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PHYSICOCHEMICAL AND SENSORY PROPERTIES OF BLENDS OF PINEAPPLE-CARROT WINE

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ABSTRACT

Study was conducted to develop non-alcoholic wine using pineapple (*Ananas comosus*) and carrot (*Daucus carota*) blend. Red grape wine was used as the control.Pineapple and carrot blends were mixed in varied in proportions. Physicochemical and sensory analyses were done on all the wine samples during primary fermentation and after aging for thirty days. Results of physicochemical analyses revealed that pH ranged from 3.80 to 3.20 while temperature was between 28 ^{o}C and 27 ^{o}C, total dissolved solids ranged between 0.13 to 0.15 % and sugar content (^{o}Brix) varied significantly from 11.00 to 13.35. The specific gravity was between 1.04 and 1.07 while titratable acidity ranged from of 0.28 to 0.76 % and that of alcohol content was from 0.05-1.10 %. Vitamin C content varied significantly from 257.00 to 44.00 µg/ml. Samples were subjected to sensory evaluation and there was a significant difference in colour, clarity, sweetness, aroma, astringency and overall acceptability. From the quality assessment sample with 40% carrot and 60% pineapple juice was the most preferred sample by the panelist. Thus, non-alcoholic wine can be successfully produced from pineapple and carrot.

Keywords: pineapple, carrot, non-alcoholic wine, physicochemical, sensory

INTRODUCTION

The post-harvest shelf life of maximum of fruits and vegetables is very limited due to their perishable nature **(Bhardwaj and Pandey, 2011).** Due to improper post-harvest handling and inadequate processing facilities nearly 20 to 50 per cent of horticultural production are loss **(Kasso and Bekele 2016)**. Wine is one of the oldest forms of alcoholic beverages and can impart benefits to human beings according to **Kempraj and Dasgupta (2011). Saleem and Basha(2010)** reported that moderate consumption of red wine helps in preventing cardiovascular diseases (CVD), increasing the high-density lipoprotein cholesterol plasma levels, decreasing platelet aggregation, antioxidant effects, and by restoration of endothelial function. Wine is an alcoholic beverage typically made of fermented fruit juice**.** Most fruits and berries have the potential to produce wine. Wine making involves the use of yeast to ferment the 'must' of a chosen fruits for a number of days, depending on the objective of the winemaker. The yeast which is the main organism responsible for alcoholic fermentation usually belongs to the genus *Saccharomyces* **(Okeke *et al.*, 2015).** Production of wine from these fruits could help reduce the level of post-harvest loss and increase variety of wines **(Ogodo *et al.*, 2015).**

Pineapple (*Ananas comosus* (L.) Merr. Family: Bromeliaceae] is one of the most important commercial fruit crops in the world **(Baruwa, 2013)**. The fruit consists of vitamins, and minerals, including potassium, copper, manganese, calcium, magnesium, vitamin C, β-carotene, thiamin, B_6, folate, as well as soluble and insoluble fiber and bromelain **(Hossain *et al.*, 2015)**. The residue left after juice extraction contains large quantities of vitamin A and is used as a component of livestock feed **(Muntari *et al.*, 2012)**. Pineapples contain good sugar proportion which makes it suitable for wine making **(Adaikan and Ganesan, 2004).** Carrot (*Daucus carota*) is a biennial plant that grows a rosette of leaves in the spring and summer, while building up the stout taproot that stores large amounts of sugars for the plant to flower in the second year. The carrot (*Daucus carota* subsp. *sativus*) is a root vegetable, usually orange in colour, though purple, red, white, and yellow varieties exist. Carrots have anti-diabetic, cholesterol and cardiovascular disease lowering, anti-hypertensive, hepatoprotective, renoprotective, and wound healing benefits. The cardio and hepatoprotective, anti-bacterial, anti-fungal, anti-inflammatory, and analgesic effects of carrot seed extracts are also reported by **Silva Dias (2014)**. Considering the importance and properties of these fruits, it is of more advantage to have blends of the product for wine production. This will enhance and improve the properties and health of the consumers. Therefore, the present study focussed on determination of physicochemical and sensory properties of blends of pineapple-carrot wine

MATERIALS AND METHODS

Materials

Mature and ripe pineapple and carrot were procured from Ipata market while red grape was procured from Shoprite Supermarket, Fate Road, Ilorin, Kwara State, Nigeria. Other materials used were granulated sugar, instant dry bakers' yeast, gelatin, sodium metabisulphite, bentonite, distilled water, funnel, aluminium foil, paper tape, marker, holes.

Methods

Preparation of juice from red grape

The procedures were carried out according to **Ibegbulem *et al.* (2014)** with modifications. All equipment were washed and sterilized with 0.2g/l sodium metabisulphite (dissolved in little water and fresh solution was used). Red grapes (fresh and juicy) were washed with distilled water to remove dirt. They were put in a sterilized small wooden mortal and crushed with pestle. The crushed grapes were put in a clean muslin cloth and pressed to extract juice from the skin. The juice extracted was put in a plastic container and measured (0.75 litre); 0.25 litre of clean water was added to make 1 litre juice in the container and was labeled as sample 'R'. 0.2g/l of sodium metabisulphite was dissolved in a little juice from sample R and mixed with the control sample. This was done to prevent browning, oxidation and fermentation of juice to vinegar. The sample R was covered with clean muslin cloth and left to ferment for 24 hours.

Preparation of juice from carrot

Method of **Howard et al. (1996)** was used for preparation of carrot juice. Matured carrot (10 kg) were sorted, washed, trimmed and sliced with a stainless steel knife. The carrot slices were weighed and blended with portable water (2.5

L) in a warring blender (*Howard et al*., 1996). The blended carrots roots were filtered using a muslin cloth to obtain the juice. The carrot juice was portioned into 5 different transparent plastic containers into various proportions. Sample A had 50%, Sample B was 40%, Sample C contained 30%, Sample D was 20%, and Sample E contained 10% carrot juice.

