



Research Article

Effect of storage temperature on the quality parameters of soft and non-alcoholic malt drinks sold locally in Nigeria

Michael Akomaye Akpe*, Michael Chukwudi Ogbuji, John Akwagiobe Agwupuye

Department of Pure and Applied Chemistry, University of Calabar, P.M.B. 1115, Calabar, Nigeria

Abstract To study the effect of storage temperature on the quality requirements of soft and non-alcoholic malt drinks sold in a local market in Calabar, Nigeria, the effect of temperature changes on quality parameters was determined at a temperature range of 30–50°C. The mean values were compared with the Nigerian Industrial Standards 217:2008 & 290:2013, National Science Education Standards 2005, and FAO/INFOODS Databases in Nigeria 2018, respectively. For the soft drink, they revealed that as the temperature increased from 30 to 50°C, bitterness increased from 1.27 to 1.33 EBU, pH decreased from 2.99 to 2.78, total acidity increased from 0.014 to 0.030 g/L, original gravity decreased from 1,041 to 1,032 °Saccharin, ascorbic acid content decreased from 116.52 to 6.74 mg/L and sugar content decreased from 10.9 to 9.9 mg/L, respectively. For the malt drink, the results revealed that bitterness increased from 6.6 to 9.7 EBU, pH decreased from 5.0 to 4.52, total acidity increased from 0.006 to 0.025 g/L, original gravity decreased from 1,055 to 1,045 °Saccharin, ascorbic acid decreased from 441.13 to 87.30 mg/L, sugar content decreased from 14.0 to 13.4 mg/L, respectively. Alcoholic content was not detected in both drinks. The results showed that increase in storage temperature affects the quality parameters and nutritional values of these drinks linearly with time.



OPEN ACCESS

Citation: Akpe MA, Ogbuji MC, Agwupuye JA. Effect of storage temperature on the quality parameters of soft and non-alcoholic malt drinks sold locally in Nigeria. *Korean J Food Preserv*, 29(5), 663-676 (2022)

Received: June 16, 2022
Revised: August 05, 2022
Accepted: August 06, 2022

***Corresponding author**
Michael Akomaye Akpe
Tel: +2349046359092
E-mail: akomayekpe2015@gmail.com

Copyright © 2022 The Korean Society of Food Preservation. This is an Open Access article distributed under the terms of the Creative Commons Attribution Non-Commercial License (<http://creativecommons.org/licenses/by-nc/4.0>) which permits unrestricted non-commercial use, distribution, and reproduction in any medium, provided the original work is properly cited.

Keywords drink, quality requirements, storage, temperature effect

1. Introduction

Soft and non-alcoholic malt drinks exist in various forms and brands, and are produced and marketed by different brewing industries across Nigeria and internationally (Obuzor and Ajaezi, 2010). These drinks are readily consumed on daily basis especially, when undergoing tedious activities like hard work or sport. Also with their relatively affordable prices, they are highly consumed during leisure and relaxation outings, and used to serve the general public in celebrations such as traditional marriages, weddings, parties, naming ceremonies, child dedication, funerals etc. Soft drinks which are called “soft” in contrast to ‘Hard drinks’ contain small amounts of alcohol or none, but the alcoholic content must be less than 0.5% of the total volume (Pune, India - February 14, 2019). According to Lugasi and Hovari (2003), soft drinks are a group of non-alcoholic beverages

useful to quench thirst in a pleasant way, and contain some useful compounds like vitamins, saponins, polyphenols, etc, with antioxidant properties. They usually contain carbonated water, a sweetener and a natural or artificial flavour. The sweetener may be sugar, high fructose corn syrup, fruit juice, a sugar substitute (like honey) or a combination of these. Soft drinks may also contain ingredients like colourants, preservatives, nutrients etc. Some amount of alcohol may be present in a soft drink, but its content must be less than 0.5% of the total volume of the drink in many countries or localities. Examples of these soft drinks available in Nigeria include Coke, Fanta, Sprite, La Casera, Pepsi, 7up, Fayrouz etc. They are packaged in many container types including cans, glass bottle and plastic bottles of different sizes ranging from small bottles to large multi litre containers.

In addition to thirst satisfaction, soft drinks contain other constituents such as vitamins, phosphate and acids, which are of nutritional and health value (Maurice, 2010). The major ingredients in the production of soft drinks are water, liquid sugar, flavour concentrates, citric acid which can either be in the form of powder or syrup. These are mixed in their various proportions in the water tank to for a perfect mixture. The water tank is sterilized with ultraviolet radiation or by flash pasteurization (quick heating and cooling of water) to eliminate bacteria that may be present in the sugar or flavor. To prevent air absorption, manufacturers often mix their ingredients inside a chamber that is pressurized with carbon (IV) oxide. The water-based mixture is finally carbonated at the exact cold temperature of the liquid. This is followed immediately with packaging and sealing of containers to preserve the carbon pressure in the liquid mixture, and concluded with labeling.

Non-alcoholic malt drinks on the other hand, are drinks whose worts are prepared from barley and cereal adjuncts without fermentation. Thus, it is produced by dissolving wort granulates in water, filtration and addition of pure hop aroma followed by carbonation (Kamil, 2003). Malt drinks have a lot of health benefits such as protection against coronary heart diseases, cancers and ulcers (Bamfort, 2002). Some of the popular brands in Nigeria include Malta Guinness, Amstel Malt, Maltina, Hi Malt, Grand Malt, Dubic Malt, etc.

Soft and non-alcoholic malt drinks are widely distributed at fast food restaurants, movie theatres, shops, supermarkets, hotels, clubs etc., and freely available at festivals, child dedication ceremonies, weddings, funerals, birthday parties and other celebrations (Bamfort, 2002). Historically, non-alcoholic malt drinks were used as food for children and the sick because it has a lot of health benefits such as protection against coronary heart disease, cancers, and ulcers (Bamfort, 2002). The manufacturers of these malt drinks have found inventive ways of breathing new life into old time brands by updating the products, making them appealing to new consumers. The most vibrant strand of growth may lie within the market for non-alcoholic malt drinks in the Middle East, Muslim populations in the West and some Christian groups that forbid the drinking of alcohol (Livonen and Parthington, 2007). In Nigeria, they have now turned out to be the drink preferred in most social gatherings for health or religious belief. The products for the manufacturing process of non- alcoholic malt drink are malt, sugar and hops. The production generally is by dissolving wort granulates in water, filtration and adding pure hop aroma, followed by carbonation (Kamil, 2003; Lommi and Ahvenainen, 1997). There are many ways to improve the taste of non-

alcoholic malt drinks and higher levels of hops (Murray and Van der Meer, 1997).

