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Effects of Forced Ripening on the Nutritional Value and Safety of Consumable Banana

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ABSTRACT: This article investigated the effects of forced ripening using calcium carbide (CaC_2) on the nutritional value and safety of banana. The objective of the investigation was to determine the risk portrayed with the application of artificial agents for ripening banana fruits because the use of chemical as fruit ripening agents is now common among fruit vendors in Port Harcourt. Banana fruits were subjected to natural and artificial ripening using 20g/kg and 40g/kg CaC_2. The ripened fruits were subjected to nutritional and heavy metal analysis using standard methods. The fruits subjected to natural ripening, using 20g of CaC_2 and 40g of CaC_2 took 8 days, 3 days and 2 days respectively to complete the ripening process. The corresponding shelf lives were 10 days, 4 days and 3 days for naturally ripened banana, 20g of CaC_2 and 40g of CaC_2 ripened banana samples respectively. The naturally ripen banana showed the following characteristics: unattractive light yellow peel colour with black spots and blackish yellow stalk colour. The enhanced ripen banana had smooth uniform (lemon yellow) peels color without spot while the stalk remained green. The result of the nutritional analysis showed the following: moisture content (52.19% in natural to 63.87% in aided ripening), ash content (1.66% in natural to 4.73% in forced ripening), fat content (0.55% in natural to 0.29% in induced ripening), protein content (5.33% in natural to 2.81% in enhanced ripening), fibre content (0.53% in natural to 0.11% in supported ripening) as well as carbohydrates content (39.74% in natural to 28.19% in enhanced ripening). The results of the heavy metals analysis showed Arsenic in CaC_2 ripened samples as 0.037 – 0.083ppm and Phosphorous as 89.479 – 141.603ppm. The findings indicate that ripening of Banana fruits with CaC_2 reduces fruit quality and releases toxic elements into the fruit which poses health hazards to consumers.

KEY WORDS: Calcium carbide, banana fruit, ripening, nutritional value, arsenic, phosphorous.

I.INTRODUCTION

Food safety is the ability of food not to cause harm to the consumer thereby fulfilling the purpose of eating. Ensuring healthy, safety and availability of food is a key performance indicator for determining food security. Food security and safety is a critical challenge globally especially in developing countries owing to the activities of crafty business men, absence or inefficient food and drug regulators. Fruit vendors and farmers are using different unauthorized substances in virtually all food stages: planting, processing and storage (Mursalat et al., 2012). In Nigeria, some of the food products are unfit for intake because of adulteration (Mba, 2018).

Banana fruit (musa esculentus) is a major fruits grown and consumed virtually all over the globe because of its nutritional values (Willett, 1994). This fruit is widely noted as a source of balanced nutrients because of the various mineral salts contents and high quantity of carbohydrate along high vitamin A and C content (Hong et al., 1996; Dragović-Uzelac et al., 2009). Banana possess the following health benefits; reduction of danger of high blood pressure, stroke risk, cholesterol lowering effect, kidney health support and ability to remedy heart burn as well as healthy teeth and bone potentials (Kumar, et al., 2012). Banana is exists in different sizes and colours with prolonged and bent shape. Banana is the only fruit that contains all needed vitamins and minerals and the world's best seedless fruit available all part of the world (Picq et al., 1998). Ripened banana fruit is consumed raw and is common in Sub-Sahara Africa and Asia(Adeniji et al., 2007).

Banana consumption cuts across every age and it supplies essential calories and micronutrients. Once harvested, it must first pass through artificial or natural ripening process before for consumption. Ripening is a biochemical process that involves a series of physiological changes in colour, aroma, flavor and texture. Ripening involves transformation of chemical composition (eg conversion of starch to sugar) resulting in changes in physical appearance. This process makes

