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Energy Drink Consumption: Pattern and Effect on Commercial Drivers in Kumasi

By

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A Thesis Submitted to the Department of Biochemistry

Faculty of Biosciences

College of Science

In Partial Fulfilment of the Requirements for the Award of Master of Philosophy Degree in

FORENSIC SCEINCE

November 2019

DECLARATION

"I, Elizabeth Lomokei Pobee, declare that this thesis is a presentation of my original research work. Wherever contributions of others were used, every effort has been made to reference and acknowledgement them duly.''

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DEDICATION

Every challenging work, needs self-effort as well as guidance of others especially those who are very close to my heart. I humbly dedicate this thesis to my sweet loving mother; whose affection, love, encouragement and prayers brought me such a success along with all my friends.

ACKNOWLEDGEMENT

“*Though the fig tree does not bud*

and there are not no grapes on the vines

though the olive crop fails

and the fields produce no food,

though there are no sheep in the pen

and no cattle in the stalls,

yet I will rejoice in the lord,

I will be joyful in God my savior”

Habakkuk 3:17-18

My earnest appreciation goes to my research supervisor, Dr. Alexander Kwarteng for his tremendous contributions and providing instrumental supervision all through the study. I wish to acknowledge Prof. Peter Twumasi and Dr. Salifu Pandam. I say thank you. I am also indebted to Mr. Emmanuel Atsu Amewu and Mr. Deryl Kuevi for all the help you freely offered to me. I am grateful.

I am also grateful to my family for the financial and emotional support during the course of my studies. God bless you all. Lastly, my kind appreciation goes to my friend and colleague; Evelyn Yeboah, I am really grateful for your contributions towards the success of this study.

ABSTRACT

For decades, the consumption of caffeinated beverages intended to "energize" has increased significantly. In Ghana, commercial drivers in major cities are rather at risk of daytime fatigue because of the many trips these drivers make to earn more money due to lack of regulation on the number of trips one makes in a day. Field observation shows that many commercial drivers rely heavily on energy drinks, however not much on this has been investigated. To address this, a cross-sectional study was conducted on 210 commercial drivers across five taxi/bus stations in the Kumasi Metropolis. A structured questionnaire was used to collect demographic data and other information on the drivers' pattern of energy drinks consumption. Five brands of energy drinks were sampled and analysed for presence of psychoactive agents such as benzodiazepines, cocaine, methamphetamine, opiates, tetrahydrocanobinoids and tramadol using the dip 6 test kit. HPLC was used to detect and quantify caffeine in the energy drinks and Atomic Absorption Spectrophotometer for detection of heavy metal contamination. The study showed the absence of the psychoactive agents' benzodiazepines, cocaine, methamphetamine, opiates, tetrahydrocanobinoids and tramadol in the energy drinks. However, varying amounts of caffeine were detected in the energy drinks. The study also showed significant association between the number of trips and the number of bottles of energy drinks consumed ($r = 0.631$. p-value < 0.05). Hence, an increase in the number of bottles will cause an increase in the number of trips taken. The R square value 0.398 (~0.4) shows a 40% probability that consumption of energy drinks makes drivers make more trips. This result is desirable enough to lead drivers on to consume more energy drinks, thereby making them only go on long hours of drive while reducing their efficiency (by causing restlessness, insomnmia and confusion) as drivers on the road due to the cognitive changes of the psychoactive substance. Heavy metal iron was detected in all of the energy drinks tested, and copper in one of them, all below the allowed concentrations. In conclusion, this study showed a high consumption of energy drinks among the drivers with no regard to safety on our roads.

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CHAPTER ONE

INTRODUCTION

1.1 Background

Decades ago, the demand for drinks containing caffeine, taken to energize, has risen so much. Red Bull, a popular energy drink, recently showed about 97% of the annual total sales in the beverage industry whereby 20% of the retail beverage store is all made up of energy drinks. (O'Brien *et al*., 2008).

Energy drinks are made up of varying ingredients with different concentrations. Caffeine, guarana extract, taurine and ginseng serve as the main components while amino acids, vitamins and carbohydrates are some of the excipients added (Reissig *et al*., 2009). However, this additional ingredients provide some useful benefits to accomplish the main goal when these drinks are consumed (Reissig *et al*., 2009). Energy drinks are supposed to provide; sustenance, improve performance, concentration and endurance. The makers, however, pitch their product on people who need a lot of stamina such as athletes, students and folks in professions that need sustained alertness. These drinks are also demanded more during late night dance parties that need sustained energy for prolonged activity into late hours (Reissig *et al*., 2009)

In some settings, energy drinks may additionally contain alcohol and recreational pills like ecstasy or alternative amphetamines (Pennay *et al*., 2011). People between 15 and 30 years and commercial drivers are notably interested in energy drinks owing to the increase in the sale. The highly sweetened nature of the caffeinated energy drinks is comparable to alternative soft drinks and is thought to contribute to increased body fat.

Caffeine is the main psychoactive component in energy drinks (Andrews *et al*., 2007). Most often, the drinks contain very high amount of caffeine which makes it highly demanded resulting in excessive intake and toxicity. Though caffeine is related to enhancements in psychological responses, like memory and concentration enhancement, its pharmacological functions, whether or not alone or together with alternative ingredients, are not entirely understood (Lieberman *et al*., 2002). Caffeine when taken in the body through the mouth is fast and completely absorbed, within 4.5 hours before it completely leaves the body. The effects of sustenance, alertness and reduction in fatigue is also seen in rats (Lieberman *et al*., 2002).

Caffeine acts as an antagonist on the A1 and A2 adenosine receptor subtypes which is found on the central nervous system (Davis *et al*., 2003). Taurine being one of the main active ingredients in the drinks also has many benefits to provide both biological and physiological effects but its effect of taurine in high amount is not very well understood but its effects is mostly found on the central nervous system (Wu and Prentice, 2010). Taurine (2-aminoethyl sulfonic acid), a sulfonated β-amino acid mostly provided in consumables is also synthesized from cysteine, mainly in the liver. Majority of taurine is found mostly in the retina, skeletal muscles, cardiac muscles, heart, and liver and it is the most abundant amino acid in the human system (Schuller-Levis and Park, 2003).

A national road safety report of 2007 in Ghana, showed that a minimum of six persons are killed daily through road traffic accidents (Coleman, 2014). The report showed that 25% of pedestrian death involved children while 60% of road traffic accidents were linked to careless driving. Five regions in Ghana, (Ashanti, Eastern, Greater Accra, Central and Western) recorded 80% of the total accidents (Coleman, 2014). Speeding has been identified as a major factor in road traffic accidents in Ghana. However, it is of interest to note that there are other alarming factors that could contribute greatly to this problem. These include human behaviour, driving under the influence of certain substances that affect one's cognition such as alcohol, cannabis and caffeine (Zall Kusek and Rist, 2004).

Commercial drivers who go on very long trips are vulnerable to fatigue when on the roads hence are known to using stimulants and substances containing caffeine to stay awake. The effectiveness of caffeine for enhancing alertness throughout monotonous task performance has antecedently been incontestable in laboratory and driving simulator settings. After adjustment to doable unsupportive factors, consumption of caffeinated substances to assist driving alertness was related to an exaggerated risk of crashing among long distance commercial motor vehicle drivers (Pennay *et al.*, 2011). In Ghana, commercial drivers may be at risk of daytime fatigue because of the many number of trips they make to earn more money, they tend to depend on other psycho-active substances to achieve this.

1.2 Problem Statement

Energy drinks when consumed reduces tiredness. This is because of the high amount of caffeine in it. The demanding nature of certain workloads makes some of the Ghanaian working class more vulnerable to these energy drinks. The purchase of energy drinks among drivers seems to have gone very high in recent time. It is alleged that most of these energy drinks are highly patronized by both long distance and town running bus drivers.

In response to the high demand in energy drinks, so many brands have been introduced in the market. However, other substances are added to these drinks to increase the effects, these then put the consumer at risk. High amounts of caffeine from the American association of practitioners Nurses and FDA (Food and Drugs Authority) causes irritability, restlessness, fast heartbeat, nervousness and insomnia when the consumption of more than 400 mg of caffeine in a day (Alsunni and Badar, 2011).

There have been series of research works on the effects of energy drinks on different groups of the population. In relation to commercial drivers in Ghana and energy drinks, less work has been done so far to assess the frequency of consumption of energy drinks. This research seeks to investigate the content of energy drinks and whether these energy drinks if confirmed that the drivers are taken higher amount drivers could affect their efficiency, by causing lethargy, restlessness, insomnia, on the drivers while on the road.

1.3 Aim

To determine the content and the effect of consumption of energy drinks on the efficiency of commercial drivers in Ghana.

1.4 Specific Objectives

- To determine the presence and amount of psychoactive agents in energy drinks on the Ghanaian market.
- To investigate the consumption pattern of energy drinks and their effect on commercial drivers.
- To assess the quality of labels and heavy metal contamination of the energy drinks

CHAPTER TWO

LITERATURE REVIEW

2.1 History of energy drinks

Energy drinks are sugary fizzing drinks that are created from considerable quantities of caffeine along with sugar and additives like B complex vitamins, amino acids like taurine and guarana that are flavored stimulants. The term “Energy Drinks” is used because of the actual fact that the ingredients within the drinks give customers extra energy. The Japanese’s started commercializing lipovitan in little brown coloured glass bottles within the early Nineteen Sixties (Heckman *et al*., 2010). The size of the bottles used then was made up of a focused quantity of the beverage and this can be compared to a full-size of the beverage of nowadays. Different ones like Gatorade were additionally commercialized to enhance stamina in sports men and women (Heckman *et al*., 2010). Athletes used these drinks to reinforce their performance throughout coaching and competition, thanks to their probably ergogenic ingredients (Alamdari *et al*., 2007).

North American food market had their share of energy drinks with bizzare names, catchy slogans and pricey selling campaigns that currently occupy a major portion of the trade (Rambe and Jafeta, 2017). In 1985, Jolt Cola was the leading energy drink in Northern part of America. At the time, it had been essentially advertised as a cola with considerable quantities of caffeine and sugar (Rambe and Jafeta, 2017). It focused on students and busy professionals as their major selling strategy. Europe had their share of The Red Bull energy plunge in 1987 and to the US in 1997. Red bull was the precursor of the trendy energy drinks and it still continues to be the foremost, perceived complete within the trade (Rambe and Jafeta, 2017).

Energy drinks are continually being produced with the hope of expanding the growing clientele. Manufacturers on the other hand, are progressively manufacturing drinks with complicated mixtures of medicative ingredients, with ever higher levels of caffeine responding to the in pour of recent product with that they have to vie (Rambe and Jafeta, 2017). A dose of 85-250 mg caffeine might lead to feelings of attentiveness, small lethargy, and mitigated flow of thought, Whereas, excessive caffeine (250-500 mg) results in agitation, sleeplessness and hypokalaemia (Rath, 2012). The rising quality of energy drinks has enhanced intake of caffeine, particularly among the youth. However, in line with makers, these drinks are supposed to additionally promote health through healthful properties. Irrespective of their use and supposed positive effects, users today buy energy drinks for diverse reasons: energy boosters, stay awake during the night, stress reliever, among others (Paddock, 2008).

The packaging of caffeinated drinks eliminates all ambiguousness because the drinks are mostly advertised for persons between 11 to 25 years. (Reissig *et al*., 2009). At the end, the intake of caffeinated beverage drinks is probably going to become even more worldly accepted. Caffeinated drinks are promoted with vibrant explanations and stimulating names that create them to seem good to taste. Advertisers develop a lot of appealing slogans to make it more appealing to users and distinguish it from its competitors (Reissig *et al*., 2009). The makers have developed common slogans such as “Get spiked” “Party sort of a Rock star” and “Feel the freak” as a selling ways of caffeinated drinks, The linguistic and pictures of such marketing firms do not seem to be directed at mature adults (Reissig *et al*., 2009

Sugar and caffeine are the main ingredients that gives energy drinks their properties (Schulze *et al*., 2004). Most of recent studies have brought to the realisation, the relationship that co-exist between glucose sweet beverage intake and high bodily mass (Schulze *et al*., 2004). Reduction in the intake of added sugar can help in management of weight, hence there should be considerable reduction in the intake of sugar-sweetened beverages. (Malinauskas *et al*., 2007).

Although the psychoactive agents concentration in energy drinks is characteristically as that in coffee, caffeinated drinks have increased caffeine because they are often presented in considerably enormous volumes (Babu *et al*., 2008). By some laws, caffeine does not need to be enumerated on the labels unless it has been explain to the merchandise severally as a psychoactive substance so, shoppers could also be utterly concern of the number of alkaloid they are consuming.

