Evaluation and Consequences of the pH and Caffeine Content of Energy Drinks Marketed in Delta State, Nigeria

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Received 19 April 2020; accepted 29 May 2020, published online 06 July 2020

Abstract

Energy drink are acidic beverages with high sugar and caffeine content. They may also be referred to as "Sugar Sweetened Low pH Caffeinated Drink". Though, the health benefits of energy drink are controversial, while they are believed to be energy boosters, enhance capacity to concentrate and also to improve physical and mental performance; it consumption may lead to degenerated health such as delayed child bearing/infertility, miscarriage, obesity or stomach ulcer as consequence of caffeine poisoning and the lowering of the body pH. This study is poise to investigate and review the acidity level alongside the caffeine content of energy drink samples, and also examine the relationship between pH, sugar metabolism and it consequences in man.

Keyword: Energy Drink**,** Beverage, pH, Caffeine, Sugar, Blood buffer, Stomach buffer

Introduction

Energy drinks may also be referred to as "Sugar Sweetened Low pH Caffeinated Drink". They are beverages that contains high level of substances capable to excite any bodily functions and tend to stimulate the brain and the central nervous system [1]. Fortified with minerals such as vitamins or carnitines, they induce alertness, elevated mood, wakefulness, increased speech and appetite [2]. [3] in their study reported that these drinks are believed to be energy boosters, enhance capacity to concentrate and also to improve physical and mental performance. Research by [4] revealed that energy drinks are different from other beverages and soft drink, in that Soft drinks are mainly carbonated water, sugar and flavoring, while energy drink contains high concentration of caffeine – a nitrogenous compound of the alkaloid group, a substance that has a mask physiological effects. Also, sports drinks contain water, electrolytes and sugar. They are typically designed to replace lost water during activities. But energy drinks have added caffeine and other ingredients that manufacturers believe induces sustain energy and "boost" performance. [5] in their study on the manufacturer assertion of energy drink boosting energy is reported to holistically designed to correct moral and social behaviour, in which the stimulant effects of the drink were said to be derived from the specific concoction of ingredients. General survey revealed that the stimulant effects of energy drink are due primarily to caffeine. [6] in their study reported that Energy drink contain about 80mg of caffeine per can, a lot of sugar coupled with other energy inducing substances [1]. [2] in their publication reveals that the excess consumption of it may upset stomach buffer by relaxing the esophagus, which can cause heartburn and irritate the stomach lining and gut. In some cases, it can also cause cramps, diarrhea, nausea and vomiting in some people. Energy drink are targeted toward teenagers, young adult and physically active individual - students, athletes and anyone else who wants an

extra energy kick. Most people prefer the drink chilled and most time, mixed with beer and spirit to make a high energy cocktail. Study from consumers that combine energy drink and alcohol revealed that alcohol is a depressant and has a tranquilizing effect on the body that can make the consumer unaware of the quantity consumed. A study revealed that men who combined energy drinks with alcohol felt alert and sober even while they were actually drunk. And since both alcohol and energy drinks cause dehydration when combined, they may results to a drop to body fluids to dangerous levels. According to reviewers, people who have drank energy drinks have described the taste as ranging from "medicinal" to "molten Sweet Tart. General survey revealed that amidst the negative reports on energy drinks, it is seen to be a fast growing venture because it is perceive to have numerous benefits to consumers. Again, energy drinks produce feelings of wakefulness, and productivity. Consumers enjoy greater amount of caffeine and because energy drinks are served cold, they can be consumed much quicker than coffee, which is usually only sipped due of its hotness. Faster consumption leads to caffeine getting into the bloodstream quicker. It also comes with a variety of flavor and options - Where the flavor of coffee and tea does not appeal to caffeine addicts, energy drink are beneficial for those that want a caffeine boost. Though, the study of the effects of the bioaccumulation of energy drink is reported to have negative effects. [7] for example, found energy drinks to alter the heart function of a healthy adults, while general survey linked energy drink consumption to other unhealthy behaviors, such as smoking and "alcoholism". [8, 9] in their article revealed that energy drink may contained other added stimulants depending on the manufacturer, such as "guarana" - herb used to prevent tiredness and improve mental speed. It is also used to promote weight loss and increase sexual desire; "taurine" – a supplement used to improve memory and endurance; "ginseng" - a herb used to help reduce stress, strengthen muscles, and improve endurance; "synephrine" (bitter orange) - a herb used to promote weight loss; "L-carnitine l-tartrate" (LCLT) - a supplement used to increase energy, memory, and speed. It also is used to break down fat; "yerba mate" – a herb used to prevent tiredness and improve mood; "gingko" - a herb used to increase focus and prevent tiredness; St. John's Wort" - herb used to reduce stress and improve mood; "Carnitine" – An amino acid that plays a role in fatty acid metabolism; "Creatine" - An organic acid that helps supply energy for muscle contractions; "Inositol" - A member of the vitamin B complex (not a vitamin itself, because the human body can synthesize it) that helps relay messages within cells in the body. This study owes its significance to the fact that literature exposes the controversies associated with the ingestion of energy drinks both in short and long terms with focus on their individual components. For instance, [10] reported in their study that caffeine activates AMP-activated protein kinase (AMPK), which is a key enzyme that coordinates several signaling pathways that are involved in maintaining cellular energy homeostasis [11]. However, some studies have also highlighted the occurrence of negative effects by the consumption of energy drinks, such as an increase in the heart rate, and systolic and diastolic pressures and a decrease in the cerebral blood flow [12, 13]. They also reported that caffeine causes sympathomimetic effects, intensifying heart activity and increasing blood pressure [14]. There is little baseline study on the relationship between the bioaccumulation of sugar, the caffeine content and the high pH level of these energy drinks as a result of their consumption. Consumers in the Niger Delta region ingest energy drinks alongside other alcoholic drinks and beverages, simply because of the degree of ignorance of the biochemical effects of these drinks. There is an urgent need for the Federal Ministry of Health and stakeholders to educate and sensitize the masses on the effects of consuming energy drink in relation to caffeine poisoning, pH and the sugar content of these drink. Hence, the objectives of this study is to examine the caffeine content and pH level of some selected energy drinks consumed in Delta State, Nigeria.