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the fruit to become edible, attractive and sweeter for consumption. Ripening of fruits can be carried out naturally or artificially. During ripening, the fruits skin colour changes from green to yellow which attract birds, animals and man.
Banana fruit is characterized with short shelf life (highly perishable) which results in high post-harvest losses of between 20-50%. Quality deterioration accounts for most of this losses (Ajayi and Mbah, 2007; Zewter et al., 2012). Singal et al., (2012) noted that bananas are harvested while green to minimize the post-harvest spoilage rate because of the high moisture contents and thereafter ripened when needed. Synthetic substances are usually employed to quicken the ripening process. These substances include CaC_2 ethylene glycol, ethylene gas etc. Others include African bush mango leaves, Palm leaves, Yellow Pawpaw leaves, torch light battery, potash and ash (Ajayi and Mbah, 2007). According to Singal et al., (2012), the commercial practice is to use these ripening agents to artificially ripen the fruits at the destination market before retailing. The high cost of ethylene gas (a natural ripening agent) production often leads to use of available, cheap but hazardous substances like calcium carbide to ripen banana fruits in large quantity (Singal et al., 2012; Ajayi and Mbah, 2007).
The original application of CaC_2 is for welding but now finds another application in enhancing fruits ripening like banana in most regions in Nigeria. The dissolution of CaC_2, in water evolves acetylene that speeds up fruit ripening rate (Fattah and Ali, 2010**).** Generally, fruits ripened with CaC_2 are softer, with fresh peel but poor in flavor/quality. CaC_2 are used for ripening other fruits common in Africa because of its low cost. The hazards with the use of CaC_2 for edible fruits can be traced to the presence of arsenic and phosphorous (Siddiqui and Dhua, 2010). CaC_2 based acetylene gas affects the neurological system by inducing prolonged hypnoxia which gradually leads to headache, memory loss, mental confusion, mood disturbance, sleepiness and seizures. The toxicity of fruits ripened with CaC_2 is widely reported (Singal et al., 2012; Orisakwe et al., 2012; Hakim et al., 2012) The absence, inadequacy and non-implementation of legislative control also contributes to the application of uncertified ripening enhancers is causing a lot of deaths through food poisoning, due to internal organ malfunction, weakening and subsequent destruction. This present study is therefore carried out to determine the effects of enhanced ripening of banana with calcium carbide.

A.Materials and methodology

The main materials for this study is unripe but matured bunch of banana and CaC_2.

B.Sample Collection

Freshly harvested bunch of green but mature unripe banana was purchased from Choba market in Port Harcourt, Nigeria. The CaC_2 used as ripening agents was purchased from a reliable chemical dealer in Port Harcourt, Nigeria.

C.Sample preparation

The banana bunch was cut and separated into three (3) groups of six (6) banana fingers of approximately the same size. These samples were washed with clean water, dried, weighed and kept in clean polyethylene bags. The CaC_2 was weighed using a weighing balance (Mettler AE 166 model) according to the desired specifications (0.00, 20 g/kg and 40 g/kg CaC_2) and then wrapped in a paper with labels on each and kept at the bottom of a plastic container.

D.Ripening technique

Ripening was induced in the two groups using locally available commercial procedures. There were three set ups of transparent plastic containers containing 1kg of banana samples. The two levels of the CaC2 groups (20g and 40g) were then dropped each at the bottom of two of the container set ups with the third set up containing no CaC_2. The fruit samples and the CaC_2 in the containers were then moistened by sprinkling 5ml of water to release the gases necessary to effect ripening. All the containers were properly closed and placed at least 3 metres from each other in the same room (same condition of temperature, pressure and sunlight or illumination).
There were three containers containing 0.00 (NRB - naturally ripened bananas), 20g/kg (ARB20 - artificially ripened bananas with 20g of CaC_2) and 40g/kg (ARB40 - artificially ripened bananas with 40g of CaC_2) of CaC_2 per kg of the fruit samples respectively. The third group without CaC_2 was ripened naturally and served as the control.
The possible major side reactions of CaC_2 impurities that could release toxic gases into the fruit samples during ripening are presented in Equations 1 and 2 below:

$$Ca_3P_{2(s)} + 6H_2O_{(l)} \rightarrow 3Ca(OH)_{2(s)} + 2PH_{3(g)} \quad (1)$$

$$Ca_3As_{2(s)} + 6H_2O_{(l)} \rightarrow 3Ca(OH)_{2(s)} + 2AsH_{3(g)} \quad (2)$$

E.Determination of physiological properties

Sensory methods (or observations) were used to assess the observable differences that occurred between the natural ripening process and the CaC_2 induced ripening process. Changes observed on daily intervals were recorded. Ripeness was determined by softness and yellow coloration of peel. Physical characteristics: color (peel and stalk), flavor, rate (ripening time and shelf life) were observed and recorded.