Temperature is known as one of the factors affecting chemical or biochemical reactions whether natural or synthetic. According to Johnson et al. (2013), analysis of the effect of Nigerian market storage conditions on ascorbic acid, titratable acidity and pH values of selected packaged citrus fruit juice were carried out from three months to ten months from the day of production, and the results showed that there was gradual decrease in ascorbic acid contents and pH values with increase in storage period irrespective of the brands. Definitely, the change in the ascorbic acid content and pH was related to the change in the storage temperature. The vitamin C content in fresh orange juice showed different values at different temperatures and shelf life, 39.75 ± 1.000 , 23.00 ± 1.520 and 31.50 ± 1.000 mg/100 mL for fresh, boiled and a week shelf life, respectively (Davey et al., 2000). Murcia et al. (2000) carried out a study and reported that the fresh watermelon juice shows a different vitamin C content at different temperatures and shelf lives which are 27.5 ± 1.250 , 16.70 ± 1.420 and 21.63 ± 1.625 mg/100 mL, for fresh, boiled and a week shelf life, respectively. Heat and water reduce vitamin C content, cooking reduce the vitamin C content in fruit juice because vitamin C is sensitive to heat, water and air. Rickman et al. (2007) have also reported that the rate at which vitamin C content decreases in fresh tomato juice shows different values at different temperature and shelf life which are 19.13 ± 1.630 , 10.83 ± 2.600 and 15.63 ± 0.625 mg/100 mL for fresh, boiled and a week shelf life, respectively. All these studies point to the fact that changes in storage or environmental temperature affects the quality of different malts and fruit juices.

It is an established fact in science that increases in temperature affects the rate of chemical and biochemical reactions. Besides, several researches have been carried out on the effect of different temperatures on the vitamin C content of many fruit juices namely; orange juice, watermelon juice, tomato juice, etc. in different parts of the world (Davey et al., 2000; Murcia et al., 2000; Rickman et al., 2007) as cited earlier. However, the problem is that many of these drinks are produced, distributed, consumed and preserved anyhow possible in Nigeria without the knowledge of the effect of storage temperature on the quality and potency of the drinks. Many people are only concerned about the expiry date in the label on the drinks as a proof of potency. Besides, there is no evidence in literature of any research study carried out on the effect of temperature on the individual quality requirements or parameters of soft and non-alcoholic malt drinks, in Nigeria. Considering the tropical climate and weather of Nigeria, and Africa in general, environmental temperatures are high most of the time, with average room temperature higher than 25°C and sometimes above 30°C . Therefore, it is possible that decomposition reactions can be initiated among the various ingredient in soft and non-alcoholic malt drinks over time as their storage and environmental temperature rises due to heat absorption and that might affect the quality of these non-alcoholic drinks or beverages. It might also interest one to know that even after the quality regulatory agencies in Nigeria like Standards Organization of Nigeria (SON) and National Agency for Food and Drug Administration and Control (NAFDAC) have tested and certified the quality of these drinks for consumption, they may still decompose and diminish in quality earlier than their expected expiry dates due to poor storage conditions or temperature

especially with the epileptic electrical power supply in Nigeria which would have aided preserving these drinks by refrigeration at low temperatures devoid of chemical decomposition.

The purpose of this study is to determine the effect of storage temperature on the quality requirements of soft and non-alcoholic malt drinks sold and consumed in local markets in Nigeria and create awareness to manufacturers and consumers of these products on the effects of temperature on their quality and educate them on the best storage temperature or conditions. Additionally, we aimed to provide relevant information to the government through its relevant quality regulatory agencies on the effects of storage temperature on the quality of these drinks and the reliability of expiry dates/shelf lives based on the findings, for proper monitoring and evaluation of quality standards of products, and finally, to serve as a reference document for further research or a baseline study.

2. Materials and methods

2.1. Sample collection and preparation

One of most popular brands each of the soft and non-alcoholic malt drinks bought from a local market in Calabar, Cross River State for the analysis of their quality requirements at 5 different temperatures. The samples were divided into five sets. The first set was conditioned in a water bath at 30°C, others at 35°C, 40°C, 45°C and 50°C, respectively. The equilibration time for each sample was 45 min. All reagents used were of analytical grade (British Drug House (BDH), Poole, England), while the instruments calibrated according to the required procedures. The methods used were based on the Association of Official Analytical Chemists (AOAC, 2005). Some procedures were carried out in

Chemistry Department Laboratory, University of Calabar, while some were carried in the Jawaharlal Nehru Centre for Advance Scientific Research, Jakkur, Bangalore, India.

2.2. Sample analysis and procedures

The conditioned samples were for the quality requirements namely: bitterness (EBU), pH, total acidity as citric acid (g/L), ethyl alcohol content (% v/v), original gravity [°Saccharin (% v/v)], ascorbic acid content (mg/L) and sugar content (% v/v) at temperatures of 30°C, 35°C, 40°C, 45°C and 50°C, respectively. These quality requirements were compared with Nigeria Industrial Standards for soft drink (NIS 217, 2008), malt drinks (NIS 290, 2013), National Science Education Standards 2005, FAO/INFOODS Databases in Nigeria 2018 respectively.

2.2.1. Bitterness measurement (EBC method)

Bitterness was measured using UV-VIS spectrophotometer at 275 nm according to European Brewery Convention (EBC) method. The apparatus used include a Centrifuge 800-B, a 6800 UV/VIS spectrophotometer (JENWAY) and thermostat water bath HH-6. Procedure: 5 mL of the sample (degassed by shaking), 0.5 mL of 3 M HCl and 10 mL of iso-octane were measured into a centrifuge tube and shaken vigorously for 15 minutes and centrifuge at 3,000 rpm for 3 min to separate the phases and break the emulsion. After separation of phases, the isooctane phase was carefully decanted and allowed to stand in the dark for 30 min and the clear supernatant was immediately transferred into a quartz cell and the absorbance measured at 275 nm in the UV-visible spectrophotometer (AOAC 970.16, 2005).

$$\text{Bitterness (EBU)} = \text{Absorbance at 275 nm} \times 50.$$

2.2.2. Determination of pH

A pH meter with glass electrode (Uniscopie PHS-3E pH meter, Surgifriend Medicals, England) was used. Reagents used were buffer 4.0 and 7.0 solutions and distilled water. Procedure: 100 mL of the sample was transferred into clean beaker rinsed severally with distilled water and lastly the sample. The calibrated pH meter was then inserted in the sample and pH reading recorded (AOAC 945.10, 2005).