There have been a lot of debate on the performance effects of energy drinks, even though it is marketed based on these effects. An example is Red Bull, which advertises several importance of its consumption including enhanced performance, stamina, attentiveness, among others (Babu *et al*., 2008). Consumers sometimes wrongly have confidence in the fact that taken more is better and ingest several volumes of these drinks. Due to the very fact that there are not any laws to the commerce of energy drinks, those who do not have enough knowledge as to the bad consequences of caffeine may be associated with magnified degree of caffeine inebriation (Reissig *et al*., 2009). In Australia and Ireland, alleged bereavements linked to caffeinated drinks have been reported, more than 2 people died in Sweden after ingesting high amounts of Red Bull: two other deaths took Red Bull with alcohol and the other deaths took the drinks after an exercise session (Woolsey *et al*., 2015). Most eatery in Sweden have stopped selling Red Bull due to these developments. Most countries in Europe have banned Red Bull because of some advices from their health experts. The European Union has also made some moves by enforcing the manufacturers of caffeine containing beverages to have a health cautionary label insisting "high caffeine content" as at 2004 (Woolsey *et al*., 2015).

Not much analysis has been administrated on the effectiveness of these drinks on the psychological feature and physical performance though energy drinks are oversubscribed worldwide for quite a decade. There are no reports or printed studies concerning the precise state of affairs of caffeinated drinks ingestion, arrays of consumption or the impact of these drinks among young adults in African countries. Because of the disagreeable life-style of university folks due to their stress filled routines and exams, they become liable to the utilization of energy drinks, thus stand a very high chance of consuming psychoactive containing substances, with most of them not knowing the toxic effects of these substances on their health. They are entirely taken by the unreliable exciting effects of energy drinks, inflicting them to feel less befuddled than they really are (Maughan and Griffin, 2003).

2.2 Energy drink content

2.2.1 Caffeine

Caffeine has become one of the ubiquitous substances in our world now, such that about 85% of adults in the US are reported to consume caffeine (Frary *et al*., 2005). Energy drinks are now the most patronized drink usually among the youth and individuals with manual jobs. These drinks are known to contain stimulants such as caffeine (McLellan and Lieberman, 2012). The food and drug administration in US, in collaboration with their institute of medicine, arranged a seminar to review the safe use of caffeinated products due to the alarming consumption of caffeine in the country (McGuire, 2014). However, it has been demonstrated that a daily intake of up to 400 mg of caffeine does not pose a health danger for healthy adults (Doepker *et al*., 2016). Documented works have shown the effects of caffeine in bodily and psychical performances (Burke, 2008). Moreover, not enough researches have been put together to explain the impacts of caffeine on bodily and psychical performances (Goldstein *et al*., 2010).

Recent caffeine assessment has concentrated on problems related to the sporting community. caffeine amounts of 85-250mg in foods and drinks have shown evidently that , they can increase plasma concentration to levels that block adenosine receptors (Laurienti *et al*., 2002), and thus, significantly exerting central nervous system (CNS) effects. It is conjointly evident that caffeine is abused in several activity settings, similarly, as alternative activities like sports, wherever best physical and psychological function is precarious to performance and productivity.

There is a need to critically examine these issues since the demand for stimulants (caffeine) in sports or occupations are usually affected by high fatigue. The problematic impacts of caffeine may, however, be addressed by assessing the pharmacokinetics and pharmacodynamics of the caffeine.

This work focuses mainly on the behavioural impacts of caffeine particularly on cognitive function which consequently affects productivity. This involves an assessment of its impacts on physical performance and addresses the impacts of caffeine in multiple occupational environments on bodily and psychical functioning. It has a rapid absorption rate that reaches maximum plasma levels just in an hour, taking into account significant individual variability. Caffeine is, however, assimilated quicker in the form of gum than in food, owing to its rapid assimilation through the cells of the mouth (Kamimori *et al*., 2002).

Caffeine is speedily circulated through any bodily tissue and promptly by passes the blood brain-barrier to work. It also, has a relatively longer half-life, normally 3–5 h (Laurienti *et al*., 2002), therefore, interacts with beleaguered tissues for extended given period. Factors which include, feeding habits, hepatic impairment, and the use certain hormonal drugs can change its mean period (Reissig *et al*., 2009).

Caffeine is structurally identical to adenosine (Laurienti *et al*., 2002). Adenosine has 4 distinct receptors. This subtypes has an exclusive tissue distribution and pharmacological profile (Svenningsson *et al*., 2004). These receptors are not very controlled as consumption of caffeine goes up (Varani *et al*., 2000), though sensitivity may vary among individuals. Previously, the impacts of caffeine were believed to be due to the promotion of intracellular Ca^{2+} release, but it was found that these impacts happen with very elevated, non-physiological levels of caffeine.

The smallest micro molar tissue dose of caffeine is able to block all the subunits receptors because of the uncontrolled different concentration of caffeine which is taken in (Laurienti *et al*., 2002), however, caffeine exerts its pharmacological effects on bodily enhancement by causing a launch of ca^{2+} ions from the sarcoplasmic reticulum (Cappelletti *et al*., 2015),the improvement of bodily enhancement can also be attributed to the contraction in the muscles of the skeleton, which is as a result of the nitric oxide pathway. (Tarnopolsky, 2008). The subunits of the receptors of adenosine are the major cause for the behavioral changes that come with caffeine intake but this is not verily explained. The two subunits of the receptors are found more in the brain and peripheries. While the A1 subtype is found more in different sections of the brain ((Landolt, 2008), the A2a subtype is found in the brain areas such as striatum, and olfactory tuber and is strongly inhaled by fibers that absorbs dopamine (Landolt, 2008).

In animal studies, adenosine A1 receptor activation are said to suppress the discharge of some neurotransmitters. Blockaded of the adenosine A1 receptor by caffeine, enhance the launch of the A2a subtype above. Caffeine has been related to violent conducts owing to its repressive impacts on noradrenaline launch (Mahoney *et al*., 2012). The intake of caffeine with xanthine drugs causes a reduction in the excitatory threshold which can lead to epilepsy. This occurs by antagonizing the adenosine and glutamatergic neurons (Lazarus *et al*., 2011).

The Adenosine receptors create competitive and powerful different monomers in distinct areas of the brain with dopamine D1and D2 receptors. These can be proved by restricting A2a receptors in the striatum, by antagonizing the impacts of adenosine and by inadvertently promoting the stimulating impacts of dopamine on brain function by binding to its second dopamine receptor.Caffeine-induced anguish was connected with subunits of the A2 receptor and the second dopamine receptor in Homo sapiens (Childs *et al*., 2008).

The impacts of the psychoactive agents on stimulation occurs by reactions of the first adenosine receptors found in the frontal brain in relation to an indirect impact on some structures of the central nervous system by activation of all the adenosine subunits receptors (Ferre, 2010). Research models on the CNS have suggested the capacity of the inhibition of the highly affinity adenosine subunits receptors to improve alertness within the phases of sleep deprivation, daytime tiredness therapy and Parkinson's disease hypokinesia (Silkis, 2009). Excitation of the subunits receptors of the adenosine should trigger chronic depression. Hitherto, using caffeine as an inhibitor of the adenosine subunit receptor can encourage arousal of some neuronal excitations and decrease the blockaded of stimuli to theses neurons. All the above reactions are probable to result in increased excitement and increased psychomotor activity following Intake of caffeine during sleep loss (Bodenmann *et al*., 2012).

Solitary nucleotide heterogeneity of just the A2a gene that also codes for the A2 receptor were recognized at place 1083 as thymine and cytosine substitutions. Around 15 and 20 percent of people have affinity to just thymine, while above 35 percent have affinity to just cytosine (Childs *et al*., 2008). The above differences seem to affect a human beings reaction to the exciting impacts of caffeine (Bodenmann *et al*., 2012).

Edibles such as tea or coffee has had impacts on cognitive tasks for millennia and has been a common means of enhancing multiple elements of psychical functions (Snel and Lorist, 2011). Although there has been widespread science consensus on the behavioral impacts of caffeine, some information on particular functional elements stay contentious (Smith *et al*., 2011). A widely known knowledge that the intake of caffeine raises "lesser" psychical functions such as easy onset time, and it can also influence "greater" psychical functions such as issue resolving (Kosslyn *et al*., 2001).The reason might be that there are very less researches on higher psychical function, where the accessible trials differ significantly from the techniques used (Brunye *et al*., 2010). The scientific evidence on psychical basic activities is that the alkaloid in amounts of below 300 mg enhances fundamental elements of psychical efficiency; attention, observance and response time. (Snel and Lorist, 2011). Moreover, small and sufficient doses of caffeine have little impact on sensory functions to a very alarming levels (Lieberman *et al*., 2002).

Taken very minute doses can boost ones pleasures and decrease euphoria. Caffeine improves arousal in a dose-dependent way. Concentrated doses boost pressure in the head, euphoric effects, and restlessness (Stafford *et al*., 2007). The way caffeine influences bodily actions relies on the degree of excitement of people going through inquiry, particularly the magnitude to which participants are sleep ridden or exhausted, compared to those who have very good rest. (Nehlig, 2010).

There seems to be a pragmatic connection between excitement and efficiency, meaning, low exuberance is linked to very low efficiency, while high psychical excitement is linked with enhanced bodily stamina, but just to some specific levels according to Yerkes-Dodson law, when the level of excitement becomes too much, the performance lowers. Thus, the pre-dose activation level of a subject before ingesting caffeine will affect the impacts experienced (Wood *et al*., 2014). Given an increased amount of caffeine to a person under great stress, is probable that it will enhance efficiency because in this situation caffeine encourages a favourable amount of excitement, thus; caffeine promotes the excitement of the subject to the center array of the Yerkes-Dodson curve.

Alternatively, providing a certain dose to someone who is well-rested and extremely excited may deteriorate instead of enhance efficiency, for the reason being that, caffeine generates a level of a very high arousal, as stated in Yerkes-Dodson law, which will break down psychical functions.

In reference to our ordinary daily social settings, there really is proof that individuals ingest caffeine to attain a self-fulfillment, maximum height of excitement by modulating their overuse of caffeine before they approach their self-fulfilled level of excitement and psychical efficiency (Harvanko *et al*., 2015).

Helpful impacts are likely to be detected in caffeine experiments in which the doses according to research are correctly co-ordinated to the urging state of the individual. The visual depiction showing a curvilinear connection among caffeine stimulation and stamina can be challenged, as can the law (Yerkes-Dodson) itself, substantial support for both research over the previous 100 years can be seen (Wood *et al*., 2014).

It must be observed that the accurate impacts of the drug or some other psychological adderall on habits can be affected differently by the complexity of the job inquiry (Diamond *et al*., 2007), caffeine sensitivity in distinct people, sexual category or physique mass differences (Renda *et al*., 2015), the inspirational or illustrative status of participants (Diamond *et al*., 2007), and emotional instability and conviviality.

Considering the latter skills, caffeine in concentrations up to roughly 300 mg usually increases efficiency with significant unwanted effects across a broad range of psychical functions, mostly by stopping decreases in vigilance and focusing due to atrocious excitement (Lieberman *et al*., 2002). Caffeine constantly increases mood, time of onset and watchfulness when they are lowered, and knowing that the fundamental amount of excitement is crucial for the success of any job, it is reasonable that caffeine becomes beneficial in tired conditions. Rejuvenated (non-insomnia) people involved in long, boring operations such as, long hours of driving can benefit substantially from 200 mg of caffeine and doses varying from 200 to 600 mg are useful for sleep-deprived people (Carvey *et al*., 2012).

2.2.1.1 Acute effects on memory

There have been mixed discoveries on the special pharmacological impact of the alkaloids (caffeine) on memory when investigations were carried out (Warburton *et al*., 2001). They tested the consequences of caffeine on 42 rested participants. Forward to consumption of caffeinated beverage having 80 mg of caffeine and found that while the drink absorption enhanced concentration and quantitative perceptive, there stood no variations in unwritten or nonverbal recollection. Their findings are somehow confirmed by the studies by Amendola *et al*. (1998). Amendola discovered that, caffeine in 60, 120 and 250 mg doses caused a dose-dependent enhancement in awareness, but took no important effect on the re-collective phrases displayed in a fixed long list of topics. While researchers in 1986 (Terry and Phifer, 1986) carried out a survey on university students, who were not sleep deprived and found that 100 mg of caffeine led to worse remembrance of words, especially words that occur in the center or end of a rehearsed list (Amendola *et al*., 1998). Nevertheless, there was not much careful control into these studies. Also there are discrepancies in the experiments carried out on the outcome of caffeine on other parts of re-cognitive abilities. Caffeine's impacts on restoration of re-cognitive functions are extremely inconsistent (Smith *et al*., 2011).

While caffeine has beneficial impacts on specific components of the memory, it can be influenced by the drugs impacts on smaller tasks such as consciousness, and as hitherto mentioned, it regularly follows the U-shaped deactivation curve. For instance, a researchers found that the actual impact of caffeine on false memories in heavy users with no more than a dose of 100 mg, while the effects reached its peak at 200 mg, while a higher dose of 400 mg did not result in a further rise (Mahoney *et al*., 2012).

