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PHYSICOCHEMICAL, ANTIOXIDANT AND SENSORY PROPERTIES OF BLACK VELVET TAMARIND (*Dialium guineense* wild) PULP AND CARROT (*Daucus carota*) JUICE BLENDS

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Abstract
This study aimed at evaluating the antioxidant capacities, physicochemical properties and consumer acceptability of juices produced from blends of black velvet tamarind and carrot. Tamarind and carrot juices were produced and blended at different ratios (100:0, 70:30, 50:50, 30:70, 0:100). Total phenolics (Folin–Ciocalteu assay), antioxidant activity (2, 2-diphenyl-1 picrylhydrazyl (DPPH) radical scavenging assay), flavonoid, vitamin A, vitamin C, physicochemical properties (total soluble solid, pH, total titratable acid, viscosity) and consumer acceptability of the blends were determined. High proportion of carrot juice in the mix significantly ($p < 0.05$) decreased the viscosity, total titratable acid, total soluble solid of the juice while increase in tamarind significantly ($p < 0.05$) increased the antioxidant activity of the juice. On the other hand, inclusion of carrot juice in the blends significantly ($p < 0.05$) increased vitamin A content which ranged from 2454.16 to 5633.66 µg RAE/100 ml. Vitamin C content ranged from 27.69 to 53.03 mg/100 ml. Overall acceptability of the juice blends increased significantly with increased inclusion of carrot juice. The study showed synergistic effects of tamarind and carrot on nutritional and sensory properties of the juice blends. This indicates another potential area of utilization for tamarind pulp.

Keywords: Velvet tamarind pulp, carrot juice, antioxidant activity, sensory evaluation

Introduction
Oxidation reactions that occur particularly in the human body are likely to produce free radicals which in turn bring about various disorders including atherosclerosis, arthritis, ischemia and reperfusion injury of many tissues, gastritis and cancer (Seal, 2011). Antioxidants prevent these oxidative damages caused by free radicals in the body, through reactions and scavenging of free oxygen radicals as well as catalytic metals chelation (Percival, 1996). The cheapest and most effective ways of exposing the body to more antioxidants is through consumption of fruits and vegetables or their products (Aires *et al*., 2013). Combination of two or more fruits and/or vegetables provide synergistic nutrients availability that cannot be obtained from the individual fruits or vegetables (Lee, 2016). Most nutritional recommendation for healthy living prescribes at least two servings of fruits and three servings of vegetables per day (Agudo, 2005). In developing countries, there are quite a number of factors affecting the consumption of fruits and vegetables. One of such factors is "food cost" (Miller et al., 2016). Affordability of households influences the consumption rate of fruits and vegetables. Therefore, exploring the food potential of an underutilized and abandoned fruit like tamarind becomes very relevant to the countries where the fruit is indigenous.

Dialium guineense commonly known as African black velvet tamarind is a multipurpose tropical fruit tree with each part of it used for one of either nutritional or medicinal purpose (Arogba et al., 2006; Kumar and Bhattacharya, 2008). It is a rich source of vitamin C, fibre, sugars, acids, polysaccharides, small amounts of protein, lipid and possess some antioxidant properties (Ogungbenle and Ebadan, 2013) yet underutilized and limiting in other nutrients. Black velvet tamarind is obviously among the abandoned fruit in Africa since none of the African countries produces it at commercial scale (Caluwé and Damme, 2010). The problem of limiting nutrients and astringent taste of tamarind pulp makes supplementation with carrots a necessity. The resultant juice is expected to be less acidic with improved taste and nutritional properties. Carrot (*Daucus carota*) a member of the family *Apiceae*, is a rich source of β-carotene (a precursor of vitamin A) and other vitamins like thiamine, riboflavin, vitamin B-complex and minerals (Bazilla et al., 2012). Composite fruit blending is one of the best methods to improve nutritional quality of fruit juice. It can improve the vitamin and mineral content depending on the kind and quality of fruits and vegetables used (De Carvalho et al., 2007). Previous works have reported an increased carotenoid content with increased carrot extract in juice blends (Awsi and Masih 2012; Ogundele et al., 2016).
There are relatively few studies on juice blends containing tamarind in literature. The study of Khan et

al. (2017) developed fruit juices from blends of tamarind and plum. Similarly, Banerjee (2015) determined the effects of hydrocolloids on tamarind juice. These studies were done mainly on *Tamarindus Indica* specie. Therefore, the objective of this study is to develop fruit juices from blends of carrot and black velvet tamarind pulp and evaluate the effects of different proportion of the fruit on the physcochemical, antioxidant and sensory properties of the juice blends.