Preparation of juice from pineapple

The procedures were carried out according to modified method of **Idise (2012)**. All equipment were washed and sterilized with 0.2g/l sodium metabisulphite solution (dissolved in little water and fresh solution was used). Six large, matured, ripe, juicy and un-bruised pineapples were washed with distilled water to remove dirt. The pineapples were weighed on digital weighing scale (10.5 kg). Pineapple skins were peeled by a stainless steel knife. Each pineapple fruit was cut into two equal halves and the inner hard core was removed. The fruits were cut into smaller pieces and juice was extracted by pressing in muslin cloth. Juice extracted from the pineapple fruit was weighed in measuring cylinder to be 5 L and then mixed with 2 L clean water to make 7 L. The pineapple juice was portioned into 5 different transparent plastic containers (containing the carrot juice) into various proportions. Sample A had 50%, Sample B had 60%, Sample C contained 70%, Sample D was 80% and Sample E contained 90% pineapple juice. The composite juice blends (i.e. pineapple juice + carrot juice) were mixed together in all the 5 plastic containers using a wooden stirrer. 2 L of the composite juice blends was in each plastic containers of Samples A, B, C, D and E. Sample A to E of the juice blends in plastic containers were sterilized by the addition of 0.2g/l sodium metabisulphite (dissolved in little juice and fresh solution was used). The plastic containers were covered with clean muslin clothes and left to ferment for 24 hours. The various proportions of the juice are presented in the Table 1.

Table 1 Recipe of the juice blends

Sample	Red grape juice (%)	Carrot juice (%)	Pineapple juice (%)
R	100	-	-
A	-	50	50
B	-	40	60
C	-	30	70
D	-	20	80
E	-	10	90

Preparation of the starter culture by rehydration

Rehydration of starter culture (i.e. yeast - *Saccharomyceses cerevisiae*) allows the yeast cells to absorb their cellular water. This was done to ensure a high cell count of healthy yeast and also enhance their growth and development. 250 mls of boiled distilled water was measured in measuring cylinder and cooled to 35 ^{o}C. Instant dry yeast (0.5 g) was sprinkled into 10 mls of distilled water in a 100 ml beaker. It was covered with aluminium foil and left for 15 mins. This was repeated 5 times for the other 5 samples. The jar was swirled to suspend the yeast and stirring was done. The yeast cultures were left to ferment for another 10 mins before they were inoculated into the musts (which have fermented for 24 hours) in the 6 fermenting containers.

Inoculation with rehydrated starter culture

All samples of the prepared must were inoculated with the same quantities (25ml) of rehydrated yeast. The rehydrated yeast was poured into the 6 plastic containers containing the musts and was stirred for 1 minute. The inoculated musts were covered with clean muslin clothes.

Fermentation of the musts

After inoculation, the primary fermentation (aerobic) was initiated by stirring the mixture with aeration to facilitate the growth of *Saccharomyceses cerevisiae*. The samples were covered with clean muslin clothes and held for 4 days with daily mixing and agitation to ensure aerobic fermentation. After primary fermentation has advanced sufficiently, the fermented musts were filtered off to separate it from the residue (pomace). The muslin clothes were removed from the 6 samples.

Distillation of the wine samples

Distillation of the wine samples was done on the 4th day of the fermentation period. Distillation of the wine samples was done at 95 ^{o}C for 2 hours. Distillation set-up comprises of a conical flask put on a hot-plate and a Liebig condenser was connected while the distillate passes out from the heated wine samples through the outlet; a thermometer was inserted to ensure a constant temperature range.

Physicochemical analyses

Titratable acidity determination

Titratable acidity was done by titration method according to AOAC, (2005) method. It was determined at 48 hours interval of the 4 days fermentation period and after aging for 1 month (i.e. 30 days). 10 ml of each sample was pipetted in a 50 ml conical flask and titrated against 0.1M NaOH with 2 drops of phenolphthalein indicator. The volume of base used was recorded at the end point of the titration that is, when the sample turned and stayed light pink. Titratable acidity was measured and calculated as tartaric acid equivalent in g/ml. This was done in duplicate for each sample in every titration.
Titratable acidity (tartaric acid, g/ml) = V_1 x M x 75 x 100/ 100 x V_2
Where,
V_1 = volume of NaOH (final reading – initial reading)
M = molarity of NaOH
V_2 = volume of acid (sample)..

Sugar content determination

Digital hand-held wine refractometer, RHWN-25BrixATC was used to determine the sugar content in the wine samples. Few drops of sample were put on a sample plate of the refractometer, sample plate is closed and the refractometer is held up to a natural light source. Reading was then taken in (^{o}Brix) directly from the sight scale of the device. It was determined at 48 hours interval of the 4 days fermentation period and after 1 month aging (30 days).

pH determination

pH was determined using Hanna Instrument pH meter, range 0.0-14.0 pH, resolution 0.1 pH and accuracy 0.1 pH, according to **AOAC (2005)** method. The pH meter was calibrated and then dipped in each sample. Readings were recorded for all samples at 48 hours interval of the 4 days fermentation period and after aging for 1 month (30 days).

Temperature determination

It was determined at 48 hours interval of the 4 days fermentation period and after aging for 1 month (30 days). Mercury-in-glass thermometer was used to measure temperature changes in each sample in (^{o}C). It was dipped in each sample and the point at which mercury stopped on the thermometer was noted and recorded for all samples.

