



CHEMICAL EVALUATION OF CARBONATED DRINKS AND EFFECT OF CAFFEINE CONSUMED THROUGH THEM ON FEMALE LECTURERS' BONE HEALTH IN KANO STATE

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Abstract

The study was carried out to evaluate the chemical composition of carbonated drinks and the effect of caffeine consumed through it on female lecturers' bone health in Kano State. Four research objectives guided the study, among which were to identify the commonly consumed carbonated drinks and others. Four research questions were raised that guided the study also. Descriptive survey research and domestic experimental design were used for the study and the population comprised 2,281 female lecturers in five selected tertiary institutions in Kano State. Proportionate random sampling technique was employed for sample selection and a sample of 340 respondents was determined using Taro Yamane statistical formula. Data were collected using a well-structured questionnaire of a five-point Likert Scale and the instrument consisted of two sections, namely Part A and B. Frequency, percentage, mean, standard deviation and the result of the domestic experiment were used to analyse the demographic data and answer the research questions. The findings revealed that the commonly consumed carbonated drinks in Kano State were soft and energy drinks with a mean score of 3.10, and the rate of consumption with a grand mean score of 3.34 indicated a high consumption rate. The findings from the experiment revealed that caffeine in the drinks caused withdrawal of calcium from the bone, leading to osteoporosis, rheumatism and arthritis. The study concluded that caffeine affects bone mineral density, making the bone susceptible to breakage. The study

recommended, among others, that female lecturers should endeavour to replace carbonated drinks with organic drinks from fruits and vegetables.

Keywords: Chemical, Carbonated drinks, Caffeine, Female Lecturers, Bone Health

Introduction

The act of eating and drinking is actually a culture of the human race, which gears towards satisfying one of the biological (biogenic) needs of human beings that must be met first in Maslow's hierarchy of needs. In this process, human beings are likely to come in contact with a lot of things that can endanger health in their daily interactions with fellow humans, prepared foods and drinks, and the micro-organisms in the environment in which they find themselves as consumers of both food and drinks. Among those things may be food contamination through micro-organisms on food that leads to toxin formation, and when consumed through food and drinks becomes dangerous to health. Human bodies can be made toxic through the types of things ingested as food, which pave the way for infectious diseases like typhoid fever, venereal diseases and the like. Subsequently, an increasing concern over indiscriminate consumption of toxic chemicals in diets has given rise to major increased incidences of diet-related non-communicable diseases due to excessive intake of some food nutrients like fats, sugars and salt, and addicted lifestyle over some foods. Many families in Nigeria are on the verge of experiencing a rise in these chronic diet-related diseases associated with indiscriminate carbonated drinks consumption; such diseases as hypertension, diabetes, cancers, ulcers, dementia, Alzheimer's disease, Parkinson's disease and others are linked to toxic chemicals consumed through carbonated drinks such as soft and energy drinks.

Chemicals are substances with defined composition; they are made of one or more elements and characteristic properties, existing in any state like solid, liquid or gas. They have characteristic properties such as odour or toxicity, and everything in the universe is made of chemicals, from the air we breathe to the objects around us in the environment. Chemicals range from naturally occurring, for example the capsaicin that makes peppers spicy is a natural chemical; to synthetic chemicals including those used in plastics, fibres and fertilizers (Londrigan, 2023); and to biological chemicals, with the human body itself as an example, which is made of and relies on the reaction of many chemicals to function, for example DNA

(deoxyribonucleic acid) and haemoglobin carrying essential functions. The term chemical is often used normally to refer to substances that are artificial or potentially harmful, and there are naturally occurring chemicals in the environment from gases in the air to the minerals in the soil. Many chemicals, whether artificial or natural, tend to be toxic.

Their toxic effect is determined by the chemical's nature, how much is absorbed and the body's ability to metabolise and eliminate it. These chemicals are encountered in everyday products like household cleaners and medicines, insecticides, cookwares and plastics, as well as industrial materials like solvents, for example nail varnish dissolvers, and heavy metals in some foods and drinks (Murillo, 2023).