Materials and Methods

Black velvet tamarind and carrot

The black velvet tamarind (*Dialium guineense) and carrot (Daucus carota*) used for this study were obtained from Ijemiri market, Akure, Ondo state, Nigeria. Initial sorting and grading of the raw materials were done prior to sample preparation.

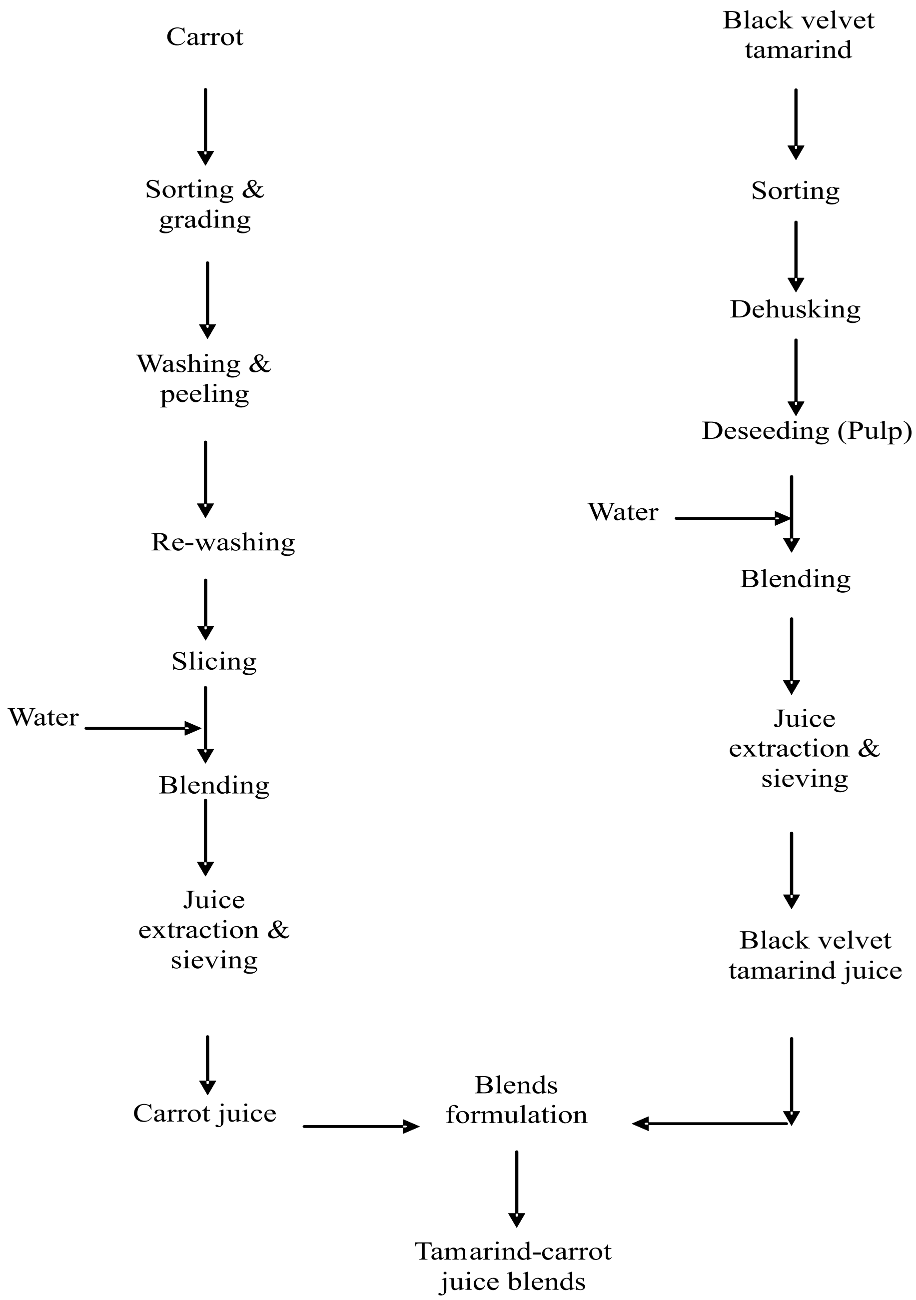

Figure 1: Flowchart for the preparation of tamarind-carrot juice

Preparation of carrot and velvet tamarind pulp juices
About 2.5 kg of fresh carrot were washed and peeled using a sharp knife and re-washed after peeling. This was followed by slicing into smaller sizes to aid blending. The carrot slices were divided into five portions with each weighing 500 g. To each part 750 ml of water was added and blended using a Kenwood blender, sieved using muslin cloth and pressed by hand to extract fresh carrot juice as described in Figure 1. The resulting juice for each part blended amounted to 1000 ml. The encapsulated velvet tamarind fruits were dehusked to separate the seed from the pulp. A total weight of 2.0 kg of pulp was obtained. Likewise the pulp was divided into five portions with each weighing 400 g and each portion was blended with about 1 liter of water followed by sieving with a muslin cloth. The slurry obtained from each portion after sieving was 1 liter by volume. The blends of tamarind - carrot juice were formulated according to Table 1.

Table 1 . Formulation of Tamar ind - carrot juice blends.

Sample	Blending ratio (ml)
TC100/0	1000:0
TC70/30	700:300
TC50/50	500:500
TC30/70	300:700
TC0/100	0:1000

*TC: Tamarind - carrot ratios

Determination of Total Soluble Solids, Total Acidity and pH Determination
Total soluble solid was determined according to official methods of AOAC (1990). A drop of juice was placed on a refractometer (Westover Model RHB-32; Southwest United Industries, Tulsa, OK) after calibration and total soluble solids were measured at 20°C and recorded as °Brix. In determining total acidity, 10 ml of the fruit juice was diluted to 80 ml using distilled water and titrated against 