KWAME NKRUMAH UNIVERSITY OF SCIENCE AND

TECHNOLOGY (KNUST)

COLLEGE OF SCIENCES

FACULTY OF BIOSCIENCE

DEPARTMENT OF BIOCHEMISTRY AND BIOTECHNOLOGY

EVIDENCE OF ALCOHOLIC BEVERAGES LACED WITH CANNABIS SOLD IN BARS IN THE ACCRA METROPOLIS

THIS THESIS IS SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF AN MSc IN FORENSIC SCIENCE

KAFUI NKROMA

APRIL, 2018

DECLARATION

I hereby declare that this submission is my own work towards the MSc. And that, to the best of my knowledge; it contains no material previously published by another person or material which has been accepted for the award of any other degree of the University except where due acknowledgement has been made in the text.

Kafui Nkroma	……	……
(PG4429115)	Signature	Date

Certified By:

Dr Samson Pandam Salifu	……	……
(Supervisor)	Signature	Date

Dr Peter Twumasi	……	……
(Head of Department)	Signature	Date

ACKNOWLEDGEMENT

Firstly, am most grateful to the almighty God whose strength and inspiration has seen me through this study. I wish to express my sincerest gratitude to my supervisor Dr Pandam Samson Salifu, and Dr Christpher Larbie for their patience, guidance and constructive criticism which made it possible for the completion of this thesis. I thank the Head and entire staff of the Department of Biochemistry and Biotechnology of KNUST and Forensic tutors for their encouragement. My special gratitude goes to Mr James Ataki, and Dr F.C.Mills-Robertson who took part in making this endeavor possible.

I would like to acknowledge Dr Paul Fosu and Mr Peter Ashittey and the entire staff of Standards Authority for granting me access to their facilities to enable me complete my thesis.

My final thanks goes to Mr Michael Akleshie for his contributions in diverse ways to the success of this work.

ABSTRACT

Alcohol is consumed for recreational purposes and it is not a strictly controlled substance. Misuse of alcohol can lead to severe consequences – socially and health of an individual. Alcohol is sold in bars, pubs and recreational places where people meet to chat, share a drink and to socialize. The aim of this work was to investigate potential adulteration of cannabis in alcoholic beverages that are sold in bars in the Accra Metropolis. Sixty (60) local and foreign alcoholic beverages were sampled from bars and pubs in the slums, unplanned and planned areas in the Accra Metropolis. The samples were first screened for presence of cannabis using presumptive Fast Blue B test and GC-MS was used for the identification, and quantification of the three main cannabinoids; tetrahydrocannabinol (Δ9 – THC), cannabinol (CBN) and cannabidiol (CBD) in the alcoholic beverages. The locally produced alcoholic beverages had the highest level of CBN (193.87%) while the foreign alcoholic beverage sampled from another location of Accra had highest value of 96.21% (w/w) Δ9 – THC. The average value of CBN (25.93%) was greater than the average Δ9 – THC content (5.25%). This means the cannabis used as adulterants were of old stock. This work uncovered higher levels of cannabis in alcoholic beverages sold in the Accra Metropolis. This could have health implications to customers who unknowingly purchased and consumed alcoholic beverages adulterated with cannabis that are sold in local bars in the Accra Metropolis. To the authors knowledge, this work is first of its kind to demonstrate lacing of alcoholic beverages with hazardous cannabis sold in bars.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER ONE

1.0 INTRODUCTION

Drug misuse and drug abuse are a major threat to the health of millions of people and lead to the loss of human life. Cannabis and alcohol are widely consumed drugs throughout the world, and have been used as drugs for many centuries (European Monitoring Centre for Drugs and Drug Addiction, EMCDDA, 2014). Studies by Newbury *et al.* (2010) and Budney and Lile (2009) have shown that the proliferation in the trade of cannabis and alcohol has also led to an increase in drug related crimes including robbery, stealing, driving under the influence of drugs, murder, rape, domestic violence and a plethora of health issues like cardiovascular diseases, pneumonia, tuberculosis, HIV, psychosis and schizophrenia (Weiser *et al*., 2006: Wicki *et al*., 2010).

The drug menace is a canker that has been exacerbated by illiteracy, broken homes, peer pressure, moral decadence, stressful life events, emotional distress and novelty seeking (Weiser *et al*., 2006: Wicki *et al*., 2010). Cannabis popularly known in Ghana as "ntampi", "bonsam tawa" or "wee" compared to alcohol has been proven through research to have more subtle effects (Adu-Gyamfi and Brenya., 2010). Cannabis is less addictive, cheap and has comparatively less withdrawal problems than other psychoactive substances hence its preffered use to other drugs by patrons (Adu-Gyamfi and Brenya., 2010).

Locally brewed alcohol called "akpeteshie" adulterated with cannabis commonly reffered to as "wee bitters", "lacquer" or "atemuda" is a cannabis edible patronized by drug users in Ghana. "Akpeteshie" is a cheaper alternative to other foreign and locally produced drinks and consumed mostly by the poor (Crumpton *et al*., 2015). The World

Drug Report of 2015 by the United Nations Office on Drugs and Crime stated that 21.5 % Ghanaians, aged 15 to 64, smoked marijuana or used another cannabis product in 2014, Ghana is currently the first in Africa and the third in the world in cannabis or marijuana use, behind North Cambodia and North Korea (UNODC, 2014). Alcohol is a chemical substance or a drug that is a depressant which is consumed for recreational purposes. Alcohol even though, not an internationally controlled substance, when abused can lead to disastrous consequences (Crumpton *et al.*, 2015). In the developed countries, laws and sanctions pertaining to its use serve as a way of restricting use. For example it is mandatory to show your identification card before entering a pub or bar in the United States (Adu-Gyamfi and Brenya., 2010).

In Ghana children are most of the time sent by adults to local bars to buy alcohol. Parents are unknowingly inculcating the culture of alcohol use into their children at a very young age (Luginaah, 2003). Several studies done by Damsere (2015), Forson (2015) and Ryan (2014) have revealed that alcohol abuse has contributed to the increase in road accident injuries, pedestrian fatalities, reckless driving, poor academic performance among students and domestic violence in Ghana as well as the developed countries. Alcohol adulterated with other substances, claiming to be aphrodisiacs or meant to cure erectile dysfunction is advertised on television at odd hours of the day. The popular "Akpeteshie" infused with cannabis (wee bitters) is believed by proponents to improve sexual activities (Crumpton *et al.*, 2015). Research by Bramness *et al.*, (2010) concluded that cannabis and alcohol when used in combination had a more severe psychoactive effect than when used individually. The consumption of either foreign alcoholic beverages (such as wines and whiskeys) or locally produced alcoholic

beverages such as pito, Alomo Bitters, Kasapreko, Striker, Pusher or Ginseng and gin (Akpeteshie) is also very common among Ghanaians (Luginaah, 2003).

1.1 Problem Statement

Psychoactive substance misuse and abuse is a major problem worldwide. The most commonly used and abused psychoactive substances in Ghana and worldwide are cannabis and alcohol (UNODC, 2015). In recent times Ghanaian alcoholic beverage sellers have experimented with lacing alcoholic beverages with psychoactive substances like cannabis (Adu-Gyamfi and Brenya, 2014). However little is known about the psychoactive substances which have been combined in any of these sometimes lethal cocktails. Alcohol on its own is a potent psychoactive substance and when other psychoactive substances are added, it can have an adverse effect on the human body hence the need to investigate these substances.

1.2 Main objective

To investigate cannabis adulteration in alcoholic beverages sold in local bars of the planned, unplanned and slum areas within the Accra Metropolis.

1.2.1 Specific objectives

- To determine the presence, prevalence and concentration of Cannabis adulterated local and foreign alcoholic beverages sold in the planned, unplanned and slum areas of the Accra Metropolis.

- To determine the varieties of Cannabis used in adulterating foreign and local alcoholic beverages sold in local bars of the planned, unplanned and slum areas in the Accra Metropolis.
- To determine whether slums, planned or unplanned areas have the highest crime rate based on the results obtained.

1.3 Justification

The purpose of this project is to research into the use of cannabis as an adulterant in alcoholic beverages serving as a reference to provide empirical information to assist policy makers in formulating awareness campaigns, policies, and interventions to uphold law and order, with the aim of creating a safer and healthier Ghana.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Psychoactive substances

Psychoactive substances are substances that can cross the blood brain barrier and can have an adverse effect on the brain and central nervous system when taken into the body. Some psychoactive substances may be controlled or illegal or used medicinally (Bersani, 2013). Psychoactive drugs are divided into different groups according to their pharmacological effects Stimulants, Depressants and Hallucinogens are examples of commonly used psychoactive substances (Malenka *et al.*, 2009). Stimulants are psychoactive substances that block the reuptake or the efflux of dopamine and norepinephrine resulting in increased activity of their circuits. Some examples are amphetamine, caffeine, cocaine, and nicotine (Bersani, 2013). Depressants are psychoactive substances that reduce neurotransmission levels by facilitation of GABA and inhibition of glutamergic or monoaminergic action. Some examples are ethanol (alcoholic beverages), opioids, barbiturates, benzodiazepines (Matson *et al.*, 2009). Hallucinogens are psychoactive substances that disrupt the nervous system and brain by mimicking the serotonin pathway. Some examples are psilocybin, LSD, Salvia divinorum and nitrous oxide (Bersani, 2013).

Psychoactive drugs can be introduced into the body by oral ingestion as a tablet, capsule, powder, liquid, and beverage and through inhalation, injection, subcutaneous, intramuscular, and intravenous route, across the rectum by suppository and enema; and through inhalation by smoking, vaporization and insufflation "snorting". The efficacy of

each method of administration varies from drug to drug (Malenka *et al.*, 2009). Psychoactive substances affect an individuals' nervous system, which causing changes in a person's mood, cognition, perception and behaviour. Every psychoactive drug has a unique effect on one or more neurotransmitters or neuroreceptors in the brain.

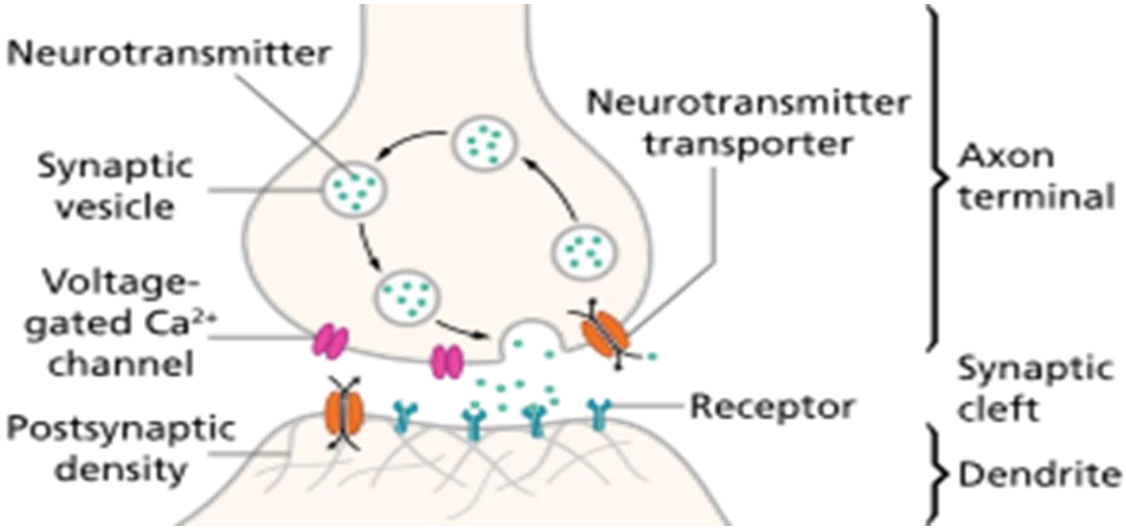


Fig 2.1 An illustration of the major elements of neurotransmission (Splettoesser, 2015). The neurotransmitter is released by the presynaptic neuron (top) which activates receptors on the postsynaptic cell (bottom).

Psychoactive substances, either block the receptors on the post-synaptic neuron (dendrite), or block reuptake or affect neurotransmitter synthesis in the pre-synaptic neuron, also referred to as axon (Bersani, 2013). Pyschoactive substances differ in their effects on the brain, however drugs like alcohol, cannabis and cocaine, produce a surge of the neurotransmitter dopamine in the part of the brain called the basal ganglia

(Volkow *et al.*, 2016). Neurotransmitters are responsible for sending messages between nerve cells. As psychoactive substance use increases the nerves ability to adapt to the stimuli transmitted by the surge and hence a higher amount of the same drug is needed to produce the same effect. This leads to tolerance of the body to the drug and hence dependence of the body to the drug (Huigjen *et al.*, 2015).

The parts of the brain called the prefrontal cortex and the extended amygdala of the brain are affected by substance use, changes occur which explain dependence and withdrawal syndrome. (Solano-Castiella *et al.*, 2010). The prefrontal cortex and the extended amygdala control pleasure and pain respectively, these parts of the brain control the spontaneous drives to seek pleasure and avoid pain and compel a person to act in a certain way. The prefrontal nerve endings are affected in substance abuse and cause a normal adult to lose the ability to control their impulses (Huigjen *et al.*, 2015).

2.2 Cannabis

Cannabis is the genus of a flowering herb that grows annually and has male and female types. The leaves are palm leaf like shaped and compound with serrated leaves. The leaves have a unique pattern of venation which makes it very easy to distinguish it from other species with similar leaves (Elsohly, 2007). This makes it easy for macroscopic identification even in the case where only tiny portions of the leaves are available for analysis, however this requires special expertise and equipment (UNODC, 2009). The Cannabis plant is believed to have originated from the mountainous regions of the Himalayas, and is grown in mostly tropical and humid regions of the world. It has been

used by ancient civilizations since prehistoric times for its perceived healing properties, mind altering characteristics and for fiber (UNODC, 2006).

2.2.1 Cannabis Strains

There are two main cannabis strains, these are pure and hybrid. The pure varieties of cannabis are *Sativa, Ruderalis* and *Indica*. The tallest strain, *C. sativa*, has long branches and internodes and its leaves are long and narrow with five leaves on each stem. It takes a longer time to bloom and has high level of cannabinoids (Green, 2001). The *sativa strain* is mostly grown for recreational purposes due to its high tetrahydrocannabinol and low cannabidiol concentration (Hillig, 2005).

The *Indica* strain is of a medium height, bushy, has wider leaflets and matures faster comparatively to the other strains. The *Indica* stain is also grown mainly for medicinal purposes due to its low tetrahydrocannabinol and high cannabidiol concentration (Hillig, 2005). The shortest strain, *Ruderalis* is comparatively shortest in height among the three strains and produces trace amounts of cannabinoids and thus is used only for breeding purposes because of its ability to flower repeatedly irrespective of the amount of sunlight present (Budney and Lile, 2009).