Carbonated drinks are alternative drinks outside water that people take to quench thirst and regain strength when they are famished. They are sweetened non-alcoholic beverage drinks that contain sugars, artificial coloration, water, stabilizers, flavourings, preservatives and sometimes nuts and fruit mixtures. They are often called carbonated drinks because they are produced by incorporating dissolved carbon dioxide gas, which gives them the fizzy and bubbling sound as they are opened, and while the gas tries escaping it results in a fizzy sound showing readiness for consumption. Carbonated drinks come in varieties of colours and flavours depending on the type and brand. They can be bottled or canned, and can be soft or energy drinks, with different brand names such as soft drink, Pepsi Cola, Lacasera, Fanta, 7up, malt drinks, Fearless, energy drink, Monster, Celsius, Mountain Dew, Lucozade and the like. These drinks do not contain alcohol and so have no tendency of making the consumer tipsy (Pixels, 2025). People crave carbonated drinks preferably when they are chilled, and the drinks are deemed widely acceptable due to their non-alcoholic nature and are preferred mostly for picnics, get-togethers for friends, and parties such as weddings, cocktails, naming ceremonies and the like. Despite the popularity and the hydrating benefits of carbonated drinks to humans, they have their dark side on human health, which is as a result of containing some toxic chemicals in the form of caffeine and heavy metals like lead, mercury, cadmium, chromium, antimony and arsenic. These chemicals have deleterious effects like renal failure, heart problems, diabetes and others on major bodily organs, in such a manner that people hardly recover from these sicknesses (Constantino et al., 2023).

Health is a state of wellbeing in the body, mind and spirit, and is more than just the absence of disease. The World Health Organization (WHO, 2015) defined health as a condition whereby

wholesome physical agility, cognitive reasoning and social well-being are maintained. Physical health entails having bodily functions and processes working well, having strength and stamina to carry on with things one enjoys, taking care of oneself and having a lower rate of getting sick. Mental health (cognitive health) means being able to recognize one's capabilities of managing life's stresses, being productive at work and contributing positively to the community's welfare, while social health means interacting and relating meaningfully with the social environment, making use of personal resources to influence or cope with the environment. Health, diet and exercise habits contribute to healthy living, which is in accordance with Snell and Truswell (2025), who observed that certain types of diet can prevent and may decrease diseases, but diseases shoot up when there is deviation from principles of healthy living, which is a way of life involving making choices to promote a healthy body and mind, and is a function of a variety of factors a group of people can experience in their environment at large, which include material conditions as well as social, cultural, economic and environmental factors which, interacting positively between them, have an important role to play in determining how well a person looks. A healthy lifestyle can help minimize the risk of serious unhealthy conditions that lead to death, like hypertension, diabetes, chronic kidney disease and cardiovascular diseases, which occur due to unhealthy lifestyle such as eating habits, addicted habit to drinking of all manner of drinks, both soft, energy and alcoholic drinks, smoking of all manner of cigarettes and others; these culminate in unhealthy dietary habits and lifestyle (Crespo, Ortega, Graviles, De Guzman, Dionsio, Alfonso, Bernado and Medena, 2022). Dietary habits could be described as the habitual decision an individual or culture makes when making a choice of what food to eat. Dietary habits and these choices play an important role in the quality of life, health and longevity (Mbah, 2018). Many people, due to dietary habits and choices, decide to go on with empty calories in the form of carbonated drinks (soft and energy drinks) and flour products, which female lecturers in Kano tertiary institutions are among. From the researcher's interactions with some of these lecturers, it was discovered that some of them formed the habit of "must have a soft drink" to wash down their meals; some take it because of lack of time to prepare their mid-day food from home to school for lunch time; some take these drinks due to lack of knowledge on the nutritional implications attached to these drinks; while for others it is just mere laziness for food preparation, so they use it to pacify hunger during lunch time in the school.

Female lecturers are women who work as lecturers in tertiary institutions (university, college or polytechnic), meaning they are employed to deliver lectures and teach students in their area of expertise (specialization). Their role is to plan and deliver lessons, prepare teaching materials, lead seminars, assign coursework, grade assignments, and they may conduct research in their field and assess students' learning. Their status as females highlights the importance of gender representation in academia, aiming to achieve gender parity in teaching positions (Taylor and Tello, 2024). A female lecturer in a university refers to one who holds the academic position of a lecturer, meaning she teaches undergraduate courses at the university level, typically with a focus on research and knowledge dissemination within her field of expertise. They deliver lectures, guide students in their studies and may supervise postgraduate students. Academically, lecturer can sometimes be an entry-level position and can also hold higher academic ranks like senior lecturer, associate professor or professor, depending on their experience and research achievements. Female lecturers rely on consuming these drinks perhaps due to societal norms, taste preferences and lifestyle, and because marketing and advertising strategies also often depict these drinks as stylish and necessary for peak performance, influencing consumer attitudes. They take them during studying and free time alongside snacks to boost their strength to make more input in their work (Choudhury, Abdel and Galasko, 2018). The present research evaluated the chemicals in carbonated (soft and energy) drinks and the effect of caffeine consumed through them on female lecturers' bone health in Kano State.

