhil dissertation on the topic above. The information you provide in this document will be treated as confidential and used for academic purposes only.

Thank you.

Please tick the right boxes and where you have to write you do so in the spaces provided. Thank you.

1. What is your age group?

18-25 ☐ 25-30 ☐ 30-35 ☐ 35-50 ☐

2. **Gender?** Male ☐ Female ☐

3. What is your occupation? ……..

4. **What is your level of education?**

None ☐ Primary ☐ JHS ☐ SHS ☐ Tertiary ☐

5. Do you consume energy drinks?

Yes ☐ No ☐

6. How long have you been consuming energy drinks?

.....

7. **How many bottles are drank**; in a day ☐ a week ☐ a month ☐

8. What is your perception about energy drinks in general?

……..

9. Why do you consume energy drinks?

To work ☐ To stay awake ☐ To study ☐ Stamina (sexual intercourse) ☐

To mix with alcohol ☐ Other, please specify……

10. What time of the day do you consume it?

Morning ☐ Afternoon ☐ Evening ☐

11. What brand is your favorite?

……

12. What influences your choice?

Cost ☐ Potency ☐ tast ☐ flav ☐ others, please specify…….

13. What do you consume it with?

……

14. Do you know of the difference between sports drinks and energy drinks?

Yes ☐ No ☐

15. Do you have a general idea about caffeinated drinks?

Yes ☐ No ☐

16. Do you know of any health problems associated with energy drinks consumption?

Yes ☐ No ☐

17. Have you ever experienced any after effect?

Yes ☐ No ☐

18. If yes, what was it?

……..

APPENDIX III

One-way ANOVA: caffeine Concentration versus energy drink

Method

Null hypothesis	All means are equal
Alternative hypothesis	At least one mean is different
Significance level	α = 0.05

Equal variances were assumed for the analysis.

Factor Information

Factor	Levels	Values
energy drink	9	5star, bigboss, bullet, lucozade, red bull, run, rush, storm, xploza

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
energy drink	8	103921	12990.1	21726.71	0.000
Error	18	11	0.6		
Total	26	103931			

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
0.773230	99.99%	99.99%	99.98%

Means

energy drink N Mean StDev 95% CI 5star 3
241.027 0.210 (240.089, 241.965) bigboss
3 296.557 1.489 (295.619, 297.495) bullet 3
311.200 0.802 (310.262, 312.138) lucozade 3
121.150 0.613 (120.212, 122.088) red bull 3
314.243 0.721 (313.305, 315.181) run 3
292.500 0.476 (291.562, 293.438) rush 3
340.540 0.701 (339.602, 341.478) storm 3
308.943 0.229 (308.005, 309.881) xploza 3
308.877 0.900 (307.939, 309.815)

Pooled StDev = 0.773230

Fisher Pairwise Comparisons

Grouping Information Using the Fisher LSD Method and 95% Confidence

energy drink N Mean Grouping
rush 3 340.540 A red bull
3 314.243 B bullet 3
311.200 C storm 3
308.943 D xploza 3
308.877 D bigboss 3
296.557 E run 3
292.500 F 5star 3
241.027 G lucozade 3
121.150 H Means that do not
share a letter are significantly
different.

One-way ANOVA: sugar concentration versus energy drink

Method

Null hypothesis All means are equal

Alternative hypothesis at least one mean is different

Significance level $\alpha = 0.05$

Equal variances were assumed for the analysis.

Factor Information

Factor Levels Values energy drink 9 5star, bigboss, bullet, lucozade, red bull, run, rush, storm, xploza

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value energy drnk
	8	4389.33	548.667	152.72	0.000
Error	18	64.67	3.593		
Total	26	4454.00			

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
1.89541	98.55%	97.90%	96.73%

Means

energy drink N Mean StDev 95% CI 5star
3 100.33 2.08 (98.03, 102.63) bigboss 3
109.67 2.08 (107.37, 111.97) bullet 3
112.67 2.52 (110.37, 114.97) lucozade 3
88.667 1.528 (86.368, 90.966) red bull 3
111.000 1.000 (108.701, 113.299) run 3 112.33
2.08 (110.03, 114.63) rush 3
113.67 2.08 (111.37, 115.97)

storm 3 74.67 2.08 (72.37, 76.97) xploza
3 110.000 1.000 (107.701, 112.299)

Pooled StDev = 1.89541

Fisher Pairwise Comparisons

Grouping Information Using the Fisher LSD Method and 95% Confidence

energy drnk N Mean Grouping
rush 3 113.67 A bullet 3
112.67 A B run 3 112.33
A B red bull 3 111.000 A B
xploza 3 110.000 B bigboss
3 109.67 B 5star 3 100.33
C lucozade 3 88.667 D
storm 3 74.67 E

Means that do not share a letter are significantly different.

APPENDIX IV

Caffeine concentration calculation

Concentration of sample = $\frac{area\ of\ sample}{area\ of\ caffeine\ standard} * concentration\ of\ caffeine\ standard$

Average area of caffeine standard =8547.72168m

Concentration of caffeine (natural caffeine) =0.3mg/ml

Red Bull caffeine concentration = $\frac{8952.96728}{8547.72168}\ x\ 0.3$ = 0.3142229338

0.3142229338 x 1L(1000ml) =**314.24mg/L**

Total sugar concentration calculation

Total sugars = $\frac{mass\ from\ refractometer}{100}\ x\ net\ volume\ of\ energy\ drink$

Red Bull Total sugar concentration = $\frac{11.1}{100}\ x\ 1L(1000ml)$

Red Bull energy drink caffeine concentration is **111.00 g/L**