Alcohol content (ethanol) determination

This was done with an alcohol meter. The alcohol meter was dipped in each sample and readings were taken for each sample in (%/v). It was determined at 48 hours interval of the 4 days fermentation period and after aging for 1 month (30 days). The volume of each sample was noted, and the alcohol content is calculated thus:
Alcohol = (original gravity (OG) – final gravity (FG) / 7.36 (%/v) (specific gravity method)
Alcohol concentration (in %/volume) =
alcohol concentration (in g/l) x 0.1267 (conversion factor)

Specific gravity determination

This was done with a digital hand-held wine refractometer, RHWN-25 Brix ATC as with the procedure for brix content. It was determined at 48 hours interval of the 4 days fermentation period and after aging for 1 month (30 days). Readings were taken for each sample and specific gravity was calculated from the refractometer as:
Since hydrometer is an ideal device for determining specific gravity of liquid in Baumé, using a refractometer,
Baumé = 145 – sample value/145

Total dissolved solids determination

It was determined at 48 hours interval of the 4 days fermentation period and after aging for 1 month (30 days) with the use of Hanna Instruments H19812-5, 4-in-1 pH meter [pH/EC/TDS (ppm)/T (^{o}C) respectively]. The device was calibrated, dipped and swirled in each sample. Readings for all samples were taken in (ppm) on the transparent screen and then recorded. The readings in ppm were converted to % as: ppm/10 000.

Vitamin C content determination:

The estimation of L-ascorbic acid was done by calorimetric method according to **Salkić and Selimović (2015)** method.

Sensory Evaluation

Sensory evaluation was done in accordance with the method of **Ogodo *et al.* (2015)** after aging the wine samples for 1 month (30 days). Sensory evaluation of 6 wine samples were carried out in the morning by 15 panelists who were regular wine consumers, at the Home Economics and Food Science Department, University of Ilorin, Ilorin, Kwara State. Among which were lecturers and students of University of Ilorin, Ilorin, all above 18 years of age. Sensory attributes evaluated in all the 6 samples are: sweetness, aroma, colour, astringency and overall acceptability using 9 point hedonic scale of 1 to 9, where 1 indicates like extremely, 5 is neither like nor dislike, and 9 indicate dislike extremely. The hedonic scale may be used to determine degree of acceptability of one or more products.

Statistical Analysis

All the results of the analyses were subjected to Analysis of Variance (ANOVA) to obtain the significance difference between the mean values using Last Significance Difference, LSD ($p \leq 0.05$) following one-way ANOVA and DUNCAN (1956). Statistical analyses were done using SPSS version (16.0) software.

RESULTS AND DISCUSSION

Physicochemical analyses

Changes in pH of wine samples during fermentation periods and after aging for thirty days is shown in Fig 1. The pH values of the fruit non-alcoholic wines were low and acidic throughout the period of fermentation. The pH of the wine was below 4.00. The values ranged from 3.70 to 3.80 on the first day; 3.50 to 3.60 on the third day; 3.20 to 3.50 before and after distillation on the fourth day and 3.20 to 3.50 on the thirtieth day after aging. Sample R was not significantly different from other samples (i.e. A to E) at $P < 0.05$ on the first day and third day; however, it was significantly different ($p<0.05$) on the fourth day and thirtieth day (after aging). Sample A, C, D and E had the highest value of 3.80, while Sample R and B had the least value of 3.50 on the first day. Sample A and C had the highest value of 3.60, while sample B, D and E had the least value of 3.50 on the third day. Sample B had the highest value of 3.50, while sample R and D had the least value of 3.20 on the fourth day before distillation. On the fourth day after distillation, sample A had the highest pH of 3.50, while sample R and D had the least pH value of 3.20. Sample A had the highest value of 3.50, while sample R and D had the least value of 3.20. The pH value of the wine samples decreased during the primary fermentation periods, and then remains constant during the thirty days aging period. The increase in acidity of the wine samples showed that the wine samples would keep well as acids preserves food products. A similar observation has been reported by **Reddy and Reddy (2005).** Similar decrease in pH with fermentation period were reported by **Ibegbulem *et al.* (2014)** on pineapple wine and **Ogodo *et al.* (2015)** for mixed fruits (banana, pawpaw and water melon). The observed changes in the pH of the wines could be due to production of acids during fermentation and changes arising from microbial succession. According to **Okeke *et al.* (2015)** in production of pineapple and watermelon wine, pH of the wine was within acidic range throughout the period of fermentation.

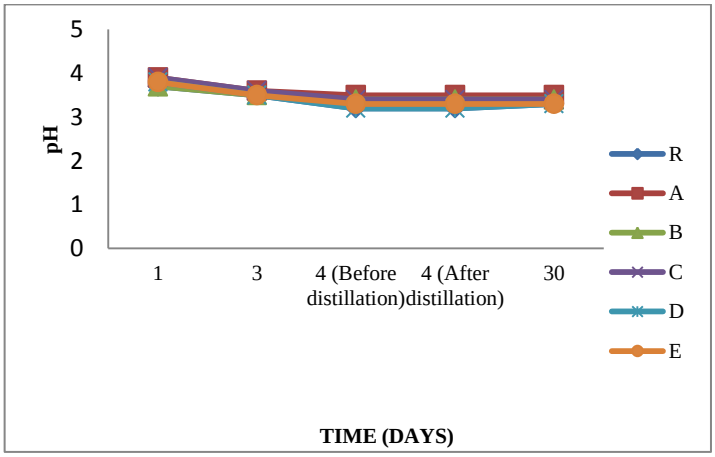

Figure 1 Changes in pH values of the wine samples during fermentation periods and after aging

Legend: R – Grape wine (100% grape juice), A – pineapple-carrot non-alcoholic wine (50% pineapple juice: 50% carrot juice), B – pineapple-carrot non-alcoholic wine (60% pineapple juice: 40% carrot juice), C – pineapple-carrot non-alcoholic wine (70% pineapple juice: 30% carrot juice), D – pineapple-carrot non-alcoholic wine (80% pineapple juice: 20% carrot juice), E – pineapple-carrot non-alcoholic wine (90% pineapple juice: 10% carrot juice)