2.2.3. Determination of total acidity as citric acid

Reagents used were 0.1 M NaOH and phenolphthalein indicator. Procedure: 10 mL of 1 in 100 dilution of the sample was poured into a conical flask and 3 drops of phenolphthalein indicator were added and titrated with 0.1 M NaOH solution in the burette to an end point (AOAC, 2005). Total titrable acid as citric acid in 1 mL of 0.1 M NaOH = 0.0064 g citric acid.

$$\text{Total acidity (\%)} = \frac{\text{Weight of citric acid} \times 100}{\text{Weight of sample used}}$$

2.2.4. Determination of ethyl alcohol (% v/v)

A total of 250 mL of sample was collected and poured in the 500 mL round bottom flask. The condenser was connected between the round bottom flask and the 250 mL conical flask. Bumps were added to the sample to avoid breakage or spillage. The sample was heated and the distillate collected at 78°C boiling point. After cooling, it was poured into a 100 mL measuring cylinder. The alcoholmeter was inserted into the sample in the cylinder and readings were taken and recorded (AOAC, 2005).

2.2.5. Determination of original gravity (OG)

The materials used include a weighing balance, density bottles and distilled water. Procedure: the specific gravity (relative density) which is same as the final gravity was determined by dividing the weight of a certain volume of the sample in the density bottle by the weight of the same volume of distilled water in density bottle (EBC, 2018).

The original gravity was obtained using the formula:

$$\text{ABV} = 131.25 (\text{OG} - \text{FG})$$

where OG is the original gravity, FG is the final gravity and ABV is the 'alcohol by volume' which is equal to ethyl alcohol (%v/v). It is expressed as °Saccharin (%v/v).

2.2.6. Determination of ascorbic acid

The reagents used were 1.0 M H₂SO₄, 1% starch indicator, 0.05 N iodine and distilled water. Procedure: 50 mL of distilled water was added to 2.5 mL of 1.0 M H₂SO₄ acid in 250 mL conical flask. 5 mL of the sample was added to the flask, followed by 5 mL of 1% starch indicator and then mixed properly. 0.05 N solution of iodine in the burette was used to titrate the solution to a pale black end point (BP, 2003).

The ascorbic acid concentration was obtained from the formula below.

$$\text{Ascorbic acid (mg/L)} = \frac{\text{Volume of iodine} \times 8.826 \times 100}{\text{Volume of sample used}}$$

2.2.7. Determination of sugar

This was achieved using a refractometer (OPTi

Digital Handheld Refractometer, UK). Procedure: 2 drops of the sample were deposited at the optical surface of the meter. The lower part of the observed bluish colour was read and recorded (AOAC 935.64A, 2005).

2.3. Statistical analysis

Three replications of the experiment were carried out for each measured value and the data reported as the mean \pm standard deviation (SD) or

standard error (SE), with $n=3$. SPSS version 20 (IBM Corp.) software was used to carry out significant test on the data obtained from experimental procedure at $p<0.05$, while Origin 5.0 (Origin Lab Corp.) software was used to carry out regression analysis on the data to ascertain the linear relationship between the quality parameters and storage temperature. The significance indication was also stated using small letters of alphabets in the results.

Table 1. Mean values of the different quality requirements of soft drink sold in local market in Nigeria at different temperatures

Parameters	Storage temperature (°C)				
	30	35	40	45	50
Bitterness (EBU)	1.27 \pm 0.01 ^{1&2)}	1.29 \pm 0.01 ^b	1.30 \pm 0.01 ^b	1.32 \pm 0.01 ^c	1.33 \pm 0.01 ^c
pH	2.99 \pm 0.01 ^a	2.92 \pm 0.01 ^b	2.89 \pm 0.01 ^b	2.83 \pm 0.01 ^c	2.78 \pm 0.01 ^d
Total acidity as citric acid (%)	0.014 \pm 0.001 ^a	0.019 \pm 0.001 ^b	0.024 \pm 0.001 ^c	0.026 \pm 0.001 ^c	0.030 \pm 0.001 ^d
Ethyl alcohol (%v/v)	ND ³⁾	ND	ND	ND	ND
Original gravity °Saccharin (%v/v)	1041 \pm 1.0 ^a	1038 \pm 1.0 ^b	1037 \pm 1.0 ^b	1034 \pm 1.0 ^c	1032 \pm 1.0 ^c
Ascorbic acid (mg/L)	116.52 \pm 0.1 ^a	88.26 \pm 0.2 ^b	61.78 \pm 0.15 ^c	34.11 \pm 0.2 ^d	6.74 \pm 0.01 ^e
Sugar content (mg/L)	10.9 \pm 0.1 ^a	10.7 \pm 0.1 ^b	10.5 \pm 0.1 ^b	10.2 \pm 0.1 ^c	9.9 \pm 0.1 ^d

¹⁾Values reported in mean \pm SD ($n=3$).

²⁾Different superscript letters indicate significant difference ($p<0.05$) between values in the same row.

³⁾Not detected.

Table 2. Standards for soft drink (NIS 217, 2008) specific requirements¹⁾

Parameter	Requirement (max.)
Carbon dioxide	11.0 g/L & nil for non-carbonated drinks
Total acidity as citric acid	5.0 g/L (0.5%)
Sugar content	15% except soda water & club soda which shall be nil
Quinine	75 mg/L
Ethyl alcohol	0.5%
Orthophosphoric acid	600 mg/L
Caffeine	150 mg/L
Benzoic acid	300 mg/kg (without ascorbic acid)
Benzoic acid	250 mg/kg (with ascorbic acid)
Sulphur dioxide	70 ppm
Sorbic acid	350 mg/kg

¹⁾Standards Organisation of Nigeria (SON), 2008.

3. Results and discussion

The results of the analysis of the quality requirements soft and non-alcoholic malt drink are presented along with their standards in Tables 1-4. The graphs of the regression analysis carried out using Origin version 5.0 software on the data to show the linear relationship between the different quality requirements or parameters and temperature are presented in Fig. 1 to 6 and Fig. 7 to 12 for soft and non-alcoholic malt drink respectively.