2.2.1.2 Chronic of caffeine effects on recollection

Furthermost study on recollection has concentrated on the severe impacts of caffeine intake, but some study has been done on the effect of long period use of caffeine. These usually indicate a positive impact of caffeine. Epidemiological findings proposed a connection between excessive caffeine use and a decreased risk of developing neurodegenerative diseases (Cappelletti *et al*., 2015), and though a latest meta-analysis of epidemiological studies called into question the connection between coffee / tea intake and behavioral illnesses (Kim *et al*., 2015).

All the same, a survey conducted with 9000 grownups by Jarvis (1993), discovered a beneficial connection among maladaptive caffeine consumption and visuospatial performance. With growing age, these impacts became stronger. This is coherent with a research of 1875 adolescents that found that frequent consumption of caffeine was correlated with very strong long-term recollection as compared to short-term (Hameleers *et al*., 2000). The findings were also partly compatible with the researches (Johnson-Kozlow *et al*., 2002), who noted that older females who swallowed enormous quantities of caffeine all through their lives worked much more efficient than people who take less caffeine on recollection and other psychical functions. Maybe these recollections impacts in geriatrics are correlated with some neurological problems and neuroprotective changes that already been theoretically connected to high period of caffeine use (Laurienti *et al*., 2002). Conversely, they may necessarily owe to the reality that they are healthier; more psychically intact aged people only want to ingest high amounts of caffeine as compared to the unhealthy colleagues, as there is strong proof of health issues leading to a reduction in caffeine consumption (Harvanko *et al*., 2015). Greater intake of caffeine may cause psychical decrease in geriatrics, there is no comparable impact in younger participants (Harvanko *et al*., 2015).

2.2.2 Taurine

Taurine (2-aminoethyl sulfonic acid) is among the most extensive amino acids in the human body that includes sulphur, predominantly found in retina, skeletal and tissues in the heart muscles (Imagawa *et al*., 2009) . This protein derivative is acquired through the oxidation of some major amino acids that are produced in the body (Stipanuk, 2004). This amino acid can also be discovered in popular food products like meat and some sea food. Survey has found out that regular daily consumption of taurine is within 50 to 450 mg (Shao and Hathcock, 2008).

The integration of the amino acids into caffeinated drinks and some beverages has greatly enhanced over the previous 10 years, making taurine among the most commonly ingested and researched protein (Shao and Hathcock, 2008). The amino acid is related to a multitude of bodily activities including neuro-activation, cellular membrane stabilization and intracellular calcium modulation in both in vitro and in vivo (Asiedu-Larbi, 2017). More study is desired to be able to understand the fundamental pharmacological actions (Heckman *et al*., 2010).

Taurine was seen to improve stamina efficiency and help to reduce the accumulation of acids after workout (Imagawa *et al*., 2009). Inside the body, taurine primarily passes through declension to form salts in the bile as much as depletion to sulfate (Triebel *et al*., 2007b). The type of metabolism enables for increased nutritional consumption of taurine, metabolized unchanged in the urine (Triebel *et al*., 2007b). Techniques are being created to distinguish the differences in synthesized taurine and those that are naturally occurring (Gioacchini *et al*., 1995). Even so, more study is required to determine if there is an important distinction between those which are naturally occurring and synthetic sources (Heckman *et al*., 2010). Energy drinks comprise higher levels of synthetic taurine. Taurine examination in 80 separate energy drinks which was sampled showed a taurine mean dose of 3170 mg / L corresponding to 755 mg/9 ounces (Triebel *et al*., 2007a). Multiple trials revisions have been done to find the impact of the amino acid at separate dosage extending from 376 to 8100 mg per day, confirming with no injurious effects to the body (Zhang *et al*., 2004). Even though there is no proof of the amino acid causing negative health impacts, interest has been raised as there has been insufficient research on the impacts of big amounts of the amino acids in conjunction with other components frequently found in the caffeinated drink (Heckman *et al*., 2010).

2.2.3 Guarana

Guarana was discovered in a plant called *Paullinia cupana*, mostly found in the southern part of America. It arose from Brazil in the basins of amazon, which already has a lengthy past of use (Angelo *et al*., 2008). The drug is frequently recognized as the fruit it creates from its small-berry. The berries contains about 2 or more dark seeds, which are accountable as the comestible portion of the *paullinia cupana* (Scholey and Haskell, 2008). The grains consist of a substantial quantity of alkaloids, whereby the effect seen is the same as comparing a gram of guarana to 40 mg of caffeine (Finnegan, 2003). Theobromine and theophylline are other xanthine alkaloids contained in guarana, but at much reduced concentrations relative to caffeine (Weckerle *et al*., 2003). Theobromine and theophylline are however contained in guarana at much reduced concentrations comparable to caffeine (Majhenič *et al*., 2007). Guarana over time has become an increasingly prevalent naturally occurring ingredient in caffeinated drinks, mainly because of its stimulating impact (Scholey and Haskell, 2008). It has also been indicated that it is discharged slowly compared to pure caffeine, resulting in a more calm and longer stimulating impact (Scholey and Haskell, 2008). The reason for this slower discharge is that guarana is insoluble in water and contains both amino acids and tannins (Edwards *et al*., 2005).

Conversely, no statistically significant correlation showing the production and absorption of caffeine from guarana has been done. It has been recommended to enhance psychical efficiency, brain stress, fatigue and mood in therapeutic appropriate dosages; an impact backed by so many revisions (Scholey and Haskell, 2008). The drug was connected with the induction of fat breakdown, likely owing to its methyl xanthine in-situ (Lima *et al*., 2005). In addition, this substance has also been revealed to produce no noxious impacts when eaten in both elevated doses and chronically lower doses (Majhenič *et al*., 2007).

2.2.4 Ginseng

For many decades, herbal Ginseng is being used by individuals in Eastern Asian nations. This countries have used it as a treatment for multiple illnesses and to promote longevity (Nam *et al*., 2005). The primary industrial genus of ginseng is the Panax ginseng, often known as Korean or Asian ginseng. Furthermore, Siberian ginseng *(Eleutherococcus senticosus)* is not really a ginseng as it includes eleutherosides as one of its major components and no ginsenosides. *Panax ginseng* from the Araliacae family is a tiny, perennial tree that grows very well in the shades that approaches about 60 cm in length. The entire ginseng plant has been used to treat a lot of disease condition, moreover, the root is the most astute and increases commercial sales. The ginsenoside levels are at their maximum concentrations in the roots during their 5th to 6th year of development, hence harvesting is optimal at this stage (Mahoney *et al*., 2012). Red ginseng can be prepared using the roots of ginseng. Immediately after harvesting of the roots it receives yet more processing such as, aeration and decolourising of the stem roots with sulphur dioxide developing "white ginseng" or sweltering the stem roots and airing it to form "red ginseng" (Mahady *et al*., 2001).

2.2.5 Yerba mate

Yerba mate *(Ilex paraguariensis)* is indigenous to the Southern part of America where it is mostly used as tea (Heck and de Mejia, 2007). The plant is known for its diverse bioactive constituents; phytochemicals, proteins, trace minerals, and vitamin complexes (Heck and de Mejia, 2007). The health benefits of this plant are enormous due to its diverse bioactive constituents. Reportedly, the plant has both anti-inflammatory and anti-diabetic properties (Bastos *et al*., 2007).

Yerba mate has proved in laboratory to kill cancerous cells as well as inhibiting Topoisomerase II, which performs a critical role in meiosis and mitosis hence works to prevent cancerous cell multiplication (Heck and de Mejia, 2007). Nonetheless, human studies are required (Heckman *et al*., 2010). Based on laboratory studies, the herb is known in managing obesity (Arçari *et al*., 2009). According to De Morais, the herb considerably enhanced the serum lipid conditions in nonlipidemic and dyslipidaemia persons (De Morais *et al*., 2009).

To add up, the herb is capable of stimulating the nervous system owing to its extraordinary amount of caffeine content, the main reason it is added to energy drinks. The amount of caffeine in one cup (8 ounce) of yerba mate tea is equal to about 78 mg, which is similar to 8 ounces of Red Bull, which contains 80 mg (Heck and de Mejia, 2007). Despite its positive attributes, issues have been raised whether there is any link between the herb and specific types of cancer in the, mouth, oesophageal, lungs, and kidney (Heck and de Mejia, 2007).Nevertheless, no definitive substantiation to prove that this claim true. Issues of cancer were attributed to the lifestyles of people that consume the tea. Most people at the southern part of America take this tea while smoking. (Heck and de Mejia, 2007).

2.2.6 B vitamins

B complex vitamins namely: riboflavin, niacin, pantothenic acid, pyridoxine and cobalamin. Each of these vitamins partakes in critical roles in cellular processes. They are included as ingredients in energy drinks. A usual 250 mL can of regular energy drink may contain recommended daily allowance of 80% B6 and 20% of B12 and B3 (niacin) (Heckman *et al*,. 2010). The container comes in different sizes and volumes and it may hold several servings. The inclusion of major amounts of B vitamins has been noticed to be more in very high caffeinated drinks like blue jeans Energy which contains 90% of the recommended daily allowance for B12 and 10% of the recommended daily allowance for B6 (Heckman *et al*,. 2010). Reportedly, consuming large quantities of B vitamins enhances mental alertness and concentration (Heckman *et al*,. 2010). B vitamins can be derived from fruits and meat (Heckman *et al*,. 2010). The frequently employed in energy drinks are Vitamins B2, B3, B6 and B12. Vitamin B12 is a co-enzyme in the breaking down of carbohydrates (Heckman *et al*., 2010).

Vitamin B3 plays a number of roles; as a co-enzyme in vitality breakdown and other biological processes to take toxins out of the body (Wardlaw *et al*., 2009). B6 vitamin is made up of a group of 3 chemically identical complexes, in which all can be transformed into the B6 co-enzyme which supports the use of essential chemicals in the body. Nerve function and folate metabolism are facilitated by Vitamin B12 (Wardlaw *et al*., 2009). Due to the fact that the B vitamins are soluble in water, as soon as the recommended daily allowance is achieved, the superfluous of the vitamins are taken out of the body system through urinating. Though intake of enormous quantities of B vitamins is not detrimental to health, the reason backing the large quantities of the vitamin B complexes in the caffeinated drinks is not very well justified (Heckman *et al*., 2010).

2.2.7 Ginkgo Biloba

Ginkgo Biloba aids with memory retention, concentration and circulation. Its benefits can be felt by consuming 60 mg as a standard dose (Yunusa and Ahmad, 2011). Nonetheless, the quantity of Ginkgo in energy drinks is of no benefit to the consumer. Ginkgo Biloba has side effects which include diarrhoea, headaches, dizziness, heart palpitations, and restlessness. People on antidepressants are not advised to take it (Yunusa and Ahmad, 2011).

2.2.8 L-Carnitine

L-Carnitine as an amino acid is originally produced in the liver and kidneys. L-carnitine aids in energy boosting and metabolic processes. It is a thermo genic which helps in the increment of weight loss and improving, stamina during exercise; this is how it interacts with the body (Yunusa and Ahmad, 2011).

2.2.9 Glucuronolactone

Glucuronolactone is found in the human body in the form of glucose which is broken down by the liver. It aids in freeing hormones and the biosynthesis of vitamin C. Glucuronolactone is included to the ingredients of energy drinks to aid with glycogen supply by inhibiting new constituents from diminishing glycogen supply in the tissues (Yunusa and Ahmad, 2011).

2.2.10 Creatine

Creatine is evidently gained from the ingestion of high protein animal flesh. Creatine aids with vitality supply to the cells of the body and is often employed in caffeinated drinks and products meant for body builders (Yunusa and Ahmad, 2011).

2.2.11 Acai Berry

Acai Berry is acquired from the Acai palm tree which is a component mostly found in more and more energy drinks. The plant is indigenous to the southern part of the pacific. The Acai fruits are enriched in toxicants, as much as compared to other berries. Most of the acai berry beneficial impacts are folkloric lacking any scientific backing (Yunusa and Ahmad, 2011).

2.2.12 Milk Thistle

Milk Thistle is a constituent considered in a small number of energy drinks. It functions by improving the function of the liver by detoxifying it. It is employed in caffeinated drinks not for its vitality improving qualities but as an agent to prevent the fraternisation of these beverages with alcohol, due to the fact that milk thistle functions in helping with the effects of too much liquor intake and also detoxifying the hepatic tissues from alcohol. Studies have shown that the quantity used in these caffeinated drinks poses health issues to the consumers (Yunusa and Ahmad, 2011).

2.2.13 L-theanine

This is a type of protein derivative derived from tea leaves. Reportedly, it is capable of improving concentration by calming the brain. It is because of this reason, it is added to the ingredients of the new energy drinks coming onto the market (Yunusa and Ahmad, 2011).

2.3 Energy drink marketing

After it was ushered into the United States in the early 1990s, the caffeinated drinks market increased from $400 million to $4 billion within four years, the market is reported to increase by 12% annually and it surpassed $9 billion by the year 2011 (Reissig *et al*., 2009).North America is the leading worldwide consumer of energy drinks with about 37% of world-wide volume in 2008. Asia Pacific had about 30% and West Europe with 15% consumption of energy drink. However, Asia had a decline in 2008 consumption pattern , with intake falling by 18% following a 41% drop in sales in Thailand (Reissig *et al*., 2009).