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F.Determination of the Ripening time and shelf life

The fruit ripening time was measured as the time it took the whole fruit (banana) samples to change colour from green to yellow according to Sobukola et al., (2010), while the shelf life was determined as the period (usually in days) after ripening and commencement of spoilage (appearance of shrinkage, wrinkles and discolouration).

G.Sample processing and pretreatment

The samples were peeled and the fleshy part of the fruit (endocarp) was chopped with stainless steel blade to make nearly uniform size. This was to facilitate analysis of the pieces at the same rate. The thoroughly shredded and homogenized banana samples paste were split for the purpose of moisture determination and the other part was dried in oven at 105°c for proximate and elemental determination. The dried samples were labeled according to their groups and kept at moderate temperature in an airtight container for analysis in the laboratory. The naturally ripened sample served as the control to monitor possible nutritional changes during ripening.

H.Determination of moisture content

The banana samples inherent water content was determined in line with AOAC (2005) procedure: A clear, dried aluminum dish was weighed (W_1) then 5g of the thoroughly shredded and homogenized banana sample paste was weighed into the dish (W_2). The dish and its contents was shaken for uniform distribution of sample then in oven at controlled temperature of 100°c for 2hours then, removed to a desiccator followed by cooling. The weight of this dish was noted as W_3.

The percentage moisture content was computed as follows;

$$moisture = \frac{W2-W3}{W2-W1} \times 100 \qquad (3)$$

Where, W_1= initial weight of empty aluminum dish, W_2= weight of aluminum dish + sample before drying and W_3= final weight of dish + sample after drying

I.Ash content Procedure

The measuring of the ash contents of the banana fruit samples were carried out in line with AOAC (2005) specification. A crucible previously washed and dried 120 minutes at about 100°C was cooled in a desiccator before weighing (W_1). The combined weight of 5.0 g of the banana sample and empty crucible was noted as W_2. The contents of the crucible was then ashed in furnace operating at 600°C for 120 minutes thereafter the crucible was removed, cool in a desiccator and reweighed (W_3).

Total ash was computed as follows:

$$\%\, Ash = \frac{W3-W1}{W2-W1} \times 100 \qquad (4)$$

Where, W_1= weight of empty crucible, W_2= weight of crucible + sample before ashing and W_3= weight of crucible + sample after ashing.

J.Determination of fat content

Filter paper was used to line the inside of a thimble shaped equipment, weighed and weight was then zeroed. The thimble containing 2g of each of the samples was places into a holder then 250cm^3 of petroleum ether was added with the aid of funnel. Extraction was carried out using warm solvent dripping into the contents of the thimble for about 4 hours on a high setting. The extract (ether plus the fat extract) were transferred into a clean beaker, weighed and labelled W_1. The beaker containing the extract and ether were heated in an oven operating at 70°C for half an hour, removed and cooled. The weight of the beaker and the fat content was re-measured as W_2

The percentage crude fat was estimated using Equation 5 below:

$$\%fat = \frac{W2-W1}{weight\ of\ sample} \times 100 \qquad (5)$$

Where, W_1= weight of beaker, W_2= weight of beaker (g) + fat extract (g)

K.Protein determination

0.2g of sample and 15cm^3 of H_2SO4 acid were placed in a digestion tube then tube was swirled gently for about 5 minutes until the contents of the tube became homogenous. Thereafter, 5.0 g of Kjeldahl catalyst mixture was added then the solution was subjected to continuous heating until it became clear. The temperature was then increased and the solution allowed to boil for 2 hours. The solution was the removed allowed to cool and it then transferred into 100cm^3 volumetric flask, diluted with distilled water and mixed thoroughly.

For the distillation, 10cm^3 of 2%boric acid was poured into an Erlenmeyer flask (100cm^3) then 2 drops of mixed indicator added. 10cm^3 aliquot of the digest was then transferred into a distillation apparatus followed by the addition of 15cm^3 of 40% NaOH previously prepared into the mixture. The nitrogen was allowed to distill into boric acid/indicator flask for 20 minutes. The distillate was titrated with 0.025N H_2S04 to a pink end point then the burette reading was recorded

The percentage of protein content was computed in line with method by Jolaoso et al. (2016):