0.1 NaOH using phenolphthalein as indicator and the result expressed as percentage citric acidity. pH of the juice sample was measured according to the procedure of Pearson (1981). The parameter was measured using KENTEIL 7020 electric pH meter. The meter was standardized with buffer solutions at pH 4.0 and 7.0 before measurement.

Viscosity Measurement
Viscosity of the tamarind-carrot juice was determined according to the method of Natukunda et al. (2015) using a Brookfield Viscometer (Brookfield LVDV-II+ P, Brookfield Engineering Laboratories, Inc., Middleboro, MA). Tamarind-carrot juice (500 ml) was loaded into a glass beaker reservoir (cylindrical shape) of 600 ml capacity and was allowed to equilibrate at room temperature. Spindle LV-1 was used to measure viscosity of juice, using rotational speeds ranging between 0.3 and 1.5 revolutions per minute (rpm). The recording of the viscometer output commenced three minutes after the onset of the experiment. Analysis was carried out in triplicate.

Determination of Vitamin A Content of Tamarind - Carrot Juice Blends
Vitamin A was determined according to AOAC (1990) method. Sample (0.2 ml) was measured, 36 ml absolute alcohol and 0.6 ml of 5 % potassium hydroxide was added. It was boiled gently at 50 °C under reflux (covered with cotton wool and wrapped with foil paper) for 30 min in a stream of oxygen free nitrogen. It was rapidly cooled and 6 ml of water was transferred to separating funnel. It was washed with 3x50 ml petroleum ether and β-carotene was extracted by shaking for 1 min. After complete separation, the lower layer was discarded and the extract washed with 4 x 50 ml water, mixing cautiously during the first two washes to avoid emulsion formation. The washed extract was evaporated down to about 5 ml and the remaining ether was removed in a stream of nitrogen at room temperature. The residue was then dissolved in sufficient isopropyl alcohol to give a solution containing four ml. Thereafter, the extinctions at 310, 325 and 334 nm and the wavelength of maximum absorption were measured.