Commercializing of caffeinated drinks was not varied at the start. Especially in the United States of America, its market was intended predominantly at sports persons demonstrating that caffeinated drinks marketing were focused to specific groups. Due to the "go lifestyle" of young adults between 18 to 34 years, lately the marketing of energy drinks has been aimed at the youth (Reissig *et al*., 2009).

Red bull has come a long way by having the biggest portion of the market. In 2011, Red Bull recorded a total market sale of 11.4% higher than 2010 which was about 5.132 billion cans of Red Bull sold worldwide. However, Red Bull has dominated the market with about 40% shares worldwide dominating about 42% in United States whereas other drinks share the rest (Heckman *et al*., 2010).

The intake of energy-drink is approximately 34% of which, 18-24 year olds being consistent consumers (O'Brien *et al*., 2008). Students average a minimum of one energy-drink in a month for various reasons according to (Miller, 2008).

In the marketing of energy drinks, there have been advertised claims of performance enhancing like effect; Red Bull establishes that on intake of the commodity, performance and attentiveness will be enhanced, making users to drink more to get the stated desires. In addition, several energy-drink firms employ advertising strategies by marketing the products with sporting activities to advertise their products (Heckman *et al*., 2010). Also, new alcoholic energy drinks similar in packaging to the non-alcoholic ones are target risk taking youth. Some energy drink marketers indicate on their product label as well as their advertisements certain cautions about their product for consumers (Seifert *et al*., 2011).

These industries are bringing in more innovative products and they have proven to be exceedingly successful and more products are estimated in the coming years (Heckman *et al*., 2010).

2.4 Regulation

Drinks containing caffeine is a real big deal and a challenge owing to the long-lasting intake of tea and coffee which are natural constituents. Due to this, several nations have been doing their best to control the labelling, supply and commercialization of energy-drinks that amalgamate large amounts of caffeine. The inscription" high caffeine content" is expected to be labelled on the can of the drinks as demanded by the European Union (Albisinni, 2011). Canada also has a regulation that warns energy drink users to use 500 mL per day according to the label instruction on the can (Brache and Stockwell, 2011). In Norway energy drinks example red bull are only sold in pharmacies. Denmark has prohibited the sale of red bull (Ari Kapner, 2004)

The Food and Drug Authority (FDA) in USA impose a minimum of caffeine (71 mg) for each 350 mL of drink. Producers claim their products are "supplements" making regulations very simple for their productions which are, not to have any caution labels on it, either are they expected to perform analysis on their product before commercialising. Furthermore, there are no restricted regulations for to children (Seifert *et al*., 2011).

The Food and Drug Authority in Ghana does not have stringent regulations on the tolerable limit of caffeine content in energy drinks. Most of the energy drinks do not come with cautionary labels; advising on the use and quantity of caffeine in the drink. For example, for drugs that are sold over the counter which contain some stimulants, it is essential to have specified labels on them like "do not give to persons below 12" whilst energy drink of 500 mg are sold without such warnings (Reissig *et al*., 2009).

Several countries have either banned or specified regulations on sale and use of energy drink. In Argentina, for example, the senate is making efforts to prohibit the sale of energy drinks at nightclubs. It is recommended that persons are not supposed to take energy-drinks and alcohol at the same time. In Norway, only pharmacies are authorized to sell Red Bull energy drink. In Uruguay and Turkey, the commercialization of all energy drinks has been prohibited. In Germany 11 out of 16 states have completely expelled energy producing drinks after they established that they contained traces of cocaine (Seifert *et al*., 2011).

2.5 Transportation in Ghana

Public transportation is an essential portion of national growth. When there is economic growth, cities expand, which then necessitates the need for public transportation to help mobility of citizens. There are two major public transportation systems by road in Ghana: the 'trotro' and taxis. These means of transport are mostly used by lower income earners for their daily routines. A major number of Ghanaians fall into this group making public transportation (trotro and taxis) an important component of the national economy. When public transportation is appropriately attended and made attractive, some parts of safety and overcrowding alarms can be significantly reduced. Nevertheless, developing countries which patronise public transports are faced with challenges, these challenges may differ from country to country (Pucher *et al*., 2004).

The speedy development of Ghana's urban population joined with the failure of the rail network has put a massive strain on the road urban transport systems, as a result road traffic accidents, congestion, and noise, air pollution (carbon and toxic gas) among others are prevalent. There is little or no attention given to these life-threatening problems in public transportation in most developing countries. People, however, engage in a lot of trips when economic activities increase or when there is population growth such as communities increasing into cities, household settings and activity change.

In the past few years, such changes have been so fast that the growth of public transportation seems to always holdup behind. It is, therefore, of vital importance for government to infuse into the transport industry for people to get safe, reliable, accessible and comfortable means of moving about.

Public transport is an open transportation system that is easily accessible to the general public and usually operated by government or private personnel. In 1898, the first rail line was constructed from Takoradi to Tarkwa to aid in the commercial exploitation of gold and timber. It was during this time that public transportation became enhanced in the country as a number of individuals were into this trade. In 1927, the Accra Town Council started to operate bus transport services in the country (Yobo, 2013). Factors such as environmental factors, energy considerations and increasing productivity and economic growth calls for the promotion of an efficient transportation system in a country (Yobo, 2013).

Problems associated with public transportation are enormous and mostly common in developing countries, for instance Ghana. The rapid demographic and economic growth suggest an increase in mobility of people, however, the emergence of commercial motorcycle transport only gives an indication of inadequate public transport services in the country. It is, therefore, expected that, the transportation industry develops at equal pace in order to avoid certain unwanted incidents such as discomfort, accidents and substantial level of anxiety among commuters. The poor transportation services in the industry can be associated with certain factors in both the formal and informal sectors. These include; Reliability, Safety, Regulations, Environmental and economic factors

These can be minimized by enforcing comprehensive policies in the public transport industry such as the right to operate as a commercial vehicle, area of coverage, maintenance of vehicles and safety standards of operation. According to the Ministry of Transport, about 95% of transport services in the urban public transportation is now dominated by the private sector but their quality of service is questionable (Blonigen and Wilson, 2006).

Finance can be said to be the major limitation in the management of a commercial or public transportation industry as a number of internal operations are foreign exchange driven; car component parts, servicing equipment, tyres and fuel all need to be imported. Again, managers of urban transports usually fall short to include asset replacement policies and programs in their corporate plans. Most of the times revenues which can be used to finance asset replacement programs are exhausted by inflation and other economic pressures.

Maintenance of public local transport is a challenging issue, vehicles tend to decline in efficiency and safety due to high cost of operations and maintenance. Eventually, its operation as a public transport comes to a stop. In most developing countries, mini-vans are used as public transport. It takes a maximum of twenty passengers around the city and countryside. The trotro scheme works around a principle central to the Ghanaian society: waiting for fully loaded vehicle before setting off. There is no arranging, no map outlining directions and no advance tickets sold. One has to wait at the side of the road or at the stations to board them. This enterprise is privately owned and is geared toward the needs of the people (Asiedu-larbi, 2017).

The conductors mostly hit the roof or side of the van to interest passengers and notify the driver when to stop or leave a bus stop. This form of transportation is used by almost 70% of Ghanaian commuters as of 2010 (Aseidu-Larbi, 2017). In Ghana, trotros are licensed by the government, but the industry is questionably self-regulated. In the nonexistence of the government's controlled and regulatory frame, groupings called associations oversee the operations of the trotros. These groups may collect dues, set routes, manage terminals, and fix fares (Asiedu-Larbi, 2017).

2.6 Road traffic accidents in Ghana

Ghana is not an exception from this public health problem. The local newspapers and the news media do the major coverage of these road accidents, at places where the road accidents are actually seen. The National Road Safety Commission sometimes report such incidences themselves to the media for coverage when they need views on the compiled road accidents at the end of the year. The coverage from the commission and the media does not really give a clear national picture as to the challenges of the health burden of the accidents on the roads. A national road safety report of 2007 showed that a minimum of six persons are killed daily through road traffic accidents (Coleman, 2014).

Vehicular factors also contribute to road accidents, this led to the commissioning of the Driver and Vehicle Licensing Agency (DVLA) as a statutory body in Ghana. The DVLA is supposed to check roadworthiness of all cars in the country (this has not been fully achieved). The importation of 'accident' cars because they are cheaper, along with the already existing poorly maintained old cars should satisfy the requirements of the DVLA before they are allowed for use.

Lack of the required yearly review of maintenance status together with the mechanical safety of vehicles, especially older vehicles makes them more disposed to Road Accidents, the bad road network in the country. Human factors, which include the driver factor as previously stated, and others such as vehicular use enforcement personnel (including policemen, Driver and vehicular licensing authority and customs staff), all play major roles in the initiation of Road Traffic Accidents. These are as a consequence of poor understanding or deliberate disregard of road codes, driving under the influence of certain substances that affect one's cognition such as alcohol, cannabis and caffeine, overloading vehicles (especially, commercial drivers) and bribery and corruption of enforcement personnel (in the cases of Road Traffic Infringement) which is seen as one major disturbing factor (Zall Kusek and Rist, 2004).This is so severe that it nullifies the entire importance of vehicle and driver regulation. The ease of drivers to pay off their way out of breaching the rules and inadequate personnel in the enforcement authority promotes the violation of driving codes, leading to rampant road accidents (Zall Kusek and Rist, 2004).

This factor puts pressure on the appropriate and exact documenting of information, and collection of information to come up with the best statistics to inform decision-making. Lastly gathering of information or availability is marked as a limiting step in developing countries (Zall Kusek and Rist, 2004).

CHAPTER THREE

MATERIALS AND METHODS

3.1 Materials

Table 3.1: Energy Drinks Sampled from Tech Junction, Kumasi

Sample (Energy drinks)	Manufacturer	Manufactured date	Expiry date	Batch number	Source
Lucozade	GlaxoSmithKline	-	01/02/19	199D00 276	Provision shop, Tech Junction; Kumasi
5 Star	Multi Pac Limited	-	13/06/19	0164	Hawker, Tech bus station
Storm	Kasapreko company limited	-	10/04/19	SED19218S	Hawker, Tech bus station
Rush	Twellium Industrial Company Limited	-	15/09/19	TW/301;34	Hawker, Tech Junction
Run	Twellium Industrial Company Limited	-	02/10/19	TW/2 22;26	Hawker, Tech Junction

Table 3.2: Energy Drinks Sampled from Atonsu Station, Kumasi

Sample (Energy drinks)	Manufacturer	Manufactured date	Expiry date	Batch number	Source
Lucozade	GlaxoSmithKline	-	01/10/19	L8288K10	Hawker, Atonsu station
5 star	Multi Pac Limited	-	17/02/20	L8288K10	Hawker, Atonsu station
Storm	Kasapreko company limited	-	06/11/19	SED038195	Hawker, Atonsu station
Rush	Twellium Industrial Company Limited	-	22/01/20	TW/16:54	Hawker, Atonsu station
Run	Twellium Industrial Company Limited	-	02/10/19	TW/216:22	Hawker, Atonsu station

Table 1.3: Energy Drinks Sampled from Kejetia, Kumasi

Sample (Energy drinks)	Manufacturer	Manufactured date	Expiry date	Batch number	Source
Lucozade	GlaxoSmithKline	-	01/07/19	F80049	Provision shop
5 star	Multi Pac Limited	-	19/03/20	0077	Provision shop
Storm	Kasapreko company limited	-	10/04/20	SED058195	Provision shop,
Rush	Twellium Industrial Company Limited	-	09/09/19	TW/300:04	Provision shop
Run	Twellium Industrial Company Limited	-	24/08/19	TW/209:10	Provision shop

Table 3.4: Energy drinks sampled from Sofoline bus station, Kumasi

Sample (Energy drinks)	Manufacturer	Manufactured date	Expiry date	Batch number	Source
Lucozade	GlaxoSmithKline	-	N/A	N/A	Provision shop, Sofoline main station
5 star	Multi Pac Limited	-	11/05/19	0066	Provision shop, Sofoline main station
Storm	Kasapreko company limited	-	N/A	N/A	Provision shop, Sofoline main station
Rush	Twellium Industrial Company Limited	-	N/A	N/A	Provision shop, Sofoline main station
Run	Twellium Industrial Company Limited	-	02/09/20	TW/211:35	Provision shop, Sofoline main station

Table 3.5: Energy drinks sampled from VIP bus station.