Purpose of the Study

In our society today, there are a lot of health challenges, among which are non-communicable diseases which occur through unhealthy lifestyle and eating habits. These diseases lead to a high mortality rate among people. Such diseases as cardiovascular disease, diabetes, renal disease, hypertension, ulcers, cancers and the like are caused by unhealthy lifestyle of addiction to certain unhealthy diets such as consumption of carbonated drinks which have a lot of toxins in the form of heavy metals and caffeine. These toxins cause major health challenges in the human body. The main purpose of the study was to evaluate the chemicals in carbonated drinks and the effect of caffeine consumed through them on female lecturers' bone health in Kano State, Nigeria.

Specifically, the study:

1. identified the commonly consumed carbonated drinks by female lecturers in Kano;
2. determined the rate of consumption of carbonated drinks;
3. determined the mineral content of carbonated drinks (soft and energy drinks); and
4. determined the effect of caffeine consumed through them on female lecturers' bone health, using a rabbit for the experiment.

Research Questions

The following research questions were raised to guide the research study.

1. What are the commonly consumed carbonated drinks by female lecturers in Kano?
2. What is the rate of consumption of carbonated drinks among female lecturers in Kano State?
3. What is the mineral composition of carbonated drinks (soft and energy drinks)?
4. What is the effect of caffeine on female lecturers' bone health as determined through experiment with a rabbit?

Significance of the Study

Significantly, the research will be of importance to the lecturers, students, office workers and travellers who depend on carbonated drinks and snacks as sources of energy during work hours, lecture time and while in transit, to shift from these drinks to natural sources for their drinks. It will also be of benefit to homemakers, meal and event planners, as they learn to prepare and serve natural drinks from fruits, vegetables and nuts alongside the meals at events and occasions as healthy alternatives to carbonated drinks. Having learnt the implications of these drinks, Home Economics departments of every tertiary institution should open eating outlets, like canteens and cafeterias, where healthy foods and drinks are served, to bridge the gap of time constraint at work by female lecturers and to minimize many terminal diseases that attack people, especially female lecturers that depend on snacking and drinking of fizzy drinks. The study will also be of help to health workers, doctors, dieticians and nurses in guiding and advising patients properly on what to eat or avoid in improving their health status. The findings will be of benefit to Home Economics extension workers that visit rural communities to teach them about health implications of carbonated drinks. From this study, government agencies like NAFDAC, NDLEA, FAO and others will make it mandatory to inspect what is pushed into the market for consumption and ensure these producers do not

exceed the permitted limit of toxins in these drinks, for consumers to live healthily. This study will benefit future researchers who specialize in food and nutrition and related fields, as it relates to development of new recipes for foods and drinks using local fruits and vegetables available in their homes and roadsides instead of relying on fizzy drinks, for enhancing good health.

Materials and Method

Design of the Study

The study adopted survey and experimental design. The survey research design was used to determine the commonly consumed carbonated drinks and the rate of consumption among female lecturers in Kano State, while the experimental design was used to determine the mineral content of carbonated drinks and the effect of caffeine as one of the toxic chemicals on the bone health of female lecturers who consume these drinks, using a rabbit for the experiment.

Area of the Study

The domestic experiment on the effect of caffeine content in the form of toxins consumed in carbonated drinks (soft and energy drinks), with reference to soft drink and energy drink, was carried out at the home residence of the researcher in Sabon Gari in Fagge Local Government Area of Kano State, Nigeria. Kano is one of the 36 states of Nigeria, located in the northern region of the country. According to the national census done in 2006, Kano State was the most populous state in Nigeria. The recent official estimate taken in 2016 by the National Bureau of Statistics found that Kano State is still the largest state by population in Nigeria. The state was created in 1967 out of the northern region, and it borders Katsina State to the north-west for about 210 km (130 miles), Jigawa State to the north-east for 355 km (221 miles), Bauchi State to the south-east for 131 km (82 miles) and Kaduna State to the south-west for 255 km (150 miles). Kano State is an arid region, meaning it has a very dry climate with less than 25 cm or 10 inches of rainfall annually, which begins late in the month of May and lasts for four months, ending by September. Notwithstanding the climatic condition, Kano people are mostly farmers due to their enormous farmland. They use the irrigation method for farming, which makes their farm produce continuous all year round; this is done partly for the irrigation process and terminates as soon as rainfall comes. The second part begins soon after the irrigation harvest is over, that is, by the arrival of rainfall by the end of May. Due to their farm

produce, especially groundnut, the State is credited with the name “Groundnut Pyramid City” in addition to other farm produce. Kano is a mixed population of Hausas and Fulanis, with their languages as Hausa and Fulfulde respectively. As farmers, the Fulanis specialize in cattle rearing while the Hausas cultivate farmland for farm produce. Two-thirds of the population engage in farming occupation while one-third are marketers, artisans and teachers, where the female lecturers in tertiary institutions in Kano State belong (National Bureau of Statistics, 2016).

