

RESEARCH ARTICLE

Effects of artificial ripening of banana (*Musa spp*) using calcium carbide on acceptability and nutritional quality

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ABSTRACT

Freshly harvested bunches of green matured banana were collected from a private garden in Dawakin kudu Local Government while Calcium carbide was purchased from Na'ibawa fruit Market all in Kano State. Different levels (0, 5, 10, 15, 20 and 25 g/kg) of CaC_2 coded A, B, C, D, E and F were used in a two stage ripening method adopted to emulate the process used by local banana retailers in Kano State, Nigeria. During the first stage, bunches of banana and CaC_2 were enclosed in an airtight HDPE chamber for 48 hours at $34\pm 8^\circ\text{C}$ while in the second stage the HDPE was replaced with jute bag and water sprinkled regularly to maintain low temperature and minimize water loss. This stage was maintained at $32\pm 8^\circ\text{C}$ for 22 hours. Parameters evaluated were proximate composition, vitamin C, titratable acidity and pH. Sensory parameters evaluated were appearance, sweetness, aroma, firmness, mouth feel and acceptability. Percentage moisture, ash and lipid were found to be increasing with increase in CaC_2 concentration. Protein, fibre and carbohydrates contents were found to be decreasing with increase in CaC_2 concentration. Vitamin C, titratable acidity and pH contents were also found to be decreasing with increase in CaC_2 concentration. Samples with 20 and 25g CaC_2/kg fruit were found to have the best sensory characteristics but results in higher moisture which may significantly affects the shelf life of the fruits. Higher ash contents recorded in samples E and F was a reflection of high concentration of CaC_2 used in their ripening.

Keywords: Acceptability banana, carbide, ripening, quality

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INTRODUCTION

Fruits are important in human nutrition because they supply vitamins and minerals to the diet, provide variety to the food and make food appetizing. They also contained fibre, water, vitamins, sugars, minerals, protein, cellulose and various photochemicals which protect human body against various disorders (Dhembare, 2013). Fruits are highly perishable after harvest particularly under tropical conditions (Adesida et al., 2011).

Banana is a climacteric fruit belonging to the family Musaceae and it is usually eaten as supplementary food or as a whole meal (Adekalu et al., 2011, Vaidya et al., 2016). It is the 4th most important global food commodity (after rice, wheat and maize) grown in more than 100 countries over a harvested area of approximately 10 million hectares with an annual production of 88 million

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tonnes (UNCST and PBS, 2007). Banana is rich in Vitamins A and C, carbohydrates, elements such as phosphorous, potassium, magnesium, selenium and iron. Banana is also recommended for salt free diet because of its low content of sodium chloride (Adekalu et al. 2011; Kumar et al., 2012; Abdul-Rahaman et al., 2015).

Ripening is a natural physiological process that makes the fruit sweeter, more palatable, edible, nutritious, softer and attractive (Gupta, 2017; Siddiqui and Dhua, 2010). It is associated with colour changes due to the pigments that are already present or are produced during ripening (Gupta, 2017). Fruits attain their desirable flavour, quality, colour, and other textural properties during ripening (Bhattarai and Shrestha, 2005).

Fruits naturally ripen after attainment of physical and biochemical processes which are irreversible and ultimately lead to the senescence of the fruits. Whether fruits ripen on the plant or after harvest, the general changes associated with the process are easily recognizable. During ripening, fruits soften, change colour and develop characteristic aroma and flavour. There is also a reduction of sourness and increase in the sweetness due to decrease in acidity and increase in sugars (Siddiqui and Dhua, 2010).

Artificial ripening is done to achieve faster and uniform ripening. It is the process by which ripening is controlled and products may be achieved as per requirement by controlling different parameters (Bhattarai and Shrestha, 2005). Artificially ripened fruits may develop uniform and attractive surface colour but the tissue inside remain green and the fruit generally have shorter shelf life (Hossain et al., 2015).