The changes in temperature of the wine samples during fermentation and after aging for thirty days is shown in Fig. 2. There were fluctuations in the temperature of the wine samples throughout the period of fermentation. The temperature during pineapple-carrot non-alcoholic wine production increased during primary fermentation periods then decreased and remains constant during aging. On the first day of primary fermentation, temperature was between 27 and 28 ^{o}C; 29 and 30 ^{o}C on the third day; 31 ^{o}C on the fourth day before distillation; 30 ^{o}C on the fourth day after distillation and 28 ^{o}C on the thirtieth day (after aging). There was no significance difference in temperature for all the wine samples throughout the fermentation periods. On the first day, sample R had the highest value of 28 ^{o}C, while sample A, D and E had the least value of 27 ^{o}C. On the third day, sample B had the highest value of 30 ^{o}C, while sample A, C, D and E had the least pH value of 27 ^{o}C. On the fourth day before distillation, all the wine samples had mean temperature value of 31 ^{o}C. On the fourth day after distillation, all the wine samples had values of 30 ^{o}C. On the thirtieth day (after aging), all the wine samples had values of 28 ^{o}C. According to **Ogodo *et al.* (2015), f**luctuations in temperature of the wine samples could be as a result of biochemical changes occurring during the metabolism of the substrates by the fermenting organisms. After the fourth day, the temperature decreased gradually till the thirtieth day after maturation. This might be due to diminishing of the desired nutrients for yeast growth and concomitant decrease in their activity. Fermentation temperature affects the aroma, overall and sensory properties of wine. Low temperature fermentation is advantageous because it preserves an array of desirable aromas and flavours produced during primary fermentation **(Torija *et al.*, 2003)**.

Apart the results of the analyses were subjected to Analysis of Variance (AN

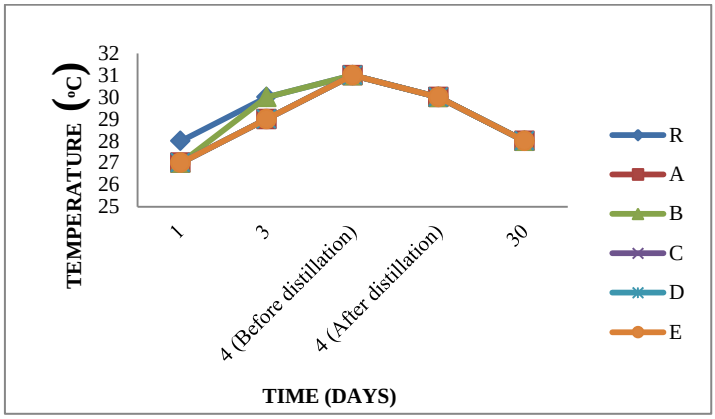

Figure 2 Changes in temperature of the wine samples during fermentation periods and after aging

Legend: R – Grape wine (100% grape juice), A – pineapple-carrot non-alcoholic wine (50% pineapple juice: 50% carrot juice), B – pineapple-carrot non-alcoholic wine (60% pineapple juice: 40% carrot juice), C – pineapple-carrot non-alcoholic wine (70% pineapple juice: 30% carrot juice), D – pineapple-carrot non-alcoholic wine (80% pineapple juice: 20% carrot juice), E – pineapple-carrot non-alcoholic wine (90% pineapple juice: 10% carrot juice)

In Fig. 3, changes in total dissolved solids of the wine samples during fermentation periods and after aging for thirty days were shown. The total dissolved solids obtained in the wines increased gradually. Total dissolved solids were in the ranged of 0.06 - 0.14% on the first day; 0.08-0.16% on the third day; 0.13 - 0.19% on the fourth day before and after distillation, and 0.13 - 0.19% on the thirtieth day (after aging). There were significant differences ($p>0.05$) in the values during fermentation periods except the third day. Sample B and D had the highest total dissolved solids of 0.14% on the first day, while sample R had the least value of 0.06%. On the third day, sample E had the highest value of 0.16%, while sample R had the least value of 0.08%. On the fourth day before and after distillation, sample A had the highest total dissolved solids value of 0.19%, while sample R had the least value of 0.13%. On the thirtieth day (after aging), sample A had the highest value of 0.19%, while sample A had the least value of 0.13%. These low values of the total dissolved solids could be attributed to the efficiency of the yeast in fermentation. It also implies that consumers are not exposed to the risk of taking in too much solid into the body. Results of the present study agree with the reports of **Idise (2011)**.

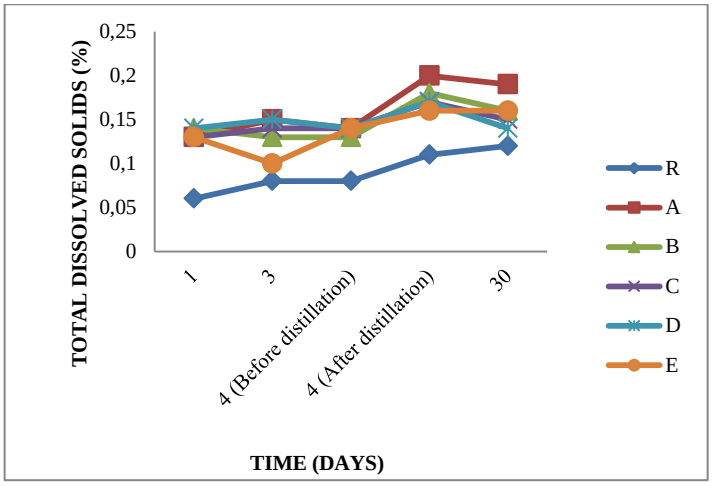

Figure 3 Changes in total dissolved solids of the wine samples during fermentation periods and after aging
Legend: R – Grape wine (100% grape juice), A – pineapple-carrot non-alcoholic wine (50% pineapple juice: 50% carrot juice), B – pineapple-carrot non-alcoholic wine (60% pineapple juice: 40% carrot juice), C – pineapple-carrot non-alcoholic wine (70% pineapple juice: 30% carrot juice), D – pineapple-carrot non-alcoholic wine (80% pineapple juice: 20% carrot juice), E – pineapple-carrot non-alcoholic wine (90% pineapple juice: 10% carrot juice)