Vitamin A = [Abs. @ 325 x 6.815) – (abs. @ 310 x 2.555) – (abs. @ 334 x 4.26)] x 1830.

Determination of Vitamin C Content of Tamarind - carrot juice Blends
Vitamin C content of the juice blends was determined using AOAC (1990) method. The diluted sample (50 ml) was pipetted into 100 ml volumetric flask and 25 ml of 20 % metaphosphoric acid was added as stabilizing agent and made up to mark. The solution (10 ml) was dispensed into a small flask and 2.5 ml of acetone was

added and titrated with the indophenol solution until a faint pink color persist for 15 s and vitamin C contents of the samples were recorded as mg/100 ml.

Determination of Total Phenol Content (TPC) of Tamarind - carrot Juice Blends

The phenolics concentration was determined using spectrophotometric method according to Singleton et al. (1999). The reaction mixture was prepared by mixing 0.5 ml of the extract, 2.5 ml of 10 % Folin-Ciocalteu's reagent dissolved in distilled water and 2.5 ml of 7.5% $NaHCO_3$. Blank was concurrently prepared**,** containing 0.5 ml distilled water, 2.5 ml of 10 % Folin-Ciocalteu's reagent dissolved in distilled water and 2.5 ml of 7.5 % of $NaHCO_3$. After which the samples were incubated in a thermostat at 45 °C for 45 min. The absorbance was determined using Genesys 10-UV spectrophotometer (Thermo Electron Corporation) at λmax = 765 nm. All the samples were prepared in triplicate and the mean value of absorbance was obtained. The total phenolic contents were calculated on the basis of the calibration curve of gallic acid and expressed in milligrams gallic acid equivalents (GAE) per 100 ml of juice.

Determination of Total Flavonoids Content (TFC) of Tamarind - carrot Juice Blends

The content of flavonoids were determined using spectrophotometric method (Quettier *et al*., 2000).The sample contained 1 ml of the extract and 1 ml of 2 % $AlCl_3$ solution dissolved in methanol. The samples were incubated for 1 h at room temperature. The absorbance were determined using Genesys 10-UV spectrophotometer (Thermo Electron Corporation) at λmax = 415 nm. The samples were prepared in triplicate for each analysis and the mean value of absorbance was obtained. The same procedure was repeated for the standard solution of rutin and the calibration line was constructed. Based on the measured absorbance, the concentration of flavonoids was read (mg/ml) on the calibration line; then, the content of flavonoids in extracts was expressed in milligrams rutin equivalent per ml of juice.

Total Antioxidant Activity of Tamarind - carrot Juice Blends

The determination of the free radical scavenging activity of each of the crude extract was carried out using the DPPH (2, 2-diphenyl-1- picrylhydrazyl) assay as described by Mensor et al. (2001) with slight modifications. Various concentrations of 250, 125, 50, 25 and 10 µg/ml of the extract in methanol were prepared. 1.0 ml of a 0.3 mM DPPH in methanol was added to 2.5 ml solution of the extract, and allowed to stand at room temperature in a dark chamber for 30 mins. The change in colour from deep violet to light yellow was measured at 518 nm using Genesys 10-UV spectrophotometer (Thermo Electron Corporation). The decrease in absorbance was then converted to percentage Scavenging activity (%) using the formula:

$$\text{Scavenging activity: } \frac{\text{Abs control - Abs sample}}{\text{Abs control}} \text{ X } 100$$

Sensory Evaluation of Tamarind - carrot Juice

Sensory evaluation was conducted to determine consumer preference and acceptability of the juice obtained from velvet tamarind and carrot blends using 9-point hedonic scale where 9 and 1 are like extremely and dislike extremely, respectively. Thirty untrained panelists drawn from the Department of Food Science and Technology, Federal University of Technology, Akure, Ondo State, Nigeria carried out the sensory evaluation. The attributes assessed include appearance, aroma, taste, after taste, thickness and overall acceptability. The samples were coded with three digits and presented to the panelist at random to guard against any bias.