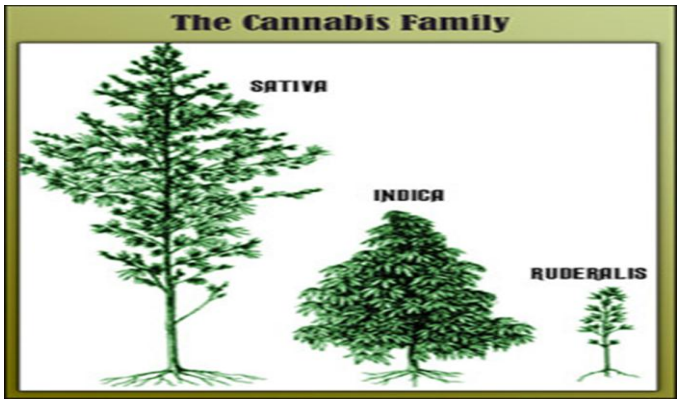


Fig. 2.2 The three main strains of Cannabis (Budney, 2014)

2.2.2 Hybrid Varieties of Cannabis

Hybrid Varieties were developed to amplify or increase the intensity of a particular Characteristic in the cannabis plant, which would differentiate that particular strain for the purposes of hemp or fibre, drug, or breeding purposes (Sharma, 2001).

2.2.2.1 Hemp

The hemp variety of cannabis is a strain of cannabis that is grown by industries for the manufacture of hemp fibre. It is also grown mainly for fibre and seed and has a low cannabinoid content (Rosenthal, 2007). The most beneficial property of this plant is its ability to grow at a very fast rate. Hemp fibre can also be processed into plastics, paints, insulation and animal feed (Tourangeau, 2015).

2.2.2.2 White widow

This is a hybrid of 60% *indica* and 40% *sativa*. This type of hybrid takes characteristics from both *indica* and *sativa*. This type of hybrid is grown mainly for its medicinal characteristics (Rosenthal, 2007).

2.2.2.3 Skunk

The skunk is a hybrid strain of cannabis made up of 75% sativa and 25% indica. It was one of the earliest breeds of cannabis to have the high tetrahydrocannabinol (THC) property of the sativa along with the short growth duration and high yield of the *indica* (Rosenthal, 2007).

2.2.2.4 Sinsemilla

A new cultivation technique results in a special treatment of the cannabis plant to produce a breed sinsemilla, which means without seeds. Sinsemilla is the unfertilized flowering buds of the female cannabis plant. This plant does not produce any seeds and has a high concentration of THC. The male and female plants are separated at an early stage of development to ensure that the female plants are not pollinated (UNODC, 2006).

2.2.3 Forms of Cannabis

Cannabis is consumed in three main forms; Herbal or plant material, Hashish and Cannabis oil (Sharma, 2007).

2.2.3.1 Herbal Cannabis

This is the ground portion of flowers, leaves and/or branches. This form of cannabis is normally compressed and sold as parcels. Herbal cannabis is wrapped in paper and smoked by users. The herbal form can also be soaked in alcohol to obtain the popular wee bitters (Crumpton, 2015). Herbal cannabis can also be mixed with pastries cakes or muffins and is also used to prepare toffees. These are often referred to as cannabis edibles (Drake, 2002).

Fig. 2.3 Herbal Cannabis (source: U.S. Drug enforcement Association)

2.2.3.2 Hashish

Hashish is extracted from glandular hairs known as trichomes. These trichomes contain high levels of cannabinnoids. Some strains of cannabis contain large amounts of trichomes and are specifically grown for this purpose (Thomas, 2007).

Fig. 2.4 Hashish (Source: U.S. Drug Enforcement Association)

A powder rich in trichomes is sifted from the ground plant material of cannabis and pressed into cakes or by scraping the resin that falls of the surface of the cannabis plant and rolling it into balls. The colour of hashish varies from black to golden brown as depending on the variety of cannabis it is obtained from as seen in **Fig. 2.4** (EMCDDA, 2008).

2.2.3.3 Hashish oil

Hashish oil is one of the products from hashish production. Solvent extraction by maceration, infusion or percolation are methods used in producing Hashish oil. The remaining product is filtered and evaporated to form a sticky resinous herbal liquid as seen in plate 2.3 Fresh plant material is not suitable for hashish oil production. A wide variety of alcohols and other solvents can be used for hashish oil production but the most suitable of these are non-polar solvents. Non-polar solvents will not extract the water soluble parts of hashish and hence produce a hashish oil with better taste, odour and a higher efficacy (Thomas, 2007).

Fig. 2.5 Hashish oil (Source: U.S. Drug Enforcement Association)

2.3 Cannabinnoids

In 1964 Dr. Raphael Mechoulam, Professor of Medicinal Chemistry at the Hebrew University of Jerusalem, was the first to identify delta-9-tetrahydrocannabinol (Δ-9THC), as the main psychoactive component of cannabis (ElSohly, 2007). Cannabinoids are a class of diverse compounds that acts on cannabinnoid specific receptors that alter neurotransmitters in the brain. Ligands for these receptor proteins include the endocannabinoid which occur naturally in the body (Patcher Mechoulam, 2006). Phytocannabinoids, occur naturally in cannabis and some other plants. The primary and most psychoactive cannabinnoid in this group is tetrahydrocannabinol psychoactive compound. 113 different cannabinnoids can be isolated from cannabis, each of which exhibit varying effects (Pacher and Mechoulam, 2011).

The main classes of cannabinoids are tetrahydrocannabinol (THC), cannabidiol (CBD) and cannabinol (CBN) and these are concentrated in viscous resinous structures known as glandular trichomes. Tetrahydrocannabinol distribution on the cannabis plant is localized with the flower buds having the highest concentrations, then the leaves closest to the buds, and the lowest concentrations in the leaves furthest away from the buds. The

stalks and the seeds of the Cannabis plant do not contain tetrahydrocannabinol (Sharma, 2007)

2.3.1 Tetrahydrocannabinol (Δ-9THC)

Tetrahydrocannabinol (Δ-9THC) which is the primary psychotropic component of cannabis mimics the actions of anadamide and 2-arachionoylglycerol neurotransmitters which occur naturally in the brain. This cannabinoid produces the effects of psychotropism when it binds with the Cannabinnoid (CB) receptors in the brain. The IUPAC name of tetrahydrocannabinol is (6aR,10aR)-6,6,9-trimethyl-3-pentyl-6a,7,8,10a-tetrahydro-6H-benzo[c]chromen-1-ol, Molecular Formula : $C_{21}H_{30}O_2$ and Molecular Weight: 314.4g/mol Log P: 6.99 (octanol/water) (EMMCDA, 2014).

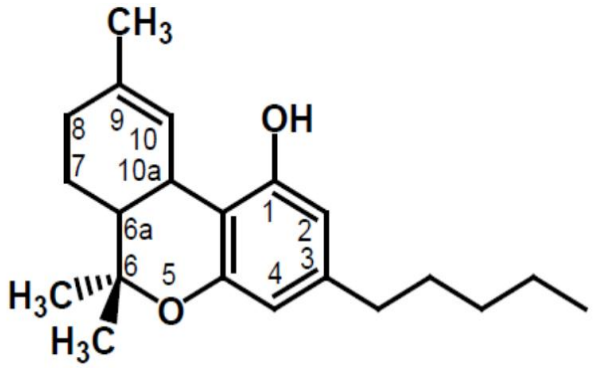
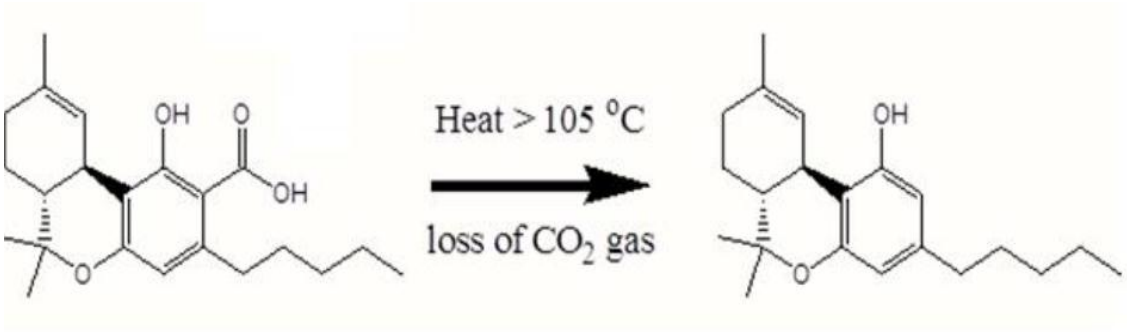


Fig 2.6 Chemical structure of Δ9-THC

THC is a quite unstable non crystalline hydrophilic compound which is easily degraded by heat, light, acids and atmospheric oxygen (Brenneisen, 2007.; Elsohly and Slade., 2005; European Monitoring Center for Drugs and Drug Addiction, 2013; Leffingwell and Road, 2003) There are seven double bond isomers of this compound of which only two are naturally occurring namely, Δ9- THC and Δ8-THC . Δ9- THC, (−)-trans-Δ9-

THC, is the main stereoisomer. Δ9- THC has four isomers centering around 2 chiral centres located at C4 and C5. Only two isomers, (-)-cis- Δ9- THC and (-)-trans- Δ9-THC occur naturally with (-)-trans-Δ9-THC being the most abundant. In the cannabis plant, Δ9 –THC acid A is present to a much greater extent and over time is catalysed by heat like smoking to Δ9-THC. The chemical reaction which takes place is decarboxylation (Mechoulam and Hanus., 2002; Brenneisen, 2007 ; Elsohly and Slade, 2005).



Δ9 –THC acid Δ9-THC

Fig. 2.7 Decarboxylation of Δ9-THC acid to Δ9-THC

2.3.2 Cannabidiol

Cannabidiol (CBD) is not psychotropic and is actually rather known to counteract the effects of cognitive impairment associated with the use of cannabis. Cannabidiol does not have any affinity for CB1 and CB2 receptors. Cannabidiol has also been shown to act as a receptor agonist. CBD can help in promoting sleep and depressing libido. It also affects the uptake of adenosine which in turn affects some biochemical processes in the body. Cannabidiol is a naturally occurring cannabinoid in the plant and is structurally

very similar to tetrahydrocannabidiol. The IUPAC name of Cannabidiol is 2-((1R,6R)-3-Methyl-6-(prop-1-en-2-yl)cyclohex-2-enyl)-5-pentylbenzene-1,3-diol.Molecular Formula: $C_{21}H_{30}O_2$, Molecular Weight: 314.46 g/mol and Log P: 5.79(Octanol/ water (Hardwick, 2008).

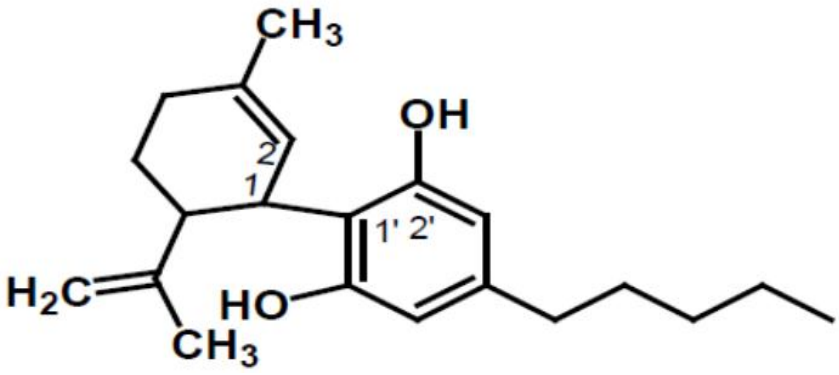


Fig 2.8 Structure of Cannabidiol

Δ2 -CBD is a naturally occurring constituent of cannabis which, similarly to Δ9-THC, it is a hydrophillic compound with an octanol. It is light sensitive and easily degraded but at a different rate, and oxidizes in the presence of oxygen. There are seven double bond isomers of cannabidiol but only Δ2 -CBD occurs naturally (Hardwick, 2008).

2.3.3 Cannabinol

Cannabinol (CBN) is produced when the fresh cannabis plant is degraded due to exposure to air, light or heat. It is the primary product of tetrahydrocannabinol degradation, the more degraded it becomes, the cannabinol concentration increases. It is not a naturally occurring cannabinoid in the plant but a product of degradation. The IUPAC Name of Cannabinol is 6,6,9-trimethyl-3-pentyl-benzo[c]chromen-1-ol,

M(Leffinwell, 2013). Molecular Formula: $C_{21}H_{26}O_2$, Molecular Weight: 310.43 g/mol and Log P: 6.23 (Octanol/ water) (Leffinwell, 2013).

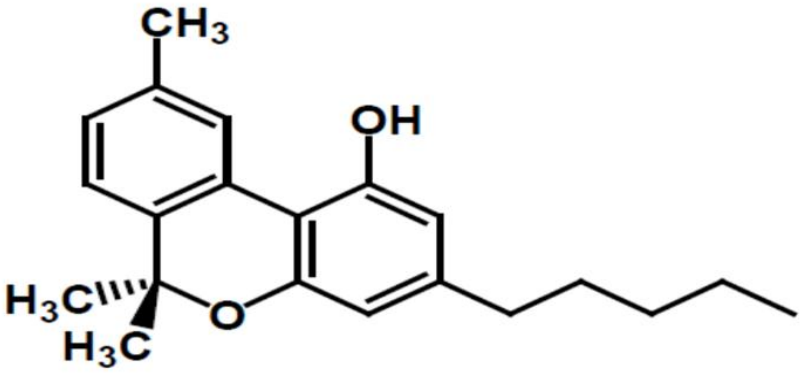


Fig 2.9 Structure of Cannabinol

CBN is an aromatized compound produced by the oxidation of Δ9-THC. In fresh and carefully dried cannabis, the presence of CBN is indicative of degradation. CBN levels in Cannabis normally increase when Δ9-THC levels decrease and vice versa, and levels of CBN are influenced by many factors, including storage and experimental conditions that cannabis is exposed to (Leffinwell and Road, 2013).

2.3.4 Other Cannabinnoids

Cannabigerol (CBG) is not psychotropic but has an overall effect on Cannabis. It acts as receptor antagonists, and CB1 receptor antagonist and binds to the CB2 receptor. Tetrahydrocannabivarin (THCV) It is an antagonist of Δ-9THC at CB1 receptors and reduces the psychoactive effects of Δ9THC. Although cannabidivarin (CBDV) is usually a minor constituent of the cannabinoid profile, enhanced levels of CBDV have been reported in feral cannabis plants from the northwest Himalayas, and in hashish from Nepal. Cannabichromene (CBC) is non-psychoactive and does not affect the

psychoactivity of Δ-9THC. It is also more prevalent in tropical cannabis varieties. Cannabinnoids produce their physiological and behavioural characteristics by interacting with specific membrane bound receptors. Two known types of cannabinnoid receptors exist in animals, reptiles, birds and fish, these are CB1 and CB2 (Iseger and Bossong, 2015).

2.3.5 Cannabinoid receptor 1

CB1 receptors occur mostly in the basal ganglia, limbic system, cerebellum and the hippocampus, medulla oblongata regions of the brain and the male and female reproductive systems and the human anterior eye and retina (Pacher and Mechoulam, 2011).

2.3.6 Cannabinoid receptor 2

CB2 receptors occur predominantly in the immune system with the largest population in the spleen, and the human cerebellum. These receptors are responsible for the anti-inflammatory and purported therapeutic effects of cannabis (Pacher and Mechoulam, 2011).

2.3.7 Cannabis edibles

Cannabis edibles are normal every day foods that have been adulterated or infused with cannabis and hence contain cannabinoids. The psychoactive components of cannabis are fat soluble and are very well extracted into the edible when prepared with oil, butter or margarine (Leffinwell and Road, 2013). The effects of oral ingestion of cannabis takes a longer time to manifest and the duration of the effects are also longer than when

smoked, this is because absorption of the drug is slower when ingested (Leffinwell and Road, 2013).