Sample (Energy drinks)	Manufacturer	Manufactured date	Expiry date	Batch number	Source
Lucozade	GlaxoSmithKline	-	N/A	N/A	Hawkers, VIP station
5 star	Multi Pac Limited	-	13/06/20	0068	Hawkers, VIP station
Storm	Kasapreko company limited	-	N/A	N/A	Hawkers, VIP station
Rush	Twellium Industrial Company Limited	-	N/A	N/A	Hawkers, VIP station
Run	Twellium Industrial Company Limited	-	02/12/20	TW/216:40	Hawkers, VIP station

3.2 Chemicals and reagents

- Caffeine reference standard was obtained from Amponsah Effah Pharmaceuticals Limited, Acetic acid and methanol was from Analar Normapur (Analytical grade), nitric acid, hydrochloric acid and hydrogen peroxide was from British Drug Houses (BDH) chemicals.
- HNO_3 (65 %)
- Energy drinks from venders with different batches.

3.3 Equipment and apparatus

- Perkin Elmer HPLC Chromera Version 4.1.0.6386 from Perkin Elmer, USA, Elmasonic S 30 H from Perkin Elmer, USA, Hettich manual centrifuge from Andreas Hettich, Germany, Bellstone Analytical Balance/Satorius CPA623S Analytical Balance from Bellstone-Australia, volumetric flask, micropipette, beaker, spatula and centrifuge tubes.
- Atomic absorption spectrophotometer from Guangzhou Allfine Medlab Co., Ltd, China, Beaker, hotplate and test tubes.
- Dip 6 drug test kits

3.4 Study design

The study began with an exploratory research where questionnaires were given out to commercial drivers to gain insight on the usage of energy drinks amongst them. Samples of energy drinks on the market were obtained at the various study sites and subjected to analytical methods.

3.5 Study Area

This study was carried out in Kumasi, specifically at major bus terminals. In Ashanti Region, Kumasi is located at the centre of the region. It is also the regional capital Kumasi is about 500 kilometers north of the equator and 200 kilometers north of the Gulf of Guinea. It includes a surface of 254 km^2. The population of Kumasi Metropolis (1,730,249) constitutes 36.2 percent of the complete population of the region of Ashanti (4,780,380). It includes 826,479 males (47.8 %) and 903,779 women (52.2 %). The Metropolis covers a land region of 214.3 square kilometres, which is 0.9 percent of the land area of 24,389 square kilometres. The Metropolis has a population density of 8,075 individuals per square. Km.The metropolis is the Ashanti region's most populous area. The town includes 10 sub-metropolitan areas-Manhyia, Tafo, Suame, Asokwa, Oforikrom, Asawase, Bantama, Kwadaso, Nhyiaeso and Subin (Service, 2013).

3.6 Study Sites

The following bus stations/terminals were used for the study:

Figure 3.1: A map showing the various study sites

Lorry stations

Figure 3.2: Atonsu lorry station

(N06º39.757´W001º33.005)

Figure 3.3: Kejetia lorry Station

(N06º39.779´W001º33.035´)

Figure 3.4: Sofoline lorry Station

(N06º41.959´W001º39.029´)

Figure 3.5: Tech junction lorry station

(N06º41.211´W001º34.326´)

3.7 SURVEY

3.7.1 Sampling Method

Purposive sampling was used to select five (5) bus stations for the study. These bus stations were selected because of how populated these stations are and the fact that all these stations have many inflow and outflow of buses at terminals in Kumasi. A convenience sampling technique was used to select the participants who were at the bus stations. Those who met the criteria for the selection and willing to participate were recruited into the study until the required 200 sample size was reached.

3.7.2 Data Collection

Assistants in the collection of the data were trained on the use of the questionnaire and other data collection tools. Pre-tested structured questionnaires were administered to the respondents at their various bus stations. The questionnaires were adjusted where necessary to reduce or eliminate any biases and errors. The questionnaires asked specific questions about their usage and consumption of energy drinks.

3.7.3 Sample Size and Population

The selection of the respondents was limited to Drivers of Public transport vehicles (Taxi and Trotro). The non-probability sampling technique was used in this study. Purposive sampling, which is an example of non-probability sampling technique, was adopted in identifying key respondents. This is because the survey required certain groups of respondents who had been involved in public transportation operations. Statistical method was used in establishing the sample size for trotro and taxis for the study. The sample size was determined using the following simplified formula (Singh and Masuku, 2014), $\mathbf{n}=\frac{N}{1+Ne2}$, Where n is the sample size, N is the population size, and e is the level of significance. The population size was the number of trotro and taxis registered with DVLA for the 2011 in the metropolis. This calculated from the percentage composition of traffic count (51.1%). The total number of registered vehicles in the metropolis was 200,116 in 2011 (Asiedu-Larbi, 2017). The estimated taxis and trotro vehicle population in the metropolitan area was calculated as 51.1% of 200,116. This gave an estimated 102,260 taxis and trotros working within the metropolis. Using a significance of 10%, a minimum sample of size of 100 was obtained. The sample size used for the survey was 200 commercial drivers.

3.8 ASSESMENT OF HEAVY METALS IN THE ENERGY DRINKS USING ATOMIC ABSORPTION SPECTROPHOTOMETRY

Digestion

A volume of 50 mL of each sample was used in the digest ion process; into a pre-washed conical flask. A volume of 20 mL of concentrated nitric acid was added and shaken to ensure uniform mixing. The mixtures were heated on a hotplate at 150 ℃ till the brown nitrous oxide ceased and a clear solution was obtained. More nitric acid was added and heated in cases where the solution was not clear till a clear solution was obtained. The mixture was then heated to digest and free the metals.

The completely digested samples were allowed to cool to room temperature, transferred quantitatively into test tubes, and assayed for the presence of the analysts of interest using the Atomic Absorption Spectrometer.

3.9 DETERMINATION OF CAFFEINE CONTENT IN THE ENERGY DRINK SAMPLES USING HIGH PERFORMANCE LIQUID CHROMATOGRAPHY

3.9.1 Establishment of Chromatographic Conditions

3.9.1.1 Mobile Phase Determination

To obtain a suitable mobile phase to aid complete resolution of the energy drinks, different ratios such as 90:10, 80:20, 75:25 and 70:30 of acidic water-methanol solvent system were tried. Finally, a ratio of 70:30 acidic water-methanol solvent system aided the complete and better resolution within the shortest period, hence was used as the mobile phase. The acidic water was a combination of distilled water-acetic acid in 75:0.05 ratio.

3.9.1.2 Stationary Phase Determination

Since the mobile phase was polar, a nonpolar stationary phase was used to achieve a shorter retention time. A C-18 column (Zorvax 300SB; 4.5 × 250 mm, 5 µm from Agilent) was employed.

3.9.1.3 Determination of Caffeine Content in Energy Drink Samples

A standard solution of 0.0012 g/mL was prepared by weighing 0.12 g of pure caffeine powder into 100 mL of water. Aliquots of the already prepared solution was taken to prepare standard concentrations of 15 mg/L, 30mg/L, 60 mg/L, 120 mg/L and 240 mg/L and was used in plotting the calibration curve. An amount of 5 mL of the energy drinks (Lucosade, Storm, Run, Rush and 5 Star) was taken. The samples were degassed using a sonicator. After the samples were centrifuged to remove any impurities. Subsequently, 400 µL of each sample was taken and diluted with 400 µL of water. Twenty microlitres of the sample was injected into the injection valve of the HPLC machine with an analysis time of 13 minutes. Detection was done at a maximum wavelength of absorption of 270 nm.

3.10 PRELIMINARY TEST USING DIP 6 DRUG TEST

A quantitative amount of each of the 25 different batches of the energy drinks were poured into a different beaker. The beakers were labelled according to the various brands of drinks. The drink was poured from the beakers into the cap of the test kits. The sticks were dipped into the cap and after 5 minutes the readings were taken.

CHAPTER FOUR

RESULTS

After carrying out the survey on the usage of the drinks among some commercial drivers in Kumasi and the various analyses on the drinks consumed, these are the results of the findings;

4.1 Findings on Survey

For this study, 210 commercial drivers were recruited following the explanation of the study protocol. The study participants' age ranged from 16 to 71 years with a mean age of 36.6 ±10.89. It was found that most of the drivers were between the ages of 26 and 46 years old. The study covered five major bus terminals in Kumasi with Atonsu having the most participants; 90 (42.9%), Tech Junction 55 (26.2%), Sofoline 44 (19.0%), Kejetia 15 (7.1 %) and VIP station 10 (4.8 %) as shown in Table 4.1. The study recorded 82 (39.1%) drivers making less than 5 trips in a day, 81 (38.6 %) making 5 to 10 trips and 47 (22.4 %) making more than 10 trips in a day. Within the number of trips, 173 (82.4%) drove less than 5 hours per trip, 34 (16.2 %) made 5 to 10 hours per trip and 3 (1.4%) made more than 10 hours per trip. From Table 4.1, it can be inferred that almost all of the participants had knowledge on the usage of energy drinks.

Table 4.1: Characteristics of Study Participants

CHARACTERISTIC	CATEGORIES	NUMBER	PERCENTAGE
Age with mean age of 36.6 ±10.89	<20	7	3.3
	21 – 30	59	28.1
	31 – 40	59	28.1
	41 – 50	41	19.5
	51 – 60	10	4.8
	61 – 70	5	2.4
	>71	2	1.0
	Total	183	87.1
	System Missing	27	12.9
		210	100
Station	ATONSU	90	42.9
	KEJETIA	15	7.1
	SOFOLINE	40	19.0
	TECH JUNCTION	55	26.2
	VIP	10	4.8
	Total	210	100.0
Number of trips daily	<5	82	39.0
	5 – 10	81	38.6
	>10	47	22.4
	Total	210	100.0
Hours per trip	<5	173	82.4
	5 – 10	34	16.2
	>10	3	1.4
	Total	210	100.0
Knowledge on ed.	Yes	208	99
	No	0	0
	System Missing	2	1
		210	100

Most of the drivers 206 (98.1%), agreed to taking the energy drinks; 144 (68.6%) took the drinks to stay alert, 26 (12.4%) took it for recreational purposes whiles 39 (18.6%) took it for other personal reasons. Nevertheless, some also took the drinks for one reason or the other. Only 84 (40%) of the drivers actually had an idea of the negative effects of the drinks while 122 (58.1%) had no idea of the negative implications of these drinks. 102 (51.9%) confirmed to take 1 to 2 bottles of the drink in a day, 57 (27.1%) took 3 to 5 bottles in a day while 40 (19%) took more than 5 bottles a day.

Among the most popular energy drinks taken, 5 Star was the most highly consumed with 59 (28.1%) followed by 50 (23.8%) who took Run energy drinks, 28 (13.3%) took Rush energy drink and 31 (14.8%) consumed other energy drinks. 201 (95.7%) of the drivers confirmed to take the drinks while driving. 9 (4.3%) said they do not take the drinks while driving. The survey also informed us about the frequency of use of these drinks. 129 (61.4%) confirmed to take the drinks every day, 37 (17.6%) consume them 2 to 3 times a week, 21 (11%) consume them once a week while 20 (9.5%) took the drinks at other times depending on their preferences. Some participants confirmed to some reactions when these drinks are not taken; 126 (60%) feel indifferent when the drinks are not taken. 52 (24.8%) felt very tired when the drinks were not taken whiles 30 (14.3%) felt very uncomfortable when not on the drinks (Table 4.2).

Table 4.2: Consumption and usage of energy drinks

VARIABLES	CATEGORIES	NUMBERS	PERCEN.
CONSUMPTION OF ENERGY DRINKS	YES	206	98.1
	NO	4	1.9
	Total	210	100.0
POS EFFECTS OF ENERGY DRINKS	REDUCE SLEEP	144	68.6
	RECREATION	26	12.4
	OTHERS	39	18.6
	Total	209	99.5
	System Missing	1	.5
		210	100
NEG EFFECT OF ENERGY DRINKS	YES	84	40.0
	NO	122	58.1
	Total	206	98.1
	System	4	1.9
		210	100.0
TYPE OF ENERGY DRINKS CONSUMED	RUN	50	23.8
	STORM	42	20.0
	5 STAR	59	28.1
	RUSH	28	13.3
	OTHERS	31	14.8
	Total	210	100.0
NUM. OF BOTTLES	1 – 2	109	51.9
	3 – 5	57	27.1
	> 5	40	19.0
	Total	206	98
	System Missing	4	2
	Total	210	100.0
USAGE WHILST WORKING	YES	201	95.7
	NO	9	4.3
	Total	210	100.0
FREQUENCY OF CONSUMPTION	EVERYDAY	129	61.4
	2 - 3 TIMES/WEEK	37	17.6
	ONCE A WEEK	23	11.0
	OTHERS	20	9.5
	Total	209	99.5
	Missing	1	.5
		210	100.0

REACTION TO NON-CONSUMPTION	FEEL VERY TIRED	52	24.8
	DO NOT FEEL COMFORTABLE	30	14.3
	INDIFFERENT	126	60.0
	Total	208	99.0
	Missing	2	1.0
		210	100.0

Association between number of bottles and number of trips daily

To establish whether there is any association on the quantity of energy drinks consumed and number of trips a driver makes in a day, a Chi-square test of independence was performed. The analysis showed a significant difference between the quantity of energy drinks consumed and the number of trips made in a day as shown in Table 4.3.

