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Evaluation of chemical composition, microbial quality and sensory acceptability of beetroot-ginger flavoured functional drinks sweetened with date syrup

Arukwe Dorothy Chinomnso*[1], Omodamiro Rachel Majekodunmi[2], Nwanagba Nkeiruka Lilian[1], Ijioma Chigozie Nelson[1]

[1]*Department of Food Science and Technology, College of Applied Food Sciences and Tourism, Michael Okpara University of Agriculture, Umudike, Abia State, Nigeria.*

[2]*National Root Crops Research Institute, Umudike, Nigeria, Kampala International University, Uganda.*

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ABSTRACT

This study evaluated the phytochemical, vitamin, microbial quality and sensory acceptability of functional drinks produced from blends of beetroot and ginger sweetened with date fruit syrup. Six blends were proportioned from juices of beetroot and ginger sweetened with date syrup and labeled as samples ICN (100:0), CHO (95:5), NGO (90:10), OJO (85:15), DMJ (80:20) and OJK (70:25) where sample ICN served as the control. The phytochemical, vitamin and microbial quality of the functional drinks were determined using standard analytical methods, while the sensorial evaluation was done by the 9-point hedonic scale. The results depicted that noticeable disparities ($p<0.05$) existed in the phytochemical and vitamin content of the functional drinks. The phytochemical content ranged from 0.1-0.38 mg/100 mL and 0.21 – 0.43 mg/100 mL for flavonoid and phenol respectively. The vitamin content results showed that vitamin A decreased, while vitamins B9 and C increased with a rise in the proportion of ginger in the mixtures. The microbial results showed that the bacterial and fungal loads decreased significantly ($p<0.05$) with the rise in the inclusion of ginger into beetroot. However, the bacterial and fungal loads of the functional drinks increased as the days of storage increased to 28 days. No coliform was detected in the drinks up to the 28th day of storage. The sensory results showed that sample NGO (90:10; beetroot: ginger) had the highest scores for appearance, aroma, taste, mouth feel and general acceptability. This study has shown that microbiologically safe functional drinks can be produced from blends of beetroot and ginger sweetened with date syrup.

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1. Introduction

Functional beverages are non-alcoholic drinks that contain different nutrients such as ascorbic acid, Tocopherol, beta-carotene, among others, and offer benefits of dietary phytochemicals (1). It has been reported that consumption of functional foods and drinks would deliver health and wellness to consumers (2).

*Corresponding author. Tel.: +2348063646516
E-mail address: Dorarukwe@gmail.com

Functional beverage category is one of the most significant drivers of new product development (NPD) in recent years, and the market for functional drinks is predicted to enlarge more oing to the inclination toward lifestyle diseases (3) such as diabetes, hypertension, high cholesterol, among others.

Beetroot (*Beta vulgaris*) is found to be the 10th most powerful vegetable with antioxidant properties (4) which helps to prevent oxidative damage to cells thereby reducing the risks of cancer and cardiovascular diseases. Other than as a food, it plays another role as a natural colorant. Garden beet juice is a popular health food. Ginger *(Zingiber officinale)* is a medicinal plant that has been widely used all over the world, and it has anti-microbial activity and thus can be used in the treatment of bacterial infections (5). The presence of ginger in nutraceutical preparation possibly will provide defense against diabetes, cardiac and hepatic disorders (6).

Date syrup is a concentrated and liquid date sugar which is a natural sweetener extracted from date fruit. Dates contain large quantities of sugars, majorly fructose and glucose but reduced in fat and protein. Date is a reasonable source of many minerals and vitamins such as potassium, phosphorous, calcium, iron and zinc, and vitamin A, B1, B2, B3 and C (7). Date fruit is also a good source of antioxidants with good free radical scavenging property. It also has antihyperlipidemic, and anticancer properties (8). It is expected that the functional drinks produced from the blends of beetroot, ginger and date will offer some health benefits to the consumers such as protection from diabetes, cardiovascular related problems, cancer, high cholesterol, among others.

In spite of being rich in nutrients and having several health benefits, knowledge about beetroot consumption is very low and is limited to a small group of people. Thus, beetroot has suffered the problem of under-utilization. Also, the earthy flavor of beetroot is a drawback to its utilization. Therefore, the addition of ginger and date syrup to beetroot in juice production will impart a pronounced flavor, mask the earthy smell of beetroot, and sweeten the drink. Furthermore, in the recent times, people are very conscious of their nutrition and safety of their diets especially locally produced foods and drinks. Therefore, it is very pertinent to ascertain the microbial quality of any new product being introduced to consumers. This study will provide relevant information on the use of blends of beetroot, ginger and date fruit as functional drinks, and this will also help to improve the income of people involved in cultivation of the crops, production and marketing culminating in uplifting their living standards. More so, production of the functional drinks at commercial level may benefit the economy of Nigeria. The major goal of this study was to assess the phytochemical composition, vitamins contents, microbiological quality and sensory acceptability of beetroot-ginger flavoured functional drinks sweetened with date syrup.