2.3.8 Effects of Cannabis Use

Short term use of cannabis causes euphoric feelings, stress reduction, paranoia, driving impairment, loss of memory, cardiovascular problems, driving impairment and increased appetite. Long term use of cannabis causes psychosis, cannabis use disorder, liver disease, and heart Disease (Molleman and Demuth, 2007).

2.4 Cannabis dependence

Cannabis abuse leads to dependence of the abuser to the drug. Cannabis use can lead to an increased dependence of the user to the drug and in most cases they can experience withdrawal problems. When there is long term use of the drug, changes occurs in the absorption, distribution, metabolism and excretion pathways and pharmacodynamic changes also occur (Gordon *et al.*, 2013). Regular abuse of drugs results in the need of a higher dose to achieve the same prior desired effect and in the long term reducing the effectiveness of cannabinoid receptors. The cannabis user eventually develops tolerance to the main psychoactive ingredient, Δ-9THC. No medicinal cure has been discovered for the treatment of cannabis dependence, however, psychotherapeutic methods of treatment have been developed (Gorden *et al.*, 2013).

Although not medically serious, cannabis withdrawal symptoms occurs in about a half of all patients are being treated for cannabis use disorders. Some likely symptoms are dysphoria, disturbed sleep, gastrointestinal symptoms, and decreased appetite. Symptoms start in the first week of abstinence from cannabis and normalize after some

weeks (Hasin *et al.*, 2015). A proven sign of cannabis dependence is the tendency of a person to spend more time than the recreational user, recovering from the use of, or obtaining cannabis (Danovitch and Gorelick., 2012). Some addicts become so used to cannabis that it becomes an integral part of their life. People who are cannabis dependent will continue to use it even though they are aware of the negative effects of its use (Budney *et al.*, 2007).

Cannabis use is linked with comorbid mental health complications, such as mood and anxiety disorders, and stopping cannabis use is difficult for some users. Psychiatric comorbidities are often present in dependent cannabis users including a range of personality disorders (Danovitch and Gorelick, 2012). Cannabis dependency is often due to prolonged and increasing use of the drug. Increasing the strength of the cannabis taken and an increasing use of more effective methods of delivery often increase the progression of cannabis dependency (Budney *et al.*, 2007). Dependence on cannabis is more common among heavy users. Marijuana use can lead to increased tolerance and withdrawal symptoms when trying to stop (Bogelt *et al.*, 2013).

Prolonged cannabis use leads to both pharmacokinetic changes in distribution, metabolism, and also pharmacodynamic changes (how the drug interacts with target cells) to the body. These changes require the user to consume high doses of the drug to achieve a common desirable effect (known as high tolerance), reinforcing the body's metabolic systems for eliminating the drug more efficiently and further down regulating cannabinoid receptors in the brain (Budney *et al.*, 2007).

These effects compound themselves in that the chronic user must consume more frequently to overcome the accelerated clearance, and high doses to overcome the blunted response to receptor activation. Cannabis users have shown decreased reactivity to dopamine, suggesting a possible link to a dampening of the reward system of the brain and an increase in negative emotionality and addiction severity (Madras, 2014).

Cannabis users minds and bodies become tolerant to the effects of THC leading to them becoming dependent on it. Tolerance to the behavioral and psychological effects of THC has been exhibited in research experiments involving teenagers, adults and animals. The mechanisms that lead to this tolerance to THC are thought to be changes in cannabinoid receptor function (Budney *et al.*, 2007). Certain factors increase the risk of developing cannabis dependence and studies conducted over a number of years have made it easier for researchers to determine aspects of social and psychological development which directly affect cannabis use (Malenka *et al.*, 2009).

There is no effective medicine to cure cannabis dependence so psychotherapeutic models are mostly the treatment option (Marshall *et al.*, 2014: Danovitch and Gorelick, 2012). Most treatment falls into the categories of psychological or psychotherapeutic, intervention, pharmacological intervention or treatment through peer support and environmental approaches (Marshall *et al.*, 2014). Screening and brief intervention sessions can be given in a variety of settings, particularly at doctor's office which is of importance as most cannabis users seeking help will do so from their general practitioner rather than a drug treatment service agency (Malenka *et al.*, 2009).

Cognitive behavioral therapy (CBT), motivational enhancement therapy (MET), contingency management (CM), supportive-expressive psychotherapy (SEP), family and systems interventions, and twelve-step program (Scinska *et al.*, 2009) are the types of Psychological treatments used in treating individuals with cannabis dependency. Dronabinol, entacapone, acetylcysteine, and atomoxetine are used in this treatment and have been proven to reduce the desire by the user to consume cannabis and also lessen the symptoms of withdrawal (Danovitch *et al.*, 2012).

2.5 Cannabis Potency Trends

Cannabis is believed by researchers to have increased in potency since its popular use in the 1960s and 1970s and recent reports point in the same direction. This marked change can be attributed to the access of information provided by findings from researchers into Cannabis potency. Users and dealers are privy to this information and thus have learnt better ways of deriving the psychoactive component Δ-9THC (UNODC 2006). Cannabis addicts now use the more potent flowering buds instead of the leaves as was done in the 1970s. One of the reasons that have caused the perceived increase in cannabis potency is not the cannabis in particular but the acquired knowledge of the best part of the plant to use to obtain desired results (UNODC 2006).

Another reason for this new trend is the knowledge of cross breeding and the now more popular indoor growing of Cannabis which have a positive effect on Δ-9THC concentration. Hybridisation has led to the cultivation of highly Δ-9THC potent strains like the skunk and sinsimella. Indoor cultivation is an innovation in cannabis cultivation

that has been studied to shorten the growth cycle thereby increasing yields and increasing the potency of the plant (UNODC, 2006).

In 2004, the European Monitoring Centre for Drugs and Drug Addiction (EMCDDA) conducted a study that concluded there has been an increase in cannabis potency and that this was due to the now popular use of cannabis grown indoors. Studies conducted in the United States and the United Kingdom have all reported increases in the potency of cannabis over the year (EMCDDA, 2008).

2.5.1 Potency Testing in Cannabis

The main objective of potency testing is the quantification of the main cannabinoid content. The identification and quantification of Δ-9THC and CBD is of particular interest in the analysis of cannabis. Δ-9THC is considered to be the main psychoactive component in recreational cannabis while CBD is the medicinal component. These criteria are used to determine the potency of cannabis in close association with the Δ9THC content (Ruppel and Kuffel., 2013).

2.5.2 The Function of Precursors in Potency Testing (HPLC and GCMSD)

Tetrahydrocannabinnol acid (THCA) and cannabidiol acid (CBDA) are highly heat sensitive compounds which are decarboxylated by heat during smoking, cooking or in the hot GC injection port into the more psychoactive form Δ-9THC.THCA is the most abundant cannabinoid in the cannabis plant and has been proven by research to be a medicinal drug (Ruppel and Kuffel, 2013).

The HPLC is used for the analysis of THCA, Δ-9THC and other precursors in their natural forms, it gives a more accurate result without the need for derivitisation. The GC-MS however is only able to determine the Δ-9THC component without the precursors (Brenneisen, 2007.; Elsohly and Slade., 2005; European Monitoring Center for Drugs and Drug Addiction. 2013;Leffingwell and Road, 2003). This limitation can however be rectified by derivitisation or ensuring that the injection port is at an optimum temperature to cause the conversion of all the precursors to the psychoactive form or prior heating of the sample to the analysis (Ruppel and Kuffel, 2013).

2.6 The Chemistry of Alcoholic Beverages

Alcohol in chemistry is an organic compound in which the hydroxyl functional is attached to a saturated carbon atom. Alcohols are chemical compounds that have the general formula R-OH. Alcohols are classified into primary, secondary and tertiary domains depending on the kind of carbons that bear the -OH group.

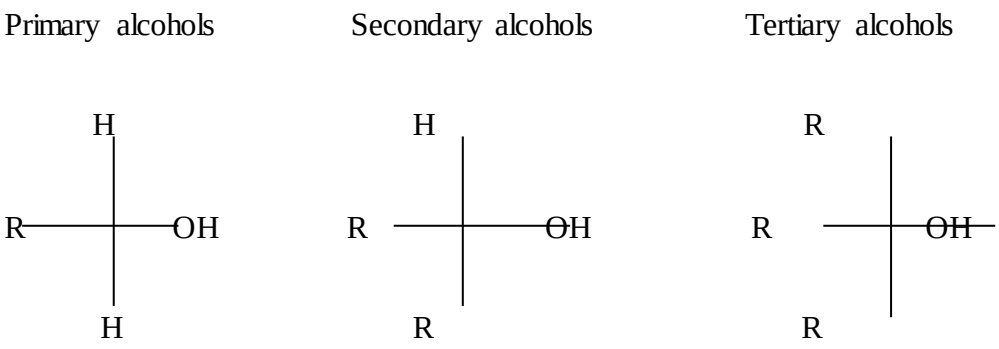


Fig. 2.10 Structure of alcohols (Smith and March, 2007)

Alcohols are structurally partly made up of water and an alkane. The hydroxyl group as seen in **Fig. 2.10** gives the alcohol its physical properties and the alkyl group modifies these properties. The hydroxyl group gives alcohol its polar qualities and the ability to bond with hydrogen. Alcohols have higher boiling points and the lower alcohols are miscible with water (Smith and March, 2007).

The primary alcohol ethyl alcohol or ethanol, popularly called alcohol is the common chemical used in alcoholic beverages. Alcoholic beverages have been consumed by humans since prehistoric times. Alcohol has an odour described as hanging or biting to the oral and nasal passages. Ethanol can be obtained from fermentation of glucose in fruits, grapes, sugarcane and starchy foods like millet, corn, barley and other root tubers. Most of the processes in alcohol production involve conversion of sugar to glucose or starch to sugar and then to glucose with ethanol as a by-product (Smith and March, 2007). Enzymes in these reactions include conversion of sucrose by the enzyme invertase into glucose and fructose and conversion of glucose by a group of enzymes called zymase into ethanol.

2.6.1 Alcoholic Beverages

Alcoholic beverages are drinks that contain ethanol, a depressant which when consumed in small amounts causes euphoria, reduced anxiety, and sociability and in higher doses causes intoxication (drunkenness), stupor and unconsciousness. Long-term use of alcohol can lead to abuse, addiction, and alcoholism (Robinson, 2006). The concentration of alcohol in a beverage is usually stated as the percentage of alcohol by volume (ABV) the number of milliliters (ml) of pure ethanol in 100 ml of beverage.

2.6.2 Distilled and Undistilled alcoholic Beverages

Two main types of alcoholic beverages exist, these are distilled and undistilled. Distilled alcoholic beverages include brandy, whiskey, and rum. Undistilled alcoholic beverages includes wines, and beers. Distilled beverages normally have alcohol concentration of or higher than 30% whilst undistilled beverages have an alcohol percent not higher than 20% (Nickels, 2015). Undistilled beverages undergo fermentation of a substrate like fruit or grain mash by yeast. Fermentation ceases at a point when yeast cells are killed by production of ethanol (Scinska, 2000).

2.6.3 Undistilled Alcoholic Beverages

Wine is a fermented beverage produced from grapes. Wine has a longer fermentation process and a longer process of aging (months or years), resulting in an alcohol content of 9%–16% ABV. Wine is also made from fruits other than grapes, such as plums, cherries, or apples. Sake is a popular example of "rice wine" (Nickels, 2015). Beer is an alcoholic beverage fermented from grain mash. It can be made from barley or a blend of several grains. Beer is the most consumed alcoholic beverage in the world (Nelson, 2005).

2.6.4 Distilled Alcoholic Beverages

A distilled drink or liquor is an alcoholic drink produced by distilling the mash of fermented grain, fruit, or vegetables. Unsweetened, distilled, alcoholic drinks that have an alcohol content of at least 20% ABV are called spirits (Robinson, 2006). Distilled drinks such as vodka, gin, baijiu, tequila, whiskey, brandy, and soju are examples of distilled drinks and have an alcoholic content of about 40% or more. Distilling

concentrates the alcohol and eliminates some of the congeners. Freeze distillation concentrates ethanol along with methanol and fusel alcohols (Nickels, 2015).

2.6.5 Gin Production

Gin is a spirit made from substrates of an agricultural origin flavoured with juniper berries, initially used in prehistoric times as a herbal drug. Gin has been made by humans for many centuries, and different techniques exist for the gin production (Burglass, 2011).

Gin production varies from producer to producer, however there are three basic steps to gin production. In the first stage of distillation, spirit derived from fermentation of agricultural substrates like grains of barley is distilled in a column still to a high proof, flavorless spirit (Buglass, 2011). In the second stage, the vapor of the spirit is passed through a compartment that contains juniper berries and other botanicals. Essential oils and flavors are absorbed into the vapour of the spirit as it passes through this compartment. The condenser changes the vapour into a liquid form called gin (Forbes, 1997). At the third and last stage, pure water is added to the gin to reduce the volume of alcohol to the legally acceptable level after which it is bottled. Some types of gin require a maturation stage but most don't (Brownlee, 2002).

Gin production has evolved since it was first discovered, however it can be broadly divided into three main methods. There are three basic methods for gin production, pot distilled gin, column distilled gin and compound gin (Forbes, 1997).

2.6.6 Pot Distilled Gin

This method of distillation was one of the earliest to be discovered. A fermented substrate of barley and other grains was pot distilled and then distilled again in the presence of botanicals to achieve the desired flavour. The derived product was then aged in wooden casks to obtain a malty flavour which had a resemblance to whiskey (Williams, 2015).

2.6.7 Column distilled gin

A fermented substrate of sugarcane, grapes, beetroot, or potatoes was distilled in a column or coffey still. The derived vapour was then passed through a basket containing juniper berries and other substrate containing aromatic compounds (Buglass, 2011). This basket was put in a part of the still so the vapors could pass through it to absorb the flavors to achieve a gin flavor. Gin produced by this method had a lighter flavor (Williams, 2015).

2.6.8 Compound gin

These are made by simply flavouring neutral spirits with natural flavourings and redistillation process is not applied to these lower quality gins (Brownlee, 2002).

2.6.9 Whiskey Production

Whiskey is a distilled alcoholic beverage made from different varieties of fermented grain mash which is later aged in charred wooden casks made of white oak. Types of fermented substrate used for whiskey are barley, corn and rye (Nickels, 2015). This type of alcoholic beverage is produced in copper column stills. The copper metal

removes sulphur compounds from the alcoholic vapours to produce a high quality whiskey. The process of aging in charred wooden casks gives whiskey its taste, flavor and other components to give its distinctive taste, odour and flavor (Brady, 2000).

2.7 Akpeteshie

Akpeteshie is a locally brewed alcoholic spirit produced in Ghana and other West African nations by distilling palm wine or sugar cane juice. Consumption of this high-proof spirit is increasing in West Africa (Akyeampong, 2001). Akpeteshie is distilled from palm wine or sugarcane. This sugar cane liquid or palm wine is first fermented in a large barrel, sometimes with the help of yeast (Crumpton, 2015).

After this first stage of fermentation, fires are built under the barrels in order to bring the liquid to a boil and pass the resulting vapour through a copper pipe within cooling barrels, where it condenses and drips into sieved jars. The boiled juice then undergoes a second stage of fermentation. The resulting spirit is between 40 and 50% alcohol by volume (Luginaaha, 2003).