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1000 ml in H_2SO_4 = 1000 ml in NH_3 = 17.0g NH_3 = 14.0g N (6)
1 ml in H_2SO_4 = 1 ml in NH_3 = 0.014g N (7)
$$\% Nitrogen = \frac{0.014 \times VD \times TV \times N}{Weight\ of\ sample(0.2g) \times AD} \times 100 \quad (8)$$
Where,
VD = digest volume, N= acid normality, TV= titre value, AD = digest's aliquot, F = nitrogen to protein conversion factor (6.25).
Therefore, Total protein = %N×6.25 (9)

L.Fibre determination

2.0g of the banana sample was weighed (W_1) and wrapped with a filter paper and placed in a funnel. The sample was then extracted using three 25cm^3 portions of ether and then subjected to s vacuum for complete drying. The extract was transferred by brushing into a 600cm^3 beaker of the digestion apparatus, then 200cm^3 of 1.25% sulfuric acid (H_2SO_4) solution previously prepared was added. A beaker was thereafter placed on the digestion apparatus (with pre-adjusted heater) and allowed to boil for exactly half an hour. The beaker was made to rotate occasionally to prevent solid adherence to the sides, the beaker was removed and the content subjected to filtration with the aid of a Buckner funnel while the beaker was rinsed with 50-75cm^3 of hot water and washed through funnel. This process was repeated thrice with 50cm^3 portions of water and sucked dry. The residue was transferred to the beaker by blowing through funnel. This was followed with the addition of 200cm^3 of boiling 1.25% NaOH solution, returned to hearth and boiled for another 30minutes. The beaker was then removed, filtered washed with 25cm^3 of boiling 1.25% H_2SO_4 acid solution, 50cm^3 portion of water and 25cm^3 of alcohol in sequence. The fibre matter and residue were subjected to drying at a temperature of 130^{o}C for 2hours then removed, cooled in a desiccator and re-weighed (W_2), then re-heated to a temperature of 600^{o}C to a constant weight, and then cooled in desiccator and reweighed again (W_3).
$$\% \text{ fibre} = \frac{W2 - W3}{\text{Weight of the sample}} \times 100 \quad (10)$$

M.Determination of Carbohydrate content (%)

The percentage carbohydrate content was computed based on (AOAC, 2005):
$$\%Carbohydrate = 100 - (\%moisture + \%ash + \%protein + \%fibre + \%fat) \quad (11)$$

N.Heavy metals determination

The recommended method by Association of Official Analytical Chemists (2000) was employed for the samples' heavy metals analysis. The samples were first digested prior to AAS analysis.

O.Digestion

The sample digestion was carried out by placing 1.0g of the sample into a glass tube used for digestion, then 12ml of HNO_3 was added and the mixture kept for 24 hours at room temperature. Thereafter, 4.0 ml $HClO_4$ was added to the mixture and transferred into a fume cupboard for the digestion process. The temperature was raised gradually from 50^{o}C to 250-300^{o}C and the digestion was completed within a space of 70 - 85 min with appearance of white fumes as evidence of completion. The mixture was then allowed to cool and the contents of the tubes transferred to 100 ml volumetric flasks. The volumes of the contents were then raised to 100 ml by adding distilled water. The wet digested solution was later transferred to an accurately labelled plastic bottles.

P.AAS Analysis

The digested samples were employed for metal quantification by AAS (700, Perkin-Elmer) with acetylene/air gas mixture. The metals analyzed using this method were cadmium (Cd), lead (Pb), Phosphorus (P) and Arsenic (Ar).
The division of the molar mass of the compound of the element by the molar mass of the element provided the stock standard which was used to calibrate AAS. Portion of the prepared banana sample was aspirated into the AAS; then the air, acetylene (instrument fuel) and the sample, formed aerosol inside the AAS. Approximately 10% of the aerosol were channeled into the flame while the remaining 90% were emitted. The flame moved the sample from ground state to excited state through the process of vaporization, dissociation and atomization. The readings displayed on the equipment (in mg/l) is the actual concentration of the metal in the sample using the Equation 12:
$$metal\ (ppm) = \frac{Cm \times VD}{\text{weight of sample}} \quad (12)$$
Where, Cm = Concentration of metal calibrated reading, and VD = Volume of digest Weight of sample

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Q.Statistical analysis
The experimental data obtained from the laboratory were subjected to one way analysis of variance (ANOVA) using Microsoft excel package version 2010. The treatments were replicated two times. The acceptable level of significance was 5% ($p < 0.05$)