Population for the Study

The population for the study comprised all the female lecturers in five selected tertiary institutions in Kano. A total of 2,281 female lecturers formed the target population, which comprised female lecturers in the following institutions: Yusuf Maitama Sule Federal University of Education Kano, Bayero University Kano, Kumbotso State University Kano, Kano State Polytechnic Kano, and Federal College of Education Kano.

Table 1: Population and Sample Size for the Study

S/N	Female lecturers in various institutions	Population	Sample
1.	Federal University of Education Kano	600	89
2.	Bayero University Kano	485	73
3.	Kumbotso University Kano	472	70
4.	Kano State Polytechnic Kano	390	58
5.	Federal College of Education Kano	334	50
	Total	2,281	340

Source: Statistical Record of Academic Staff in Five Tertiary Institutions in Kano, 2020–2024.

Sample Size and Sampling Procedures

The sample size for this study comprised 340 female lecturers from the five (5) selected tertiary institutions. The sample size was determined using the Taro Yamane statistical formula for a finite population. Proportionate stratified random sampling was also employed to determine the number of female lecturers that were selected from each of the sampled institutions; each sample stratum has the same sampled fraction. The j^{th} sample size is given as:

$$n^j = (k \times n) / N$$

Where:

n^j = size of the j^{th} stratum

k = population size in the stratum

N = entire population

n = sample size

Instrument for Data Collection

A well-structured and designed questionnaire by the researcher was used to collect data from female lecturers in tertiary institutions in Kano State. The questionnaire was titled “Chemical Evaluation of Carbonated Drinks and Effect of Caffeine Consumed Through Them on Female Lecturers' Bone Health in Kano State, Nigeria”. The questionnaire was structured and designed focusing on the purpose and research questions of the study. The questionnaire has two parts, namely Part A, which focused on the bio-data of the respondents and contained three items that include status, educational qualification and years of working experience of the respondents. Part B had 50 item statements divided into four (4) sections, designed to assess the respondents' opinion on chemical evaluation of carbonated drinks and the effect of caffeine consumed through them on female lecturers' bone health in Kano State. Section A focused on commonly consumed carbonated drinks in Kano State. Section B sought the respondents' opinion on the rate of consumption of carbonated drinks in Kano State. Section C focused on the determination of mineral content of carbonated drinks in the form of toxins, while Section D dealt with the effect of caffeine on female lecturers' bone health discovered through domestic experiment with a rabbit. The questionnaire items were further divided into two parts, A and B. Part A contained questions only meant for female lecturers, while Part B contained questions on mineral composition and the effect, meant for doctors and laboratory experts to answer. The Likert rating scale of five points with responses of Strongly Agree (SA), Agree (A), Undecided (U), Disagree (D) and Strongly Disagree (SD) and their numerical values of 5, 4, 3, 2 and 1 respectively was used. The female lecturers were requested to indicate their opinion by ticking (✓) in the appropriate boxes, the responses that suit the items. The questionnaire was used because it eliminates the tabulation problems of classification, interpretation and summary. The instrument was validated by two professors in the Home Economics department of Michael Okpara University of Agriculture Umudike, Abia State, an educational statistician in the same university, and a professor in educational research in Yusuf Maitama Sule Federal University of Education, Kano State. The suggestions of these experts were incorporated in the final draft of the questionnaire before it was used for data collection.

Source of Raw Materials

The rabbit was bought from the Gwale Veterinary Hospital in Gwale Local Government Area to ascertain the reliability of the experimental rabbit, while the carbonated drinks (soft drink and energy drink) were purchased from a fizzy drinks shop near the researcher's residence at Sabon Gari in Fagge Local Government Area, Kano, and the improvised empty bama bottles were obtained from the researcher's home in Sabon Gari, Kano.

Procedure for Data Collection

There were two procedures for data collection in this research; they include data collection through survey and data collection through experiment.

Data Collection through Survey

On approval of the research proposal, the researcher obtained a letter of introduction from the Department of Home Economics, College of Applied Food Science and Tourism (CAFST), Michael Okpara University of Agriculture Umudike (MOUAAU), Abia State, to request permission from the various tertiary institutions selected, to administer the questionnaire for the study to the female lecturers in those institutions. The researcher reached a consensus with those institutions on when to visit them for the administration of the questionnaire in order to collect data. Having been granted consent, the researcher requested four research assistants from four of the five institutions to help in administering the instruments in their institutions, while the researcher handled the remaining one. The researcher explained the content of the questionnaire to the assistants before allowing them to administer it to the targeted respondents, who were the female lecturers. The questionnaires were then administered by the researcher and the four research assistants to the female lecturers of the selected tertiary institutions in Kano State. These respondents were allowed one week to fill the questionnaire before collection.