Fig. 2.11 Local Production of Akpeteshie

Akpeteshie is not professionally bottled or sealed, but instead poured into unlabeled used bottles. The spirit can be bought wholesale from a brewer or by the glass at bars. Although not commercially advertised, the drink is very popular (Luginaaha, 2003). This is partially due to its price, which is lower than that of other locally produced bottled or imported drinks. This locally brewed drink is associated more with the poor due to its low cost (Akyeampong, 2001).

2.7.1 Long and short Term effects of Alcohol use

The short-term effects of alcohol use are euphoric feelings, a sense of wellbeing, sociability, decrease in anxiety, impairment of motor skills, unconsciousness, central nervous system depression and anterograde amnesia (Grattan and Vogel-Scholt., 2001). Long term effects of alcohol use are alcoholism, damage to the central nervous system, chronic pancreatitis, alcoholic liver disease, malnutrition and organ damage (NIAAA, 2000; Guerri and Pascual., 2010).

2.7.2 Breath analysers and blood alcohol content

Breath analysers are instruments used to measure the amount of alcohol on a persons breath, if the legally accepted limit is exceeded the person can be arrested by the police or monitoring body at the time (Vukovic *et al.*, 2015). The blood alcohol concentration (BAC) which is level of alcohol or ethanol in a persons blood can also be determined from the results of the breath analyser test. The result of the breath analyser test is proportionated in a ratio 1:2100 to determine the blood alcohol content (BAC). The

legal limit of impairment varies in every country, In North America and Belarus the values are 0.02% and 0.03% respectively (Vukovic *et al.*, 2015).

2.7.3 Alcohol dependence

Alcohol dependence is when a person becomes physically, mentally and psychologically dependent on drinking alcohol and can also be referred to as alcohol use disorder (Malenka *et al.*, 2009). Alcohol dependence in recent times is used to refer to alcoholism as a term in order for people not to internalize the idea of cure and disease, but so they can view alcohol as a chemical they may use to cope with outside pressures (American Psychological Association, 2009). For a person to be diagnosed as suffering from alcohol dependence, the individual must have exhibited at least three out of the seven symptoms of alcohol dependence as stated in the DSM-IV (Diagnostic and Statistical Manual of Mental Disorders) criteria for alcohol dependence, over a 12-month time frame. The DSM-IV criteria are as follows:

- Tolerance
- Withdrawal symptoms
- Use in larger amounts or for longer periods than intended
- Persistent desire or unsuccessful efforts to cut down on alcohol use
- Time is spent obtaining alcohol or recovering from effects
- Social, occupational and recreational pursuits are given up or reduced because of alcohol use

- Use is continued despite knowledge of alcohol-related harm (American Psychological Association, 2009).

The Alcohol Use Disorders Identification Test (AUDIT) is considered the most accurate alcohol screening tool for identifying potential alcohol misuse, including dependence. It was developed by the World Health Organisation, designed initially for use in primary healthcare settings with supporting guidance (Clark, 2005). Its use has replaced older screening tools such as CAGE (an arcronym describing the four level of screening) but there are many shorter alcohol screening tools, mostly derived from the AUDIT. The Severity of Alcohol Dependence Questionnaire (SAD-Q) is a more specific twenty-item inventory for assessing the presence and severity of alcohol dependence (Scinska *et al.*, 2000).

Also, people who are dealing with the effects of alcohol dependence, are able to reduce their dependence by the use of ((Diagnostic and Statistical Manual of Mental Disorders) DSM-IV, and this is achieved by using the principles of DSM-IV to control the use of alcohol (Hasin *et al.*, 2015). This comprises a social learning approach that helps them to withstand external pressures by re-learning their pattern of drinking alcohol. The only way an individual can be said to be in remission is by the absolute abstinence from alcohol (Clark, 2005).

2.7.4 Treatment of Alcohol Dependent People

There are two main types of treatments for alcohol dependent people, and these are, for severe alcoholics and people at risk of becoming alcohol dependent (Clark, 2005). Alcohol dependence can be treated using programmes like relapse prevention, support

groups, psychotherapy, and setting short-term goals. The Twelve-Step programme which is also used for cannabis dependence can also be used in treating alcohol dependence (Hasin, 2007).

2.8 Instrumental Methods

A variety of instrumental methods exist for the determination of psychoactive substances in edible samples. In the present study, the Gas Chromatographic Mass Spectrophotometer (GC-MS) was used because of its accuracy, sensitivity and the nature of the samples used (Brock, 2011).

2.8.1 Gas Chromatographic Mass Spectrophotometer (GC-MS)

The Gas chromatograph is a method of analysis that combines the principles and parts of a mass spectrometer and gas chromatograph to determine the different elemental constituents within a sample (Brock, 2011). The GC-MS is the most widely used instrument for compound analysis in forensic science due to its ability to identify all the constituents in a chemical sample. The mass spectrometer was developed and originated by James and Martin in 1952 (Pavia *et al*., 2006). The computer since then has gone through a lot of technological advancements which has contributed to improvements in the size, sensitivity of the instrument and reduction of the time taken to analyse samples (Alon and Amirav., 2009).

The first quadruple mass spectrometers were produced by Robert E. Finnigan and Mike Uthe in 1964, by Electronic Associates Incorporated. By the 2000s computerized GC/MS instruments using quadrupole technology had become both essential to chemical research and one of the foremost instruments used for organic analysis (Brock, 2011).

Today computerized GC/MS instruments are widely used in environmental monitoring of water, air, and soil and also in monitoring of agriculture and food safety; and in the discovery and production of medicine (Brock, 2011). Sometimes two molecules can have similar patterns of fragmentation in a mass spectrometer hence the need to use an analytical method like the gas chromatography mass spectrometer which incorporates two different analytical methods in one to ensure a finer degree of accuracy and eliminates or reduces the degree of error in substance identification (Alon and Amirav, 2006).

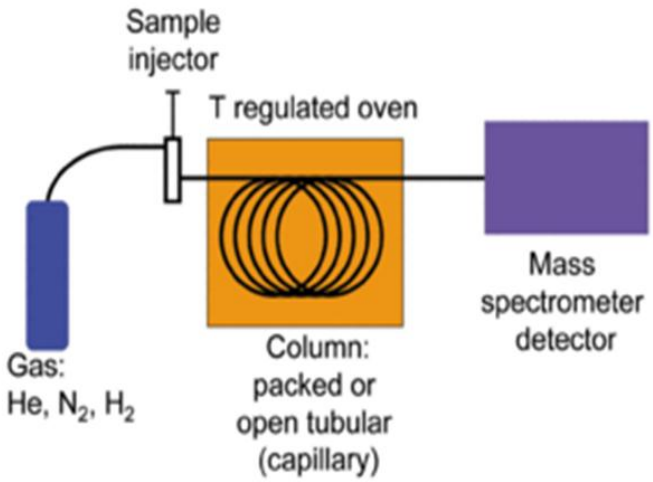


Fig. 2.12 Parts of a GC-MS (Brock, 2011)

2.8.2 The Column

The gas chromatograph comprises a capillary column which is differentiated depending on the type of sample being analysed. The columns dimensions (length, diameter and thickness) and phase properties also differ from sample to sample (Smith et al., 2010).

As the sample travels through the length of the column molecules in the sample mixture are separated due to their relative affinities to the stationary phase of the column. The molecules retained by the column are eluted from the column at specific times (retention time) (Smith *et al.*, 2010). A gas chromatographic column consists of a tube containing an inert solid which has been coated with a relatively volatile liquid phase called the stationary phase. The carrier gas is passed through the packed material and the analytes are separated according to their differences in their partition coefficients. The carrier gas is passed through the packed material and the analytes are separated according to their differences in their partition coefficients (Amirav, 2008).The mass spectrometer then captures, ionizes, accelerates, deflects, and detects each ionized molecule separately by breaking each of them into fragments and measuring each using their mass-to-charge ratio (Alon and Amirav, 2006).

2.8.3 Carrier Gases

Carrier gases used for the gas chromatograph needs to be of quality and the desired pressure to achieve efficient separation of components of the analyte. Gases like nitrogen, helium or hydrogen in compressed gas cylinders are normally used. The carrier gas should be free of oxygen to prevent destruction of the gas chromatograph (Pavia *et al.*, 2006).

2.8.4 Injection System

The injection system is made up of a simple septum injector into which samples are put into the column. The sample is injected into the splitless injector and vaporized in a heated chamber which later passes into the capillary column (Pavia *et al.*, 2006).

2.8.5 The Detector

The detector is a device in the gas chromatograph that detects the compounds in the gas stream as it leaves the column. The most common type of spectrometer associated with gas chromatography is the quadruple mass spectrometer commonly referred to as the mass selective detector (MSD). Other types include Time of flight (TOF), Tandem quadruple (MS-MS) and GC-Tandem MS (Smith *et al.*, 2010).

2.8.6 Sample Ionization

Ionization aids fragmentation of the various atoms in the sample. There are three methods of ionization that are used in a gas chromatographic mass spectrometer. These are electron ionization, cold electron ionization and chemical ionization (Amirav *et al.*, 2008).

2.8.7 Electron ionization

The separated molecules from the gas chromatographic enter the mass spectrometer where they are collided with electrons emitted from the filament (Alon and Amirav, 2008).

2.8.8 Cold electron ionization

In this process of ionization, the molecules are allowed to cool before collision with electrons from the filament. This cooling is aided by the addition of helium gas and passing the electrons through a supersonic nozzle to produce a very powerful molecular beam (Amirav *et al.*, 2008). The cold electron ionization method is preferred due to its

ability to give a more comprehensive and abundant molecular ion spectra (Sloan *et al.*, 2009).

2.8.9 Chemical ionization

Methane or ammonia is introduced into the mass spectrometer using either the positive chemical ionization or negative chemical ionization techniques. The reagent gas will lead to a soft ionization of the molecules. This technique ensures that mass fragments closely resembling that of the analyte of interest are obtained (Amirav *et al.*, 2008).

2.9 Analysis on the GCMSD

The GC-MS instrument is used for the qualitative and quantitative determination of substances. The operator or analyst should have a good knowledge of atomic and molecular masses, this has been made easier by the incorporation of libraries in more recent models of the GC-MS. A comparative analysis is done by comparing the spectrum to the library on the computer to determine the identity of the substance (Brock *et al.*, 2011).

2.9.1 Rural Urban migration

Rural Urban migration is the movement of the rural poor from the rural areas to the cities in the search of work and a better standard of life. It is a problem that has plagued civilizations for many years. The rapid and uncontrolled movement of these people as studied by (Owusu *et al.*, 2015) puts a strain on resources and security in the cities. The resultant effect of this is the increase in the number of slums and unplanned areas (Owusu , 2015).

While a lot of studies have been done on poverty and its relation to crime, there has not been a conclusive formula or theory regarding it mainly because of its dependence on varying factors (Sampson and Bean, 2006) believed that poorer areas of cities like slums were isolated and therefore had a higher crime rate, however (Fafchamps and Minten, 2005) debunked this claim by the theory that better policing in these areas could solve this problem.

2.9.2 Slums

A slum is a run down or dilapidated area within a city or town, which houses the urban poor or people who have migrated from the rural areas in search of greener pastures. Most slum areas lack reliable water and electricity services, standard facilities for sanitation and have houses made of cheap and low quality building materials. Security provisions are usually lacking in these areas mainly as a result of the dense population in these areas (De Wit and Burner, 2009).

2.9.3 Unplanned Areas

An Unplanned area is a settlement, in a city or town with low income workers, who build their houses haphazardly using cheap building materials. The unplanned areas are more upscale in comparism to the slums, but still have sanitation management issues, unreliable utility services and high crime rates (El-Shafie, 2010).

2.9.4 Planned areas

A Planned area or community is a meticulously designed settlement which is constructed in a previously undeveloped or virgin landscape (Wim, 2010). The affluent

live in these settlements, and is characterized by reliable utility services, well designed buildings and excellent security services (Wim, 2010).

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Study Area

The Accra Metropolis is made up of 60 planned, unplanned and slum areas. The Accra metropolis has an estimated population of 2.27 million and lies between latitudes 5º 5557´N and 5º 3321´N and longitudes 0º 1963´ E and 0º 1147´ E and a total land area of 1.73 square kilometres (Wanted in Africa, 2011). Local bars in Accra are clandestine wooden structures where the people go to drink alcoholic beverages especially the local gin Akpeteshie (Akyeampong, 2001). These bars are very shanty (table top and wooden structures) in the slums and unplanned areas and a bit upscale (containers and concrete shops) in the planned areas. Local bars are places where couples and friends meet to sit and chat over a drink, hence they are recreational places (Crumpton, 2015).

Fig. 3.1 A Map of Accra Metropolis (Google, 2016)

3.1.1 Study Design

This study area was clustered in 30 based on proximity and one sampling point (bars and pubs) was conveniently selected.

3.2 Sample collection

Sampling was done from 30 local bars selected from the clustered areas in planned, unplanned and slum areas in Accra Metropolis using UNODC protocols. UNODC protocols are a set of guidelines that ensure that sampling and analyses meet standards set by the World body (UNODC, 2006). Two samples, one locally brewed and a foreign alcoholic beverage were bought randomly from each local bar. Protocols for sampling and methods of analysis for psychoactive substances, the samples about 8ml each were collected in bijou bottles, labeled, put in ice chests (Fig. 3.2) and transported to the laboratory where they were stored in fridges. The samples were collected from November 2016 to January 2017.

Fig. 3.2 Materials used for Sample collection source: Getty images, 2015

3.3 Materials

Presumptive tests or a simple field test was carried out on all the sixty (60) samples to give an idea of the type of psychoactive substance present; this was followed by a confirmatory test with an analytical instrument, GC-MS.

3.4 Fast Blue B Salt Test

One milliliter (1 ml) of the sample was transferred into a clean test tube and a small amount of Fast Blue B salt in an anhydrous mixture in a ratio of 2.5:100. A Drop of chloroform was added and 1 ml of 0.1N aqueous sodium hydroxide added and shook for about two minutes. The resultant solution separated into two layers after two minutes, the lower layer had a purple-reddish color change indicating the presence of cannabis as seen in Fig 3.3**.**

Fig. 3.3 Presumptive test

3.5 Confirmatory Analysis

3.5.1 GC-MS Analysis

The Gas Chromatography-Mass Spectrometer (GC-MS) was used for confirmatory analysis for presence of cannabis. The psychoactive constituents of cannabis if present were processed for GC-MS analysis.