Materials and Methods

The glassware were soaked overnight with chromic acid solution, washed thoroughly with water and detergent and finally rinsed with deionized water. The chemicals and reagents used were of analytical grade. The energy drinks were purchased in triplicate from different retail shops in Warri, Delta State, Nigeria. The energy

drinks were: Bullet (blue can), bullet (black can), power horse, red bull, Emviron, Fab and red alert.

Determination of pH

The pH of the different energy drink samples were determined using a mettler Toledo pH meter, which had been calibrated with buffer solutions of pH 4.0, 7.0 and 9.04

Standard Preparation/Calibration

100 ppm standard caffeine solution was prepared by dissolving 9.91 mg of caffeine in 100 ml chloroform. Different aliquots were taken from the 100 ppm solution and diluted with chloroform in 25 ml volumetric flasks to prepare a series of solutions of 5 ppm, 10 ppm, 15 ppm, 25 ppm and 30 ppm. The wavelength of maximum absorption was determined by scanning one of the standard solutions. The maximum absorption was observed at 290 nm. The calibration was carried out to obtain the linear range of sample concentrations. The absorption of each solution was measured in a Perkin Elmer Lambda 25 UV/visible spectrophotometer at 290 nm using a 10 mm quartz cuvette. The absorbance values were plotted against concentrations to generate a calibration curve.

Extraction of Caffeine from Energy Drink Samples

2.5 ml of each sample was measured into a 200 ml separating funnel using a 5 ml pipette. 10 ml chloroform was measured into the same separating funnel containing the sample. The caffeine in the sample was extracted by shaking and inverting the funnel containing the sample and chloroform at least three times and venting the funnel after each inversion. The chloroform layer was collected through an ashless filter paper into a 25 ml volumetric flask and covered. Another 10 ml of chloroform was added to the remaining content of the separating funnel for further extraction, and the chloroform layer combines with the initial one. The extracted content in the 25 ml volumetric flask was made up to mark with chloroform. This was repeated for all the energy drink samples.

Spike Preparation

2.5 ml of a particular sample was measured into a separating funnel. 2.5 ml of a known standard solution was also added to the separating funnel containing the sample. Caffeine was extracted as described above for the samples.

Caffeine Determination

Analysis of the caffeine content of the extracts was carried out using a Perkin Elmer Lambda 25 UV/visible spectrophotometer. Aliquots of the extracted samples were placed into glass cuvettes and their absorbencies read from the spectrophotometer to obtain the caffeine concentrations.

Results and Discussions

Once an energy drink is consumed, the body chemistry may be altered for the next twenty four (24) hours [3]. According to [3], it may only takes ten minutes for the body to absorb the caffeine content. The presence of caffeine in the blood inhabit adenosine. This makes the heart rate and blood pressure to begin to rise. Within the next 15 – 45 minutes, the caffeine content is maximum in the bloodstream, the individual begins to feel more alert as the stimulant begins to affects him or her. During this period, all the caffeine is fully absorbed and the liver begins to respond by absorbing more sugar into the bloodstream. Hence, in the first 1 hour, the body begin to experience a sugar crash and the effect of caffeine dyeing down. Here, the individual begins to feel tired with the energy even reducing. With the next 5 – 6 hour, the half live of caffeine is reach – the time required for the caffeine content in the blood stream to be reduced to 50%. And with this time and the close of the day, the individual start feeling the withdrawal symptom. This usually follow with headache, irritability and constipation. The results for the pH and caffeine content of the various samples of energy drink is detailed in table 1 below:

Table 1: Results showing concentration of pH and caffeine

S/N	Energy Drink Samples	pH	Caffeine Content (ppm)
1	Power Horse	2.71±0.01	33.434±0.02
2	Emviron Heath Drink	2.37±0.02	11.792±0.03
3	Forever Active Boost (FAB)	2.91±0.01	31.649±0.03
4	Hard Core	2.12±0.01	44.063±0.02
5	Red Alert	1.70±0.03	37.882±0.02
6	Bullet (Blue Can)	3.08±0.02	34.789±0.01
7	Bullet (Black Can)	3.41±0.02	6.698±0.02

Blood pH is referred to as the acidity or alkalinity of blood. [15] Defined the pH of any fluid as the measure of the hydrogen ion (H^-) concentration in it. The pH concentration of all samples of energy drinks investigated in this study ranges from 1.70±0.03 to 3.41±0.02 with Red Alert showing the lowest pH value of 1.70±0.03. Hard core has an average pH of 2.12±0.01 and Emviron Heath Drink has an average pH of 2.37±0.02. The pH values of all the samples of energy drinks investigated in this study has values of <3.50. Study shows that the variety of factors that affects blood pH includes ingestion, vomiting, diarrhea, lung function, endocrine function, kidney function, and urinary tract infection. Literature further reveal that blood acidity increases when the intake level of acidic compounds in the body rises or decreased elimination, and this can cause the pH human body to become more acidic, increasing the vulnerability to illness and disease [15], for instance a survey with resident doctors reveals that cancer and diabetes only strives in acidic environments and could be prevented or even cured if you eat an alkaline diet. The acidic nature of the energy drink is a key ingredient that gives the beverage a distinctive taste. Though, acids provides the tartness and tangy taste that helps to balance the sweetness of sugar present in the drink, [16] in their study revealed that when an energy drink or a highly acidic beverages are consumed, it leads to dental erosion - the irreversible acidic dissolution of surface tooth structure by chemical means in the absence of microorganisms. It primarily occurs when hydrogen ions interact with the surface fluorapatite and hydroxyapatite crystals after diffusion through plaque - pellicle biofilm - a process termed proton-promoted dissolution [17]. This process begins from the mouth where it is mixed with the saliva which is roughly a pH of 6.8 or 7, which is considered neutral. The pH of the saliva drop drastically to the pH of the ingested liquid content. [18] in her study on "How Energy Drinks Ruin Your Teeth" revealed that "the body will need approximately 30 minutes to buffer the saliva back to a normal pH," and "For those 30 minutes, your teeth are essentially bathed in an acidic environment - in acid." Also, bacteria grows best in acidic medium, the higher the concentration of bacteria, the more likely you are to get tooth and gum disease. The hydrogen ion concentration or acidity, as measured in pH, is primarily responsible for the immediate dissolution and softening of surface tooth structure and when this process continue for a fairly prolong period, the tooth may be severely affected. General survey reveals that since people are so wired after drinking an energy drink, they grind their teeth. This sometimes causes tooth breakage and tooth loss. The pH characteristics of this beverage increases the amount of acid in the stomach - stomach upset, cause heartburn and may also interfere with the absorption and metabolism of calcium. This process may lead to bone thinning - osteoporosis, and muscles twitch. Caffeine toxicity as a result of the ingestion of energy drink seem to be increasingly popular among teenagers and young adults, and toxicity may be as a result of the deliberate combination of energy drinks with alcohol [19]. [20] in their study reveals a relationship between the low pH values and the sugar content in energy drinks – "acidic sugar sweetened drink", and their consumption may resulting to degenerated human health [21]. [22] In their study on the nutritional and proximate composition of juice produced from Citrullus lanatus and Psidium guajava blend revealed that