The values of the sugar contents of the wine were observed to decrease during the fermentation periods (Table 2). The values were high on the first day which was the begining of the wine fermentation and due to the presence of sugar in the fermenting must. There were significant differences ($p>0.05$) in sugar content of the wine samples during the fermentation periods except the fourth day before distillation. The sugar contents of the samples on the first day were between 4.50 and 11.00 ^{o}Brix; 4.50 and 9.00 ^{o}Brix on the third day of primary fermentation; 4.00 and 8.00 ^{o}Brix on the fourth day before fermentation; 6.00 and 10.50 ^{o}Brix on the fourth day after distillation, and 10.75 and 13.35 ^{o}Brix after aging for thirty days. Sample R had the highest sugar content of 11.00 ^{o}Brix, while sample A had the least value of 4.50 ^{o}Brix on the first day of primary fermentation. Sample R had 9.00 ^{o}Brix as the highest value of sugar content on the third day, while sample A had the least value of 4.50 ^{o}Brix. On the fourth day before fermentation, sample D had the highest sugar content value of 8.00^{o}brix, while sample A had the least value of 4.00 ^{o}Brix. On the fourth day after distillation, sample C had the highest sugar content of 10.50 ^{o}Brix, while sample R had the least value of 6.00 ^{o}Brix. On the thirtieth day (after aging), sample D had the highest value of 13.35 ^{o}Brix, while sample E had the least value of 10.75 ^{o}Brix. The decrease in the sugar content may be due to the fermenting yeast on the wine and the formation of alcohol during the primary fermentation period, increase in the content after distillation was as result of the loss of alcohol during distillation, thus, more sugar was available. The increase during aging period may also be due to the sugar added as an additive (i.e. sweetener) to the wine samples, since sweet wine was desired. Reports have shown that the major problem associated with the use of tropical fruits in wine production is their low sugar content **(Ifie *et al.*, 2012)**.

Table 2 Sugar content of wine samples (^{o}Brix)

Samples	Days				
	1	3	4 (before distillation)	4 (after distillation)	30 (after aging)
R	$11.00^{a} \pm 1.00$	$9.00^{a} \pm 1.00$	$5.40^{bc} \pm 0.10$	$6.00^{b} \pm 1.00$	$10.75^{a} \pm 1.15$
A	$4.50^{c} \pm 0.50$	$4.50^{b} \pm 0.10$	$4.00^{c} \pm 0.10$	$8.20^{ab} \pm 0.10$	$12.95^{a} \pm 1.95$
B	$7.20^{bc} \pm 0.10$	$7.00^{ab} \pm 1.00$	$6.50^{ab} \pm 0.10$	$9.00^{a} \pm 1.00$	$12.30^{a} \pm 0.60$
C	$8.00^{a} \pm 1.00$	$7.80^{a} \pm 0.10$	$7.00^{ab} \pm 1.00$	$10.50^{a} \pm 0.10$	$12.30^{a} \pm 0.40$
D	$9.00^{ab} \pm 1.00$	$8.80^{a} \pm 0.10$	$8.00^{a} \pm 1.00$	$9.00^{a} \pm 1.00$	$13.35^{a} \pm 1.35$
E	$9.00^{ab} \pm 1.00$	$7.50^{ab} \pm 1.50$	$6.40^{ab} \pm 0.10$	$10.20^{a} \pm 0.10$	$10.75^{a} \pm 0.95$

Values are duplicate determinations; mean within row having different superscripts differ significantly at $P < 0.05$
Legend: R – Grape wine (100% grape juice), A – pineapple-carrot non-alcoholic wine (50% pineapple juice: 50% carrot juice), B – pineapple-carrot non-alcoholic wine (60% pineapple juice: 40% carrot juice), C – pineapple-carrot non-alcoholic wine (70% pineapple juice: 30% carrot juice), D – pineapple-carrot non-alcoholic wine (80% pineapple juice: 20% carrot juice), E – pineapple-carrot non-alcoholic wine (90% pineapple juice: 10% carrot juice)

The specific gravity values were observed to decrease from day one to day four of the primary fermentation period (Table 3). On the first day, values ranged from 1.04 to 1.06; 1.04 to 1.05 on the third day of primary fermentation; 1.40 to 1.06 on the fourth day before distillation; 1.40 to 1.07 and 1.04 to 1.06 after distillation on the fourth day; 1.04 to 1.06 after aging. There was a significant difference in all the samples on the first day, fourth day and thirtieth day (after aging), but was not on other days. Sample R, C, D and E had the highest value of 1.06, while sample A had the least value of 1.04 on the first day. On the third day, sample R, B, C, D and E had the highest value of 1.05; while sample A had the least value of 1.04. On fourth day before distillation, sample D and R had the highest value of 1.06, while sample R and A had the least value of 1.04. On the fourth day after distillation, sample B, C. D and E had the highest value of 1.07, while sample R had the least value of 1.04. Sample D had the highest value of 1.06; while sample R had the least value of 1.04 on the thirtieth day. Once the specific gravity falls below 1.0, there is less sugar in wine than alcohol. The observed changes in specific gravity of the wines with period of fermentation support the occurrence of microbes apparently due to varying tolerance for metabolic end products **(Idise, 2011)**. These results agree with reports of **Adeyemo (2012)**. Decreased in specific gravity could also be due to microbial succession, available nutrients, sugar and alcohol resulting in the production of acid.