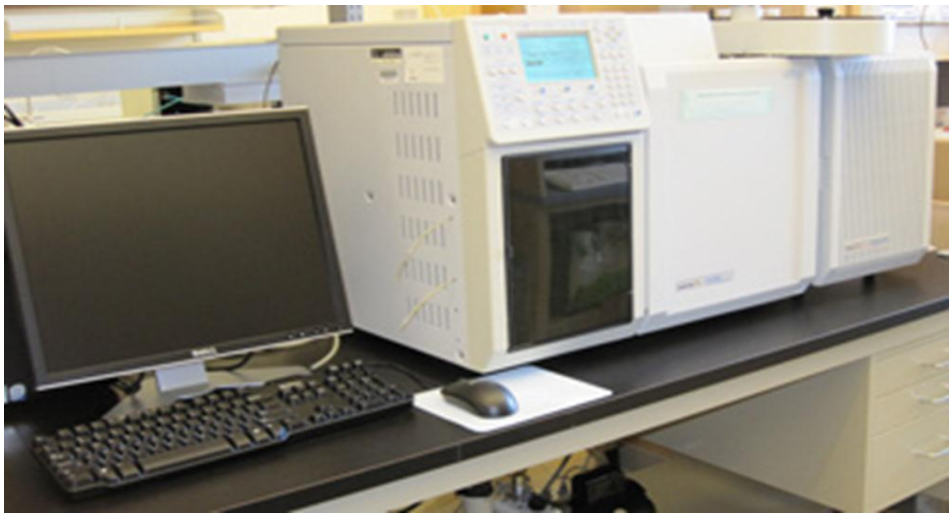


Fig 3.4 Gas Chromatography Mass Spectrometer (GC-MS)

3.5.2 Chemicals and Standards used for Analysis

References standards of CBD, CBN and Δ9–THC (Cerilliant Corporation®) were used. All standard solutions were stored at -20°C for the duration of the study. The ethyl acetate (UnivAR, Washington, United States) used for the extraction were of Gas Chromatographic grade.

3.5.3 Sample Preparation

The suspected cannabis adulterated alcoholic beverage samples were centrifuged for 5 minutes at 1500 xg set at 4 °C. 10 ml of the centrifuged sample was dispensed into an evaporating dish and evaporated to dryness over water bath at a temperature of 100^{o}C to prevent incomplete decarboxylation. The residue in the evaporating dish was then reconstituted by adding 1ml of ethyl acetate. This solution was then filtered through a 0.45 µM liter filter membrane. A blank solution of ethyl acetate was also used in the calibration of the GC-MS before and during the run. The sample was then poured into labeled GC-MS vial bottles and analysed with the GC-MS per UN recommended methods for cannabis detection, (1995).

3.5.4 Gas Chromatographic Conditions

The samples were analysed using the Varian 2200 GC-MS as seen in **Plate 3.0**. Column dimensions: 30 m X 25 0 X 0.25 Elite35, Carrier gas: 1.3 ml/min helium, Injector: Capillary split injector, split liner with glass wool, 275 °C at an injection volume of 2 µl, Detector: Mass Spectrometer, mass range: 50-400 da (UN Recommended methods for Cannabis Detection, 1994).

3.5.5 Analysis of samples on the GC-MS

Three standard cannabinnoid solutions of tetrahydrocannabinnol (Δ9–THC), cannabinol (CBN) and cannabidiol (CBD) were prepared by weighing 28.7 mg, 2.9 mg and 2.0 mg, respectively into 10 ml volumetric flasks and adding ethyl acetate to the mark and shaking to ensure homogeneity. Serial dilutions were made of the original solution to obtain standard concentrations of 100 µg/ml, 75µg/ml, 55 µg/ml, 25 µg/ml, 15 µg/ml, 5

µg/ml, 1 µg/ml, 0.5 µg/ml and run on the GC-MS to plot a calibration curve. The curve was used to calculate the concentrations of the samples and later converted into mg/100 mg (w/w). The elution orders of the cannabinoids were CBD, Δ9 – THC and CBN with retention times of 17.832, 18.491 and 18.924 minutes, respectively.

3.6 Statistical Data

The mean average cannabinoid content of the local and foreign alcoholic beverages in the slums, planned and planned areas was determined. Using a significance level of $p<0.05$, a two sample t test was performed on results obtained from alcoholic beverages from those areas. Data was presented as mean±SEM.

CHAPTER FOUR

RESULTS

4.1 Introduction

The main objective of this work was to investigate cannabis adulteration in alcoholic beverages sold in the Accra Metropolis. In this section, a presentation of presumptive tests, confirmatory tests as well as statistical inference are presented.

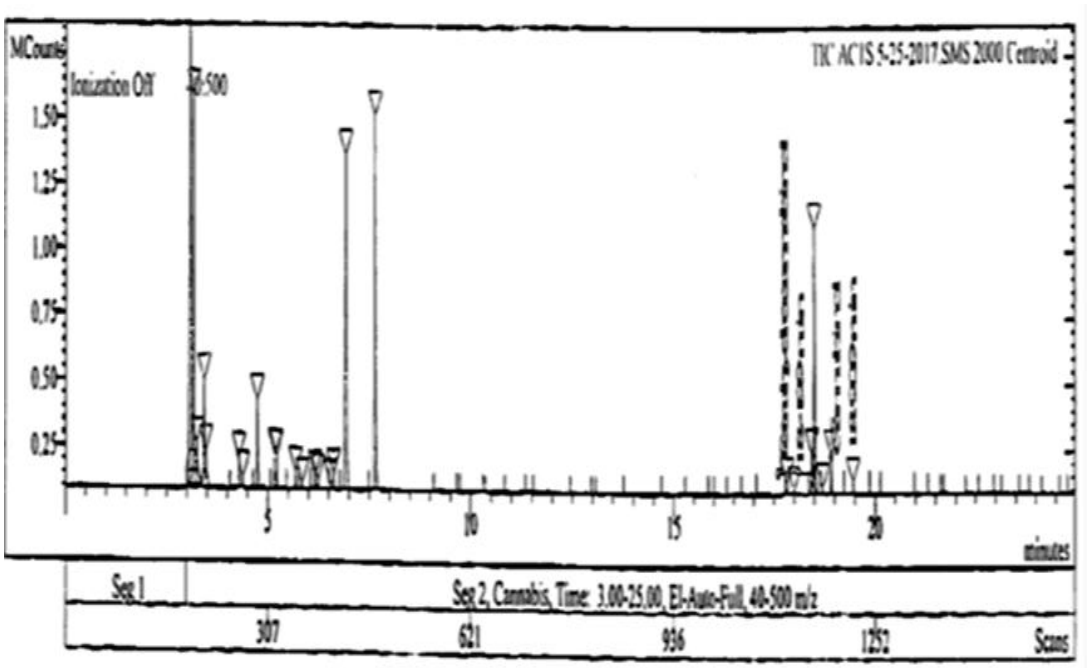
4.2 Presumptive test results for Local and Foreign Alcoholic Beverages

UNODC Fast Blue B salt kit, a colour test was used for this analysis. This test showed the presence of the main cannabinoids by a colour change of red in the local and alcoholic beverages. All the local alcoholic beverages had a positive result. The test results in general did not show much variation, however three of the foreign alcoholic beverages namely AGKP30U1 (Agblogbloshie-Kpehe catchment area), KALA25U1 (Kaneshie-Lartebiokoshie catchment area) and MFAV26U1 (Mfantseman-Avenor catchment area) all had negative results. All the foreign alcoholic beverages, which had negative results were samples taken from the unplanned areas. All samples were further subjected to confirmatory test to determine true positives. A false negative or false positive can sometimes occur in a colour test due to a number of reasons. This error can be overcomed by performing a confirmatory test, which is both qualitative and quantitative. Confirmatory tests in research are done to validate the results of a presumptive test (UNODC, 1994).

4.3 Determination of CBN, Δ9–THC and CBD with the GC-MS

Standard solutions of Δ9–THC, CBN and CBD were prepared and serially diluted and calibration curves of each standard constructed internally by the GC-MS. These curves were used to determine the concentrations of each sample. The lower limit of detection for all the three standards was 0.05 µg/ml. The concentrations of the samples were calculated by conversion of the retention factor in ppm to mg/100mg. This value is the percentage of each cannabinoid in the samples. The identities or signatures of each cannabinoid detected in the sample were established using the guidelines of the UNODC recommended methods for the identification and analysis of cannabis and cannabis products.

Figs 4.1-4.6 illustrate the spectra of the GC-MS analysis of representative of 3 local and of 3 foreign alcoholic beverage samples taken from 30 local bars in the slum, planned and unplanned areas. A pair of samples consisting of one local and one foreign alcoholic beverages per slum, unplanned and planned areas, respectively.

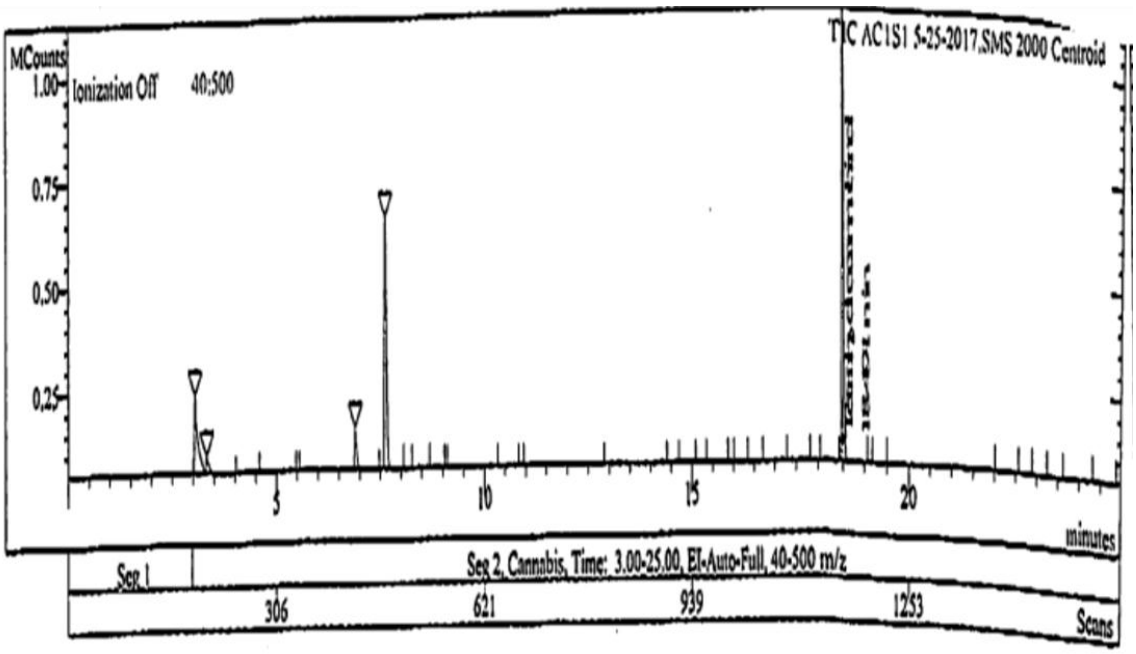


Target Compounds

#	RT	Peak Name	Res Type	Quan Ions	Area	Amount/RF
1	17.837	Cannabidiol	Miss.	231.3	0	0
2	18.499	Tetrahydrocannabinol	Fail	149.2	232950	6.017
3	18.909	Cannabinol	Id.	295.8	246973	25.822

Fig. 4.1 GC-MS spectrum of the local alcoholic beverage from slum area

In the Abuja-Chemuna local alcoholic beverage, CBN had the highest concentration of 25.82 whereas CBD and THC had no identifiable peaks and were therefore characterized as miss and fail respectively as seen in **Fig 4.1**

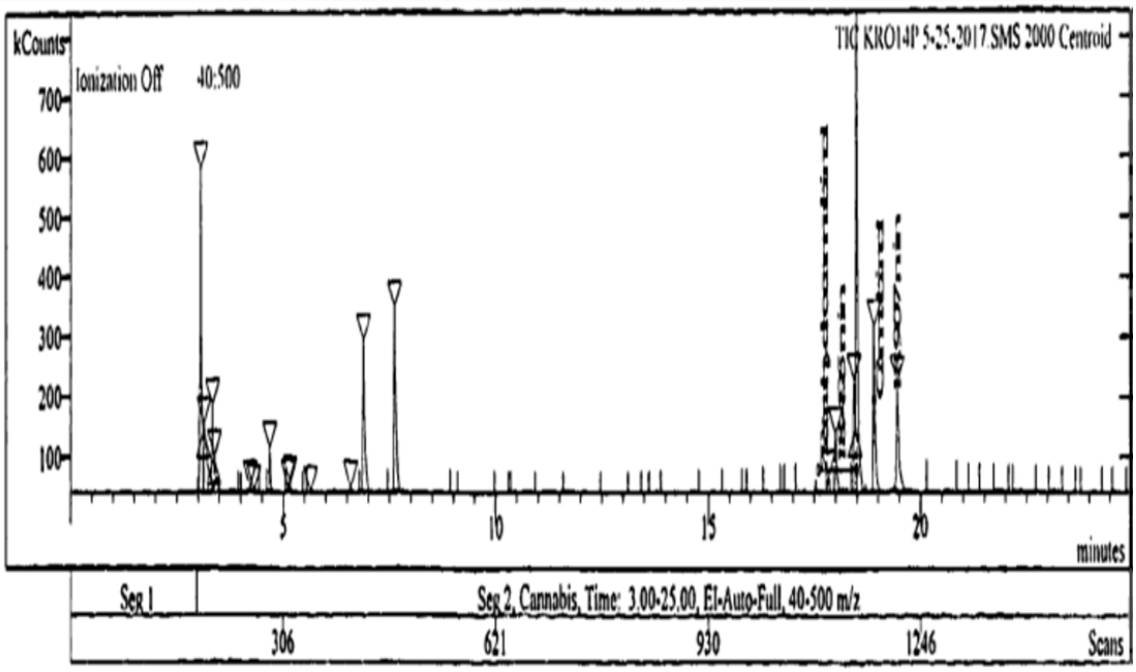


Target Compounds

#	RT	Peak Name	Res Type	Quan Ions	Area	Amount/RF
1	17.837	Cannabidiol	Miss.	231.3	0	0
2	18.491	Tetrahydrocannabinol	Id.	149.2	285484	7.375
3	18.936	Cannabinol	Miss.	295.8	0	0

Fig. 4.2 GC-MS spectrum of the foreign alcoholic beverage from slum area

A foreign alcoholic beverage taken from the same bar in the Abuja-Chemuna catchment area AC1S1 analysed with GC-MS showed Δ9 – THC peaks whilst CBN and CBD had no identifiable peaks as seen in **Fig 4.2**

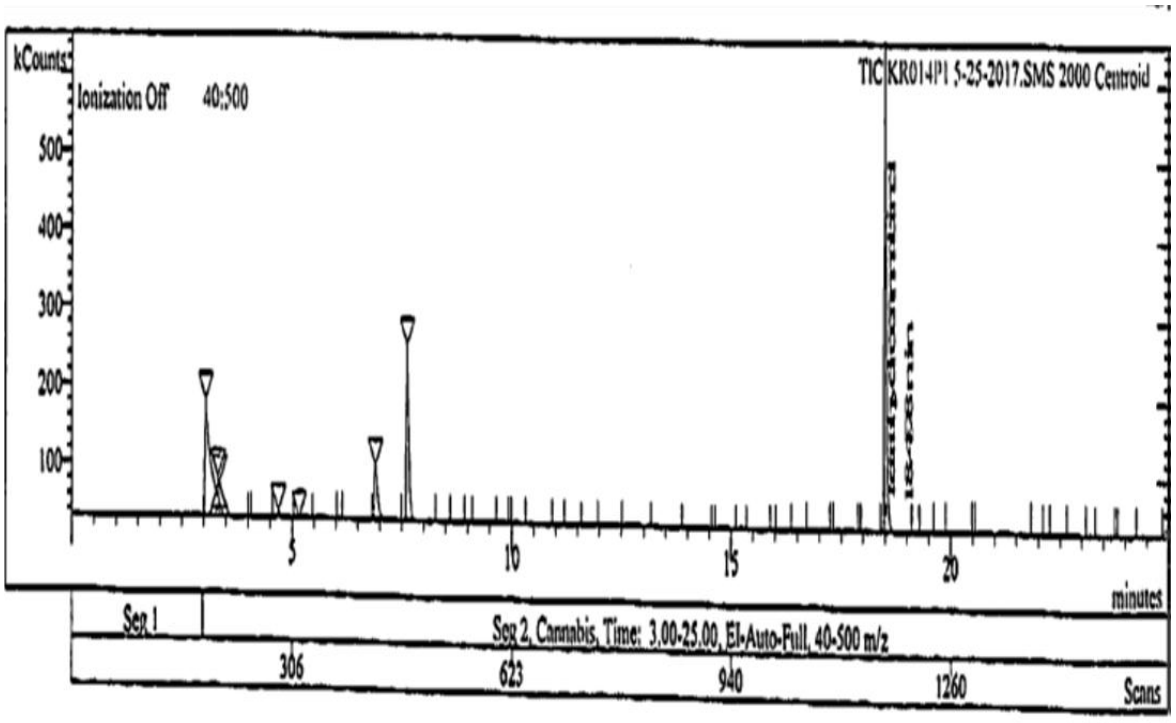


Target Compounds

#	RT	Peak Name	Res Type	Quan Ions	Area	Amount/RF
1	17.837	Cannabidiol	Miss.	231.3	0	0
2	18.495	Tetrahydrocannabinol	Id.	149.2	215523	5.567
3	18.907	Cannabinol	Id.	295.8	382239	39.598