2. Materials and Methods

2.1. Sources of raw materials

The matured fresh tubers of beetroot (*Beta vulgaris*), ginger (*Zingiber officinale*) and date fruit (*Phoenix dactylifera*) used for the study were procured from Building material market, Jos, Plateau State. All reagents for analysis were obtained from Biotechnology Laboratory of National Root Crops Research Institute, Umudike, Abia State.

2.2. Methods of sample preparation

2.2.1. Production of beetroot juice

Some quantities (3 kg) of beetroot tubers were sorted, washed, the skin scraped off, and rewashed. The tubers were sliced into 2-3 mm thickness, blended (Philips HR 2000 blender) into mash for 10 min. The mash obtained was mixed with water (1:1 w/v) and the resultant drink was filtered with muslin cloth folded into 2, 4 and 8 layers respectively, and beetroot juice was obtained (9). 2.2.2. Production of ginger juice Some quantities (2 kg) of ginger were washed and scrapped to remove superficial skin, and cut into small pieces of about 1-2 mm thickness, and then blended (Philips HR2000 blender) for 10 min. Water was added to the blended ginger (1:1 v/w). The mixture was then filtered through muslin cloth, the fibers were removed and ginger juice was obtained.

2.3. Processing of date syrup

One kilogram (1 kg) of date fruit were sorted, weighed, washed, the seed removed. The date was boiled to softness at 65°C for 10 min, and left to cool. It was then grated into mash with water (1:3 w/v). Date syrup was extracted using a muslin cloth folded into layers for proper extraction.

2.4. Formulation of beetroot-ginger flavoured functional drinks sweetened with date syrup

Preparation of the drinks involves the combination of the beetroot juice and the ginger juice with addition of date syrup as sweetener in six different blends (Table 1). The blends were labelled ICN, CHO, NGO, OJO, DMJ and OJK respectively. The mixtures were pasteurized at (LTLT at 63°C for 20 min) and packaged using a sterilized bottle by hot filling to help inactivate harmful microorganisms that could spoil the product and also improve sealing of the bottle. The packaged drink was held for 5 min (upward and inversion) to have a proper mixture, then cooled at room temperature before using for analysis.

Table 1. Formulation of beetroot-ginger flavoured functional drink sweetened with date syrup

Sample	Beetroot %	Ginger %
ICN	100	0
CHO	95	5
NGO	90	10
OJO	85	15
DMJ	80	20
OJK	75	25

2.5. Methods of analysis

2.5.1. Phytochemicals content determination

2.5.1.1. Total phenolic content

Total phenolic content was analyzed using the Folin-Ciocalteucolorimetric process (10). A portion (0.3 mL) of the functional drink was combined with Folin-Ciocalteuphenol reagent (2.25 mL). After 5 min, 6% sodium carbonate (2.25 mL) was added and the mixture was allowed to stand at room temperature for 90 min. The absorbance of the mixture was measured at 725 nm. Standard calibration curve for gallic acid in the range of 0-200 g/mL was prepared in the same manner and the result (total phenol) was expressed as mg/Gallic Acid Equivalent (GAE) per gram of extract (mg/GAE/100 g).

Total phenol= C x V/W

Note: C = concentration of gallic acid calculated from the calibration curve in mg/mL, V= volume of extract in mL, W= weight of plant ethanolic extract in g

2.5.1.2. Total flavonoid content

Total flavonoid content was determined colorimetrically using aluminum chloride ($AlCl_36H_2O$) solution and quercetin as described by Onwuka (10). One (1) mL of sample extract was placed in a 10 mL volumetric flask containing 5 mL of distilled water and 0.3 mL of 5% sodium nitrite was added and mixed. After 5 min, 0.3 mL of 10% aluminum chloride solution ($AlCl_36H_2O$) was added and the mixture was allowed to stand for another 6 min, after which 2 mL of 1 M sodium hydroxide was added and properly mixed. Absorbance of the mixture was read at 510 nm after 15-30 min, with a spectrophotometer. Quercetin (10-750 μg/mL) was used to plot a standard curve. Total flavonoid content was expressed as milligram quercetin equivalent per gram of sample mg QE/100 mL.

$$\% \text{ flavonoid} = \frac{W_3-W_2}{W_1} \times \frac{100}{1}$$

Note: W_1= Weight of sample, W_2= Weight of empty flask, W_3= Weight of flask and residue