Table 4.3: Association between number of bottles and number of trips daily.

NUM. OF TRIPS DAILY * NUM. OF BOTTLES CROSS TABULATION						Chi Square P-Value
		NUM. OF BOTTLES			Total	0.000
		1 – 2	3 – 5	> 5		
NUMBER OF TRIPS DAILY	<5	59	19	0	78	
	5 – 10	44	32	5	81	
	>10	6	6	35	47	
TOTAL		109	57	40	206	

Association between the type of energy drinks consumed and the number of bottles consumed.

Having observed that the number of trips made in a day by a driver is significantly influenced by the quantity of energy drinks consumed, we further analysed whether there is an association between the type of energy drinks and the quantity consumed. This had a p-value of 0.245, meaning, the number of bottles consumed is not dependent on the type of energy drink consumed (Table 4.4)

Table 4.4: Association between the type of energy drinks consumed and the number of bottles consumed.

TYPE OF ENERGY DRINKS CONSUMED * NUM. OF BOTTLES CROSS TABULATION						Chi Square P-Value
		NUM. OF BOTTLES			Total	.245
		1 – 2	3 – 5	> 5		
TYPE OF ENERGY DRINKS CONSUMED	RUN	25	17	6	48	
	STORM	27	9	6	42	
	5-STAR	30	13	16	59	
	RUSH	10	11	6	27	
	OTHERS	17	7	6	30	
TOTAL		109	57	40	206	

Having observed that the number of trips made in a day by a driver is significantly influenced by the quantity of energy drinks consumed, we further analysed whether there is an association between the type of energy drinks and the frequency of consumption. This had a p-value of 0.457, meaning, the type of energy drinks consumed is not dependent on the frequency of consumption.

Table 4.5: Association between the type of energy drinks consumed and the frequency of consumption

TYPE OF ENERGY DRINKS CONSUMED * FREQUENCY OF CONSUMPTION CROSS TABULATION							Chi Square P-Value
		FREQUENCY OF CONSUMPTION				Total	.457
		Everyday	2 - 3 Times/Week	Once A Week	Others		
TYPE OF ENERGY DRINKS CONSUMED	RUN	33	11	3	3	50	
	STORM	24	9	6	3	42	
	5-STAR	39	9	5	6	59	
	RUSH	18	5	3	2	28	
	OTHERS	15	3	6	6	30	
TOTAL		129	37	23	20	209	

4.1.1 Results of statistical analysis of the survey using linear regression model

4.1.1.1 Correlation between the consumption of energy drinks and the various age groups

The correlation between the consumption of energy drinks and the age groups showed a negative Pearson correlation of -0.081. The correlation showed a non-significance (1-tailed) of 0.137. This is shown in Table 4.6.

Table 4.6: Correlation between the consumption of energy drinks and the various Age groups

		CONSUMPTION OF ED	AGE GROUPS
Pearson Correlation	CONSUMPTION OF ED	1.000	-.081
	AGEGROUPS	-.081	1.000
Sig. (1-tailed)	CONSUMPTION OF ED	.	.137
	AGEGROUPS	.137	.
N	CONSUMPTION OF ED	183	183
	AGEGROUPS	183	183

4.1.1.2 Model summary

The model summary shows a correlation between the consumption of the drinks and the age groups. The R square value is 0.007, which can be expressed as a percentage (0.7 %). Table 4.7

Table 4.7: Model summary between the consumption of drinks and age groups

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.081[a]	.007	.001	.127

4.1.1.3 Correlation showing the number of trips taken and the number of bottles taken

Pearson correlation was done to find the relationship between number of trips and number of energy drinks consumed. There was a strong, positive correlation between the two variables ($r = 0.631$, p-value < 0.05) as shown in Table 4.8.

Table 4.8: Correlation showing the number of trips taken and the number of bottles taken

		NUMBER OF TRIPS DAILY	NUMBER OF BOTTLES
Pearson Correlation	NUMBER OF TRIPS DAILY	1.000	.631
	NUMBER OF BOTTLES	.631	1.000
Sig. (1-tailed)	NUMBER OF TRIPS DAILY	.	.000
	NUMBER OF BOTTLES	.000	.
N	NUMBER OF TRIPS DAILY	206	206
	NUMBER OF BOTTLES	206	206

4.1.1.4 Model summary between the number of trips taken and the number of bottles taken

The model summary from Table 4.9, shows the correlation between the number of trips taken and the number of bottles taken. The R square value is 0.398 (0.4) which can be expressed as a percentage (40 %).

Table 4.9: Model summary between the number of trips taken and the number of bottles taken

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.631[a]	.398	.395	.596

4.1.1.5 Correlation between number of trips and frequency of use of the drinks

The correlation was performed to determine whether the number of trips is influenced by the frequency of use of the energy drinks. A Pearson correlation performed showed a significant weak positive correlation of r= 0.29 as shown in Table 4.10.

Table 4.10: Correlation between number of trips and the frequency of use of the drinks

		NUMBER OF TRIPS DAILY	FREQUENCY OF CONSUMPTION
Pearson Correlation	NUMBER OF TRIPS DAILY	1.000	-.297
	FREQUENCY OF CONSUMPTION	-.297	1.000
Sig. (1-tailed)	NUMBER OF TRIPS DAILY		.000
	FREQUENCY OF CONSUMPTION	.000	.
N	NUMBER OF TRIPS DAILY	209	209
	FREQUENCY OF CONSUMPTION	209	209

4.1.1.6 Model summary between number of trips and frequency of use of the drinks

The model shows a summary of the correlation between the number of trips taken and the frequency of use of the drinks. The R square value is 0.88 which can be expressed as a percentage (8 %), as inferred from Table 4.11.

Table 4.11: Model summary between number of trips and frequency of use of the drinks

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.297[a]	.088	.084	.735

4.2: Determination of Caffeine Content in the Five Selected Energy Drinks

This is the chromatogram of the calibration curve using pure caffeine sample. This calibration curve was used to generate the equation of the line (y = 2.89159E+04x - 2.90470E+04). This equation of the line was used to determine the various concentrations of the drinks as shown in Figure 4.1.

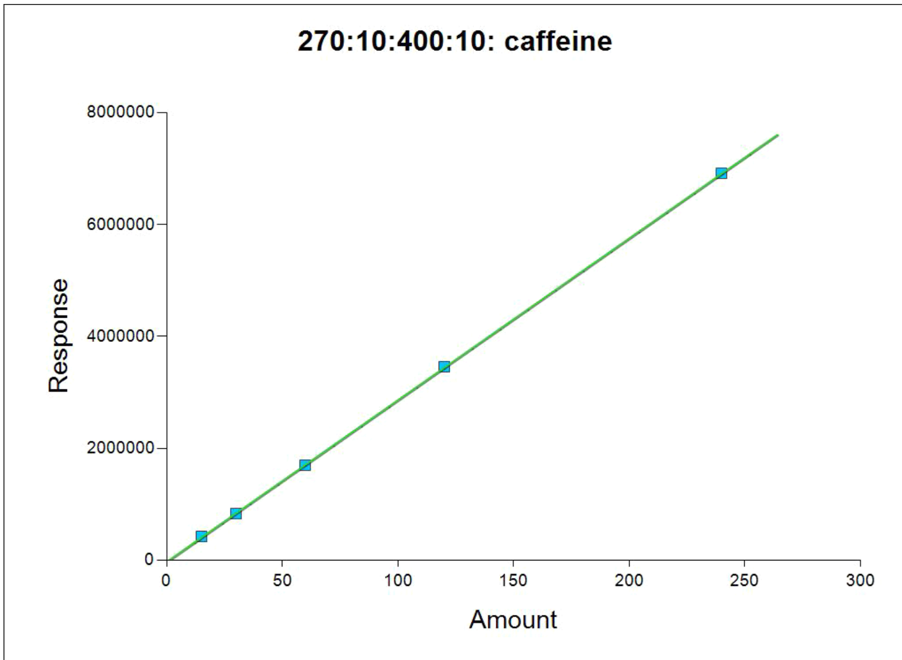

Figure 4.1: Chromatogram of the Calibration Curve Using Pure Caffeine Samples

Component Name: caffeine

Curve type: Linear

Equation: y = 2.89159E+04x - 2.90470E+04

Curve Statistics:

Intercept: -2.90470E+04

Origin Treatment:

Slope: 2.89159E+04

r^2: 0.999185

4.2.1 The Various Concentrations of Caffeine Concentration in the Energy Drinks

From Figure 4.2, Rush energy drink had the most amount of caffeine containing 116 mg in 350 mL of the drink (0.33 mg in 1 mL). Storm energy had the second highest with 104 mg in 350 mL of the drink (0.3 mg in 1 mL). Run also had the same concentration as Storm though it is made from different companies. 5-Star from multi Pac had 98 mg of caffeine in 350 mL (0.28 mg/mL) of the bottle. Lucozade which is made by GlasoSmithKline had the least amount of caffeine; 40 mg in 350 mL (0.11 mg/1 mL).

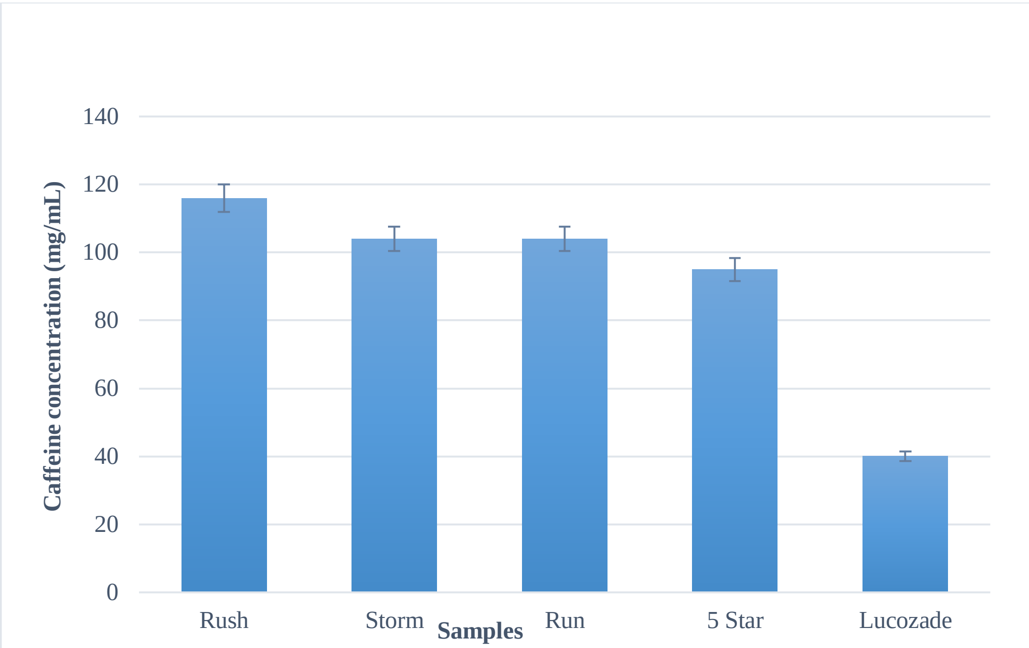

Figure 4.2: The Concentrations of Caffeine in the Energy Drink Samples

4.3 HEAVY METALS ANALYSIS OF ENERGY DRINKS

This was done to determine the content of heavy metals in the drinks and to prove the safety in consumptions.

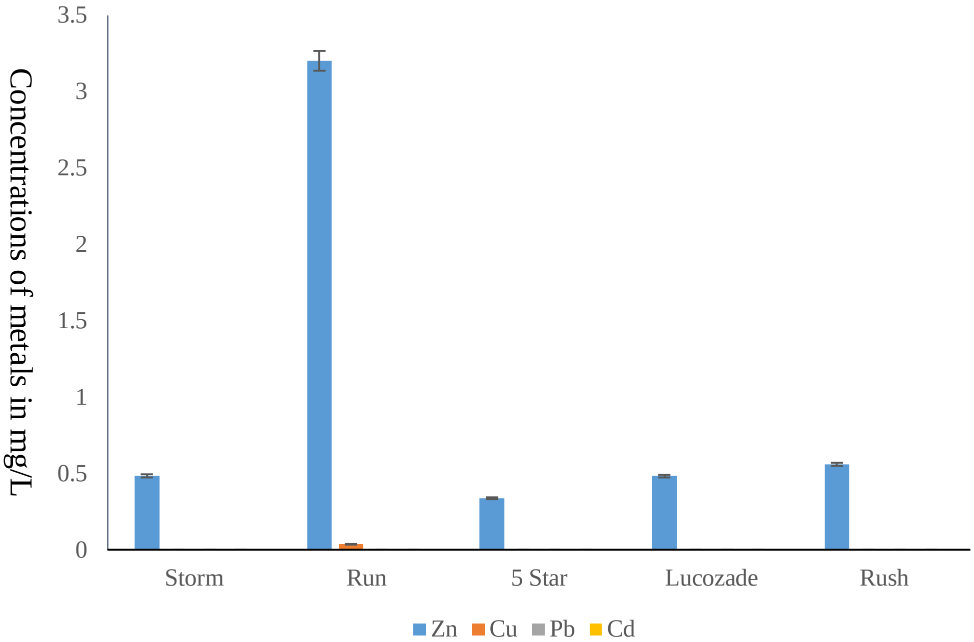

Figure 4.9: Heavy Metal Concentrations in the Energy Drinks

4.4 Results of Preliminary Test of Some Psychoactive Agents in Some Commercial Energy Drinks Used by Commercial Drivers

Five different batches of the five energy drinks were sampled and analyzed using the dip 6 drug test kit. All the batches that were analysed for the specific drug panel of the kits were absent.