Fig 4.3 GC-MS spectrum of the local alcoholic beverage from planned area

In the local alcoholic beverage, KRO14P from the Kanda-Roman Ridge catchment area CBN and Δ9–THC peaks were identified whereas CBD had no identifiable peaks, **Fig 4.3**

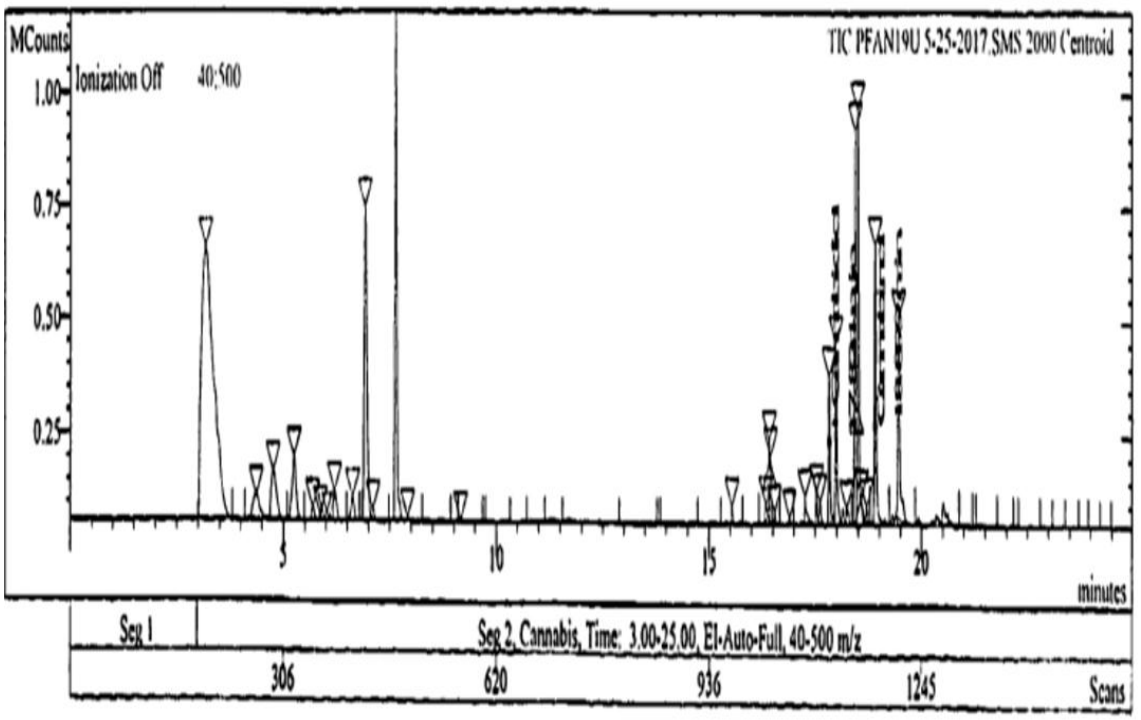


Target Compounds

#	RT	Peak Name	Res Type	Quan Ions	Area	Amount/RF
1	17.837	Cannabidiol	Miss.	231.3	0	0
2	18.498	Tetrahydrocannabinol	Id.	149.2	295075	7.622
3	18.936	Cannabinol	Miss.	295.8	0	0

Fig 4.4 GC-MS spectrum of the foreign alcoholic beverage from planned area

Δ9–THC peaks were identified whilst CBN and CBD had no identifiable peaks represented in the foreign alcoholic beverage KRO14P1 from the Kanda-Roman Ridge catchment area as seen in **Fig 4.4**.

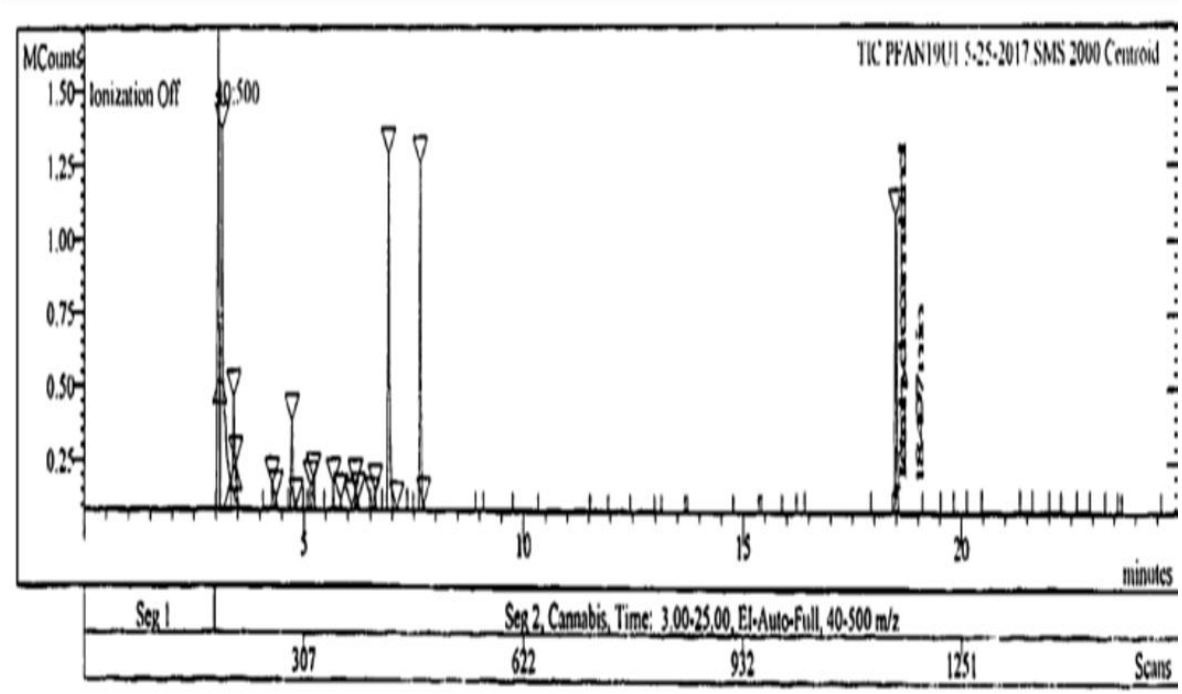


Target Compounds

#	RT	Peak Name	Res Type	Quan Ions	Area	Amount/RF
1	17.824	Cannabidiol	Id.	231.3	312242	105.570
2	18.496	Tetrahydrocannabinol	Fail	149.2	182041	4.702
3	18.899	Cannabinol	Id.	295.8	695217	71.474

Fig 4.5 GC-MS spectrum of the local alcoholic beverage from unplanned area

In the Pig Farm-Accra Newtown catchment area, PFAN19U local alcoholic beverage, CBN and CBD were identified whereas Δ9–THC had no identifiable peaks and were therefore characterized as seen in **Fig 4.5**.



Target Compounds

#	RT	Peak Name	Res Type	Quan Ions	Area	Amount/RF
1	17.837	Cannabidiol	Miss.	231.3	0	0
2	18.497	Tetrahydrocannabinol	Id.	149.2	271688	7.018
3	18.936	Cannabinol	Miss.	295.8	0	0

Fig 4.6 GC-MS spectrum of the foreign alcoholic beverage from unplanned area

Δ9–THC peak was identified whilst CBN and CBD had no identifiable peaks in the foreign alcoholic beverage PFAN19U1 from the Pig Farm-Accra Newtown catchment area as seen in **Fig 4.6**.

The concentrations of the three main cannabinoids in cannabis, CBN, Δ9–THC and CBD were calculated as mg/100 mg (w/w) for all the alcoholic beverages analysed and presented in **Table 4.1** to **4.3**. **Table 4.1** illustrates the results of cannabinoid analysis in mg/100 mg (w/w) done on samples taken from the slums of Accra.

Table 4.1 Canabinnoid concentration of alcoholic beverages in the Slums

Location	Sample ID	Cannabis Concentration in Local Alcoholic Beverages in mg/100mg			Sample ID	Cannabis Concentration in Foreign Alcoholic Beverages in mg/100mg		
		THC	CBN	CBD		THC	CBN	CBD
Slums	AC1S	0	25.80	0	AC1S1	7.38	0	0
	OL2S	0	103.64	0	OL2S1	9.58	0	0
	JU3S	4.55	0	0	JU3S1	0	0	0
	SG4S	0	26.04	0	SG4S1	6.85	0	0
	Mean	**1.14±1.14**	**38.87±22.44**	**0.0±0.0**	**Mean**	**5.95±2.07**	**0.0±0.0**	**0.0±0.0**

4.3.1 Cannabinnoid Concentrations in the Slum Areas

Δ9 – THC was not detected in the local alcoholic beverages except the sample (JU3S) from the Jamestown Ussher Fort slum areas but detected in all the foreign alcoholic beverages except the sample from the Jamestown Ussher Fort slum area. CBN was present in the local alcoholic beverages except the sample from the Jamestown UssherFort Slum and absent in the foreign alcoholic beverages. CBD was not detected in both the local and foreign alcoholic beverages in the slum areas.

Table 4.2 Cannabinnoid concentration of alcoholic beverages in Planned Areas

Location	Sample ID	Cannabis Concentration in Local Alcoholic Beverages in mg/100 mg			Sample ID	Cannabis Concentration in Foreign Alcoholic Beverages in mg/100 mg		
		THC	CBN	CBD		THC	CBN	CBD
Planned Areas	VAD5P	0	36.15	0	VAD5P1	0	36.16	0
	AER6P	2.75	86.83	0	AER6P1	6.33	1.01	0
	DZAH7P	0	36.68	0	DZAH7P1	9.32	0	0
	LC8P	0	59.80	0	LC8P1	8.20	0	0
	BCAR9P	0	193.87	0	BCAR9P1	6.78	0	0
	ELAD10P	0	58.27	0	ELAD10P1	0	8.72	0
	KL11P	0	47.26	0	KL11P1	9.43	0	0
	DAM12P	0	23.18	0	DAM12P1	17.62	0	0
	KOWR13P	4.62	40.96	0	KOWR13P1	0	0.88	0
	KRO14P	5.57	39.60	0	KRO14P1	7.62	0	0
	KOMA15P	0	19.99	0	KOMA15P1	0	1.97	0
	NRL16P	0	81.57	0	NRL16P1	10.10	0	0
	KOC17P	5.48	0	0	KOC17P1	7.25	0	0
	ABTE18P	8.61	1.06	0	ABTE18P1	96.21	0	0
	Mean	**1.93±0.78**	**51.80±12.89**	**0.0±0.0**	**Mean**	**12.78±6.56**	**3.48±2.59**	**0.0±0.0**

4.3.2 Cannabinnoid concentrationof alcoholic beverages in the planned areas

Δ9–THC was present in five (5) of the local alcoholic beverages samples; AER6P (Adabraka East Ridge catchment area), KOWR13P (Kokomlemle-West Ridge catchment area), KRO14P (Kanda-Roman Ridge catchment area), KOC17P (Korlegonno-Chorkor catchment area), and ABTE18P (Abelemkpe-Tesano catchment area). Δ9–THC was present in ten (10) of the foreign alcoholic beverages, while four (4) samples consisting of VAD5P1 (Victoriaburg-Asylum down catchment area), ELAD10P1 (East Legon-Adenta catchment area), KOWR13P1 (Kokomlemle-West Ridge catchment area), and KOMA15P1 (Korle-bu-Mamprobi catchment area) were not detected. The foreign alcoholic beverages ABTE18P1 (Abelemkpe-Tesano catchment area) had the highest level of 96.21% while AER6P (Adabraka East Ridge catchment area) had the lowest value of 2.75% for Δ9–THC with an average of 5.25% for all the 60 samples.

CBN was present in all the local alcoholic beverages except KOC17P (Korlegonno-Chorkor catchment area) and absent in all the foreign alcoholic beverages except VAD5P1 (Victoriaburg-Asylum down catchment area), AER6P1 (Adabraka East Ridge catchment area), ELAD10P1 (East Legon-Adenta catchment area), KOWR13P1 (Kokomlemle-West Ridge catchment area), KOMA15P1 (Korle-bu-Mamprobi catchment area) and ABTE18P1 (Abelemkpe-Tesano catchment area). CBD was absent in all the local alcoholic beverages except AER6P (Adabraka- East Ridge catchment area) and absent in all the foreign alcoholic beverages. The mean values of the cannabinoids have also been calculated in **Table 4.2**

4.3.3 Cannabinnoid Concentrations in the Unplanned Areas

Table 4.3 Illustrates the results of cannabinoid analysis done on samples taken from the unplanned areas of Accra. CBN was present in all of the local alcoholic beverages samples and four (4) of the foreign alcoholic beverages sampled from unplanned areas consisting of PFAN19U, NBAK23U (Nii-Boi Town-Akweteyman catchment area), DAW24U (Darkuman-Awoshie catchment area) and MPB28U (Mpoase-Bubiashie catchment area).

CBD was only detected in four (4) local alcoholic beverages and none in the foreign beverages sampled from unplanned areas of Accra. The local alcoholic beverage DAW24U (Darkuman-Awoshie catchment area) had the highest level of CBD at 149.52% and the local alcoholic beverage NBAK23U (Nii-Boi Town - Akweteyman catchment area) had the lowest value of 19.15% and the average CBD of all the 60 samples was 2.83%. The local alcoholic beverage BCAR9P had the highest CBN level of 193.87% and the foreign alcoholic beverage KOWR13P1 (Kokomlemle-West Ridge catchment area) was lowest at 0.88% and the average CBN of all the 60 samples was 25.93%.

CBN is the product of Δ9–THC breakdown or degradation. The sum of % Δ9–THC and %CBN gives an estimation of the levels Δ9–THC in a sample and can also serves as an indicator of the age of cannabis samples. BCAR9P (Burma Camp-Airport Residential catchment area) a local alcoholic beverage had the highest overall [%Δ9–THC+%CBN]value at 193.87% and the foreign alcoholic beverage KOWR13P1

(Kokomlemle-West Ridge catchment area) had the lowest [%Δ9–THC+%CBN] value at 0.88% and the average [%average [%Δ9 –THC+%CBN] of the 60 samples was 23.44%.