2.5.2. Determination of vitamins

2.5.2.1. Determination of vitamin A (Retinol)

The vitamin A content of the drink was analyzed using the method described by Onwuka (10). Five (5) grams of each sample was dissolved in 30 mL of absolute alcohol (ethanol) and 3 mL of 5% potassium hydroxide was added to it. The mixture was boiled under reflux for 30 min and was cooled quickly with running water and filtered. Then 30 mL of distilled water was included and the blend was moved into a separating funnel. Three portions of 50 mL of ether were used to wash the mixture, the lower layer was discarded and the upper layer was washed with 50 mL of distilled water. The extract was evaporated to dryness and dissolved in 10 mL of isopropyl alcohol and its absorbance was measured at 325 nm.

$$\text{Vitamin A (100 g/mg)} = \frac{100 \times Au \times C}{W \times As}$$

Note: Au =Absorbance of test sample, As = Absorbance of standard solution,

C = Concentration of the test sample, W= Weight of sample

2.5.2.2. Determination of vitamin C (Ascorbic acid)

The vitamin C content was determined by the Onwuka (10) method. Fifty (50) mL of the functional drink samples was pipetted into 100 mL volumetric flask in duplicate. Then 25 mL of 20% metaphosphoric (0.5% oxalic acid) was added as a stabilizing agent and was diluted with distilled water to 100 mL volume. It was then titrated with indophenol solution (2, 6 dichlorophenol indophenol) to a faint pink colour which persisted for 15 s. The calculation of milligram (mg) vitamin C was expressed as:

Vitamin C = mg/100 mL Juice = 20(v) x (c)

Note: v = mL indophenol solution in titration, c = mg vitamin C/mL indophenol

2.5.2.3. Determination of vitamin B9 (Folic acid)

The method reported by Nagaraja (11) was employed to analyze the vitamin B9 composition. Approximately 0.1 mL of the sample was pipetted into a volumetric flask and then liquified in 10 mL alkaline solution (0.1 mol $NaHCO_3$). It was then seperated and 1.0 mL solution was obtained. Then 2.5 mL of 1, 2-Naphthoquine-4-Sulphonate (NQS) was added into the volumetric flask and followed to mark by buffer solution of pH 11 ($NaOH/NaHCO_3$) to form deep yellow product. Then the reaction was completed to volume by buffer solution, and the resulting solution was measured at 436 nm against reagent blank treated similarly.

2.6. Microbial analysis

Bacterial, coliform and fungal counts were analyzed using nutrient agar (NA), MacConkey agar (MCA), and potato dextrose agar (PDA) respectively. One milliliter (1 mL) of every sample was sequentially moved into nine milliliters (9 mL) of the sterile diluents (peptone water) with a sterile pipette and agitated forcefully. Sequential dilution was unstopped till 10^6 dilution was procured (Cheesbrough, 2006). Aliquot portion (0.1 mL) of the 10^3, $10^4 10^5$, etc., dilutions were inoculated onto newly prepared, surface-dried nutrient agar and MacConkey agar respectively. Equal amount (0.1 mL) of the 10^4 dilution was inoculated upon potato dextrose agar. The inoculi were dispersed with a sterile (hockey stick-like) glass spreader to procure equal portion of isolates after brooding. Nutrient agar and MacConkey agar plates were brooded for 24 - 48 h at 37 ^oC, while PDA was maintained at room temperature (28 ± 02 ^oC) for 3-5 days (12). Total plate numbers for the nutrient and MacConkey Agar were done by enumerating colonies at the opposite face of the culture plates. Total colony count was transcribed in colony forming units per milliliter (cfu/mL).

2.7. Assessment of sensory characteristics of the functional drinks

The sensory attributes (appearance, taste, mouth feel, aroma, and general acceptability) of the beetroot-ginger flavoured functional drinks sweetened with date syrup were assessed by 20 semi-trained panellists who were students from the College of Applied Food Sciences and Tourism, Michael Okpara University of Agriculture, Umudike. A 9-point Hedonic scale was employed with 1 = dislike extremely, 5 = neither like nor dislike, and 9 = like extremely (13). The panellists were advised to rinse their mouths with water after tasting each sample and not to make comments during the assessment to avoid biasing other panellists decisions. They were also instructed to remark candidly about the samples on the questionnaires presented to them.

2.8. Experimental design

This study employed the completely randomized design.

2.9. Statistical analysis

All the analyses were done in triplicate. The data generated were analyzed by the one-way analysis of variance (ANOVA) using the SPSS version 23.0 software. The data analyzed were transcribed as mean ± SD (standard deviation). The Duncan Multiple Range Test (DMRT) method was employed to compare the means of experimental data at 95 % confidence interval ($p<0.05$).