3.1. Regression equations for soft drink (where T= Temperature)

All the following equations indicate a linear relationship between the quality parameters and temperature. Bitterness and total acidity increases as storage temperature increases, while original gravity, ascorbic acid, sugar content and pH decreases as temperature increases.

$$\text{Bitterness} = 1.182 + 0.003T \quad (1)$$

$$\text{pH} = 3.29 - 0.01T \quad (2)$$

$$\text{Total acidity} = -0.0086 + 0.00078T \quad (3)$$

$$\text{Original gravity} = 1054 - 0.44T \quad (4)$$

$$\text{Ascorbic acid} = 280.45 - 5.474T \quad (5)$$

$$\text{Sugar content} = 12.42 - 0.05T \quad (6)$$

The results in Table 1 shows that bitterness of the soft drink increases with increase in temperature from 1.27 EBU at 30°C to 1.33 EBU at 50°C. These values were still within the permissible limits of Nigerian Industrial Standards (NIS) as stated in Table 4. The pH also changes with temperature and decrease from 2.99 at 30°C to 2.78 at 50°C, showing a slight increase in acidity as the temperature increases. However, these values were still within the acceptable limit of National Science Education Standards (NSES) for Soft drinks (NSES, 2005). Increase in temperature causes auto- dissociation of more acid molecules in the system, causing the release of more H⁺ ions leading to increased acidity and decreased pH value. Temperature imparts on pH in two ways by causing dissociation of the sample solution and by altering the performance of the pH electrodes slightly (<https://www.techiescientist.com>). Temperature is inversely proportional to pH (www.awe-ltd.co.uk). Total acidity is the measure of the total acid content of the drink solution or

Table 3. Mean values of the different quality requirements of non-alcoholic malt drink sold in local market in Nigeria at different temperatures

Parameters	Storage temperature (°C)				
	30	35	40	45	50
Bitterness (EBU)	6.6±0.1 ^{1)a2)}	7.5±0.1 ^b	8.1±0.1 ^b	8.9±0.1 ^c	9.7±0.1 ^d
pH	5.00±0.01 ^a	4.99±0.01 ^a	4.74±0.02 ^b	4.65±0.01 ^b	4.52±0.01 ^c
Total acidity as citric acid (%)	0.006±0.001 ^a	0.009±0.001 ^a	0.016±0.001 ^b	0.020±0.001 ^c	0.025±0.001 ^d
Ethyl alcohol (%v/v)	ND ³⁾	ND	ND	ND	ND
Original gravity °Saccharin (%v/v)	1055±1.0 ^a	1053±1.0 ^a	1051±1.0 ^b	1047±1.0 ^c	1045±1.0 ^c
Ascorbic acid (mg/L)	441.13±0.02 ^a	353.04±0.01 ^b	264.78±0.01 ^c	169.97±0.01 ^d	87.30±0.01 ^e
Sugar content (mg/L)	14.0±0.1 ^a	13.9±0.1 ^a	13.8±0.1 ^b	13.6±0.1 ^b	13.4±0.1 ^c

¹⁾Values reported in mean±SD (n=3).

²⁾Different superscript letters indicate significant difference (p<0.05) between values in the same row.

³⁾Not detected.

Table 4. Standards for non-alcoholic malt drink (NIS 290, 2013) specific requirements¹⁾

Parameters	Unit	Standard malt drinks	Light malt drinks	Low sugar malt drinks
Original gravity	°Saccharin (% v/v)	1,060±5	1,050±5	1,020±5
Ethyl alcohol	(% v/v)	Nil	Nil	Nil
Carbon dioxide at 20°C	g/L	4.5–6.2	4.5–6.2	4.5–6.2
Sugar	(% v/v)	10–16	2.5–9.0	<2.5
pH	N/A	4.5±0.5	4.5±0.5	4.5±0.5
Total air (max.)	mL/L	5.0	5.0	5.0
Colour	EBC	100–300	100–300	100–300
Bitterness (isohumulone)	EBU	5–16	5–16	5–16
Ascorbic acid	mg/L (min.)	150	150	150
Sulphur dioxide	mg/L (max.)	50	50	50

¹⁾Standards Organisation of Nigeria (SON), 2013.

the total number of hydrogen ions present in a substance in the form of fixed and volatile acids. Citric acid which is the most common acid used in soft drinks production is relevant to NIS 217:2008 because it is an acidifier, flavouring agent, chelating agent and also a preservative in food and beverages like soft and non-alcoholic drinks. The values of total acidity in Table 1 also increased with temperature from 0.014% at 30°C to 0.030% at 50°C, but still within acceptable limits of NIS in Table 2. Ethyl alcohol is a requirement in the standards used to ascertain whether fermentation which is the chemical breakdown of sugars by yeast producing alcohol and carbon dioxide occurred during manufacture of soft and non-alcoholic malt drinks or not. There was no result in Table 1 as the temperature increased from 30°C to 50°C, indicating that no fermentation has taken in the soft drink yet. The results in Table 1 also showed that the original gravity, often called original extract, decreases with increase in temperature from 1,041 °Saccharin (%v/v) at 30°C to 1,032 °Saccharin (%v/v) at 50°C and it still within permissible limits of NIS (see Table 4). Original gravity is the measure of the

solids content initially in the wort before fermentation may or may not have commenced. It is relevant in the standards because it indicates the richness of the solids content in the wort, which is the total fermented and unfermented sugar. Ascorbic acid as the precursor of vitamin C, a vitamin found in various foods like citrus fruits, dietary supplement and green vegetables. It is required in the standards as it is essential in maintaining healthy connective tissue and enzymatic production of certain neurotransmitters (Webber et al., 1996). Its values in Table 1 showed that it decreases as the temperature increases, from 116.52 mg/L at 30°C to 6.74 mg/L at 50°C, but still within the acceptable limits of NIS as stated in Table 4. However, these values vary greatly from those reported by Jingyan et al. (2013) and Jutkus et al. (2015) who studied the thermal decomposition of ascorbic acid and effect of temperature and chemical stability of various forms of vitamin C respectively. This could be attributed to the fact that they studied ascorbic acid and vitamin C purely and not in a mixture with other substances or ingredients in a soft drink where there may be interferences and reaction between