II.RESULTS AND DISCUSSIONS

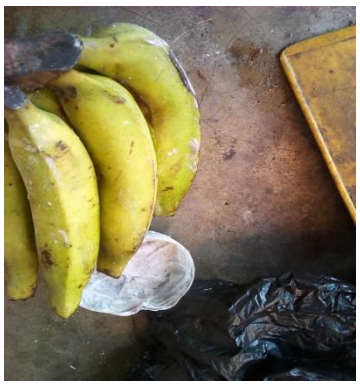
A.Ripening time and shelf life
Table 1 presents the ripening time or physiological changes of naturally and enhanced ripened banana samples at different levels (20g/kg and 40g/kg) of CaC_2 treatment.

Table 1: Ripening Time and Physiological Changes of Banana Samples

Group	Ripening Process	Physiological Properties			
		Ripening Time (Days)	Peel Colour	Stalk Colour	Shelf Life
NRB	Natural	8	Unattractive, Light yellow	Blackish Yellow	10
ARB20	CaC_2 (20g/kg)	3	Uniform, Lemon yellow	Green	4
ARB40	CaC_2 (40g/kg)	2	Uniform, Lemon yellow	Green	3

NRB→ Naturally Ripened Bananas; ARB20→ Artificially Ripened Banana with 20g/kg CaC; ARB40→ Artificially Ripened Banana with 40g/kg CaC_2

B.Photo Clip Ripened Banana Samples
Photo clip ripened banana samples using 20g of CaC_2, 40g of CaC_2 and natural ripening are presented in Figure 2 below.



20g CaC_2 treated banana

40g CaC_2 treated banana

Naturally Ripened

C.Ripening time
The ripening time for the banana fruit samples shown in Table 1 indicated that batch ARB20 (bananas treated with 20g CaC_2) took three (3) days to completely ripen while batch ARB40 (banana treated with 40g of CaC_2) took 2 days to ripen. On the other hand, natural ripening of same banana family took 8 days to completely ripen. From recorded observations, artificially ripened bananas developed yellow peels earlier than the naturally ripened bananas and this corroborates with most previous studies that ripening agents do accelerate ripening faster than when allowed to ripen naturally (Ajayi and

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Mbah, 2007, Hakim et al., 2012, Singal et al., 2012 and Sogo-Temi et al., 2014). Mba et al., (2018), confirmed that CaC_2 was able to ripen fruit samples within few days of exposure, upholding its claims as a fast ripening agent.

D.Shelf life

Table 1 showed the comparison of the shelf lives of the three samples (NRB, ARB20 and ARB40). The table showed that 20g CaC_2 treated ripe bananas had a shelf life of about 96 hours while 40g CaC_2 treated ripe bananas had a shelf life of about 72 hours while the banana samples ripened by natural process had a shelf life of about 10 days. The results implied that banana fruits that ripened naturally takes more days before spoilage and this agreed with the report of Luthfunnesa et al., (2018), which noted that naturally ripened bananas had a shelf life of 5-6 days while CaC_2 ripened banana had a shelf life of 2 to 3 days. This short shell life could be as a result of the high moisture content recorded in the bananas ripened with CaC_2 which increased with increase in CaC_2 concentration and leads to faster spoilage and perishability of fruits (Adepoju, 2008; Emebu and Anyika, 2011).

E.Peel Color

At full ripening, both 20g and 40g CaC_2 treated banana samples had uniform (lemon yellow) color as shown in Figure 1. The resulting peels were smooth and without spot. Light yellow color was observed in banana samples ripened by natural process. This also corroborated with the findings of Luthfunnesa et al., (2018) and confirmed that naturally ripened banana fruits were unattractive while those ripened artificially with chemicals were very attractive and without spots. This therefore upholds the general notion that all that glitters is not gold since CaC_2 is known to pose great danger to health of consumers.

F.Stalk Appearance

Stalk of CaC_2 treated bananas (ARB20 and ARB40) retained its green coloration while fruit portrayed bright lemon yellow color. Color changes from green to black was observed in the stalk of the banana ripened by natural process. Luthfunnesa et al., (2018), reported that the stalk colour of the naturally ripened banana samples were blackish yellow while that ripened artificially with chemicals remained green, confirming the results of this study. This implied that despite CaC_2 ripened banana samples showing evidence of being ripe, (softness and colour change), there could be possibility that the fruits were not completely ripened within.