Artificial ripening accelerates the rate of the process but affects the nutritional quality, sensory and safety of the fruits (Hossain et al., 2015). Dhembare (2013) reported that substances used as artificial ripeners have several effects on humans which include memory loss, cerebral oedema, prostate and lung cancer, quick-buck syndrome, changes in DNA and RNA as well as haematological changes. Fruits ripened artificially are overly soft, inferior in taste and flavour. Precautionary measures observed to avoid toxic effects of the substances were through washing of fruits before eating and avoidance of eating the skin of the fruits (Fattah and Ali, 2010).

Chemical commonly used to induce ripening include but not limited to ethylene gas, ethephon, ethylene glycol, ethereal and calcium carbide (Hossain *et al.* 2015). Calcium Carbide (CaC_2) is the most common and widely used artificial ripening agent probably because it is cheap and readily available. It is produced on an industrial scale for the production of acetylene used for various purposes. The commonly available grade in market is grey or brown and contains 80-85% calcium carbide. It produces garlic smell in the presence of moisture. When sprayed with water, it reacts chemically to produce acetylene (Gupta, 2017)



Acetylene acts like ethylene and ripens the fruits and vegetables by the similar process. Industrial grade calcium carbide generally contains impurities of arsenic and phosphorus that pose a number of health problems. This is the reason why its use is banned in most of the countries. But because of cheap prices and easy availability, it is still in use in many parts of the world (Gupta, 2017).

Acetylene is believed to affect the nervous system by reducing oxygen supply to the brain (Dhembare, 2015). In acute stage, it causes headache, vertigo, dizziness, delirium, seizure and even coma. In the long term, it may produce mood disturbance and loss of memory (Fattah and Ali, 2010)

MATERIALS AND METHODS

Banana Procurement and Ripening

Freshly harvested bunches of green matured banana used in the research was collected from *Kofar Arewa Dawakin Kudu* Local Government and Calcium carbide was purchased from Na'ibawa fruit Market all in Kano State. Different levels (0, 5, 10, 15, 20 and 25) of calcium carbide used per kilogram banana was used in the two stage ripening method adopted to emulate artificial ripening process used by local banana retailers in Kano State, Nigeria. During the first ripening stage, bunches of banana and CaC₂ were enclosed into airtight chamber made using HDPE. The CaC₂ was placed in each of the four corners and was not in direct contact with the fruit. Softening of the fingers mark the end of this stage and this was achieved after 48 hours at 34±8°C.

The HDPE was removed and replaced with jute bag during the second ripening stage. Water was sprinkled regularly to maintain low temperature and minimize water loss. The second stage is responsible for colour change, during this stage green fingers turns yellow. This stage was completed in 22 hours at 32±8°C.

Proximate Analyses

Moisture and ash contents of the sample were determined using hot air oven and muffle furnace methods as described by AOAC (2002). Solvent extraction method using diethyl ether was used for fat determination as reported by Onwuka (2005). Protein content and Crude fiber were determined using procedure described by Onwuka (2005). Carbohydrate content was determined by difference.

Titrateable acidity content was determined using titration method described by AOAC (2002). While pH determination was using pH meter (Crison Micro pH 2000, Crison Instruments, Spain). pH meter was calibrated by using buffer solutions of pH 4 and 7. Vitamin C was determined by titration with 2, 6 dichlorophenol indophenol as reported by Onwuka (2005).

Sensory Analysis

Sensory analysis was carried out using the seven point hedonic scale (where 1=dislike much and 7=like much) as described by Linda et al. (1991). The organoleptic properties evaluated were appearance, sweetness, aroma, firmness, mouth feel and general acceptability.

The sensory panel consisted of 20 semi trained panelists cutting across staff and students (aged between 20 and 50 years) drawn from Department of Food Science and Technology, Kano University of Science and Technology, Wudil.

Statistical Analyses

The data generated were subjected to analysis of variance (ANOVA) at 5% level of significance using Statistical Package for Social Science (SPSS 21.0 for windows) and means that were significant were separated using Duncan's multiple range test.