ascorbic acid and other constituents as the temperature increases to 50°C and above. Also, the form or source of ascorbic acid used in soft drinks could be different from that used in pharmaceuticals. Besides, these results also agree with Sarkar et al. (2021) that studied the effect of drying on vitamins, carotenes, organic acids and minerals content of mango and reported that drying significantly affects vitamin A and C content by a decrease of 20.32-92.69% and 29.94-143%, respectively. This is as a result of the increase in temperature during the drying process and period. The results in Table 1 also revealed that the sugar content of soft and non-alcoholic drinks changes with temperature. The sugar content of the soft drink decreases with increase in temperature from 10.9 mg/L at 30°C to 9.9 mg/L at 50°C but within the permissible limit of NIS (see Table 4). The reduction in sugar content with increase in temperature is due to the breaking down of sugar into simpler ones, followed by dehydration and fragmentation into aldehydes or ketones (ACBI, 2016). The results of the analysis in Table 1 shows that all standard requirements of the soft drink studied though still within the acceptable limit of NIS, change gradually/linearly with increase in temperature, indicating that deterioration of the drink may occur at temperatures of 45°C and above over a long period of storage time. Regression analysis in Fig. 1-6 showed a linear relationship between the quality parameters with storage temperature.

3.2. Regression equations for non-alcoholic malt drink (where T=temperature)

All the following equations indicate a linear relationship with temperature. Bitterness and total acidity increases as storage temperature increases, while original gravity, ascorbic acid, sugar content

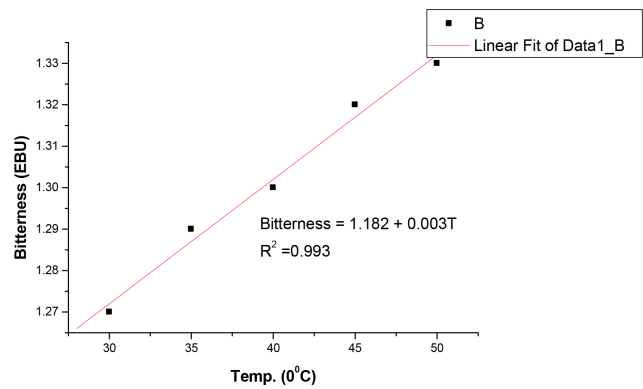


Fig. 1. Regression curve of bitterness against temperature. ¹⁾The regression equation ($\text{Bitterness} = 1.182 + 0.003T$) shows a linear relationship between bitterness and temperature. It increases as temperature increases.

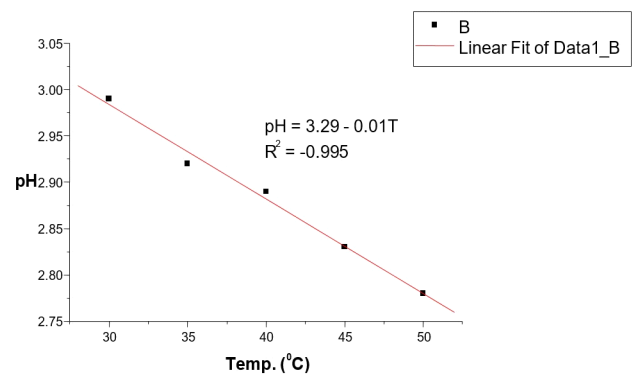


Fig. 2. Regression curve of pH against temperature. ¹⁾The regression equation ($\text{pH} = 3.29 - 0.01T$) shows a linear relationship between pH and temperature. It decreases as temperature increases.

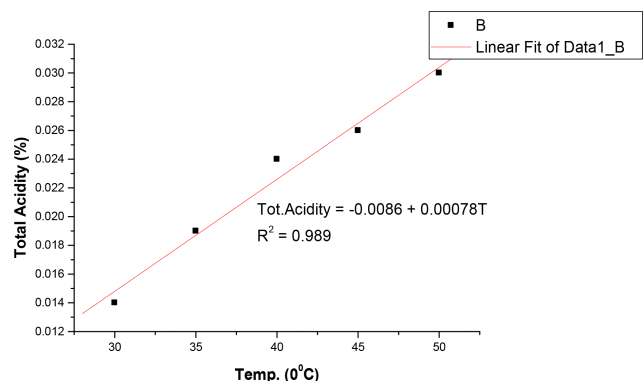


Fig. 3. Regression curve of total acidity against temperature. ¹⁾The regression equation ($\text{Tot. Acid} = -0.0086 + 0.00078T$) shows a linear relationship between total acidity and temperature. It increases as temperature increases.

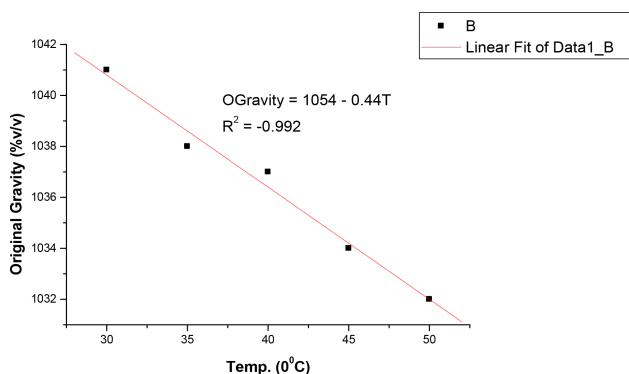


Fig. 4. Regression curve of original gravity against temperature.
 1) The regression equation (Original Gravity = 1054 - 0.44T) shows a linear relationship between original gravity and temperature. It decreases as temperature increases.

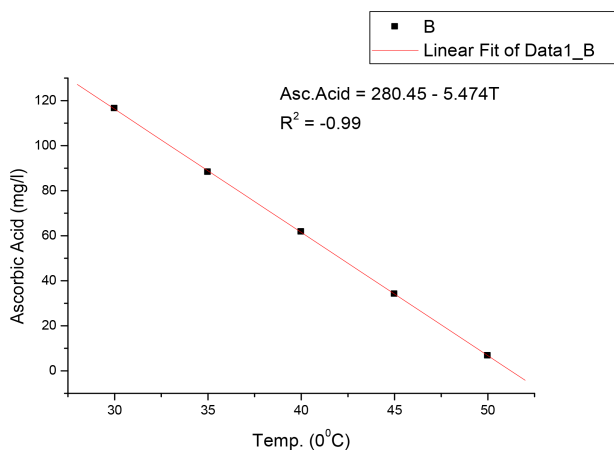


Fig. 5. Regression curve of ascorbic acid against temperature.
 1) The regression equation (Asc. Acid = 280.45 - 5.474T) shows a linear relationship between ascorbic acid and temperature. It decreases as temperature increases.