G.Nutritional Analysis of Banana Samples

The results in Table 2 showed significant difference ($p < 0.05$) in moisture content, protein, ash as well as fibre and carbohydrate between the natural and artificial ripened samples while no significant difference in the fat content ($p > 0.05$) was recorded.

Table 2: Nutritional Values of ripened Banana samples

Sample code	CaC_2 (g/kg banana)	% Moisture Content	% Ash Content	% Fat Content	% Protein Content	% Fibre content	% Carbohydrate
NRB	0	52.19	1.66	0.55	5.33	0.53	39.74
ARB20	20	59.64	3.61	0.41	3.74	0.26	32.34
ARB40	40	63.87	4.73	0.29	2.81	0.11	28.19
p-value		0.000152	0.015521	0.149735	0.021843	0.009008	0.000391

p-values less than 0.05 ($p<0.05$) are considerably different while those greater than 0.05 are not.

H.Moisture content

Moisture content refers to the presence of water in a substance or material usually in trace amounts. High moisture content in fruits is an indication of its freshness and ease of perishability (Adepoju and Oyewole, 2008; Emebu and Anyika, 2011). The results presented in Table 2 showed that the moisture contents of the banana samples: naturally ripened sample (NRB), 20g CaC_2 treated sample (ARB20) and 40g CaC_2 treated sample (ARB40) were 52.19%, 59.64% and 63.87% respectively. The results obtained implied that CaC_2 affects banana fruit moisture content especially at higher concentrations and this corroborated with the findings of Nura, et al., (2018) who reported moisture content of 63.55% - 69.69% for banana ripened with CaC_2.

The percentage moisture content increment in the samples resulting from high CaC_2quantity could mean that the compound CaC_2 weakens the fibre of the peel thereby allowing the adsorption of moisture, hence, it is better to ripen fruits naturally because of the inverse relationship between moisture content and shelf life of fruit samples.

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I.Ash content

Ash is the inorganic residue from the incineration of organic matter at high temperatures usually 500^0c to 600^0c. It provides a measure of total amount of minerals within the food (Adeyemi and Oladiji, 2009). Table 2 showed that naturally ripened sample (NRB), 20g CaC_2 treated sample (ARB20) and 40g CaC_2 treated sample (ARB40) has ash content values of 1.66%, 3.61% and 4.73% respectively. The results indicated that ash content of the naturally ripened sample had the lowest value while it increased with increase in the quantity of CaC_2 used to induce the ripening process. This agreed with the findings of Nuhu et al., (2020) that reported that banana fruit samples treated with 0.5g, 1g, 1.5g and 2.0g of CaC_2 had ash content values of 0.815%, 0.984%, 1.102% and 1.185% respectively. However, the results was at variance with the report of Mba et al., (2018), that reported that ash content are higher in naturally ripened fruit samples than in CaC_2 induced ripening.

There was significant statistical difference ($p < 0.05$) in ash content among the three groups. Onot et al., (2007) reported that ash analysis has been chiefly used for the determination of adulteration of certain foods, high ash content suggests the presence of high molecular weight elements. Nnamani et al. (2009) also reported that low ash content indicates that the mineral content is low for any product. Hence, the high ash figure in the CaC_2 ripened samples in this study suggests the presence of an inorganic adulterant and low fruit quality.

J.Fat content

Fat helps in provision of energy and plays an important role as antioxidants (Anhwange et al., 2004; NAS, 2005). Human adults are expected to acquire 20 – 35% of their calories/energy from fat. The results obtained in this study presented in Table 2 showed that naturally ripened sample (NRB), 20g CaC_2 treated sample (ARB20) and 40g CaC_2 treated sample (ARB40) had fat content values of 0.55%, 0.41% and 0.29% respectively. The result indicated that fat content decreased as CaC_2 concentration used to induce the ripening increased. This however contradicted the findings of Nuhu et al., (2020) and Nura et al., (2018), that reported with one accord that fat content will increase with increase in CaC_2 concentration in induced fruit ripening. The result obtained in this study is consistent with the report of Mba et al., (2018) that noted that banana fruits ripened with CaC_2 or torch battery have low fat content compared to those ripened naturally.