Table 3 Specific gravity of wine samples

Samples	Days				
	1	3	4 (before distillation)	4 (after distillation)	30 (after aging)
R	$1.06^{a} \pm 0.00$	$1.05^{a} \pm 0.00$	$1.04^{b} \pm 0.00$	$1.04^{c} \pm 0.00$	$1.04^{d} \pm 0.00$
A	$1.04^{d} \pm 0.00$	$1.04^{b} \pm 0.00$	$1.04^{b} \pm 0.00$	$1.05^{b} \pm 0.00$	$1.05^{bc} \pm 0.00$
B	$1.05^{c} \pm 0.00$	$1.05^{a} \pm 0.00$	$1.05^{a} \pm 0.00$	$1.07^{a} \pm 0.00$	$1.05^{c} \pm 0.00$
C	$1.06^{bc} \pm 0.00$	$1.05^{a} \pm 0.00$	$1.05^{a} \pm 0.00$	$1.07^{a} \pm 0.00$	$1.05^{ab} \pm 0.00$
D	$1.06^{bc} \pm 0.00$	$1.05^{a} \pm 0.00$	$1.06^{a} \pm 0.00$	$1.07^{a} \pm 0.00$	$1.06^{a} \pm 0.00$
E	$1.06^{ab} \pm 0.00$	$1.05^{a} \pm 0.00$	$1.06^{a} \pm 0.00$	$1.07^{a} \pm 0.00$	$1.05^{bc} \pm 0.00$

Values are duplicate determinations; mean within row having different superscripts differ significantly at $P < 0.05$
Legend: R – Grape wine (100% grape juice), A – pineapple-carrot non-alcoholic wine (50% pineapple juice: 50% carrot juice), B – pineapple-carrot non-alcoholic wine (60% pineapple juice: 40% carrot juice), C – pineapple-carrot non-alcoholic wine (70% pineapple juice: 30% carrot juice), D – pineapple-carrot non-alcoholic wine (80% pineapple juice: 20% carrot juice), E – pineapple-carrot non-alcoholic wine (90% pineapple juice: 10% carrot juice)

Titratable acidity was observed to show a steady decrease with time throughout the period of primary fermentation and then increased slightly during the 30 days aging period (Table 4). On the first day of fermentation, acid concentration in the grape non-alcoholic wine samples was observed to range from 0.69 to 0.76%; 0.23 to 0.69% on the third day of primary fermentation; 0.19 to 0.55% on the fourth day before distillation; 0.20 to 0.55% on the fourth day after distillation and 0.28 to 0.63% after the thirty days aging period. There were significant differences ($p<0.05$) in all the samples throughout fermentation periods. On the first day, sample B had the highest titratable acidity value of 0.76%, while sample D and E had the least value of 0.69%. On the third day, sample R had the highest value of 0.69%, while sample B had 0.23%. On the fourth day before distillation, sample R had the highest titratable acidity value of 0.55%, while sample E had the least value of 0.19%. For the fourth day after distillation, sample R had the highest value of 0.55%, while sample E had the lowest value of 0.20%. After aging for thirty days, sample R had the highest value of 0.63%, while sample E had the least value of 0.28%. Studies have shown that during fermentation of

fruits, low pH and high acidity are known to give fermenting yeasts competitive advantage in natural environments **(Idise, 2011)**. In this study, the results of titratable acidity of the wine fell within this limit. This implies that even if the wines are consumed in large quantities, the acidity level can easily be removed by the body system. The changes in the percentage titratable acidity of the mixed non-alcoholic wine within the period of secondary fermentation show the occurrence of malolactic fermentation **(Idise, 2011).** Low range of acidity in the present study showed the effect of distillation of the alcohol.

Table 4 Titratable acidity of wine samples (%)

Samples	Days				
	1	3	4 (before distillation)	4 (after distillation)	30 (after aging)
R	$0.71^{b} \pm 0.00$	$0.69^{a} \pm 0.01$	$0.55^{a} \pm 0.00$	$0.55^{a} \pm 0.00$	$0.63^{a} \pm 0.00$
A	$0.70^{d} \pm 0.00$	$0.44^{b} \pm 0.00$	$0.34^{b} \pm 0.00$	$0.27^{b} \pm 0.00$	$0.36^{b} \pm 0.00$
B	$0.76^{a} \pm 0.00$	$0.23^{d} \pm 0.00$	$0.30^{c} \pm 0.00$	$0.26^{c} \pm 0.00$	$0.37^{b} \pm 0.03$
C	$0.71^{c} \pm 0.00$	$0.24^{d} \pm 0.00$	$0.24^{d} \pm 0.00$	$0.24^{d} \pm 0.00$	$0.32^{c} \pm 0.00$
D	$0.69^{d} \pm 0.00$	$0.26^{c} \pm 0.00$	$0.21^{e} \pm 0.00$	$0.21^{e} \pm 0.00$	$0.29^{b} \pm 0.00$
E	$0.69^{d} \pm 0.00$	$0.26^{c} \pm 0.00$	$0.19^{f} \pm 0.00$	$0.20^{f} \pm 0.00$	$0.28^{b} \pm 0.02$

Values are duplicate determinations; mean within row having different superscripts differ significantly at $P < 0.05$