Data Collection through Experiment

A domestic experimental procedure was carried out for this experiment; this means that the experiment was conducted at home by the researcher. The experiment was carried out using bones of a slaughtered rabbit and the carbonated drinks (soft drink and energy drink), in order to determine the effect of caffeine on female lecturers' bone health. This experiment ran for a period of three months, starting from 12/7/25 to 12/10/25. The specimen and equipment

required for this experiment include bone matrix of the rabbit, soft drink and energy drink, improvised clean empty bama bottles with cover, tweezers, petri dish and spatula, sodium hydroxide solution, calcium chloride solution for control, test tubes and stands, and distilled water. In this experiment, two samples of rabbit's bone matrix from a slaughtered rabbit were submerged into 25 ml of soft drink and energy drink respectively, and observations were made after every month (four weeks) for three months (12 weeks).

From these experiments it is inferred that abnormal calcium deposits formed on the soft tissues, like the brisket bones found at the knee and joint regions, actually make these areas hard and difficult to move freely in humans; this is also known as decalcification, which occurs as a result of calcium withdrawal from the bone matrix responsible for the bone density and deposited on the bone's soft tissue (the cartilage).

Table 2: Domestic Experiment Result on Caffeine Effect on Bones of Rabbits from 12/7/25 to 12/10/25

Drinks	Initial colour of the drinks	Texture of the bones in the drinks	Smell of drinks	Final colour and texture of the drink
Soft Drink				
1st Observation	Chocolate brown	Soft like mattress foam	Fermented cassava tuber smell	Light brown and watery colour
2nd Observation	Light brown	Soft like mattress foam	Fermented cassava tuber smell	Dirty creamy and watery colour
3rd Observation	Dirty cream colour	Soft like mattress foam, and whitish sediments at bottom of container	Fermented cassava tuber smell	Dirty creamy and watery colour
Energy Drink				
1st Observation	Transparent amber colour	Soft like mattress foam	Paracetamol smell	Slippery and gummy amber colour
2nd Observation	Cloudy and gummy amber colour	Soft like mattress foam	Alcoholic smell	Slippery and gummy amber colour
3rd Observation	Slippery amber colour	Soft like mattress foam	Intense alcoholic smell	Slippery amber colour
Control (Water)				
1st, 2nd and 3rd Observations	Observations made for 3 months on bone submerged in water had no change; that means water did not affect the bone in texture, that is, the bone remained strong as it was from the start. The colour of the water did not change, only that the water showed a decaying smell and a thin oil coating on the surface.			

Source: Researcher's domestic experimental records from 12/7/2025 to 12/10/2025.

Procedures for Data Analysis

There were two procedures for data analysis. The first procedure concerned the survey method. The data collected through the questionnaire were collated and analysed using descriptive and inferential statistics. Frequency counts and simple percentage as descriptive statistics were used to analyse the demographic (bio-data) of the female lecturers, while mean was used to answer research questions one and two, and mean and standard deviation were used to answer research questions three and four. Mean was used in order to determine the respondents' level of opinion through agreement or disagreement about carbonated drinks consumption effects among female lecturers in tertiary institutions in Kano State. However, in this study, when the mean score of an item is greater than 3.00, the item was regarded as agreed by the majority of the respondents (female lecturers), and vice versa: as the mean score becomes less than 3.00, the item was regarded as disagreed.

The second procedure for data analysis involved experimentation, using rabbit bone for the domestic experiment, and the results of the observations made were used to answer research question four, while question three was answered from the mineral composition table.

Bio-Data of Respondents

Table 3: Distribution of the Respondents by Status in Five Selected Tertiary Institutions in Kano State, Nigeria

Status	Frequency	Percentage
(1) Early Career Academic Staff	105	36.84
(2) Mid-Career Academic Staff	115	40.35
(3) Professorial Academic Staff	65	22.81
Total	285	100.00

Table 3 shows the distribution of the respondents by status as categorized in five selected tertiary institutions in Kano State, Nigeria. It indicates that 105 respondents, representing 36.84%, were Early Career Academic Staff, and 115 respondents, representing 40.35%, were Mid-Career Academic Staff, while 65 respondents, representing 22.81%, were Professorial Academic Staff. This clearly indicates that all the respondents were academic staff in Kano State tertiary institutions.