Table 4.3 Cannabinnoid Concentration of alcoholic beverages in the Unplanned Areas

Location	Sample ID	Cannabis Concentration in Local Alcoholic Beverages in mg /100 mg			Sample ID	Cannabis Concentration in Foreign Alcoholic Beverages in mg/100 mg		
		THC	CBN	CBD		THC	CBN	CBD
Unplanned Areas	PFAN19U	0	105.57	71.47	PFAN19U1	7.02	0	0
	AL20U	0	90.60	0	AL20U1	7.87	0	0
	NIMA21U	0	60.92	0	NIMA21U1	10.78	0	0
	ACAP22U	7.95	1.63	0	ACAP22U1	0	34.05	0
	NBAK23U	5.77	23.15	19.15	NBAK23U1	17.45	0	0
	DAW24U	2.88	100.42	149.52	DAW24U1	6.28	0	0
	KALA25U	0	49.52	0	KALA25U1	0	0	0
	MFAV26U	0	35.69	0	MFV26U1	0	2.76	0
	BWC27U	0	50.76	0	BW27U1	8.29	1.02	0
	MPB28U	0	72.81	81.60	MPB28U1	6.99	0	0
	ODOA29U	0	60.01	0	ODOA29U1	0	5.32	0
	AGKP30U	0	6.93	0	AGKP30U1	0	0	0
	Mean	**1.38±0.79**	**54.83±9.87**	**26.81±14.00**	**Mean**	**5.39±1.6 1**	**3.69±2.81**	**0.0±0.0**

Δ9–THC was present in three (3) local alcoholic beverages, ACAP22U (Achimota-Apenkwa catchment area), NBAK23U (Nii-Boi Town- Akweteyman catchment area) and DAW24U (Darkuman-Awoshie catchment area. Δ9–THC was present in seven (7) of the foreign alcoholic beverages, while five (5) samples, ACAP22U1 (Achimota-Apenkwa catchment area), KALA25U1 (Kotobabi-Alajo catchment area), MFAV26U1 (Mfantseman-Avenor catchment area), ODOA29U1 (Odorkor-Abossey Okai catchment area) and AGKP30U1 (Agblogbloshie-Kpehe catchment area) had no detectable level. The mean values of the cannabinoids were calculated in Table 4.3

Table 4.4. Comparison Mean of Δ9–THC, CBN and CBD concentration in Alcoholic Beverages in the Slums, Planned and Unplanned areas

	THC		CBN		CBD	
Area	Local	Foreign	Local	Foreign	Local	Foreign
Slum	1.14±1.14	5.95±2.07	38.87±22.44	0.0±0.0	0.0±0.0	0.0±0.0
Unplanned	1.38±0.79	5.39±1.61	54.83±9.87	3.69±2.81	26.81±14.00	0.0±0.0
Planned	1.93±0.78	12.78±6.56	51.80±12.89	3.48±2.59	0.0±0.0	0.0±0.0
P-value	$p<0.05$	$p<0.05$	$p<0.05$	$p<0.05$	$p<0.05$	$p>0.05$

The statistical method used in this analysis was the two sample t-test. **Table 4.4** illustrates the variations of THC, CBN and CBD levels of alcoholic beverages sold in local bars in the Accra metropolis.

CHAPTER FIVE

5.0 DISCUSSION

Cannabis is the world's most abused recreational drug with a reported 147 million users globally (WHO, 2016). This drug is cultivated in almost every country across the world. In Ghana as in most countries, the growth, possession and trading of this drug is illegal. Cannabis is the most widely used recreational drug in Ghana (UNODC, 2015).

Literature on Cannabinnoid Concentrations of Cannabis and cannabis adulterated products in Ghana is very scanty hence the significance of this research work. It is imperative to note that no other researcher in Ghana has worked on cannabis adulteration in local and foreign alcoholic beverages, however Adu-Gyamfi and Brenya, (2015), Gibson (2007), Luginaa (2003) and many others have studied the socio-economic effects of cannabis and akpeteshie use on Ghanaians. No research has been done to monitor the cannabinoid levels in Cannabis adulterated alcoholic beverages. The main objective of this research work was to investigate Cannabis adulteration in alcoholic beverages. Presumptive investigation of presence of cannabis phytochemicals in 60 alcoholic beverages sold in bars using presumptive or colour tests revealed presence of the main canabinoids in the local and foreign alcoholic beverages. All the local alcoholic beverages tested positive, indicating presence of cannabis except samples AGKP30U1 (agblogbloshie-Kpehe catchment area), KALA25U1 (Kotobabi-Alajo catchment area) and MFAV26U1 (Mfantseman-Avenor catchment area) that were negative. These results proves the presence of false positives and false negatives in presumptive analysis of samples, reiterating the need for confirmatory tests in drug analysis (UNODC, 1995).

The GC-MS was used for the identification, and quantification of Δ9–THC, CBN and CBD in the alcoholic beverages. CBD and Δ9–THC resemble each other chemically, only differing with an ester bond on the Δ9–THC and position on the alcohol and a corresponding position on the CBD. The cannabinoid profile of the samples showed low quantities of CBD, varying quantities of Δ9–THC and high quantities of CBN (Mehmedic, 2010). The levels of cannabinoids present in the sample can determine the strain of Cannabis the alcoholic beverage was adulterated. The *Sativa* strain normally has high concentrations of Δ9–THC and low concentrations of CBD whilst the *Indica* Strain has low concentrations of Δ9–THC and high concentrations of CBD (Swift *et al.*, 2013). Almost all the foreign alcoholic beverages except JU3S1 (Jamestown-Ussher Town catchment area), VAD5P1 (Victoriaburg-Asylum Down catchment area), KOWR13P1 (Kokomlemle-West Ridge catchment area), KOMA15P1 (Korlebu-Mamprobi catchment area), ACAP22U1 (Achimota-Apenkwa catchment area), KALA25U1 (Kotobabi-Alajo catchment area), MFAV26U1 (Mfantseman-Avenor catchment area), ELAD10P1, ODOA29U1 (Odorkor-Abossey Okai catchment area) and AGKP30U1(Agblogbloshie-Kpehe catchment area) had high levels of Δ9–THC and low levels of CBD, which indicate that they were adulterated with Cannabis from a pure *Sativa* strain (Licata *et al.*, 2005).

The local alcoholic beverages PFAN19U (Pig Farm-Accra Newtown catchment area), NBAK23U (Nii Boi Town-Akweteyman catchment area) area), DAW24U (Darkuman-Awoshie catchment area) and MPB28U (Mpoase-Bubiashie catchment area) had low levels of Δ9–THC and high levels of CBD, which indicate that they were adulterated with Cannabis from a pure *Indica* strain (Potter *et al.*, 2008).

Age is a factor that has an influence on cannabinoid concentration. Δ9–THC is a very unstable compound due to its sensitivity to light, heat and atmospheric air, leading to its rapid

breakdown. This analysis proved that most of the cannabis used in adulterating the local and foreign alcoholic beverages were old due to the high levels of CBN present (Peltzer, 2007). It is clear that most of the Δ9–THC was converted to CBN. The local alcoholic beverage BCAR9P (Burma Camp-Airport Residential catchment area) had the maximum level of CBN at 193.87%, and ABTE18P1 Abelemkpe-Tesano catchment area had the maximum Δ9–THC level of 96.21%. This value exceeded most Δ9–THC percentages of the samples analysed with the average CBN (25.93%) value greater than the average Δ9–THC of (5.25%). The amount of CBN was greater than the Δ9–THC in most of the samples.

The samples taken from the local bars in the Planned areas of the Accra metropolis had the highest levels of cannabis adulteration. The Unplanned areas also had comparatively high levels of cannabis adulterated foreign alcoholic beverages. The slums however, came in last with the lowest values of cannabis adulteration. This could just be a plot by the owners of the bars to create a faster moving market for their products. The most astounding was the result from the slums, which may be due to regular operations by the Ghana Police Service in those areas making quite a difference or because there was an uneven distribution due to the comparatively smaller number of Slums in Accra (Owusu *et al.*, 2015).

The results of this study have however revealed that there is an alarmingly high rate of cannabis adulteration of alcoholic beverages in the Accra Metropolis especially in both the Planned and Unplanned Neighborhoods. Cannabis is divided into fibre type and drug type cannabis based on the amount of Δ9–THC and CBD (Ross, 2000). Hemp is a type of fibre produced from the Cannabis plant and is legal to cultivate, due to its low concentrations of the psychoactive component Δ9–THC (Hillig, 2005). Cannabis is termed as fibre type when it has low levels of

Δ9–THC as compared to CBD and drug type when it has high concentrations of Δ9–THC as compared to CBD.

From the results it can be deduced that MPB28U (Mpoase-Bubiashie catchment area) PFAN19U (Pig Farm-Accra Newtown catchment area), NBAK23U (Nii Boi Town-Akweteyman catchment area, and DAW24U (Darkuman-Awoshie catchment area); local alcoholic beverages were adulterated with Fiber type variety of Cannabis. All the other alcoholic beverages were adulterated with drug type Cannabis except JU3S1 (Jamestown-Ussher Town catchment area), KALA25U1 (Kotobabi-Alajo catchment area) and AKP30U1 (Agblogbloshie-Kpehe catchment area), which had no cannabinoids.

CHAPTER SIX

6.0 CONCLUSIONS AND RECOMMENDATION

6.1 Conclusion

Sixty (60) samples of local and foreign alcoholic beverages taken from 30 local bars in the Accra Metropolis were investigated for the presence of Canabinnoids. From the results of this study, almost all the samples taken were adulterated with cannabis except the foreign alcoholic beverages JU3S1 (James town-Ussher fort), KALA25U1 (Kotobabi-Alajo) and AGKP30U1 (Agblogbloshie-Kpehe catchment area).

The concentration of cannabis in the analysis shows that the cannabis used in adulterating the alcoholic beverages were old due to the high content of CBN. Almost all the alcoholic beverages were adulterated with Cannabis of the drug type except four samples that were adulterated with Cannabis of the fibre type.

Almost all the foreign alcoholic beverages had high levels of Δ9–THC and no CBD present which indicate that they were adulterated with cannabis from a *Sativa* strain. The local alcoholic beverages (4 samples) had low levels of Δ9–THC and high levels of CBD, which indicate that they were adulterated with cannabis from an *Indica* strain.

The bars in the Planned neighborhoods in the Accra Metropolis had the highest levels of cannabis adulterants in the local alcoholic beverages, while the Unplanned neighborhoods had the highest levels of cannabis adulterated in the foreign alcoholic beverages and the Slums recorded the lowest levels of cannabis adulteration in both the local and the foreign alcoholic beverages.

There were significant levels of cannabis adulteration in both the local and the foreign alcoholic beverages sold in local bars in the Planned, Unplanned areas and slums areas of the Accra Metropolis.

6.2 Recommendation

The data obtained from this work must be used as a baseline alcoholic beverage quality framework to serve as a basis for monitoring beverage quality in the Accra Metropolis to ensure safety. This data can also help the Ghana Police Service to determine neighborhoods where alcoholic beverages are being adulterated with cannabis.

The Ghana Police Service should organize more intelligent checks not only in the slums but also in the Planned and Unplanned neighborhoods to clamp down on criminals who run clandestine local bars and pubs selling cannabis adulterated alcoholic beverages.

The agencies responsible should carry out public health education within Accra Metropolis to sensitize the general public about the health risks and jail penalties associated with consuming alcoholic beverages adulterated with cannabis. Further work should be done to determine how, where and when alcoholic beverages are adulterated with cannabis.

REFERENCES

Adu-Gyamfi, S. and Brenya, E. (2014): Rehushing commentaries on the effects and potential benefits of cannabis: Lessons Ghana can learn from USA and Canada. *Published by Global Institute for Research and Education,* pp.17-18. Retrieved from https://issu.com/drsamueladugyamfi/docs.

Akyeampong, E.K. (2001). Between the Sea & the Lagoon: An Eco-social History of the Anlo of Southeastern Ghana: C. 1850 to Recent Times. *James Curry Publishers.* pp.154.

Alon, T., and Amirav, A. (2006). Isotope Abundance Analysis Method and Software for Improved Sample Identification with the Supersonic GC-MS. *Rapid Communications in Mass Spectrometry*. 20 (17): 2579–2588.

American Psychological Association (2009). ICD versus DSM. *Monitor on Psychology*. 40 (9): 63.

Amirav, A., Gordin, A., Poliak, M., and Fialkov, A.B. (2008). Gas chromatography-mass spectrometry with supersonic molecular beams. *Journal of Mass Spectrometry*. 43 (2): 141–63.

Bersani F.S., Corazza O., Simonato P., Mylokosta A., Levari E., Lovaste R., Schifano F.; Corazza; Simonato; Mylokosta; Levari; Lovaste; Schifano (2013). "Drops of madness? Recreational misuse of tropicamide collyrium; early warning alerts from Russia and Italy. *General Hospital Psychiatry*. 35 (5): 571–3.

Bogelt, L.M., Franson, K.L., Nussbaum, A.M., and Wang, G.S. (2013). The pharmacologic and clinical effects of medical cannabis". *Pharmacotherapy*. 33 (2): 195–209.

Brady, C. (2000). Encyclopaedia of Ireland: An A-Z guide to its people, places, history and culture. Oxford University press. 11.

Budney, A.J., and Lile, J.A. (2009). Moving beyond the cannabis controversy into the world of the cannabinoids. *International Review Psychiatry*. 21:91-95pp.

Budney, A.J., Roffman, R., Stephens, R.S., and Walker, D. (2007). Marijuana dependence and its treatment. *Addiction Science & Clinical practice*. 4 (1): 4–16.

Buglass, Alan J. (2011). Technical, Analytical and Nutritional Aspects. *Handbook of Alcoholic Beverages* John Wiley & Sons, Ltd. 3-4. Retrieved from http//en.m.wikipedia.org. 978470-51202-09.

Bramness, J., Strassburger, J., and Donnerstein. (2010). Impairment due to Cannabis and Ethanol: Clinical signs and Additive effects. *Journal for the Society of Addiction*. Vol (10) p.1

Brenneisen R. (2007). Chemistry and analysis of phytocannabinoids and other cannabis constituents, *Journal of Marijuana and the Cannabinoids Forensic Science and Medicine*. Vol (7) pp.17–49.

Brock, D. C. (2011). A Measure of Success. *Chemical Heritage Magazine*. 29 (1).pp. Retrieved from http://sciencehistory.org.

Brownlee, N. (2002). "3-History". This is alcohol. Sanctuary Publishing. Vol (5) pp. 84-93.

Clark, D. (2005). Background Briefing, Alcohol Dependence. *Drink and Drug News*,vol() p. 11.

Crumpton, A.K. (2015). Pan African Issues in Drugs and Drug Control: An international Perspective. *African Journal*. pp.44. Retrieved from http://www.routeledge.com

Damsere, J. (2014). Prevalence of alcohol impaired driving and riding in Northern Ghana. *Journal of Traffic Injury Prevention*. (17) pp. 222-232. Retrieved from http://www.researchgate.net

Danovitch, I., and Gorelick D.A., (2012). State of the art treatments for cannabis dependence. *Psychiatry Clinical Journal*. North Amsterdam. (Review). 35 (2): pp.309–26.