3. Results

3.1. Phytochemical and vitamin contents of beetroot-ginger flavoured functional drinks sweetened with date syrup

Table 2 shows the phytochemical and vitamin contents of the functional drinks. There were significant ($p<0.05$) differences among the flavonoid contents of the functional drinks which ranged from 0.14 to 0.38 mg/100 mL. The highest flavonoid content was recorded in DJK (75% beetroot and 25% ginger) whereas sample ICN (100% beetroot) had the least value. It was observed that an increase in the proportion of ginger brought about a rise in flavonoid content of the drinks.

The phenol contents of the functional drink domain were 0.21 to 0.43 mg/100 mL (Table 2). No notable ($p>0.05$) differences were observed among the phenol contents of the samples CHO and NGO, and between samples OJO and DMJ relatively. Significant ($p<0.05$) difference was observed in samples ICN and DJK with the least and largest values respectively and with the other samples. There was a rise in the phenol contents of the functional drinks with increase in the proportion of ginger.

The vitamin A contents of the drink domain were 31.53 to 48.84 µg/100 mL. There were significant differences ($P<0.05$) among the vitamin A contents of the drinks. Sample ICN (100% beetroot) had the largest value while sample DJK had the least value. The vitamin A content of the drinks decreased as the proportion of ginger increased.

The vitamin B_9 composition of the drink samples domain were 0.32 to 0.92 mg/100 mL. There were notable variations ($p<0.05$) in the vitamin B_9 composition of the drinks. Samples DJK and ICN recorded the largest and least values relatively. The vitamin B_9 content of the drinks improved with the increase in ginger inclusion.

There were notable variations ($p<0.05$) among the vitamin C compositions of the drinks which domain were 23.65 to 43.66 mg/100 mL. Samples DJK and ICN had the largest and least values relatively. It was observed that the vitamin C composition of the drinks went up with the rise in the level of ginger inclusion.

3.2. Bacterial loads of beetroot-ginger flavoured functional drinks sweetened with date syrup

The bacterial load of the functional drinks is presented in Table 3. There were significant ($p<0.05$) differences among the bacteria loads of the functional drinks. It was found that at 0 day, the bacteria load of the drinks ranged from 2.45×10^3 to 4.70×10^3 cfu/mL. Sample ICN (100% beetroot) had the highest bacteria load (4.70×10^3 cfu/mL) whereas sample DJK (75% beetroot and 25% ginger) had the least bacteria load. At the 7th day, the bacteria load for all the samples increased, and ranged between 3.35×10^3 cfu/mL and 5.75×10^3 cfu/mL, with blends ICN and DJK having the largest and least values relatively. This trend of increase in bacterial loads continued as the storage days increased. It was noted that as the level of ginger incorporation into the drink increased, the bacterial loads decreased.

The coliform load of the functional drinks (Table 3) shows that no coliform was detected in the drinks.

3.3. Fungal loads of beetroot-ginger flavoured functional drinks sweetened with date syrup

Table 4 shows the fungi loads of the functional drinks. There were notable ($p<0.05$) variations in the fungi load of the functional drinks. Fungal loads of the drinks ranged from 1.55×10^4 to 5.35×10^4 cfu/mL at 0 day. At 0 day, sample ICN (100% beetroot) had the greatest fungi load (5.35×10^4 cfu/mL), whereas sample DJK (75% beetroot and 25% ginger) had the lowest (1.55×10^4 cfu/mL). At Day 7, the sample ICN also had the highest fungal load (8.45×10^4 cfu/mL) while sample DJK had the least (4.05×10^4 cfu/mL). This direction of increase in fungal loads continued for Days 14, 21 and 28 respectively. It was observed that as the level of ginger incorporation into the drink increased, the fungal loads decreased.

Table 2. Phytochemical and Vitamin Contents of Beetroot-Ginger Flavoured Functional Drinks sweetened with Date Syrup

Samples	Flavonoids Mg/100ml	Phenols Mg/100ml	Vitamin A µg/100ml	Vitamin B9 Mg/100ml	Vitamin C Mg/100ml
ICN	$0.14^{f}\pm0.02$	$0.21^{d}\pm0.01$	$48.84^{a}\pm0.04$	$0.32^{f}\pm0.02$	$23.65^{f}\pm0.02$
CHO	$0.21^{e}\pm0.01$	$0.26^{c}\pm0.01$	$42.13^{b}\pm0.01$	$0.41^{e}\pm0.01$	$28.33^{e}\pm0.03$
NGO	$0.27^{d}\pm0.02$	$0.28^{c}\pm0.01$	$39.32^{c}\pm0.02$	$0.46^{d}\pm0.01$	$31.26^{d}\pm0.01$
OJO	$0.31^{c}\pm0.01$	$0.34^{b}\pm0.01$	$36.04^{d}\pm0.03$	$0.51^{c}\pm0.01$	$34.02^{c}\pm0.01$
DMJ	$0.34^{b}\pm0.18$	$0.35^{b}\pm0.01$	$34.07^{e}\pm0.00$	$0.72^{b}\pm0.01$	$38.15^{b}\pm0.05$
DJK	$0.38^{a}\pm0.0$	$0.43^{a}\pm0.02$	$31.53^{f}\pm0.02$	$0.92^{a}\pm0.01$	$44.66^{a}\pm0.05$