Table 4.12: Preliminary Test of Some Psychoactive Agents in Some Energy Drinks Used by Commercial Drivers

Stations	Energy drinks	Batch No.	Results					
			BZO	COC	MET	OPI	THC	TML
Tech Junction	RUN	TW/222:26	_	_	_	_	_	_
	RUSH	TW/301:8S	_	_	_	_	_	_
	STORM	SED19218S	_	_	_	_	_	_
	5-STAR	0164	_	_	_	_	_	_
	LUCOZADE	199D 00276	_	_	_	_	_	_
Atonsu	RUN	TW/216:22	_	_	_	_	_	_
	RUSH	TW/16:54	_	_	_	_	_	_
	STORM	SED038195	_	_	_	_	_	_
	5-STAR	0048	_	_	_	_	_	_
	LUCOZADE	L8288K10	_	_	_	_	_	_
Kejetia	RUN	TW/209:10	_	_	_	_	_	_
	RUSH	TW/300:04	_	_	_	_	_	_
	STORM		_	_	_	_	_	_
	5-STAR	0077	_	_	_	_	_	_
	LUCOZADE	F80049	_	_	_	_	_	_
Sofoline	RUN	TW/211:35	_	_	_	_	_	_
	RUSH		_	_	_	_	_	_
	STORM	SED058195	_	_	_	_	_	_
	5-STAR	0066	_	_	_	_	_	_
	LUCOZADE		_	_	_	_	_	_
VIP	RUN	TW/216:40	_	_	_	_	_	_
	RUSH		_	_	_	_	_	_
	STORM		_	_	_	_	_	_
	5-STAR	0068	_	_	_	_	_	_
	LUCOZADE		_	_	_	_	_	_

KEY:

"_"; Absent

BZO: Benzodiazepines

COC: Cocaine

MET: Methamphetamine

OPI: Opiates

THC: Tetrahydrocanobinoids

TML: Tramadol

CHAPTER FIVE

5.0 DISCUSSION

Traffic accidents can occur as result of fatigue which may results in severe consequences. In order to overcome fatigue, drivers depend on psycho stimulant, most commonly caffeine, by consuming energy drinks (Pešić *et al*., 2015). This study tends to determine the content and the effect of consumption of energy drinks on the efficiency of commercial drivers in Ghana on the roads. The drivers used vehicles that carry passengers ranging from 5 to more than 25. This study showed that commercial driving in Kumasi is entirely done by men within the ages between 20-60 years (36.66±10.891). This is similar to another study on drivers in Nigeria, where the mean age of drivers were below 45 years (Ipingbemi, 2008).

5.1 PSYCHOACTIVE AGENTS IN ENERGY DRINKS ON THE GHANAIAN MARKET

In this study no detection of psychoactive agents such as Benzodiazepines, Cocaine, Methamphetamine, Opiates, Tetrahydrocanobinoids and Tramadol were found in the energy drinks used. This was done to confirm whether the manufacturers adulterate the drinks with other psychoactive substances to be able to increase demand of their drinks. It is also possible that the specific psychoactive drug used by these manufacturers could not be picked up by the dip 6 test kits. However, varying amounts of caffeine were detected in the energy drinks. The caffeine concentrations per 350 mL in the energy drinks ranged from 40 mg for Lucozade, 98 mg for 5 Star, 104 mg for Storm and Run and 116 mg for Rush. About 52.92% of drivers usually took one to two bottles which will amount to less than 400 mg. However, the remaining 47.08% consume several bottles that may result in some adverse effect of caffeine such as restlessness, insomnia, and nervousness. A study conducted in Pakistan showed that caffeine content in energy drinks were also very high; one brand had 299.95 mg per 250 mL, the second was 508.5 mg per 250 mL, 230.9 mg per 250 mL for the third brand, the last brand analysed was 160.27 mg per 500 mL (Usman *et al*., 2015).

In most adults, unusual consumption of caffeinated drinks can be of less harm to them. Statistics recommend that the safe higher limit of caffeine consumption in healthy adults is just about 400 mg per day (Sepkowitz, 2013). The safe limit to the intake of caffeine among children is between 45 to 85 mg but mostly dependent on the weight. A limit of not more than 200 mg is required in pregnant women, however, abstinence is the best option (Lieberman *et al.*, 2002). Within the military, moderate or optimum doses may be essential to take care of or improve psychological function because of their exposure to severe stress; and it is been planned that a dose of 200 mg seems to be optimal underneath such conditions (Lieberman *et al*., 2002). Nevertheless, excessive intake of caffeine can be injurious to health. Over-consumption leads to changes in sleep patterns and has an effect on day time performance. Hence, there has to be better regulation worldwide on the consumption of these drinks because of their high caffeine content.

5.2 CONSUMPTION PATTERN OF ENERGY DRINKS AND THEIR EFFECT ON COMMERCIAL DRIVERS

Most 206 (98.1%)) of the drivers who took part in the study, were consumers of energy drinks, and this was done during driving. Most of the drivers accepted that they take the drinks to stay awake, making it obvious that these drinks are taken when they are very tired. In Kumasi, about 60% of its inhabitants depend solely on these commercial drivers to commute to their place of abode (Service, 2013). This puts a lot of pressure on these drivers because everybody wants to use this opportunity to make a lot of money. In Ghana, it is recommended that at least a driver drives not more than 8 hours per day just as most countries such as the United States (Blonigen and Wilson, 2006). Long driving could result in many consequences such as fatigue, road accident among other things. Ghana is one of the countries with high road accidents. This high number could be attributed to many factors such as bad roads, poor road signs among other things. In addition, one of the key factors, which contribute to road accident, is indiscipline on the part of some drivers. Such behavior could be influenced by the uncontrolled intake of energy drinks to control their fatigue when driving.

The National Road Safety Commission of Ghana indicates that a mandatory rest of 30 minutes after every four hours and a total of eight hours driving in a day. These drivers hereby take in anything they lay their hands on to keep them awake to be able to drive longer hours to make a lot of money. The survey shows that averagely, most drivers drive about 3 hours in a trip and they do about 5 trips in a day, which make up to about 15 hours on the average in day. In this study they then sustain themselves with energy drinks to keep them alert.

From the survey, it was noticed that 109 (51.6 %) take about 1 to 2 bottles of the energy drinks in a day, with almost 50% of the sample size consuming 3 to 5 and more than 5 bottles of the drinks in a day. The drivers concluded that these drinks are taken during driving hours. Taking 3 to 5 bottles in a day is on the high side. Intake of above 400 mg of caffeine (been the main psychoactive components in the drink), causes psychoactive effects like restlessness, fatigue and insomnia (Reissig *et al*., 2009). Considering a bottle containing about 100 mg of caffeine, taking 5 bottles in a day would not be very safe for the drivers and safety on the roads.

The study showed that majority of the energy drinks (61.4%) are taken every day by the study participants. This actually subject the drivers to tolerance and dependence. An amount of 400 mg of caffeine everyday causes dependence after sometime. This leads to restlessness, insomnia, lack of concentration and agitations (Reissig *et al*., 2009). A similar study in Serbia found that over half the respondents (drivers) never consume energy drinks (53 %), whereas 34% ingest these one time a month, the remaining 13% consume a lot of the drinks usually, and 1% of them consume the drinks many times daily (Pešić *et al*., 2015). A study conducted in Turkey reported that drivers rather consumed more of tablet caffeine than the drinks; where 72.3% of the drivers took 1-2 tablets per day, 20% took 3-4 and 7.7% more than 5 tablets a day (Yildirim, 2003). This shows how most drivers try as much as possible to deal with their fatigue to work longer hours.

The daily intake of these drinks at a high concentration does have a lot of implications to both the health of these drivers and safety on our roads. Caffeine takes about 4 to 5 hours to completely be eliminated from the blood (O'Brien *et al*., 2008). Its effect starts to reduce as its concentration starts reducing in the blood, this can reduce alertness during the time of driving. Reduction in alertness of an already tired driver could be a public health problem because the safety of the driver, passengers and other users of the roads cannot be guaranteed.

When asked of their experience for skipping consumption, 126 (60 %) felt indifferent when the drinks are not taken, 52 (24.8 %) felt very tired when the drinks are not taken whiles 30 (14.3 %) feel very uncomfortable when not on the drinks; these show that some drivers have already started becoming dependent on these drinks which is not safe for driving.

The study also showed significant association between the number of trips and the number of bottles of energy drinks consumed. There was a strong positive correlation (r = 0.631. p-value< 0.05). Hence, an increase in the number of bottles will cause an increase in the number of trips taken. The R square value 0.398 (~0.4) shows a 40% probability that consumption of energy drinks can help drivers make more trips. This result is desirable enough to lead drivers on to consume more energy drinks.

The linear regression showed a weak, negative correlation (r = -0.081, p-value = 0.137) between the consumption of energy drinks and the age groups. Although this is statistically insignificant, it shows that it is unlikely for older drivers to indulge in consumption of energy drinks. Also, the model shows that the younger drivers are more likely to consume more drinks for driving than the older generation.

5.3 QUALITY OF LABELS AND HEAVY METALS CONTAMINATION OF ENERGY DRINKS

Cadmium, and lead were absent from the samples of energy drink analysed. Zinc was found to be present in all the drinks with an average of 1.06 mg/L. Copper was absent in all the drinks except Run energy, which recorded an amount of 0.0395 mg/L.

Run energy drink had the highest amount of zinc whilst 5 Star had the lowest amount. Deficiencies related to zinc is so alarming in recent times, affecting about two billion people in the developing countries. This causes growth retardation, delayed sexual maturation, infection susceptibility, and diarrhoea mostly in children. Consuming excess in adult can lead to ataxia, lethargy, and copper deficiency. The recommended daily dietary allowance for adults is 8 mg to 11 mg (Trumbo *et al.*, 2001). From the study the zinc obtained is below the recommended dietary allowance but if the drink is taken in excess there could be an overdose of the zinc in the body.

For very healthy nerve conduction, hormone secretion, the growth of bones and connective tissue, copper may be a mineral which will be very useful. A constant copper diet, even at fully permissible concentrations, breaks down the barrier that prevents unwanted toxins from entering the brain, fuelling a rise in beta amyloid manufacturing but impeding the efficiency of issues that clear the things from the brain. Too much copper that can build up in the brain creates inflammation in the brain tissue. According to the National Academy of Sciences (2001), the suggested nutritional allowance for adult males and females is 900 μg / g and the consumption of copper from food is roughly 1,0–1,6 mg / day.

Another study performed in Ghana reported traces of some heavy metals including cadmium, copper, iron, zinc, lead, and cobalt in soft drinks (Ackah *et al*., 2014). The source of these trace of heavy metals were not identified but could be due to the source of water or non-hygienic environments where these drinks were manufactured.

One of the key things to look out for when purchasing any consumable product is the labelling, which gives information on the nutritional contents of the product, the manufacturing date and expiry date. Some of the bottle labels of the energy drinks had issues. Rush, Storm, 5-star and Rush energy drink, lack key information on their manufacturing dates on the bottles. The bottles did not have any cautionary label for the consumption of caffeine. In addition to not having the manufacturing date on the products, some failed to indicate the specific amount of caffeine concentrations on the labels. Lucozade had all the required labelling instructions; manufacturing date, amount of caffeine content present but its cautionary label caffeine was not stated on its consumption. In addition, some of the bottles purchased from the bus stations did not have their batch numbers and expiry dates visible on the bottles. This could mean that, the bottles were poorly stored hence some writings went off.

CHAPTER SIX

6.0 CONCLUSION AND RECOMMENDATIONS

- In conclusion, the energy drink samples for this study did not contain any psychoactive agents in addition to the varying amounts of caffeine. There were appreciably high levels of energy drink consumption among the drivers. They usually took them to stay active or do more work. Heavy metal contaminants were not detected except for zinc and copper which were within recommended limits. However, some of the energy drinks had poor labels which may lead to misinformation. Intake of energy drinks is on the rise and measures are needed to curb this imminent dependency and abuse to avoid the ramification that may accompany it.
- The linear regression model concludes that a rise in the number of energy drinks consumed gives a 40% rise in the number of trips taken. It also showed the higher the frequency of use of the drinks the more trips one can take; 8% chance of increase trips.