Table 4: Distribution of the Respondents by Highest Academic Qualification

Qualification	Frequency	Percentage
Ph.D	65	22.81

Qualification	Frequency	Percentage
M.Ed/M.Sc/M.Tech	115	40.35
B.Ed/B.Sc/B.Tech	105	36.84
Total	285	100.00

Table 4 shows the distribution of respondents by highest academic qualification. From the table, it implies that 65 respondents, representing 22.81% of the total respondents, have a PhD; 115 respondents, representing 40.35%, were M.Ed/M.Sc/M.Tech holders; while 105 respondents, representing 36.84%, were B.Ed/B.Sc/B.Tech holders. This vividly indicated that all the respondents were qualified enough to give accurate responses needed for the study.

Table 5: Distribution of the Respondents by Years of Working Experience

Year	Frequency	Percentage (%)
1 – 10	70	24.56
11 – 20	76	26.66
21 – 30	74	25.96
31 and above	65	22.82
Total	285	100.00

Table 5 shows the distribution of respondents by years of working experience. It showed that those respondents with 11–20 years were 76, representing 26.66%. Those with 21–30 years of working experience were 74 respondents, representing 25.96%. Those with 1–10 years of working experience were 70, representing 24.56%. Respondents with 31 years and above working experience were 65, representing 22.82%. From the distribution, there was a reasonable classification of ranks of female lecturers; this revealed that with maximum working experience the respondents are capable and knowledgeable enough to give the desired response in the items provided by the questionnaire for analysis and generalization of inferences.

Findings of the Study

The research question one on the opinion of the respondents on commonly consumed carbonated drinks was answered based on nine (9) items raised that contain close-ended item statements which relate to the variable identified in the purpose of the study, as shown below. The responses were rated in frequencies, percentages and means in Table 6.

Answering Research Question One: What are the commonly consumed carbonated drinks among female lecturers in selected tertiary institutions in Kano State, Nigeria?

Table 6: Opinion of the Respondents on Commonly Consumed Carbonated Drinks in Selected Tertiary Institutions in Kano State

		SA		A		U		D		SD		Mean
S/N	Item Statements	F	%	F	%	F	%	F	%	F	%	
1	The commonly consumed carbonated drinks by female lecturers in selected tertiary institutions in Kano include Fanta, soft drink, Pepsi Cola, 7up, Sprite, Lacasera, Fearless, Predator, energy drink, Monster, Amstel Malt, Dubic Malt, Maltina and Malta Guinness, and others.	170	60	100	35.08	5	1.75	5	1.75	5	1.75	3.20
2	The soft drinks among the carbonated drinks are Fanta, soft drink, 7up, Pepsi Cola, Lemon-lime, Sprite, Amstel Malta, Maltina, Malta Guinness and others.	110	38.6	75	26.31	35	12.28	35	12.28	30	10.52	3.60
3	The energy drinks among carbonated drinks are Fearless, Predator, energy drink, Monster, Rock-ster and others.	100	35.08	90	31.58	20	7.01	25	8.77	50	17.54	3.40
4	The soft drinks are preferred over energy drinks in Kano State.	105	36.84	105	36.84	35	12.28	25	8.77	15	5.26	3.60
5	The energy drinks are consumed most by female lecturers in Kano State.	15	5.26	40	14.04	85	29.82	125	36.84	20	7.01	2.60
6	The soft drinks that female lecturers consume most in Kano State are soft drink, 7up, Fanta and Pepsi Cola.	95	33.33	150	52.63	20	7.01	55	19.29	50	17.54	3.20
7	The energy drinks that female lecturers prefer more in Kano State are Fearless, Predator and energy drink.	20	7.01	60	21.05	75	26.31	100	35.08	30	10.52	2.80
8	Female lecturers consume soft drink because of its taste, flavour and colour.	60	21.05	115	40.35	40	14.04	55	19.29	15	5.26	3.00
9	Other commonly consumed carbonated drinks by female lecturers are dry gin, star beer, Heineken, Gulder, stout, champagne and others.	0	0	0	0	25	8.77	100	35.08	160	56.14	2.50
	Grand Mean											3.10

With the mean of 3.20 in item 1 and a grand mean of 3.10 in Table 6, it indicated that the commonly consumed carbonated drinks by female lecturers in Kano tertiary institutions were soft and energy drinks, because any score on the Likert scale above 3.00, which is the decision rule, indicated that the item is common.

Research Question Two: What is the rate of consumption of carbonated drinks among female lecturers in Kano State?

The respondents' opinion on the rate of consumption of carbonated drinks among female lecturers in selected tertiary institutions in Kano was the answer to this question, and was presented in Table 7. In order to establish the respondents' opinions on this research question, twelve (12) items were scored in frequencies, percentages and mean as shown in Table 7 below.