Values are means ± standard deviation of duplicate determination. Mean values in the same column with different superscript are significantly different ($p<0.05$).
Keys: ICN= Drink from 100% beetroot, CHO =Drink from 95% beetroot and 5% ginger, NGO=Drink from 90% beetroot and 10% ginger, OJO = Drink from 85% beetroot and 15% ginger, DMJ =Drink from 80% beetroot and 20% ginger and DJK = Drink from 75% beetroot and 25% ginger

Table 3. Bacterial Loads and Coliform Loads of Beetroot-Ginger Flavoured Functional Drinks sweetened with Date Syrup (cfu//ml)

Samples	Day 0 ($x10^3$)	Day 7 ($x10^3$)	Day 14 ($x10^3$)	Day 21 ($x10^5$)	Day 28 ($x10^6$)	Coliform counts Days (0-28)
ICN	$4.70^{a}\pm0.07$	$5.75^{a}\pm0.21$	$9.45^{a}\pm0.14$	$9.20^{a}\pm0.14$	$9.60^{a}\pm0.14$	ND
CHO	$3.80^{b}\pm0.14$	$5.20^{b}\pm0.07$	$8.85^{b}\pm0.07$	$8.05^{b}\pm0.28$	$8.75^{b}\pm0.14$	ND
NGO	$3.60^{c}\pm0.14$	$5.15^{c}\pm0.21$	$8.35^{c}\pm0.07$	$7.55^{c}\pm0.07$	$8.20^{c}\pm0.07$	ND
OJO	$3.15^{d}\pm0.00$	$4.15^{d}\pm0.00$	$8.10^{d}\pm0.07$	$6.80^{d}\pm0.21$	$7.55^{d}\pm0.28$	ND
DMJ	$2.60^{e}\pm0.07$	$3.55^{e}\pm0.07$	$7.10^{e}\pm0.14$	$5.20^{e}\pm0.28$	$6.20^{e}\pm0.07$	ND
DJK	$2.45^{f}\pm0.00$	$3.35^{f}\pm0.07$	$6.75^{f}\pm0.21$	$3.40^{f}\pm0.14$	$4.75^{f}\pm0.21$	ND

Values are means ± standard deviation of duplicate determination. Mean values in the same column with different superscript are significantly different ($p<0.05$).
Keys: ICN= Drink from 100% beetroot, CHO =Drink from 95% beetroot and 5% ginger, NGO=Drink from 90% beetroot and 10% ginger, OJO = Drink from 85% beetroot and 15% ginger, DMJ =Drink from 80% beetroot and 20% ginger and DJK = Drink from 75% beetroot and 25% ginger

Table 4. Fungal loads of beetroot-ginger flavoured functional drinks sweetened with date syrup (cfu/mL)

Samples	Day 0 ($\times10^4$)	Day 7 ($\times10^4$)	Day 14 ($\times10^4$)	Day 21 ($\times10^5$)	Day 28 ($\times10^6$)
ICN	$5.35^{a}\pm0.07$	$8.45^{a}\pm0.21$	$4.90^{a}\pm0.00$	$7.25^{a}\pm0.07$	$9.15^{a}\pm0.21$
CHO	$4.75^{b}\pm0.07$	$6.35^{b}\pm0.07$	$4.80^{b}\pm0.00$	$6.55^{b}\pm0.14$	$8.65^{b}\pm0.07$
NGO	$3.85^{c}\pm0.07$	$6.25^{c}\pm0.07$	$4.35^{c}\pm0.14$	$6.15^{c}\pm0.21$	$7.45^{c}\pm0.14$
OJO	$3.55^{d}\pm0.07$	$6.15^{d}\pm0.07$	$3.85^{d}\pm0.07$	$5.85^{d}\pm0.21$	$5.55^{d}\pm0.07$
DMJ	$2.15^{e}\pm0.07$	$5.35^{e}\pm0.21$	$3.35^{e}\pm0.07$	$3.80^{e}\pm0.07$	$4.80^{e}\pm0.00$
DJK	$1.55^{f}\pm0.07$	$4.05^{f}\pm0.21$	$3.10^{f}\pm0.21$	$2.45^{f}\pm0.07$	$4.20^{f}\pm0.21$

Values are means ± standard deviation of double analysis. Mean values in the identical column with another superscript are notably distinct ($p<0.05$).
Keys: ICN= Drink from 100% beetroot, CHO =Drink from 95% beetroot and 5% ginger, NGO=Drink from 90% beetroot and 10% ginger, OJO = Drink from 85% beetroot and 15% ginger, DMJ =Drink from 80% beetroot and 20% ginger and DJK = Drink from 75% beetroot and 25% ginger