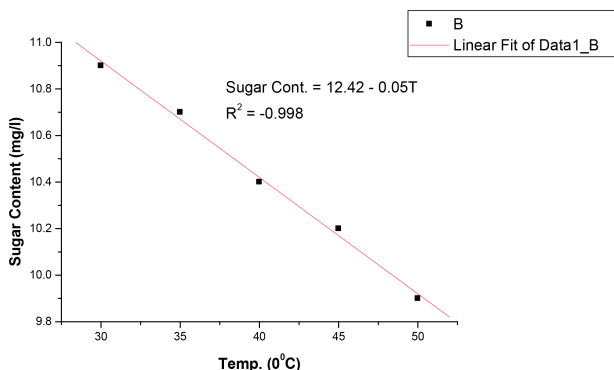


Fig. 6. Regression curve of sugar content against temperature.
 1) The regression equation (Sugar Cont. = 12.42 - 0.05T) shows a linear relationship between sugar content and temperature. It decreases as temperature increases.

and pH decreases as temperature increases.

$$\text{Bitterness} = 2.08 + 0.152T \tag{7}$$

$$\text{pH} = 5.82 - 0.026T \tag{8}$$

$$\text{Total acidity} = -0.024 + 0.00098T \tag{9}$$

$$\text{Original gravity} = 1070.8 - 0.52T \tag{10}$$

$$\text{Ascorbic acid} = 975.83 - 17.82T \tag{11}$$

$$\text{Sugar content} = 12.42 - 0.05T \tag{12}$$

The results in Table 3 showed that bitterness of the non-alcoholic malt drink increases with increase in temperature from 6.6 EBU at 30°C to 9.7 EBU at 50°C. These values were still within the permissible limits of NIS as stated in Table 4. Bitterness is obtained when non-alcoholic malt drinks made from malted barley are seasoned with hops (Brown and Clubb, 2013). It is a requirement because it does not only give the required taste but also acts as a preservative. The pH decreases with temperature and decrease from 5.0 at 30°C to 4.52 at 50°C, showing a slight increase in acidity as the temperature increases. However, these values were still within the acceptable limit of NIS shown in Table 4. The total acidity also changes as the temperature increases. It appreciated with temperature rise from 0.006 at 30°C to 0.025 at 50°C but still within the acceptable limits of NIS shown in Table 2. It is expressed in terms of citric acid content, i.e., hydrogen bonding between the oxygen atom and the hydrogen atom is broken to form the citrate as the temperature rises, releasing the hydrogen ion into the solution and reducing the pH leading to increased acidity. This may affect the quality of malt drinks negatively with time. Ethyl alcohol content of the malt was not affected by the rise in temperature like the case of the soft drink as shown in Table 1 and 3, indicating that no

fermentation has taken place, and is acceptable by NIS standards. The results in Table 3 also showed that original gravity of the malt drink studied decreases with increase in temperature from 1,055 °Saccharin (%v/v) at 30°C to 1,045 °Saccharin (%v/v) at 50°C but within the acceptable limits of NIS for standard malt drinks and light malt drinks of 1,060 and 1,050 °Saccharin (%v/v), respectively, but slightly above the low sugar malt drinks of 1,020 °Saccharin (%v/v) as shown in Table 4. The malt sample used in this study was in the category of standard malt drinks.

Original gravity is the measure of the solids content initially in the wort before fermentation may or may not have commenced. It is relevant in the standards because it indicates the richness of the solids content in the wort, which is the total fermented and unfermented sugar [Standards Organisation of Nigeria (SON, 2013)]. Ascorbic acid (vitamin C precursor) content of the malt drink also change with temperature as shown in Table 3. It decreases with increase in temperature from 441.13 mg/L at 30°C to 87.30 mg/L at 50°C, yet its values were still within the permissible limits of NIS in Table 4. This shows that storing malt drinks at 40°C and above for a long period reduces the ascorbic acid (vitamin C) content and other parameters below or above NIS standards deteriorate the quality of the malt drink. This results agree with the fact that vitamins, carotenes, organic acids, minerals etc. are significantly affected by temperature. Increase in temperature results in a decrement in vitamin A and C (Sarkar et al., 2021). The sugar content as revealed in Table 3 indicates that it decreases as the temperature rises from 14.0 mg/L at 30°C to 13.4 mg/L at 50°C but within the acceptable limits of NIS shown in

Table 4. As mention earlier, increase in temperature affects the sugar content of malt drinks and the other quality requirements of soft and non-alcoholic drinks based on the results of this study. Regression analysis in Fig. 7-12 showed a linear relationship between the quality parameters and storage temperature.

The novelty of this research is the fact that, it is the first study on the effect of storage temperature on the quality requirements of soft and non-alcoholic drinks in Nigeria. This study has also expose the fact that the potency and nutritional value of soft and non-alcoholic drinks does not just depend on the shelf-life alone but also on the storage temperature from the time of production to the time of consumption. Besides, both the regulatory agencies, manufacturers and consumers will no longer depend on the expiry date alone as a sign of potency of the drinks but also on the preservation mode and temperature.

In summary, this study has been able to establish that the different quality requirements of soft and non-alcoholic malt drinks changes linearly as the storage temperature increases over time which might lead the reduction of their quality, potency and nutritional value, even when the official expiry date has not reached. Besides, most manufacturers, sellers, consumers and even regulatory agency personnel may not even know that deterioration has gradually started since the expiry date is still far. Although these drinks are sometimes labeled “best served when chilled”, how many sellers or vendors are able to preserve them in a refrigerator for long in Nigeria with inadequate electrical power supply challenge in rural areas of the country. What about the manufacturers and major distributors who store these drinks in large

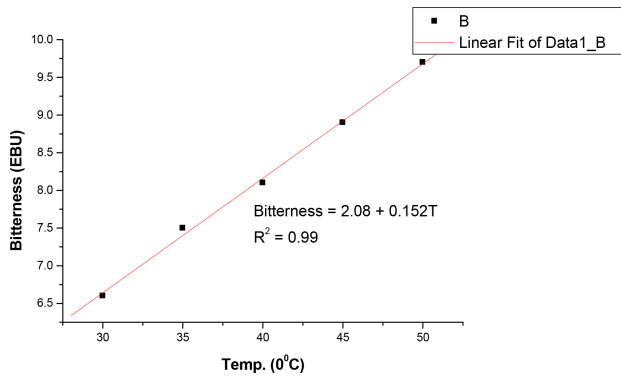


Fig. 7. Regression curve of malt bitterness against temperature. ¹⁾The regression equation ($Bitterness = 2.08 + 0.152T$) shows a linear relationship between bitterness and temperature. It increases as temperature increases.