Legend: R – Grape wine (100% grape juice), A – pineapple-carrot non-alcoholic wine (50% pineapple juice: 50% carrot juice), B – pineapple-carrot non-alcoholic wine (60% pineapple juice: 40% carrot juice), C – pineapple-carrot non-alcoholic wine (70% pineapple juice: 30% carrot juice), D – pineapple-carrot non-alcoholic wine (80% pineapple juice: 20% carrot juice), E – pineapple-carrot non-alcoholic wine (90% pineapple juice: 10% carrot juice)

Remarkable amount of alcohol was produced from the wine samples during primary fermentation with the bakers' yeast *Saccharomyceses cerevisiae*. The percentage alcohol content (ethanol) in all wine samples increased moderately from day 1 to 4 during the primary fermentation period (Table 5). In first day of the primary fermentation, alcohol content was within the range of 0.80 - 1.10%/v; 2.30 - 4.70%/v on the third day of primary fermentation; 5.20 - 7.05%/v on the fourth day before distillation; 0.22 - 1.09%/v after distillation on the fourth day and 0.05 - 0.41%/v on thirtieth day (after aging). There were significant differences ($p<0.05$) in alcohol content of the wine samples during the fermentation periods except day four before distillation and day thirty after aging. On the first day, sample R and E had the highest value of 1.10%/v, while sample A had the least value of 0.80%/v. On the third day, sample R had the highest alcohol value of 4.70%/v, while sample A had the least alcohol content of 2.30%/v. On the fourth day before distillation, samples B, C, D and E had the highest alcohol content of 7.05%/v, while sample R had the least value of 5.20%/v. On the fourth day after distillation, C and E had the highest alcohol value of 1.09%/v, while sample A had the least value of 0.14%/v. On thirtieth day, sample R had the highest alcohol value of 0.41%/v, while sample C had the least value of 0.05%/v. In general, the concentrations of ethanol contribute to the whole characteristic quality and flavour of wine **(Reddy and Reddy 2005).** There was increase in the alcoholic content of the grape wines after secondary fermentation. The alcohol content of distilled grape wine (sample R) increased from 0.33%/v in primary fermentation to 0.41%/v after secondary fermentation; that of distilled pineapple-carrot decreased significantly from 1.09 to 0.14%/v during the malolactic acid fermentation period. Differences in the alcohol level of the distilled wine sample could be due to the variation in temperature and distillation time of the wine samples.

Table 5 Alcohol (ethanol) content of wine samples (%/v)

Samples	Days				
	1	3	4 (before distillation)	4 (after distillation)	30 (after aging)
R	$1.10^{a} \pm 0.10$	$4.70^{a} \pm 0.10$	$5.20^{b} \pm 0.10$	$0.33^{a} \pm 0.01$	$0.41^{a} \pm 0.01$
A	$0.80^{b} \pm 0.10$	$2.30^{c} \pm 0.01$	$5.40^{b} \pm 0.10$	$0.14^{a} \pm 0.01$	$0.11^{b} \pm 0.01$
B	$1.05^{ab} \pm 0.06$	$4.50^{b} \pm 0.06$	$7.50^{a} \pm 0.05$	$0.22^{a} \pm 0.00$	$0.11^{b} \pm 0.01$
C	$1.05^{ab} \pm 0.06$	$4.30^{b} \pm 0.10$	$7.05^{a} \pm 0.05$	$1.09^{a} \pm 0.91$	$0.05^{c} \pm 0.01$
D	$1.05^{ab} \pm 0.06$	$4.10^{b} \pm 0.10$	$7.05^{a} \pm 0.05$	$0.22^{a} \pm 0.01$	$0.11^{b} \pm 0.01$
E	$1.10^{a} \pm 0.10$	$4.30^{a} \pm 0.10$	$7.05^{a} \pm 0.05$	$1.09^{a} \pm 0.91$	$0.14^{b} \pm 0.01$

Values are duplicate determinations; mean within row having different superscripts differ significantly at $P < 0.05$

Legend: R – Grape wine (100% grape juice), A – pineapple-carrot non-alcoholic wine (50% pineapple juice: 50% carrot juice), B – pineapple-carrot non-alcoholic wine (60% pineapple juice: 40% carrot juice), C – pineapple-carrot non-alcoholic wine (70% pineapple juice: 30% carrot juice), D – pineapple-carrot non-alcoholic wine (80% pineapple juice: 20% carrot juice), E – pineapple-carrot non-alcoholic wine (90% pineapple juice: 10% carrot juice)

Table 6 shows the vitamin C content of the wine samples. In the first day, vitamin C content of the wine samples was in the range of 108.00-257.00 µg/ml; 149.00-306.00 µg/ml on the third day of primary fermentation; 181.00-446.00 µg/ml on the fourth day before distillation; 13.00-311.00 µg/ml on the fourth day after distillation and then 44.00 - 61.00 µg/ml after the thirty days aging period. There was a significant difference in vitamin C content of all the wine samples throughout the fermentation periods. This may be due to the various proportion of carrot added to other wine samples except sample R. On the first day, sample A had the highest vitamin C content of 257.00 µg/ml, while sample R had the least value of 108.00 µg/ml. On the third day, sample A had the highest value of 306.00 µg/ml ± 1.00, while sample R had the least value of 149.00 µg/ml ± 1.00. On the fourth day (before and after distillation), sample A had the highest vitamin C content, while sample R had the least value. After aging, sample A had the highest value of 61.00 µg/ml, while sample C had the least value of 44.00 µg/ml The vitamin C content decreased significantly as a result of chemical reactions during fermentation. This observation was similar to that of **Akinwale *et al.* (2001)** where, it was reported that the vitamin C content of cashew apple wine was affected by heat treatment with value decreasing with increase duration of heat for vitamin C. The formulated wine samples in the present study provide a considerable amount of vitamin C of which sample A had the highest value of 61.00 µg/ml and sample C the lowest value of 44.00 µg/ml. The decrease in vitamin C may result from the source of raw materials used.