DeWit, J. E., and Berner. (2009).Progressive Patronage Municipalities, NGOs, CBOs and the Limits to Slum Dwellers' Empowerment. *Journal of Development and Change*. 40(5): pp.927-947.

Drake, Bill (2002). The Marijuana Food Handbook. Ronin Publishing.Vol(1) p. 18.

El-Shafie, M. (2010). Sustainability Versus Mega Urban Development Projects**.** *International Journal of Civil & Environmental Engineering IJCEE-IJENS* Vol(10) p.4.

El-Alfy, A.T., Ivey, K., Robinson, K., Ahmed, S., Radwan, M., Slade, D., Elsohly, and M. Ross, S. (2010). Antidepressant-like effect of Δ9-tetrahydrocannabinol and other cannabinoids isolated from Cannabis sativa L. *Journal of Pharmacology Biochemistry and Behavior*. 95 (4): 573–82. Retrieved from http//www.ncbi nlm nhil.gov./pmc articles PMC2866040.

ElSohly, A.M (2007). Marijuana and the Cannabinoids. *Humana Press*. p. 8.

Elsohly, M.A., and Slade, D. (2005). Chemical constituents of marijuana: the complex mixture of natural cannabinoids. Life sciences, 78(5), pp.539–48. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/16199061 [Accessed October 23, 2013].

European Monitoring Center for Drugs and Drug Addiction (EMCDDA). (2008). A Cannabis Reader. *Global issues and local experience*. Lisbon. Retrieved from http://www.emcdda.europa.eu/publications/drug-profiles/cannabis.

European Monitoring Centre for Drugs and Drug Addiction (EMCDDA). (2014). European drug report: trends and development. Retrieved from http://www.emcdda.europa.eu/system/files/publications/4541/TDAT17001ENN

Fafchamps, M. and Minten, B. (2005). Crime, transitory poverty, and isolation: Evidence from Madagascar. *Oxford University Press.* pp. 10-21

Forbes, R.J. (1997). A Short History of the art of Distillation from the beginnings up to the death of Celier Blumenthal. Brill Academic Publishers. https://www.amazon.com/Short-History-Distillation-R-J-Forbes/dp/0982405545

Forson, P.K. (2015). Frequency of Alcohol use among Injured Adults presenting to a Ghana emergency department. *Journal of Annals of Emergency Medicine.*

Green, G. (2001). The Cannabis Grow Bible. (4th ed.) p.47.

Green, K.M. 2010. Does heavy adolescent marijuana use lead to criminal involvement in adulthood? Evidence from a multiwave longitudinal study of urban African Americans. *Drug and alcohol dependence*, 112(1-2), pp.117–25. Retrieved from http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=2950879&tool=pmc ntrez&rendertype.

Gordon, A.J., Conley, J.W., and Gordon, J.M. (2013). Medical consequences of marijuana use: A review of current literature. *Current Psychiatry* (Review). 15 (12): 419.

Grattan K.E., and Vogel-Sprott, M. (2001). Maintaining an intenational control of behavior under alcohol. Alcohol clinic Experiment Result. 25(2):192-197.

Guerri, C. and Pascual, M.A. (2010). Mechanisms involved in the neurotoxic, cognitive, and neurobehavioural effects of alcohol consumption during adolescence". Alcohol. pp.44(1): pp.15-26.

Hasin, D. (2007). Prevalence, Correlates, Disability, and Comorbidity of DSM-IV Alcohol Abuse and Dependence in the United States. *Archives of General Psychiatry*. 64 (7): 830–42.

Hasin, D.S., Saha, T.D., and Kerridge, B.T. (2015). Prevalence of marijuana use disorders in the United States Between 2001-2002 and 2012-2013. *JAMA Psychiatry.*;72(12):1235-1242.

Hardwick, S.(2008). Home office cannabis potency study 2008. Scientific Development Branch. Retrieved from http://www.dldocs.stir.ac.uk/documents/potency.pdf

Hillig, K.W. (2005). Genetic evidence for speciation in Cannabis (Cannabaceae). Journal of *Genetic Resources and Crop Evolution*, 52(2), pp.161–180.

Huijgen, J., Dinkelacker, V., Lachat, F., Yahia-Cherif, L., El Karoui, I., Lemaréchal, and J., George, N. (2015). "Amygdala processing of social cues from faces: An intracrebral EEG study". *Social Cognitive And Affective Neuroscience Journal.* 10 (11): 1568–1576.

Iseger T. A., and Bossong M. G. (2015). A systematic review of the antipsychotic properties of cannabidiol in humans. *Schizophrenia Research Journal.* 162 153–161.

Jeffery, J.D.E. (2010). Aging of Whiskey Spirits in Barrels of Non-Traditional Volume,MasterThesis, Michigan University p.30

Leffingwell, J.C., and Road, A.H. (2003). Chirality & Bioactivity I. *Journal of Pharmacology*. 3(1).

Licata, M., Verri, and P., and Beduschi, G., 2005. Delta9 THC content in illicit cannabis products over the period 1997-2004 (first four months). *Annali dell'Istituto superiore di sanità,* 41(4), pp.483–5. http://www.ncbi.nlm.nih.gov/pubmed/16569917.

Luginaah, D.C. (2003). Consumption and Impacts of local brewed alcohol (akpeteshie) in the Upper West Region of Ghana: A public health tragedy. *National Institute of Health*. 57 (9): 1747-1746.

Madras, B. K. (2014). Dopamine challenge reveals neuroadaptive changes in marijuana abusers. Proceedings of the National Academy of Sciences. 111 (33): 11915–11916.

Malenka, R.C., Nestler, E.J., and Hyman, S.E. (2009). Chapter 15: Reinforcement and Addictive Disorder. *In Sydor, A. Brown, R.Y. Molecular Neuropharmacology: A Foundation for Clinical Neuroscience (2nd ed.)*. New York: McGraw-Hill Medical. pp. 364–375.

Marshall, K., Gowling, L., Ali, R.L., and Foll, B. (2014). Pharmacotherapies for cannabis dependence. *The Cochrane database of systematic reviews*. pp.12. Retrieved from https://www.ncbi.nlm.nih.gov/pubmed/25515775

Mechoulam, R., and Hanus, L. (2002). Cannabidiol: an overview of some chemical and pharmacological aspects. Part I: chemical aspects. Chemistry and physics of lipids, 121(1-2), pp.35–43. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/12505688.

Mehmedic, Z. 2010. Potency trends of Δ9-THC and other cannabinoids in confiscated cannabis preparations from 1993 to 2008. *Journal of Forensic Sciences,* 55(5), pp. 1209–17. Retrieved from http://home.olemiss.edu/~suman/potancy%20paper%202010.pdf

National Institute on Alcohol Abuse and Alcoholism (2000). Health risks and benefits of alcohol consumption. *Alcohol Research and Health Journal.* 24(1): pp.5-11.

Nelson, M. (2005). The Barbarian's Beverage: A History of Beer in Ancient Europe. Abingdon, Oxon: Routledge. p.1.

Newbury, D.B., White, M., and Wolfson, F.K. (2010). Unit of Clinical Pharmacology, University of Newcastle, Newcastle Upon Tyne NE2 4HH, UK.

Nickles, J. (2015). Certified Specialist of Spirits Study Guide *Society of Wine Educators*, p. 23.

Owusu G. (2015). Urban Crime and Poverty Nexus. *Ghana Journal of Geography*. vol.8(1) Special Issue. pp. 1-10

Pacher, P., and Mechoulam, R. (2011). Is lipid signaling through cannabinoid 2 receptors part of a protective system? Pharmacological Reviews.

Pavia D.L., Lampman, G.M., Kritz, G.S., and Engel, R.G. (2006). Introduction to Organic Laboratory Techniques: A miracle Approach (4^{th} ed.), *Cengage Learning, Brooks/Cole Publishing Co.*, pp.797-817.

Potter, D.J., Clark, P., and Brown, M.B. (2008). Potency of delta 9-THC and other cannabinoids in cannabis in England in 2005: implications for psychoactivity and pharmacology. *Journal of Forensic Sciences,* 53(1), pp.90–4.

Robbe, H. (1999) Marijuana and Actual Driving Performance, National Highway Traffic Safety Administration, US Department of Transportation, Washington D.C.

Robinson, J., (2006). The Oxford Companion to Wine. New York: Oxford University Press. Vol.3p. 279.

Rosenthal, Ed (2007). More Marijuana Varieties from the World's Great Seed Breeders, p.134.

Ross S. A., Mehmedic Z., Murphy T. P., and ElSohly M. A. (2000). GC-MS analysis of the total Δ9-THC content of both drug- and fiber-type Cannabis seeds. *Journal of Analytical Toxicology*. 4 715–717.

Ruppel, T.D., and Kuffel, N. (2013). Cannabis analysis: Potency, testing identification and quantification of THC and CBD by GC/FID and GCMS. Perkin Elmer Incorporated, 1-6. Retrieved from https://www.analyticalcannabis.com/application-notes/cannabis-analysis-

Ryan (2014). Acute Alcohol use Temporarily increases the odds of male perpetrated dating violence: A 90 day Analysis. *Journal of the National Institute of Health.*

Sampson, R.J., and Bean, L.(2006). Cultural Mechanisms and Killing Fields : A revised theory of community level racial inequality. The many colors of crime: Inequalities of race, ethnicity and crime in America. *University Press*. pp.52-60

Scinska, A., Koros, E., Habrat, B., Kukwa, A., Kostowski, W., and Bienkowski, P. (2000). "Bitter and sweet components of ethanol taste in humans". *Drug and Alcohol Dependence*. 60 (2): 199–206.

Sharma (2011). Plant taxonomy 2E.Tata McGraw-Hill Education. Pp. 459.

Sloan, K. M., Mustacich, R. V., Eckenrode, B. A. (2001). "Development and evaluation of a low thermal mass gas chromatograph for rapid forensic GC-MS analyses". *Field Analytical Chemistry & Technology Journal*. 5 (6): 288–301.

Small E. (2015). Evolution and Classification of Cannabis sativa (marijuana, hemp) in relation to Human Utilization. *Botanical. Review*. 8(1) pp.189–294.

Smith P.A., Lepage, C.J., Lukacs M., Martin, N., Schufutinsky, A., and Savage, P.B. (2010). Field-portable gas chromatography with transmission quadrupole and cylindrical ion trap mass spectrometric detection: Chromatographic retention index data and ion/molecule interactions for chemical warfare agent identification. *International Journal of Mass Spectrometry*. 295 (3): 113–118.

Smith M.B., and March J., (2007). Advanced Organic Chemistry: Reactions, Mechanisms and structure (6^{th} ed.), New York: Wiley-Interscience.

Solano-Castiella E., Anwander A., Lohmann G., Weiss M., Docherty C., Geyer S., Reimer E., Friederici AD., and Turner R (2010). Diffusion tensor imaging segments the human amygdala in vivo. NeuroImage. 49 (4): 2958–65.

Splettstoesser, T.(2015). Neuorotransmission. Schematic of a Synapse. Wikipaedia Commons. Retrieved from https://commons.m.wikimedia.org.

Swift, W., Wong, A., Li K.M., Arnold, J.C., and McGregor, I.S. (2013). Analysis of cannabis seizures in NSW, Australia: cannabis potency and cannabinoid profile. *Plos 1 Journal*, 8(7).

Thomas, A. (2007). Fats and fatty oils, Ullmans Encyclopaedia of Industrial Chemistry (7th ed.), Wiley, pp.31.

Tourangeau, W (2015). "Redefining environmental harms: Green criminology and the state of Canadas hemp industry", *Canadian journal of criminology and criminal justice*, 57(4): 528-554.

United Nations Office on Drug and Crime (2009). Recommended Methods for the Identification and Analysis of Cannabis and Cannabis Products. (2009). United Nations Office on Drugs and Crime, Vienna.

United Nations Office on Drugs and Crime (2015). World Drug Report 2015.United Nations Office on Drugs and Crime, Vienna.

United Nations Office on Drugs and Crime (2014). World Drug Report 2014.United Nations Office on Drugs and Crime, Vienna.

United Nations Office on Drugs and Crime (2010), World Drug Report 2010.United Nations Office on Drugs and Crime, Vienna.

United Nations Office on Drugs and Crime. World Drug Report (2006). The Emergence of New cannabis and the Reassessment of Health Risk. 2006; Volume 1: Analysis:172 - 185.

United Nations Office on Drugs and Crime (1994). Rapid Testing Methods of Drugs of Abuse. Manual for use by national law enforcement and narcotics laboratory personnel (ST/NAR/13/REV.1), United Nations, New York.

Vandrey, R., and Haney, M. (2009). Pharmacotherapy for cannabis dependence: how close are we? *CNS Drugs (Review)*. 23 (7): 543–553.

Volkow, N.D. Koob, G.F., McLellan A.T. (2016). Neurobiologic Advances from the Brain Disease Model of Addiction. New England. *Journal of Medicine*. 374 (4): 363–371.

Vukovic, J., Modun, D., Markovic, D., Sultovic, D., (2015). Comparism of breath and blood alcohol concentrations in a controlled Drinking study. *Journal of Substance Abuse and alcoholism*.3(2): 1029.

Wanted in Africa (2011). Neighborhoods of Accra. Retrieved from https://www.wantedinafrica.com.

Weiser, S.D., Leiter, K., Heisler, M. (2006). A population-based study on alcohol and high-risk sexual Behaviors in Botswana. *Journal of Plos Medicine,* 3(10).

Wicki, M., Kuntsche, E., Gmel, G. (2010). Drinking at European universities? A review of student's alcohol use. *Journal of Addictive Behaviors,* 35, 913–924.

Williams, O. (2015). Gin Glorious Gin: How Mothers Ruin Became the spirit of London. London Headline. Retrieved from https//en.m.wikipedia.org. 978-1-47221-534-5.

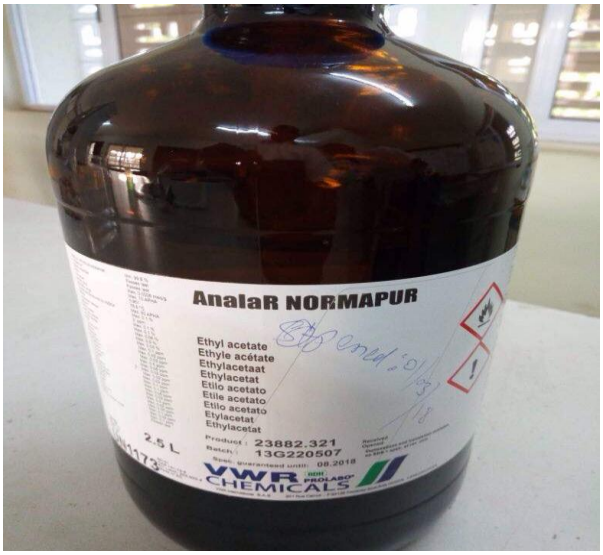
Wim, B. (2010) The foundation, planning and building of new towns in the 13th and 14th centuries in Europe. An architectural-historical research into urban form and its creation. Phd. thesis Universiteit van Amsterdam.

APPENDIX 1

A. Centrifuge

B. Water Bath

C. Ethyl Acetate



APPENDIX 2

A. Syringes

B. Filters

C.Vial tubes (GC-MS)