Statistical Analysis

The significance of tamarind and carrot percentage in the juice blends with respect to their antioxidant capacities, physicochemical and sensory parameters was determined by one-way analysis of variance (ANOVA) at 95 % confidence level and the means separated by Tukey test (Minitab 16.0, Minitab Inc., State College, USA).

Results and Discussion

Physicochemical Properties of Blends of Tamarind – carrot Juice

The statistical variations in the physicochemical properties of tamarind, carrot and blend of tamarind – carrot juices are shown in Table 2. Titratable acidity, total soluble solid and viscosity of the tamarind - carrot juice blends significantly ($P < 0.05$) increased with tamarind proportion with 100% carrot juice (TC 0/100) having 0.12%, 6.75 °**b**rix and 0.105 Pa.s (Nsm^{-2}) of titratable acidity, total soluble solid and viscosity respectively. On the other hand, 100% tamarind juice had the highest values of these parameters. Black velvet tamarind was recently characterized for its high total solid content and acidity (Adeola and Aworrh, 2012; Abiodun et al., 2017). This may be responsible for the linear relationship between acidity, °brix, viscosity and the proportion of tamarind in the juice blends. The same inference was true in the case of pH of the juice blends. The results revealed that adding carrot juice reduced the acidity of the tamarind - carrot juice. Juice of 100% tamarind had a pH ranging from 3.43 – 3.47 which is comparable to earlier observation of Abiodun et al. (2017). This may be due to the presence of tartaric acid in tamarind. Low pH (4.2 –

3.5) has been linked to flavor balance, storage stability and inhibition of microbial growth (Tiwari, 2001).Therefore, low pH of the juice blends could prevent microbial growth and improve storage stability.

Table 2. Physiochemical properties of Tamarind – carrot juice blends

Samples	TTA (%)	pH	TSS(°brix)	Viscosity (Pa.s)
TC 100/0	0.46 ± 0.03^{a}	3.45 ± 0.02^{d}	11.25 ± 0.25^{a}	0.205 ± 0.05^{a}
TC 70/30	0.36 ± 0.01^{b}	3.65 ± 0.03^{c}	10.10 ± 0.10^{b}	0.185 ± 0.04^{b}
TC 50/50	0.23 ± 0.02^{c}	3.75 ± 0.01^{c}	9.35 ± 0.05^{c}	0.155 ± 0.03^{c}
TC 30/70	0.17 ± 0.02^{d}	3.95 ± 0.04^{b}	7.10 ± 0.10^{d}	0.125 ± 0.04^{d}
TC 0/100	0.12 ± 0.01^{e}	4.85 ± 0.05^{a}	6.75 ± 0.05^{d}	0.105 ± 0.05^{e}

***Data are means of triplicate samples ± standard error mean, figures bearing different superscript in the same**
column are significantly (P < 0.05) different.
TTA=Tota l titratable acids, TSS=Total soluble solids, TC: Tamarind - carrot ratios.

Increased amounts of carrot in the juice blends resulted in significantly lower titratable acidity and astringency of the blends (Table 2). Viscosity of the tamarind-carrot juice blends also decreased as the amount of carrot increased. Viscosity of tamarind juice may be attributed to the presence of galactoxyloglucan polysaccharide found in tamarind pulp (Bhattacharya et al., 1994), which may be very low or lacking in carrot juice. Additional soluble sugar such as galactose and xylose from this amyloid glucan (galactoxyloglucan) in tamarind pulp, may have contributed to the °brix of the juice blends. Juice blends with less than 7 °brix are categorized as weak and watery, depicting low total soluble solids (Bates et al., 2001).Thus, tamarind increases the total soluble solids of the blend because carrot juice has less than 7 °brix.