Table 5. Sensory properties of beetroot-ginger flavoured functional drinks sweetened with date syrup

Samples	Appearance	Aroma	Taste	Mouthfeel	General Acceptability
ICN	$7.05^{a}\pm1.47$	$5.25^{c}\pm1.94$	$5.05^{bc}\pm2.01$	$7.25^{ab}\pm1.16$	$5.95^{b}\pm1.43$
CHO	$6.90^{a}\pm0.97$	$5.60^{bc}\pm1.98$	$5.40^{bc}\pm2.14$	$7.10^{ab}\pm1.07$	$6.40^{b}\pm1.50$
NGO	$7.50^{a}\pm0.95$	$6.90^{a}\pm1.29$	$7.00^{a}\pm1.41$	$7.35^{a}\pm0.75$	$7.40^{a}\pm0.99$
OJO	$6.65^{a}\pm1.35$	$6.50^{ab}\pm1.27$	$5.55^{bc}\pm1.61$	$6.60^{b}\pm0.94$	$5.90^{b}\pm1.61$
DMJ	$6.85^{a}\pm1.14$	$6.20^{abc}\pm1.24$	$6.25^{ab}\pm1.29$	$6.70^{ab}\pm1.08$	$6.30^{b}\pm1.26$
DJK	$7.00^{a}\pm1.26$	$5.70^{bc}\pm2.03$	$4.65^{c}\pm2.13$	$7.15^{ab}\pm1.23$	$5.85^{b}\pm1.46$

Values are means ± standard deviation of double analysis. Mean values in the identical column with another superscript are notably distinct ($p<0.05$).
Keys: ICN= Drink from 100% beetroot, CHO =Drink from 95% beetroot and 5% ginger, NGO=Drink from 90% beetroot and 10% ginger, OJO = Drink from 85% beetroot and 15% ginger, DMJ =Drink from 80% beetroot and 20% ginger and DJK = Drink from 75% beetroot and 25% ginger

3.4. Sensory properties of beetroot-ginger flavoured functional drinks sweetened with date syrup

Table 5 shows the sensory properties of the functional drinks. There were significant ($p<0.05$) differences among the drink mean scores for appearance which ranged from 6.65 to 7.50. Sample NGO (90% beetroot and 10% ginger) had the highest mean score for appearance (7.50) whereas sample OJO (85% beetroot and 15% ginger) had the lowest value.

The mean scores for aroma of the drink samples ranged from 5.25 to 6.90 and exhibited notable ($p<0.05$) variations apart from sample DMJ and sample DJK which were not noticeably ($p>0.05$) distinct from each other. Sample NGO had the highest mean score for aroma (6.90) whereas sample ICN had the lowest.

The mean numbers for taste of the drink blends domain were from 4.65 to 7.00. There were observable ($p<0.05$) variations among the drink mean scores for taste; apart from samples CHO, DMJ and ICN which were not significantly different ($p>0.05$) from each other. Sample NGO had the highest mean score for taste (7.00) whereas sample DJK had the lowest score.

The mean scores for the mouthfeel for the drinks domain were from 6.60 to 7.35. There were no remarkable distinctions ($p>0.05$) amongst the drink mean scores for mouthfeel; apart from sample NGO and sample OJO which notably ($p<0.05$) varied from the rest of the samples. Sample NGO (90% beetroot and 10% ginger) received the maximum mean value (7.35) whereas sample OJO (85% beetroot and 15% ginger) had the lowest value.

The mean scores of the general acceptability for the drinks ranged from 5.85 to 7.40, and they did not vary were perceivably ($p>0.05$), except sample NGO (90% beetroot and 10% ginger) which was remarkably different ($p<0.05$) from the other drinks. Sample NGO had the highest mean score for general acceptability (7.40), whereas sample DJK (75% beetroot and 25% ginger) had the lowest score.

4. Discussion

The increase procured in the flavonoid content of the drinks as the proportion of ginger went up suggests that ginger has more flavonoid that beetroot (Table 2). The range of flavonoid obtained in this study was lower than the values (1.25 mg/100 mL) reported for zobo drink (14). However, among the functional drinks processed in this study, the highest value of flavonoid obtained in sample DJK indicates that it will provide the body with innate resistance and protection from every day environmental and bodily toxins. Besides, various groups of flavonoids have so far been isolated with diverse notable biological actions such as anticancer, antibacterial, antifungal, anti-diabetic, anti-malaria, neuroprotective, cardio-protective, and anti-inflammatory. Thus, adding several types of flavonoids in the diet every day is greatly encouraged to support good health and lower the hazard of intense life-menacing afflictions such as diabetes mellitus, cancer, as well as the danger of experiencing a stroke or heart attack (15).