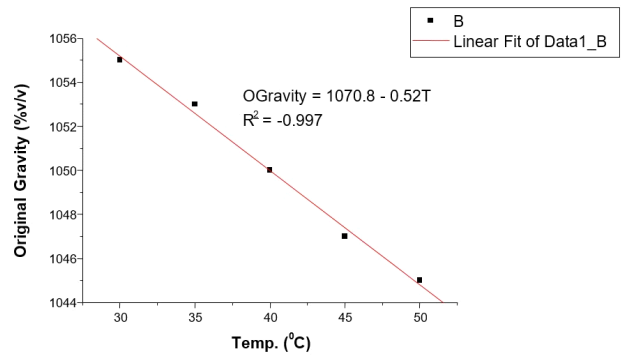


Fig. 10. Regression curve of malt original gravity against temperature. ¹⁾The regression equation ($OGravity = 1070.8 - 0.52T$) shows a linear relationship between original gravity and temperature. It decreases as temperature increases.

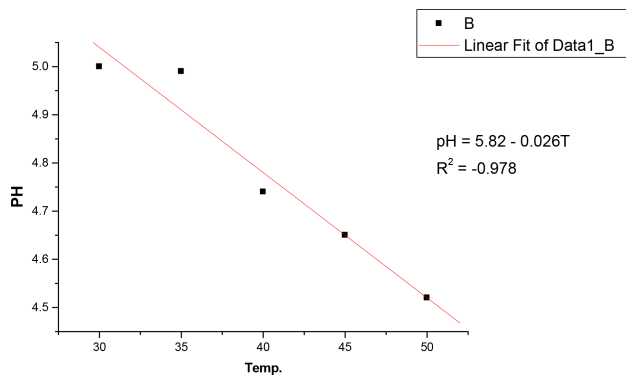


Fig. 8. Regression curve of malt pH against temperature (°C). ¹⁾The regression equation ($pH = 5.82 - 0.026T$) shows a linear relationship between pH and temperature. It decreases as temperature increases.

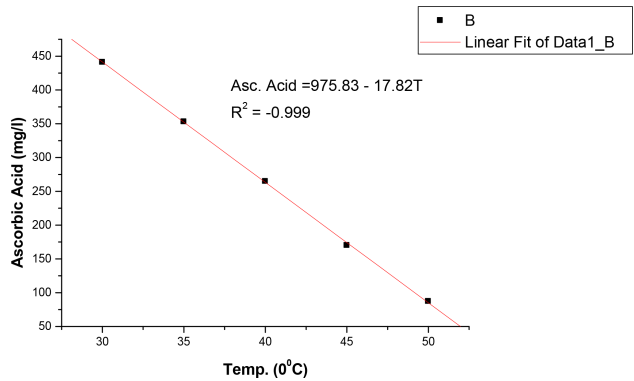


Fig. 11. Regression curve of malt ascorbic acid against temperature. ¹⁾The regression equation ($Asc. Acid = 975.83 - 17.82T$) shows a linear relationship between ascorbic acid and temperature. It decreases as temperature increases.

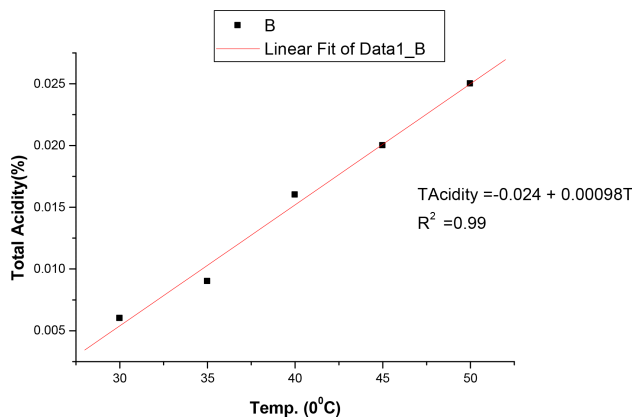


Fig. 9. Regression curve of malt total acidity against temperature. ¹⁾The regression equation ($T. Acidity = 0.024 + 0.00098T$) shows a linear relationship between total acidity and temperature. It increases as temperature increases.

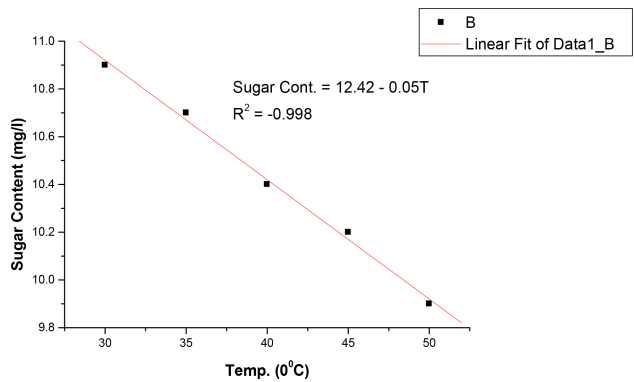


Fig. 12. Regression curve of malt sugar content against temperature. ¹⁾The regression equation ($Sugar Cont. = 12.42 - 0.05T$) shows a linear relationship between sugar content and temperature. It decreases as temperature increases.

quantities in warehouses? Yet the average room temperature of most tropical countries like Nigeria is 30°C and above. This implies that the quality and potency is not dependent on the shelf-life (the gap between the manufacturing and the expiry date) alone, but also on the storage temperature. Thus, regulatory agencies need to consider the effect of storage temperature on the quality of these drinks and their mode of preservation, in order to safeguard the health of the people.