when large amount of sugar is consumed, a significant quantity is absorbed and transported to the liver. When the liver takes in more sugar than it can handle, some if it gets converted into fat. Some of the fat get deposited in the liver, and this induced the production of fat, fat buildup and then, insulin resistance [23]. Results from a survey conducted on young female adults in the Tertiary Institutions in Delta State, Nigeria that who consumed energy drink to stay awake during their schooling days revealed that those addicted to caffeine, had treatment for either one case of fibroid; a type of kidney stone called uric acid stone; obesity or the upper gastrointestinal issues such as ulcer or reflux. Data from table 1 also revealed an appreciable amount of caffeine content in all the energy drinks investigated in this study. Caffeine (1, 3, 7 - trimethylxanthine) is a plant alkaloid with a chemical structure of $C_8H_{10}N_4O_2$ and a molecular weight of 194.19. In pure form, it is a bitter white powder. It works by blocking the effects of adenosine, a brain chemical involved in sleep. When caffeine blocks adenosine, it causes neurons in the brain to fire. Thinking the body is in an emergency, the pituitary gland initiates the body's "fight or flight" response by releasing adrenaline. This hormone makes the heart beat faster and the eyes dilate. It also causes the liver to release extra sugar into the bloodstream for energy. Caffeine affects the levels of dopamine, a chemical in the brain's pleasure center. All of these physical responses make the consumer feels as though he/she have more energy. In other words, the primary action of caffeine as an adenosine inhibitor is well established, thus counteracting the actions of this inhibitory neurotransmitter and increasing the release of other neurotransmitters including noradrenaline and dopamine, producing a moderate stimulant and mood-enhancing effect. Data obtained for energy drink in this study reveals that Hard Core has the highest concentration of 44.063 ± 0.02 ppm; followed by Red Alert has 37.882 ± 0.02 ppm. Bullet (Blue Can) and Power Horse and then Forever Active Boost (FAB) with concentrations of 34.789 ± 0.01 ppm, 33.434 ± 0.02 ppm and 31.649 ± 0.03 ppm respectively. Bullet (Black Can) has the lowest caffeine concentration of 6.698 ± 0.02 ppm followed by Emviron Heath Drink with 11.792 ± 0.03 ppm. Literature revealed that caffeine is not recommended for children under the age of 12 years [1, 2, 9] limit for teenagers is yet to be determined and as such, expected to avoid caffeine assimilation. For adults, a limit of 400 milligrams of caffeine per day (which roughly equals 4 cups of coffee, 2 cans of soda, or 2 “energy shot” drinks, however this can vary widely) is considered safe [24]. Excess dose of caffeine can over stimulate the brain which may lead to confusion, and the individual may have headache, muscle ache and irritability in an advent of caffeine withdrawal. Caffeine provides no nutritional value on its own, [25] reported infertility/delayed pregnancy for expectant mothers and miscarriage during pregnancy for female as a consequence of caffeine poisoning. Caffeine toxicity may also have negative effects on the male reproductive system. A survey conducted on men attempting to be fathers through the In Vitro Fertilization in Hospitals in Delta State, Nigeria revealed that chronic addicts to caffeine had failed IVF. Sarah Knapton in her presentation at the American Society for Reproductive Medicine annual conference in Hawaii in 2014 in [26] reported that male caffeine addicts has 25% chances of a successful IVF - an Assisted Reproductive Technology (ART), and a process of fertilization by extracting eggs, retrieving a sperm sample, and then manually combining an egg and sperm in a laboratory dish and the embryo transferred to the uterus. She believed caffeine has adverse effect on sperm at a molecular level and may as such, reduce couples’ chance of achieving clinical pregnancy. Though, literature reveals controversies associating caffeine addiction and fertility and infertility in male, other studies have it that caffeine toxicity did not affect semen quality or sperm count [27]. [27] Reported lower testosterone levels – a hormone essential for maintaining the structure and function of the male accessory sex glands. The study saw caffeine treatment caused a decrease in sperm density and percentage of motile and morphologically normal sperm in offspring during the post pubertal and adulthood periods of a rat. Caffeine assimilation may be reduced by the gradual withdrawal of caffeinated food and the consumption of “caffeine - free” or “decaffeinated” foods and drinks. Sources of

caffeine includes coffee, tea, caffeinated soda, energy drinks, chocolate, some over the counter medicines, and some prescription medications. Caffeine is also found in some dietary supplements, diet pills, energy shots, pre-workout supplements, and caffeine pills [25].

Conclusion

This study conducted on acidic beverages using samples of energy drinks as case study revealed that all the samples of energy drinks investigated has a very significant concentration of caffeine content and a low pH value. The study revealed that energy drinks can cause serious damage to the human teeth. That's because an energy drink can essentially bathe the enamel on the teeth in a highly acidic liquid. Also, the hyperactive energy produced by the drinks can also cause people to grind their teeth, causing tooth breakage and loss. Investigation in this study reveals that abnormal behaviour observed among teenage and young adults are consistent with caffeine overdose and, potentially, stimulant misuse, most times as a results of the mixing of energy drinks with alcohol. This suggests that knowledge of energy drink effects and toxicity is poor among the youth, and mixing of substances is not seen as a problem. The paper revealed that the pH and caffeine contents of the energy drinks available in the market in Nigeria, Delta State in particular are not good for human consumption. It therefore called for more enlightenment by the appropriate government agencies to educate the youth about the health implication of the consumption of such drinks. We further recommend that labelling and any marketing of these products should include appropriate health warnings.

Acknowledgement

Energy drink samples in this study were analyzed with the support of Pst. (Mrs.) Serian E. Onadipe of the Chemical Society of Nigeria, Delta Chapter.

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