Table 7: Respondents' Opinion on the Rate of Consumption of Carbonated Drinks among Female Lecturers in Selected Tertiary Institutions in Kano State, Nigeria

S/N	Statements	SA		A		U		D		SD		Mean
		F	%	F	%	F	%	F	%	F	%	
1	Female lecturers consume carbonated drinks frequently because it has become part of their lifestyle.	85	29.82	105	36.84	20	7.02	45	15.79	30	10.53	3.20
2	Female lecturers consume soft drinks always to pacify hunger when they are in school.	85	29.82	125	43.9	15	5.26	25	8.77	35	12.28	3.20
3	Female lecturers prefer snacking and drinking of soft drinks to cooked meals from home.	105	36.84	100	35.08	30	10.53	25	8.77	25	8.77	3.50
4	Female lecturers resort to soft and energy drinks consumption due to time constraint.	75	26.31	90	31.58	30	10.53	65	22.81	25	8.77	3.60
5	Female lecturers can stay healthy as they stop consuming soft drink and energy drink.	100	35.08	120	42.11	14	4.91	22	7.72	29	10.18	3.00
6	Frequent consumption of soft drink and energy drink gets someone addicted to those drinks.	110	38.6	80	28.07	28	9.82	35	12.28	32	11.22	3.40
7	The rate at which female lecturers consume soft and energy drinks ranges from 5–10 bottles/cans per week.	80	28.07	105	36.84	40	14.04	40	14.04	20	7.02	3.60
8	The rate at which female lecturers consume soft and energy drinks ranges from 1–4 bottles/cans per week.	60	21.05	110	38.6	30	10.53	39	13.68	46	16.14	3.00
9	Long-term consumption of carbonated drinks causes obesity and tooth decay.	130	45.6	90	31.6	15	5.26	27	9.47	23	8.07	3.80
10	Female lecturers consume carbonated drinks always to keep them alert and boost their energy while working.	85	29.82	100	35.08	20	7.02	30	10.53	50	17.54	3.60
11	Health challenges occur as a result of the indiscriminate consumption of carbonated drinks by female lecturers.	85	29.82	90	31.58	20	7.02	36	12.63	54	18.95	3.20
12	The attitude of frequent consumption of carbonated drinks depicts a lifestyle of addiction.	70	24.56	135	47.37	36	12.63	24	8.42	20	7.02	3.00
	Grand Mean Score											3.34

From Table 7, the rate of consumption was high with a grand mean of 3.34, higher than the decision rule of 3.00 on the Likert scale.

Research Question Three: What is the mineral composition of carbonated drinks (soft drink and energy drink)?

Table 8: Means and Standard Deviation Values of Mineral Composition of Carbonated Drinks (Soft Drink and Energy Drink) in the Form of Toxins

Samples	Lead mg/100g	Mercury mg/100g	Chromium mg/100g	Arsenic mg/100g	Cadmium mg/100g
A	0.014 ± 0.00 ^a	ND	0.02 ± 0.00 ^a	0.09 ± 0.00 ^a	0.02 ± 0.00 ^b
B	0.09 ± 0.02 ^b	ND	0.02 ± 0.00 ^b	0.08 ± 0.03 ^b	0.02 ± 0.00 ^a

Means of duplicate determination. Mean values within a column with different superscripts are significantly different ($p < 0.05$).

Key: A = 100 g soft drink; B = 100 g energy drink; ND = not detected.

Table 8 shows the mineral composition of two samples, A and B (soft drink and energy drink). The mg/100 g samples of lead content in A and B ranged from 0.014 to 0.09. The lead content of sample B is higher than the lead content of sample A, with a difference of 0.076 mg. The difference of 0.076 mg lead content shows a significant difference in the lead content. Mercury was not detected in both samples; that is the reason for the abbreviation ND, meaning not detected.

The chromium mg/100 g content of the composition ranged from 0.02 to 0.02 in both samples. The chromium content of sample A equals the chromium content of sample B, so no significant difference was noticed. The arsenic mg/100 g content of both sample A and B ranged from 0.08 to 0.09 mg. Sample A, with a higher content of arsenic, shows a difference of 0.01 mg/100 g; therefore a significant difference exists between the two samples. The cadmium mg/100 g content of samples A and B are within the same range. The content of sample A equals the content of sample B; therefore there is no significant difference in both samples. In conclusion, the mineral composition of soft drink and energy drink shows that there are toxins in the soft and energy drinks.

Research Question Four: What is the effect of caffeine on female lecturers' bone health as determined through experiment with a rabbit?

The answer to research question four was provided through the domestic experimental results in Table 2.