The increase noticed in the phenol contents of the functional drinks with rise in the quantity of ginger in the drinks infers that ginger possesses higher phenol content than beetroot. The range (0.21 to 0.43 mg/100 mL) of phenol obtained in this study was lower than 1.42 mg/100 mL obtained in zobo drink (14). The highest phenol value obtained for sample DJK implied that its consumption would have more beneficial effect on consumers since phenolic components act as antioxidant, anti-mutagenic, and scavenging activity on free radicals and prevention of pathologies such as cancer and cardiovascular heart disease (16).

The observed decrease in vitamin A as the proportion of ginger increased suggests that beetroot is richer in vitamin A than ginger (Table 2). The values of vitamin A obtained in this study was higher than the value (15.85 mg/100 mL) reported for pitanga cherry drink (17). Vitamin A performs a crucial part in the general functioning of the visual system, growth and development, and maintenance of epithelial cellular integrity, immune function, and reproduction.

The increment of vitamin B_9 as a result of rise in the addition of ginger in the drinks indicates that ginger is rich in vitamin B_9. The range of vitamin B_9 content (31.53 to 48.84 µg/100 mL) obtained in the drink samples in this study was higher than (256.00 to 301.00 µg/100 mL) reported for turmeric-fortified zobo drink (18). Intake of food products with substantial vitamin B_9 is important to contribute to preventing neural tube malfunctions, which are four times strongly probable to take place in poorer countries, such as Nigeria, than in high-income countries (19).

The viewed increase in the vitamin C composition of the drinks with the rise in the level of ginger inclusion hints that ginger has higher vitamin C than beetroot. The values of vitamin C observed in this study was less than values (126.25 - 236.70 mg/100 mL) reported for drinks made from watermelon pulp and baobab fruit pulp powder (20). Vitamin C is required for the support of healthy gums, bone formation, wound healing, and defending the body from harm by free radicals, as well as in metabolic functions such as activation of the B vitamins and cholesterol to bile acids (21).

4.1. Bacterial loads and coliform loads of the functional drinks

The decrease noticed in the bacterial loads as the level of ginger incorporation into the drink increased suggests that ginger might have some bactericidal activity (Table 3). The higher bacterial load recorded in sample ICN could be due to the greater sweetness of the drink which provided a more favourable surrounding for bacterial increment as sweetness shows that sugar is in the drink (22). Expectedly, the bacteria load of the drinks increased as the storage period expanded to 28 days. At 28 days, the drinks had a bacteria load ranging from 4.75×10^6 to 9.60×10^6 cfu/mL. Sample ICN (100% beetroot) had the highest bacteria load (9.60×10^6 cfu/mL), while sample DJK (75% beetroot and 25% ginger) had the lowest bacteria load (4.75×10^6 cfu/mL). The notable increase in bacteria load in the drinks could be attributed to binary fission, which caused the bacteria cell to grow double its starting size and then proliferate. The total bacteria load of the drinks was within the permissible limit at 0 day to 21 days, but was higher than 10^5 cfu/g which is the recommended limit for bacterial contamination of ready-to-eat food (23-28). This insinuates that the beetroot-ginger drinks should not be stored for up to 28 days but can be stored up to 21 days to mitigate spoilage.

The non-detection of coliforms in the functional drinks indicates that good hygienic practices were followed during the production of the drinks (Table 3). This is in accordance with Ogodo *et al*. (24), who reported the absence of coliform in orange, apple, pineapple, lemon, and guava drinks. The fact that no coliform was found in the drink samples processed in this study hinted that hygienic-sanitary failures did not occur throughout the production process of the drinks (25). According to Oranusi *et al.* (26), the safe food consumption standard prohibits coliforms in fruit drinks; thus, the functional drinks produced in this study are safe for consumption**.**

4.2. Fungal loads of the functional drinks

The observed reduction in the fungal loads as the level of ginger incorporation into the drink increased is beneficial (Table 4). This is because, the lower the fungi load of the drink, the greater its importance, since fungal deterioration is the major cause of significant economic wreck in food products and might also be considered as a wellspring of mycotoxins implicating public health concerns (27). The International Commission for Microbiological Specification for Foods (28) reported that convenience foods with fungi numbers between 0 and 10^3 are acceptable, between 10^4 to ≤ 10^5 are tolerable, and 10^6 and above are unacceptable. This implies that the beetroot-ginger drink should not be stored for more than 21 days and that the fungi load of the drinks was within the acceptable limit for up to 21days of storage. The lesser the fungi load of a food product, the lesser the potential to contribute to causing rhinitis, asthma, and several other illnesses, such as allergic bronchopulmonary mycoses, allergic fungal sinusitis, and hypersensitivity pneumonitis (29).