Vitamin contents of tamarind carrot juice blends

Pro-vitamin A content of the juice blends ranged from 2454.16 to 5633.66μg RAE/ 100 ml and 100% carrot juice had the highest Vitamin A contents among the juice blends. As expected pro-vitamin A contents of the juice increased as the portion of carrot in the blends increased due to the presence of carotene pigment responsible for the color of carrot. The nutritional relevance of this pigment as a precursor of vitamin A has been well established (Grune et al., 2010). Therefore, both tamarind and carrot juices and their blends are qualified as functional drinks with respect to pro-vitamin A contents. Another essential vitamin that was found abundant in the blends was vitamin C, and it ranged between 27.69 ± 0.79 and 53.03 ± 0.36mg/100 ml with 70:30 tamarind – carrot sample having the highest value (Table 3). The increase in ascorbic acid content of the fruit blends could be as a result of synergistic quantities of vitamin C in both fruits. However, ascorbic acid content of velvet tamarind has been linked with maturation stage of the fruit. The study of Adamu et al. (2015), reported about 150mg/kg ascorbic acid in matured black velvet tamarind. The result obtained for TC 100/0 (100% tamarind) is in agreement with past observation of Ubbaonu et al. (2005) that reported ascorbic acid content of velvet tamarind pulp as sufficient enough to serve as a food supplement. The present result is also in line with the observation of Okudu et al. (2017) who reported about 28 mg/100g vitamin C in jam from velvet tamarind fruit pulp much higher than those obtained from the wild tamarind (Abiodun et al., 2017). Tamarind belongs to the category of underutilized fruits (Caluwé and Damme, 2010) therefore, the quantitative similarities in its vitamin C and that of carrot, is capable of drawing more attention to its health benefits.

Total phenol, flavonoid contents and antioxidant capacity of tamarind carrot juice blends

Total phenolic and flavonoid contents and antioxidant capacity of tamarind – carrot juice blends are presented in Table 3. There was a gradual and significant increase in total phenolic content of the juice blends relative to the amount of tamarind present. Juice of 100% tamarind had the highest total phenol. The same observation was true for flavonoid contents and antioxidant activities of tamarind-carrot juice blends. Phenolic compounds are abundant and ubiquitous but primarily found in fresh fruits and vegetables and possess verifiable health promoting abilities (Omoba et al., 2015). Tamarind contributed significantly to the phenolic profile of the juice blends and by extension, its antioxidant capacities. The phenolic content of pure tamarind juice was comparable with earlier observation by Ogu and Amiebenomo (2012). However, the presence of ascorbic acid, reducing sugars and other reducing compounds present in tamarind could have led to over-estimation of total phenolic content. These compounds have earlier been implicated to hamper correct estimation of total phenol in horticultural produce when Folin Assay is applied (Sánchez-Rangel et al., 2013). In recent years, research attentions have been focused on the bioactive capacities of plant polyphenols as caveats for consumption of fruits and vegetables. For example, flavonoids have been reported to exert multiple biological property including antimicrobial, cytotoxicity, anti-inflammatory as well as antitumor activities (Sak, 2014). The most described property of flavonoids and its derivatives is their potency as powerful antioxidants capable of protecting human body from free radicals and reactive oxygen species (Formica and Regelson, 1995). This may be responsible for the linear correlation between the flavonoids and antioxidant capacities of the juice blends (Table 3). The increase in the flavonoid content of the samples can be associated with flavonoid content in tamarind pulp outweighing that of carrot. This suggests that blending carrot and tamarind could greatly enhance their bioactive compounds content, thus increasing the potential of the juice serving as nutraceutical.

Table 3 Antioxidant properties of Tamarind - carrot juice blends

Samples	Vitamin A (µg RAE/ 100 ml)	Vitamin C (mg per 100 ml)	TPC (mg GAE 100 ml^{-1})	TFC (mg RU ml^{-1})	TAA (%)
TC 100/0	2454.16 ± 0.06^{d}	32.89 ± 0.20^{c}	65.6 ± 0.09^{a}	0.112 ± 0.003^{a}	77.73 ± 0.40^{a}
TC 70/30	2651.54 ± 0.08^{cd}	53.03 ± 0.36^{a}	60.20 ± 0.06^{b}	0.090 ± 0.002^{b}	44.90 ± 0.53^{b}
TC 50/50	2771.49 ± 0.02^{c}	49.92 ± 0.50^{b}	50.30 ± 0.24^{c}	0.089 ± 0.024^{b}	43.27 ± 0.50^{b}
TC 30/70	3080.54 ± 0.05^{b}	50.42 ± 0.44^{b}	47.20 ± 0.38^{d}	0.083 ± 0.006^{c}	28.61 ± 0.96^{c}
TC 0/100	5633.66 ± 0.02^{a}	27.69 ± 0.79^{d}	33.5 ± 0.06^{e}	0.026 ± 0.009^{d}	13.42 ± 1.02^{d}

*Data are means of triplicate samples ± standard error mean, figures bearing different superscript in the same column are significantly ($P < 0.05$) different.