RESULTS AND DISCUSSION

Table 1 presents the results for proximate composition of the fruits ripened with different concentrations of calcium carbide CaC₂. The ranges for moisture, ash, lipid, protein, fibre and carbohydrate contents were found to be 60.82 to 69.69, 1.14 to 2.85, 0.52 to 0.86, 1.25 to 2.50, 1.48 to 2.49 and 23.87 to 32.53 per cent respectively. Moisture, ash and lipid contents were found to be increasing with increase in calcium carbide concentration, while protein, fibre and carbohydrate contents

were found to be decreasing with increase in calcium carbide concentration. This agreed with the finding of Sogo-Temi et al. (2014) who reported decrease in protein content and increase in moisture and mineral contents in banana samples ripened with calcium carbide. It also agreed with the report of Gunasekara et al. (2015) who recorded low levels in nutritional qualities in “Embul” banana treated with calcium carbide and ethephon.

Table 1. Proximate Composition of Banana sample ripened with different concentrations of calcium carbide CaC₂

Sample Code	CaC ₂ (g/kg banana)	Moisture	Ash	Lipid	Protein	Fibre	CHO
A	0	60.82±0.07 ^d	1.14±0.01 ^f	0.52±0.01 ^e	2.50±0.00 ^a	2.49±0.01 ^a	32.53±0.11 ^a
B	5	61.54±0.13 ^d	1.36±0.02 ^e	0.55±0.01 ^d	2.19±0.31 ^{ab}	2.41±0.01 ^{ab}	31.95±0.17 ^{ab}
C	10	61.86±0.12 ^d	1.59±0.01 ^d	0.67±0.02 ^c	1.88±0.00 ^{ab}	2.36±0.01 ^b	31.64±0.16 ^{ab}
D	15	63.55±0.98 ^c	1.94±0.03 ^c	0.78±0.01 ^b	1.56±0.31 ^b	2.20±0.02 ^c	29.97±0.71 ^{ab}
E	20	65.13±0.56 ^b	2.64±0.01 ^b	0.80±0.00 ^b	1.25±0.00 ^c	1.87±0.11 ^d	28.31±0.57 ^b
F	25	69.69±1.01 ^a	2.85±0.05 ^a	0.86±0.01 ^a	1.25±0.00 ^c	1.48±0.08 ^e	23.87±0.95 ^c

Results for vitamin C, titratable acidity and pH contents of fruits ripened with different concentrations of calcium carbide CaC₂ were presented in Table 2. The vitamin C content were found to be 28.00, 26.00, 24.00, 22.00, 16.00 and 16.00 for sample A, B, C, D, E and F respectively. Titratable acidity contents were found to be 0.13, 0.13, 0.13, 0.11, 0.10 and 0.09 for sample A, B, C, D, E and F respectively, and pH contents were found to be as 7.35, 7.34, 7.06, 7.01, 6.95 and 6.93 for sample A, B, C, D, E and F respectively. Concentrations of vitamin C, titratable acidity and pH were found to be decreasing with increase in CaC₂ concentration. Izundu et al. (2016) reported significance differences (P=0.05) in proximate parameters, titratable acidity, pH, reducing sugar and vitamin C in plantain ripening induced with calcium carbide, hot water dipping, smoke treatment, air tight packaging using polythene bag and dried plantain leaves treatment. Rahman et al (2014) reported low nutrients and high acid values in banana artificially ripen with ethephon and kerosene, but no significance difference was recorded in moisture and vitamins contents.

Results for sensory analysis presented in Table 3, highest sensory score was recorded in sample F (25g CaC₂/kg banana) and least sensory score was recorded in control sample. Acceptability was found to be increase with increase in CaC₂ concentration. The results for sensory analysis agreed with the finding of Sarananda (1990) who recommend the use of acetylene generated from calcium carbide in ripening of “embul” banana. Amarakoon et al. (1999) also recommended the use of 1g CaC₂ per kilogram fruit. The results contradict the findings reported by some researchers; Gunasekara et al. (2015) recorded low sensory scores and low levels nutritional qualities in “Embul” banana treated with calcium carbide and ethephon. Mahmood et al (2013) also reported low sensory qualities in peach fruit ripened with CaC₂, He also concluded that application of CaC₂ as artificial ripening agent not only harms business based qualities of fruits but also greatly affects the physiochemical, nutritional and antioxidant properties of fruits.