4. Conclusions

The major findings revealed that the storage or preserving temperature of soft and non-alcoholic malt drinks affects their quality requirements or standards gradually/linearly over time. Also, the potency and nutrition value of drinks should not be judged based on their manufacturing or expiry dates alone but on the storage temperature also. Therefore, it is recommended that the storage temperature for drinks should always be 25°C and below, and they should be stored by refrigeration. Also, the relevant government regulatory agencies should no longer monitor and evaluate their quality by checking expiry dates alone, but by carrying out quality control test/analysis half way into the shelf-life of these drinks and advise the manufacturers and consumers on the favourable storage temperature and conditions.

Acknowledgements

Authors acknowledged the assistance of Dr. Stephen Adalikwu and the Jawaharlal Nehru Centre for Advance Scientific Research, Jakkur, Bangalore, India, for using their Laboratory.

Conflict of interests

The authors declare no potential conflicts of interest.

Author contributions

Conceptualization: Akpe MA. Methodology: Ogbuji MC, Agwupuye JA. Formal analysis: Akpe MA. Validation: Akpe MA, Ogbuji MC. Writing - original draft: Ogbuji MC. Writing - review & editing: Akpe MA, Agwupuye JA.

Ethics approval

This article does not require IRB/IACUC approval because there are no human and animal participants.

ORCID

Michael Akomaye Akpe (First & Corresponding author)

<https://orcid.org/0000-0001-7258-7427>

Michael Chukwudi Ogbuji

<https://orcid.org/0000-0002-3575-2048>

John Akwagiobe Agwupuye

<https://orcid.org/0000-0002-1798-1058>

References

- ACBI. Characteristics of the thermal degradation of glucose and maltose solutions, 2016. Available from: <https://www.acbi.nlm.nih.gov>. Accessed Jan. 8, 2020.
- AOAC. Official Methods of Analysis. 18th ed, Association of Official Analytical Chemists, Washington DC, USA, p 935-970 (2005)
- Awe-Ltd. How does temperature affect measured pH value? Available from: www.awe-ltd.co.uk. Accessed Aug. 9, 2021.
- Bamfort S. 2002. Health benefits of non-alcoholic malt drinks. Available from: <https://www.seg.biz>press.release>. Accessed, Dec. 10, 2019.
- British Pharmacopeia. 4th ed, Vol. 1, Britain (2003)
- Brown AJ, Clubb J. The antiseptic properties of hops. Available from: <https://www.researchgate.net>. Accessed Feb. 3, 2020.
- Davey MW, Van Monatgu M, Sanmatin M, Kanellis A, Smirnoff N, Benzie IJ, Strains JJ, Favell D, Fletcher J. Plant L-ascorbic acid: Chemistry,

- function, metabolism, bioavailability and effects of processing. *J Sci Food Agric*, 80, 825-860 (2000)
- EBC. European Brewery Convention. Original Gravity °Saccharin (%) (v/v). UK, 9.43.1 (2018)
- FAO/INFOODS Databases in Nigeria 2018. Density database version 2.0. Available from: www.fao.org/density_DB_V2_0_01. Accessed Dec. 9, 2019.
- Jingyan S, Yuwen L, Zhiyong W, Cunxin W. Investigation of thermal decomposition of ascorbic acid by TG-FTIR and thermal kinetics analysis. *J Pharm Biomed Anal*, 77, 116-119 (2013)
- Johnson OR, Yetu AJ, Oloruntoba AC, Samuel S. Effects of Nigeria market storage conditions on ascorbic acid contents of selected tetrapak packaged citrus fruit juice. *J Agric Biol Sci*, 8, 179-183 (2013)
- Jutkus RA, Li N, Taylor LS, Mauer LJ. Effect of temperature and initial moisture content on the chemical stability and color change of various forms of vitamin C. *Int J Food Prop*, 18, 862-879 (2015)
- Kamil G. Technological development in production methods for alcohol free malt beverages. *Drink Technology Market*, 5, 22-24 (2003)
- Livonen J, Partington PY. Global: Malt-based drinks set for healthy growth. *Euromonitor Int*, 28, 11 (2007)
- Lommi H, Ahvenainen J. Process for the production of non-alcoholic or low alcohol malt beverage. Available from: www.freepatentsonline.com. Accessed Jan. 8, 2020.
- Lugasi A, Hovari J. Antioxidant properties of commercial alcoholic non-alcoholic beverages. *Nahrung*, 47, 79-86 (2003)
- Maurice SM. *The Soft Drinks Companion: A Technical Handbook for the Beverage Industry*. CRC Press, Boca Raton, USA, p 11-25 (2010)
- Murcia MA, Lopez-Ayerra B, Martinez-Tome M, Vera AM, Garcia-Carmona F. Evolution of ascorbic acid and peroxidase during industrial processing of broccoli. *J Sci Food Agric*, 80, 1882-1886 (2000)
- Murray CR, Van der Meer WJ. Improvements in production of fermented malt beverages. *Biotechnol Adv*, 15, 276 (1997)
- Nigeria Industrial Standard-NIS 217. Standards for Soft Drinks. Standards Organisation of Nigeria (SON), (2008)
- Nigerian Industrial Standard-NIS 290. Standards for Malt Drinks. Standards Organisation of Nigeria (SON), (2013)
- National Science Education Standards (NSES). pH Value for Soft Drinks. National Academy Press, Washington DC (2005) Available from <https://www.nsta.org/news/story>. Accessed Aug. 11, 2019.
- Obuzor A, Ajazi O. Nutritional content of popular malt drinks produced in Nigeria. *Academic journals*, 2010. Available from: www.academicjournals.org. Accessed Dec. 10, 2019.
- Pune, India-February 14, 2010. Composition of soft and non-alcoholic malt drinks. Available from: <https://en.m.wikipedia.org>. Accessed Oct. 7, 2019.
- Rickman JC, Bruhn CM, Barrett DM. Nutritional comparison of fresh, frozen and canned fruits and vegetables II: vitamin a and carotenoids, vitamin e, minerals and fibre. *J Sci Food Agric*, 87, 920-944 (2007)
- Sarkar T, Salauddin M, Sheikh HI, Pati S, Chakraborty R. Effect of drying on vitamins, carotenes, organic acids, mineral composition and microstructural properties of mango (*Mangifera indica*). *J Food Process Preserv*, 46, e16237 (2021)
- Techiescientist. Does temperature affect pH? Available from: <https://www.techiescientist.com>. Accessed Aug. 18, 2021.
- Weber P, Bendich A, Schaleh W. Vitamin C and human health: A review of recent data and relevant to human requirements. *Int J Vitam Nutr Res*, 66, 19-30 (1996)