6.1 RECOMMENDATIONS

- The study recommends that more research and attention should be placed on the behaviour of commercial drivers including what they take in during driving hours and their complete daily routine. This could reduce a lot of negligence on the roads.
- Routine preliminary test can be done on drivers regularly by appropriate stakeholders, to help remove unscrupulous drivers from our roads.
- The need for The Food and Drugs Authority to continue with periodic and random checks of these products on the Ghanaian market.

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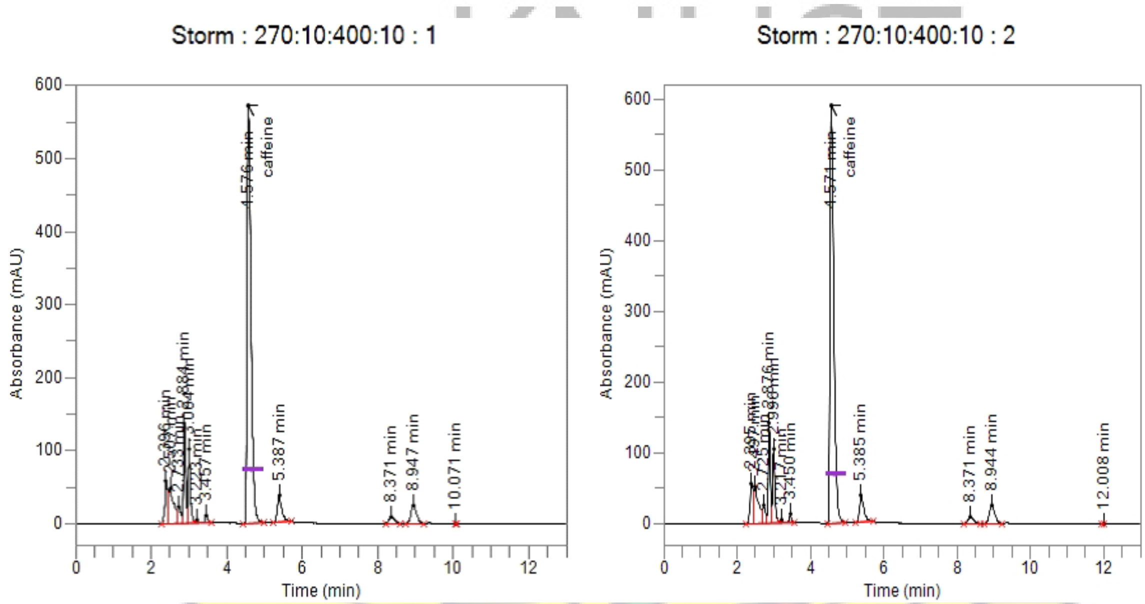
APENDEXES ONE

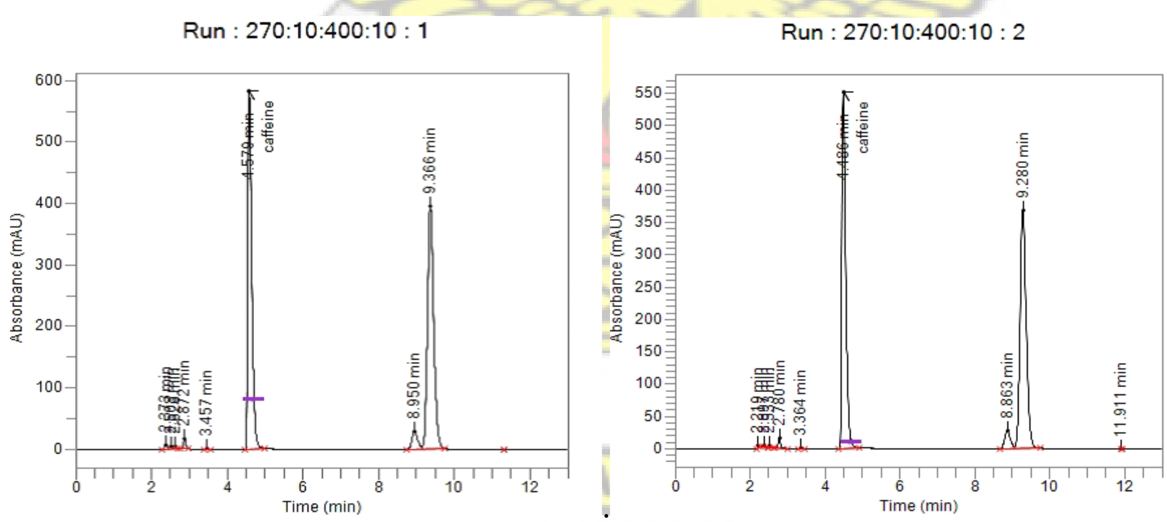
SUPPLEMENTARY DATA

1. **CHROMATOGRAMS**

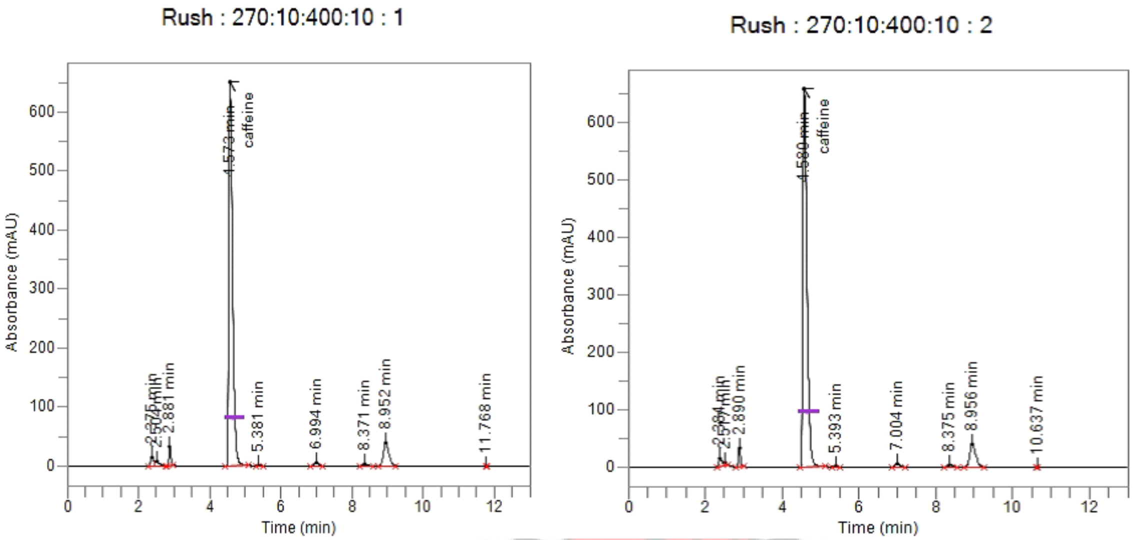
Chromatogram of the caffeine content in storm energy drink



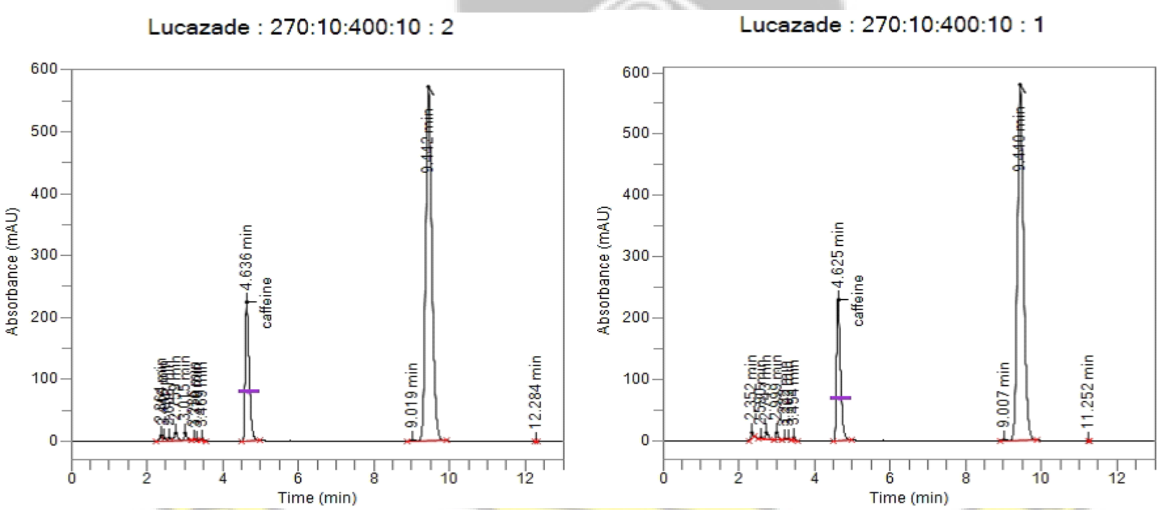
Chromatogram of the caffeine content in run energy drink



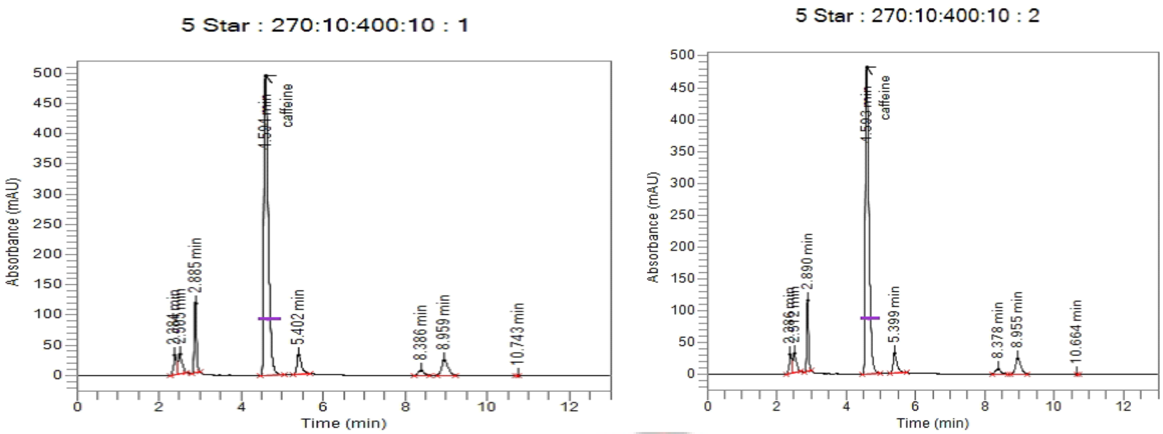
Chromatogram of the caffeine content in rush energy drink



Chromatogram of the caffeine content in lucozade energy drink



Chromatogram of the caffeine content in 5 star energy drink



APENDEXES TWO

KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY

INSTITUTE OF DISTANCE LEARNING

COLLEGE OF SCIENCE

DEPARTMENT OF BIOCHEMISTRY AND BIOTECHNOLOGY

QUESTIONNAIRE

This questionnaire seeks to gather information from commercial drivers within the Kumasi metropolis on their consumption and usage of energy drinks as well as their knowledge on its benefits and otherwise effects.

Kindly help complete this questionnaire to help in a research project on the effects of the contents of energy drinks on commercial drivers and their work.

(A) DEMOGRAPHICS

1. Gender: Male ☐ Female ☐
2. Age ---------------------------------------
3. Station -----------------------------------

(B) DRIVER'S INFORMATION.

4. How many passengers do your vehicles pick?

   Less than 5 ☐ 10 to 25 ☐ 25 and above ☐

5. Do you drive intercity of Kumasi?

   Yes ☐ No ☐

6. How many trips do you make in a day?

   Less than 5 ☐ 5-10 ☐ more than 10 ☐

7. How many hours do you make in a trip?

Less than 5 ☐ 5 to 10 ☐ more than 10 ☐

(C) Knowledge, Consumption and usage of energy drinks

8. Do you know what energy drinks are?

Yes ☐ No ☐

9. What are the positive effects of energy drinks you know?

To reduce my sleep ☐ Take it for fun ☐ others ☐ -----------------------------

10. Do you know if there are any negative effects of energy drinks?

Yes ☐ No ☐

11. If yes, what are they?

----

12. Do you take ENERGY DRINKS?

Yes ☐ No ☐

13. If yes, then why?

----

14. Which type of energy drink do you usually consume?

RUN ☐ STORM ☐ 5 STAR ☐ RUSH ☐ OTHERS ☐ ------------------

15. Why the specific kind of drink?

----

16. On the average, how many bottles of energy drink do you take in a day?

1 to 2 ☐ 3 to 5 ☐ more than 5 ☐

17. Do you use the energy drinks whiles on work duties?

Yes ☐ No ☐

18. How often do you take the energy drinks?

Everyday ☐ 2 to 3 times a week ☐ once a week ☐ others ☐ --------------

19. Where do you buy the energy drinks from

----

20. What happens when you do not take the energy drinks?

I feel very tired ☐ Do not feel comfortable ☐ indifferent ☐

THANK YOU