Table 2. Vitamin C, Titratable acidity and pH of Banana Artificially ripen using different concentration of CaC₂

Sample	CaC ₂ (g/kg Banana)	Vitamin C (g/100g)	Titratable Acidity (%)	pH
A	0	28.00±0.00	0.13±0.00	7.35
B	5	26.00±0.20	0.13±0.00	7.34
C	10	24.00±0.00	0.13±0.00	7.06
D	15	22.00±0.20	0.11±0.00	7.01
E	20	16.00±0.00	0.10±0.00	6.95
F	25	16.00±0.00	0.90±0.00	6.93

Gandhi et al. (2016) recommended the use of apple as natural ripening agent against calcium carbide in an experimental setup involve pear, tomato, apple and calcium carbide as ripening agents. The results of the research shows that banana ripening induced using apple provide product with higher nutritional and organoleptic qualities. They also reported that use of air tight chambers during calcium carbide ripening provide better sensory properties.

Table 3: Sensory Properties of Banana Artificially ripen using different concentration of CaC₂

Code	CaC ₂ (g/kg fruit)	Appearance	Sweetness	Aroma	Firmness	Mouth feel	Acceptability
A	0	4.80±1.32 ^{ab}	2.13±2.07 ^c	2.47±0.92 ^c	3.73±1.34 ^b	2.13±1.13 ^c	2.40±1.60 ^c
B	5	4.53±1.06 ^b	2.53±1.06 ^c	2.33±0.98 ^c	3.93±1.16 ^b	2.20±1.27 ^c	2.67±1.45 ^c
C	10	4.60±1.45 ^b	3.80±1.90 ^b	3.27±1.39 ^{bc}	4.87±1.36 ^{ab}	3.47±1.64 ^b	3.80±1.57 ^b
D	15	2.87±1.92 ^c	4.07±1.49 ^b	3.47±1.64 ^b	4.00±1.69 ^b	3.60±1.55 ^b	3.53±1.51 ^{bc}
E	20	5.20±1.57 ^{ab}	5.73±1.34 ^a	5.67±0.90 ^a	4.67±1.92 ^{ab}	5.27±1.75 ^a	5.33±1.40 ^a
F	25	5.80±0.94 ^a	5.80±1.32 ^a	5.33±1.23 ^a	5.40±2.17 ^a	5.87±1.46 ^a	5.93±1.34 ^a

Conclusion

The present research indicate that artificial ripening of banana using CaC₂ effects proximate parameters, vitamin C, titratable acidity, pH and sensory characteristics of the banana. Different responses were recorded in different CaC₂ concentrations. Moisture, ash and lipid contents were found to increasing with increase in calcium carbide concentration, while protein, fibre and carbohydrate contents were found to be decreasing with increase in calcium carbide concentration. Concentrations of vitamin C, titratable acidity and pH were found to be decreasing with increase in CaC₂ concentration. The results of the research also shows that CaC₂ when use as a ripening agent can improve sensory characteristics of the banana, but can significantly affect it is keeping quality because higher concentration results to higher moisture in the ripe banana. All the sensory properties studied were found to be increasing with increase in CaC₂ concentration with highest sensory scores recorded in sample treated with 25g CaC₂ par kg banana. Use of CaC₂ in artificial ripening of banana and other fruits should be regulated by authorities in Nigeria. Natural ripening agents should be used in ripening of banana and other fruits to shun the potential health risk associated with consumption of fruits artificially ripen with CaC₂. Further research is recommended to study safety of banana ripen using method described in this research. Research should also be conducted to justify the decrease in vitamin C and titratable acidity contents and increase in total acidity in the same treatment.

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