There was no significant statistical difference ($p > 0.05$) in the value of fat content among the three samples. This can be attributed to the fact that fat content of bananas remain negligible as stated in USDA (2010).

K.Protein content

Protein provides amino acids, the substrates required for the support of body protein synthesis and maintenance of cells and organs in the body. The results obtained (Table 2) showed that the protein contents in the naturally ripened sample (NRB), 20g CaC_2 treated sample (ARB20) and 40g CaC_2 treated sample (ARB40) were 5.33%, 3.74% and 2.81% respectively. This investigation confirmed that CaC_2 decreases banana fruit's protein content and the results corroborates the findings of Mba et al., (2018) and Sogo-Temiet et al., (2014). There was significant statistical difference ($p < 0.05$) in the protein contents of the samples as presented in Table 2. The value obtained significantly decreased with increased concentration of the CaC_2 which means that the CaC_2 has deleterious effects on the protein content.

L.Fibre content

Dietary fiber intake provides many health benefits; it reduces risk for developing diseases, lowers blood pressure (Keenan et al., 2002), and improves blood glucose as well as control diabetes (Anderson, 2004).

The results obtained for fiber contents in the banana samples are presented in Table 2. Naturally ripened sample (NRB), 20g CaC_2 treated sample (ARB20) and 40g CaC_2 treated sample (ARB40) had fiber content values of 0.53%, 0.26% and 0.11% respectively. Naturally ripened sample recorded the highest value in fiber contents while it decreases with increase in concentration of CaC_2 used to induce the ripening process. This assertion also agreed with the work of Mba et al., (2018) and Nura et al., (2018). There was significant statistical difference ($p < 0.05$) in fiber contents among the samples as shown in Table 2. This significant decrease in the fibre content with increase in calcuim carbide concentration while ripening fruits exposes consumers that rely on fruits as their main source of daily fibre intake to the risk of high blood pressure, diabetes and retardation of the functioning of the immune system since fibre is known to fix these disorderliness in the body (Keenan et al., 2002, and Watzl et al., 2005).

M.Carbohydrate content

Carbohydrates are a major source of energy for the metabolic activities of the human body. The results obtained (Table 2) showed that the carbohydrate content in the banana samples: naturally ripened sample (NRB), 20g CaC_2 treated sample (ARB20) and 40g CaC_2 treated sample (ARB40) were 39.74%, 32.34% and 28.19%

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respectively. The results obtained showed that CaC_2 induced ripening decreases carbohydrate content of banana fruits especially at higher concentrations. This outcome agreed with the findings of Nuhu et al., (2020) and Nura et al., (2018). Significant statistical difference ($p < 0.05$) was recorded in the carbohydrate contents of the fruit samples. This significant decrease in carbohydrate content with increase in CaC_2 used to induce the ripening could be linked to an insufficient ripening process that makes essential nutrients unavailable with the use of CaC_2. The use of CaC_2 for fruit ripening could ensure outer colour changes but not complete ripening as the fruit could still be raw inside (Rahman et al., 2008).

N.Heavy metals analysis

Table 3 presents the results of selected heavy metal compositions in the three samples ripened naturally (NRB) and with different concentrations of CaC_2 (ARB20 and ARB40).

Table 3: Heavy metal Contents in banana samples

Pollutants (ppm)	NRB	ARB20	ARB40
Cadmium	ND	ND	ND
Arsenic	ND	0.037	0.083
Lead	ND	ND	ND
Phosphorous	89.479	119.016	141.603

O.Cadmium content

Cadmium was not detected in any of the three samples ripened naturally and artificially with 20g and 40g CaC_2.

P.Lead (pb) content

Lead has no essential function in man. Food is one of the major sources of lead exposure and intake into the body. Lead has critical effects in the development of the nervous system especially in children (ATSDR, 2007). Lead was not detected in all the samples and this corroborated with the works of Koleayo et al., (2016) but contradicts the general premonition that CaC_2 usually contain various toxic metallic compounds as impurities (Igbinaduwa et al., 2018). Pb had been reported to be widely dispersed in the environment and possess the capability of harming humans (Morais et al, 2012).

Q.Phosphorus (P) content

Phosphorus improves calcium absorption and strengthens bones and teeth particularly in minors and expectant mothers. However, the presence of high amount of this metal could be an indication of phosphate toxicity in food samples (Igbinaduwa et al., 2018).