TPC (Total phenolic content), TFC (Total flavonoid content), TC: Tamarind - carrot ratios.

Sensory Evaluation Profile of Blends of Carrot/tamarind Juice

With respect to sensory monitoring of the juice blends important attributes such as colour (appearance), aroma, consistency, taste, after taste and overall acceptability were objectively evaluated by panelists. Table 4 revealed considerable organoleptic differences between the juice blends. It was observed that 100% carrot juice had higher value in each of the sensory parameter followed 30:70 tamarind – carrot juice blend. However, there seemed to be low sensory preference for the juice blends as the tamarind percentage increased. However, overall acceptability of 30:70 tamarind /carrot juice and 100 % carrot juice were considerably high with a score between 6.6 (like moderately) and 8.51 (very much), respectively. This may be due to the fact that consumers are familiar with the taste of carrot juice than tamarind. Blend of tamarind with carrot at 50 and 70 % affected all sensory attributes due to its astringent taste. Some panelists noted that 70% tamarind blend had more astringent flavor when compared to the other juices. This is due to the high acid content of the tamarind juice. The sensory properties of 100% tamarind in terms of taste, color, aroma, thickness were ranked quite low when compared to the blends.

Table 4 Sensory acceptability of the Tamarind - carrot juice blends

Attribute	TC 100/0	TC 70/30	TC 50/50	TC 30/70	TC 0/100
Appearance	2.40 ± 0.29^{d}	4.33 ± 0.35^{c}	4.30 ± 0.26^{c}	5.80 ± 0.38^{b}	8.60 ± 0.09^{a}
Aroma	3.27 ± 0.44^{c}	3.40 ± 0.33^{c}	4.07 ± 0.26^{c}	5.10 ± 0.21^{b}	8.63 ± 0.11^{a}
Thickness	4.20 ± 0.38^{c}	4.50 ± 0.34^{c}	4.90 ± 0.31^{b}	5.60 ± 0.31^{bc}	8.34 ± 0.12^{a}
Taste	3.40 ± 0.28^{d}	4.30 ± 0.34^{c}	4.43 ± 0.42^{c}	5.90 ± 0.28^{b}	8.47 ± 0.12^{a}
After taste	3.33 ±0.35^{d}	3.77 ± 0.34^{d}	5.03 ± 0.22^{c}	5.93 ± 0.34^{b}	8.23 ± 0.17^{a}
Overall acceptability	2.47 ± 0.37^{d}	4.50 ± 0.35^{c}	5.20 ± 0.21^{c}	6.67 ± 0.29^{b}	8.67 ± 0.09^{a}

*Means of triplicate samples ± Standard error mean, figures bearing different superscript in the same row are significantly ($P < 0.05$) different. TC: Tamarind - carrot ratios.

*Keys for hedonic scale used were: 9 = like extremely, 8 = like very much, 7 = like moderately, 6 = like slightly, 5 = neither like nor dislike, 4 = dislike slightly, 3 = dislike moderately, 2 = dislike very much, 1 = dislike extremely.

Conclusion

Fruit juice produced from blends of velvet tamarind and carrot showed improved physicochemical and nutritional properties with respects to titratable acidity, total soluble solid and viscosity, vitamin A, vitamin C, total phenols, total flavonoids and antioxidant capacities. The best juice blend with high antioxidant property and sensory properties is that made from 70 % carrot and 30 % tamarind blends. Apart from pro-vitamin A that decreased with the increased in tamarind proportion of the juice, every other desirable nutritional property indicated a linear increase. The result of sensory evaluation indicated higher preference for 100% carrot juice than tamarind – carrot blends due to the astringenic taste of tamarind pulp. However, this study provides valuable information on the nutritional and food-value potential of black velvet tamarind in the country where it is being relegated as abandoned or underutilized fruit.

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