4.3. Sensory attributes of the functional drinks

The sensory evaluation results of the functional drinks are shown in Table 5. Food semblance (appearance) defines how satisfying a food is before its intake (30). The range of the panelist's rating for appearance (6.65 to 7.50) in this study was within 6.60 to 8.25 obtained in African fan palm drinks (31) but above the values (6.10 to 7.01) reported for pineapple, golden melon, and watermelon drinks spiced with ginger (32). Nevertheless, the mean scores of appearance of the drink obtained in this study translate from liked mildly to liked distinctly on a 9-point Hedonic scale (13).

Aroma is a distinctive, typically pleasant smell perceived by the olfactory sense (33). The mean score of aroma (5.25 to 6.90) procured in this study was less than the values (5.45 to 8.51) observed for drinks produced from orange fruit (34). The notable variation in aromas of these drinks was expected since they were processed using different raw materials. However, the mean scores of aroma obtained in this study range from neither like nor dislike to like slightly on a Hedonic scale of 9-point (13).

Taste construes the proximal sense that demands explicit physical touch of the food with stimuli on the tongue to find out the characteristics of the food consumed (35). The range for taste (4.65 to 7.00) noticed in this study was larger than 4.25 to 5.25 procured for drinks made from jackfruit, cashew pulp, and their blends (36) and 3.80 to 7.00 reported for watermelon drinks supplemented with baobab fruit pulp powder (20). However, the mean scores for taste acquired in this study range from dislike slightly to like moderately in 9-point Hedonic scale (13).

Mouthfeel is a textural sensory characteristic that portrays the condition of being smooth or basically how the sample feels in the roof of the mouth of the assessor (37). The range of values (6.60 to 7.35) for mouthfeel noticed in this study was higher than 3.10 to 6.10 observed in *uziza, ehuru*, clove, and garlic spiced watermelon drink (38) but within 6.15 to 7.80 acquired in African fan palm (31). Nevertheless, the mean scores of mouthfeels obtained in this study translate to like slightly to like distinctly on a 9-point Hedonic scale (13).

Food acceptability clearly describes the interaction it has with the consumer at a given moment in time. The key factors that ascertain food acceptableness are the sensory attributes of food, since consumers seek foods with unique sensory characteristics (30). The highest mean score of general acceptability procured in sample NGO could be that, besides having the maximum mean score for aroma and mouthfeel, its taste was more appealing to the panelists. This claim is supported by the report of Ojinnaka and Nnorom (39) that the taste of a food finally establishes its approval or refusal, even when its appearance elicits the first reaction. The range of general acceptability (5.85 to 7.40) in this study was within the values (6.96 - 7.38) reported for pineapple, golden melon, and watermelon drink spiced with ginger (32) but was higher than (4.40 - 5.25) reported for drinks from jackfruit, cashew pulp, and their blends (36). However, the mean scores of general acceptability acquired in this study translate to neither like nor dislike to like moderately on a 9-point Hedonic scale (13).

5. Conclusion

This work has shown that good quality drinks can be produced from beetroot and ginger sweetened with date syrup. The results showed that the phytochemicals, flavonoids and phenols increased with increased inclusion of ginger in the blend. Vitamins B9 and C followed the same trend of increment with ginger supplementation. On the microbial quality, it was noticed that the bacterial and fungal loads decreased with as the level of ginger in the drinks increased. However, the bacterial and fungal loads of the drinks recorded increments as storage period elongated from 0 to 28 days, with drinks stored above 21 days having their bacterial and fungal load above the permissible limit. No coliform was detected in the drinks. In terms of sensory properties of the drinks, sample NGO (drink made from 90% beetroot and 10% ginger) had more appealing attributes like appearance, aroma, taste, mouthfeel, and general acceptability.

It is therefore recommended that ginger should be partially used to substitute beetroot up to 10% without affecting the sensory acceptability. It is also recommended that beetroot-ginger drinks should not be stored above 21 days. Further studies should be carried out on the antioxidant activities of DPPH, FRAP, and ABTS of the beetroot-ginger functional drink samples.

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Authors contributions

The authors worked collaboratively to ensure a successful delivery of the research work. The contributions of Arukwe, Dorothy Chinomnso include conceptualization, methodology, supervision, writing original manuscript, review and editing. Those of Omodamiro, Rachel Majekodunmi were supervision, conceptualization and critical revision of the manuscript. Nwanagba, Nkeiruka Lilian contributed in conceptualization and reviews. Ijioma, Chigozie

Nelson contributed in investigation, data curation, and writing the original draft.

Declaration of competing interest

Authors have no known financial and personal relationships with other people or organizations that could inappropriately influence or bias their work.

Data availability

The datasets used and/or analyzed during the study are available from the corresponding author upon reasonable request.

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