Table 6 Vitamin C content of wine samples (µg/ml)

Samples	Days				
	1	3	4 (before distillation)	4 (after distillation)	30 (after aging)
R	$108.00^{f} \pm 1.00$	$149.00^{f} \pm 1.00$	$181.00^{f} \pm 1.00$	$13.00^{f} \pm 1.00$	$51.00^{c} \pm 1.00$
A	$257.00^{a} \pm 1.00$	$306.00^{a} \pm 1.00$	$446.00^{a} \pm 1.00$	$311.00^{a} \pm 1.00$	$61.00^{a} \pm 1.00$
B	$289.00^{d} \pm 1.00$	$268.00^{b} \pm 1.00$	$230.00^{e} \pm 1.00$	$239.00^{b} \pm 1.00$	$56.50^{b} \pm 1.50$
C	$182.00^{e} \pm 1.00$	$239.00^{d} \pm 1.00$	$273.00^{d} \pm 1.00$	$150.00^{e} \pm 1.00$	$44.00^{d} \pm 1.00$
D	$231.00^{b} \pm 1.00$	$247.00^{c} \pm 1.50$	$329.00^{c} \pm 1.00$	$185.00^{d} \pm 1.00$	$51.00^{c} \pm 1.00$
E	$193.00^{c} \pm 1.00$	$161.00^{e} \pm 1.00$	$391.00^{b} \pm 1.00$	$190.00^{c} \pm 1.00$	$55.00^{b} \pm 1.00$

Values are duplicate determinations; mean within row having different superscripts differ significantly at $P < 0.05$

Legend: R – Grape wine (100% grape juice), A – pineapple-carrot non-alcoholic wine (50% pineapple juice: 50% carrot juice), B – pineapple-carrot non-alcoholic wine (60% pineapple juice: 40% carrot juice), C – pineapple-carrot non-alcoholic wine (70% pineapple juice: 30% carrot juice), D – pineapple-carrot non-alcoholic wine (80% pineapple juice: 20% carrot juice), E – pineapple-carrot non-alcoholic wine (90% pineapple juice: 10% carrot juice)

Sensory evaluation on the winw samples

There were no significant differences ($P < 0.05$) in colour, clarity, aroma, sweetness and astringency among the wine samples. In overall acceptability, sample R and other wine samples were not significantly different at $P < 0.05$ (Table 7). In terms of colour, sample C was more acceptable followed by E, R, D, A and B. In clarity, sample A was more acceptable followed by C, R and E, D, and B. For aroma, sample A and E were more acceptable followed by C, D, B and R. For sweetness, sample A was more acceptable followed by R and E, B, C and D. In astringency, sample R and B were more acceptable followed by A, D, E and C. In the overall acceptability, sample C was the most acceptable followed by A, B, D, R and E. The study shows that pineapple-carrot non-alcoholic wine can be most produced at 60% pineapple juice and 40% carrot juice respectively as this was the most accepted sample by the sensory panelists.

Table 7 Sensory evaluation parameters of the wine samples

Parameters	Wine Samples					
	R	**A**	**B**	**C**	**D**	**E**
Colour	$6.4^a \pm 0.48$	$3.7^a \pm 0.30$	$3.3^a \pm 0.49$	$6.7^a \pm 0.39$	$6.2^a \pm 0.33$	$6.6^a \pm 0.21$
Clarity	$6.2^a \pm 0.47$	$6.7^a \pm 0.39$	$5.8^a \pm 0.39$	$6.3^a \pm 0.33$	$6.1^a \pm 0.41$	$6.2^a \pm 0.43$
Aroma	$638^a \pm 0.47$	$6.9^a \pm 0.28$	$6.3^a \pm 0.43$	$6.8^a \pm 0.33$	$6.4^a \pm 0.35$	$6.9^a \pm 0.27$
Sweetness	$6.7^a \pm 0.37$	$7.0^a \pm 0.41$	$6.3^a \pm 0.35$	$6.0^a \pm 0.27$	$6.0^a \pm 0.44$	$6.7^a \pm 0.25$
Astringency	$6.5^a \pm 0.43$	$6.3^a \pm 0.50$	$6.3^a \pm 0.42$	$6.2^a \pm 0.35$	$6.3^a \pm 0.39$	$7.1^a \pm 0.32$
Overall acceptability	$6.5^a \pm 0.43$	$6.2^a \pm 0.47$	$6.5^a \pm 0.51$	$6.0^a \pm 0.34$	$6.0^a \pm 0.41$	$6.0^a \pm 0.41$

Values are duplicate determinations; mean within row having different superscripts differ significantly at $P < 0.05$

Legend: R – Grape wine (100% grape juice), A – pineapple-carrot non-alcoholic wine (50% pineapple juice: 50% carrot juice), B – pineapple-carrot non-alcoholic wine (60% pineapple juice: 40% carrot juice), C – pineapple-carrot non-alcoholic wine (70% pineapple juice: 30% carrot juice), D – pineapple-carrot non-alcoholic wine (80% pineapple juice: 20% carrot juice), E – pineapple-carrot non-alcoholic wine (90% pineapple juice: 10% carrot juice)

CONCLUSIONS

Wine was successfully produced from pineapple and carrot and was found to compare favourably with the wine produced from red grape juice in most of the physicochemical and sensory properties evaluated. The study has given an insight into the efficacy and suitability of combining fruit and vegetable for production of non- alcoholic wine. The wines produced showed appreciable differences in most of the tested parameters statistically at $P < 0.05$ confidence level. Pineapple-carrot non-alcoholic wine blend can be produced from a mixture of moderate proportion of pineapple-carrot juice (60% pineapple juice: 40% carrot juice).

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