The results (Table 3) showed that the phosphorus contents of the banana samples: naturally ripened sample (NRB), 20g CaC_2 treated sample (ARB20) and 40g CaC_2 treated sample (ARB40) has phosphorus content values of 89.479ppm, 119.016ppm and 141.603ppm respectively. The results indicated that phosphorus content of the naturally ripened sample had the lowest value but increased with increase in the concentration of CaC_2 employed for inducing the ripening process. This corroborates the findings of Nuhu et al., (2020) and Igbinaduwa et al., (2018), Calcuim carbide used in ripening of fruits contain Calcium phosphide (Ca_3P_2) an impurity that reacts with water to release a toxic gas, phosphine (Igbinaduwa et al., 2018). Bingham et al., (2001), reported that the concentration of phosphine found in acetylene released from CaC_2 was 95ppm. The high value of phosphorus reported in this study could be an indication that Phosphine (PH_3) could be possibly adsorbed into fruit samples exposed to the gas or that comes in direct contact with the CaC_2. The phosphorous concentrations in the banana fruits ripened with CaC_2 were higher than FAO limit (80-120ppm) and therefore can result in health impairment in human body ranging from vomiting, confusion, amnesia and sometimes cerebral Oedema (Imam-Hossain et al., 2015). It is therefore imperative that the use of CaC_2 in ripening fruit should be prohibited.

R.Arsenic (Ar)

Arsenic is carcinogenic in nature especially in critical internal organs: lung, kidney and bladder (ATSDR, 2003). Long term arsenic toxicity leads to multisystem disease and the most serious consequence is malignancy. The results showed that the arsenic contents in the banana samples naturally ripened sample (NRB), 20gm CaC_2 treated sample (ARB20) and 40gm CaC_2 treated sample (ARB40) were 0.00ppm, 0.037ppm and 0.083ppm respectively.

The results agreed with the findings of Nuhu et al., (2020) and Igbinaduwa et al., (2018). Calcuim carbide used in ripening of fruits contain Calcium arsenide (Ca_3Ar_2) an impurity that reacts with water to release a toxic gas known as arsine (ArH_3) (Igbinaduwa et al., 2018). Bingham et al., (2001), reported that the concentration of arsine found in acetylene

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released from CaC_2 is about 3ppm. The increment in the arsenic content of the banana samples ripened with different concentration of CaC_2 could be an indication that the arsine gas released in the process were possibly adsorbed into the fruit samples exposed to the gas or that comes in direct contact with the CaC_2. Uwaezuoke et al, (2018), confirmed that the arsenic and phosphorous hydrides in CaC_2 are fat soluble, and may dissolve in the outer layer of fruits and can also diffuse from peel to flesh of fruits, causing health hazards.

Arsenic poisoning also results in diarrhoea, and weakness as well as eye damage, ulcers and throat sores (Renu et al., 2019). This is a confirmation that the application of CaC_2 to induce ripening of fruits poses great danger and risk to the survival of the consumers. Its use should be banned and the fruit sellers and consumers sensitized on the risk they are exposed their customers to.

III.CONCLUSION

This paper evaluated the dangers associated with the use of CaC_2 to enhance banana fruit ripening. The study considered the changes in physiological and nutritional quality of the fruit ripened naturally and with 20g and 40g of CaC_2. CaC_2 reduced the ripening time and the shelf life. Nutritional quality of bananas were negatively affected in the samples ripened with CaC_2. The high moisture contents in the fruits ripened with CaC_2 are responsible for the fruits' short shelf life. The high value of phosphorus and arsenic in CaC_2 ripened samples reported in this study is an indication that Phosphine (PH_3) and arsine (ArH_3) released from the chemical during ripening could be adsorbed into fruit samples exposed to the gas or that comes in direct contact with the chemical. This study has indicated that the use of CaC2 to induce ripening poses great danger and risk to the survival of mankind. Therefore, the use of CaC_2 as an agent to induce ripening should be banned completely and defaulters punished. The fruit sellers and consumers should be sensitized periodically by the national agency for food and drug administration and control (NAFDAC) on the risk they are exposed to when this chemical is used in ripening and Government and public institutions should create awareness to the public on how to identify fruits ripened artificially with chemicals.

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