Discussion of Findings

Based on the respondents' opinion on research question one on the commonly consumed carbonated drinks by female lecturers in Kano State, the findings of the study revealed that soft drink, 7up, Sprite, Pepsi Cola, Lacasera, Fearless, Monster, energy drink, Amstel Malta, Dubic Malt, Maltina and Malta Guinness were the major ones commonly consumed, apart from others. This finding is in line with the findings of Al-Saikhan (2020) and Gunja and Brown (2017) that the new millennium allowed a wave of highly caffeinated energy drinks, such as energy drinks and soft drinks, e.g. Fanta, soft drink and malt drinks, targeted at youths, but popularly consumed as non-alcoholic beverages by workers, students and even female lecturers in tertiary institutions in Kano State. Al-Saikhan (2020) also agreed that these carbonated drinks are the second most common dietary supplement used by young people, especially university students and even lecturers, due to their capacity for hydrating effect and energy exertion after a hard day's work, of which 30% of each of these groups consume carbonated drinks on a daily basis. The possible explanation of this finding is that soft and energy carbonated drinks are consumed in Kano State among female lecturers in tertiary institutions.

Based on the respondents' opinion on research question two on the rate of consumption of carbonated drinks among female lecturers in selected tertiary institutions in Kano, the finding revealed that consuming carbonated drinks up to 10 cans/bottles per week is actually on the high side. With a grand mean consumption rate of 3.34, it indicated very high consumption among female lecturers in selected tertiary institutions in Kano. This finding is supported by the findings of Murillo (2023) that consuming far too much and too many carbonated drinks over time, in the guise of making more input into performance in their work by office workers, public transport drivers, students and lecturers, poses a high health risk, e.g. chronic heart disease, due to the drinks' high level of sugar and stimulants, thus showing a high rate of consumption. The findings of Constantino et al. (2023) also revealed that a 70% escalation of caffeine consumption in energy drinks ignorantly among youths on a daily basis indicated a high consumption of carbonated drinks, which is in agreement with the present research's findings about female lecturers.

The mineral composition of carbonated drinks (soft drink and energy drink) is in the form of toxins, e.g. heavy metals and caffeine. Minerals are essential inorganic substances that need to be obtained from food. They are important for proper functioning of organs and wellness of the body, and are also the electrolytes required for hydration and blood pH regulation (Okafor

and Usman, 2015). Minerals are grouped into important and non-important minerals; furthermore, the important minerals are divided into macrominerals such as Na, Ca, Mg and K, that are needed in large amounts (>100 mg/day). Microminerals are needed in smaller amounts for the functioning of the body also, and they include Fe, Zn, I, Se, Cr, F, Mo and Co. Non-important minerals (metals) are heavy metals such as lead, mercury, cadmium, chromium, arsenic and antimony. These minerals have no meaningful value to the human body except incurring damage, and they are found in the environment through which they contaminate food such as carbonated drinks, regarded as food, but unfortunately the permitted limits allowed during manufacture are always exceeded, thereby causing damage to the body's organs; even at the lowest limit these metals still have an effect on the body's organs (Engwa et al., 2015). The findings from the mineral composition table showed that only mercury was not detected in both soft drink and energy drink, but all others were present. This means that as these drinks are consumed by people, particularly female lecturers, they ignorantly consume these metals, which end up damaging their organs as discovered in the experiments using the rabbits. The finding is in line with Yi et al. (2016), who discovered that caffeine interferes with bone repair and decreases bone mass, causing increased risk of bone loss and fractures. On the other hand, heavy metals in these drinks also affect organs like the bone, the kidney, liver, muscles and the hair, as discovered from the histological results of the experiments carried out by Rasheed et al. (2021), Abonar et al. (2021) and Haroun et al. (2020).

Conclusion

From the results of the domestic experiments with soft drink and energy drink, it is indicated that caffeine affects the bone mineral density, causing fragility of the bone leading to arthritis, rheumatism and osteoporosis among female lecturers who consume carbonated drinks in Kano State, Nigeria.

Recommendations

Since the experiments revealed that there was severe calcium loss, shown as the dissolved whitish sediments in the containers of soft drink and energy drink and the whitish deposits on the bone submerged in soft drink, indicating that calcium was withdrawn from the bones, which leads to bone thinning and breakage, the researcher therefore suggests that:

1. Female lecturers should put a stop to carbonated drinks because they are an unhealthy diet. They should replace carbonated drinks with fruit and vegetable drinks, and should develop the habit of preparing foods and drinks from home for their lunch time at school.
2. Home Economics departments in Kano State tertiary institutions should endeavour to open eatery outlets to help these lecturers when they are hungry. Moreover, each institution must have canteens, cafeterias and bukaterias for people to help themselves when they are hungry.
3. Fresh fruit shops should be installed on the school premises for healthy options among lecturers.

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