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VARIATION IN NUTRITIONAL PROPERTIES OF MANGO (*MANGIFERA INDICA*) JUICE BASED ON VARIETAL DIFFERENCE AND THERMAL HOLDING TIME

– Research paper –

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Abstract: This research demonstrated the significance of variety and thermal holding time (THT) at constant temperature (95 ºC) on quality characteristics of mango juice. Eighteen samples from Mado, Julie and Kent mango varieties were produced using full factorial design. Quality parameters, sensory and microbial properties were determined. Variety and THT were significant for most notable variables considered except for some sensory properties. Juice of Julie had the highest vitamin C at 60s, while Mado were superior in virtually all other chemical parameters; having 31.93 – 49.97 µg/100g pro-vitamin A, 51.10 – 113 mg/100g total phenol, 25.60 – 81.40 mg/100g total flavonoid, 1.26 – 1.48 mg/L tannin and 12.60 – 13.60% ºBrix. Microbial qualities were influenced by THT; with 60s long enough to achieve stable products. PCA cluster analysis further emphasized variety as the most quality-determining factor in mango juice.

Keywords: Mango juice, varietal difference, thermal holding time, Cluster analysis

INTRODUCTION

Seasonal gluts and postharvest losses are the two major hindrances preventing availability of fruits and vegetables throughout the year in developing countries (Jolayemi & Adeyeye, 2018). Therefore, processing of fruit into fruit juice classified as those without pulp ("clarified" or "not clarified") and those with pulps ("pulps", "purees", and "nectars") and dry fruits have become the usual methods of extending freshness and availability of fruit especially during off-season (Lozano, 2006). However, the quality of fruit products is equally affected by agronomical (varietal/cultivar, maturity, degree of ripeness) and technological (time-temperature combination, packaging and storage conditions) factors (Arah et al., 2015; Rouphael et al., 2012). Mango is a popular climacteric fruit that comes in different cultivars but only few are of commercial and economic significance. Cultivars such as 'Mado', 'Kent' and 'Julie' are very common in the tropics in addition to several others with varying physicochemical and sensory characteristics (Wibowo et al., 2015). In order to improve shelf stability of such a highly perishable horticultural produce; mango is commonly processed into different secondary products. Pasteurization is a commonly applied thermal treatment suitable for acid-based foods to extend the shelf life and maintain its microbial safety (Rawson et al., 2011). Therefore, selection of mango cultivar suitable for different processing conditions becomes a necessity in order to maximize the nutritional benefits of its products. There are several thermo-processed mango products in the market and few examples include canned slices, mango juice, jam, puree and nectar (Wibowo et al., 2015).

The fruit contains many essential micro and macronutrients with innumerable nutritional importance. Studies have attributed regular consumption of mango to prevention of certain type of cancer, better iron assimilation, and high immune responses (Shahid et al., 2015). The edible portion contains mainly of mono and disaccharides the quantities, which depend on cultivar and stage of ripeness. In addition to the sugar contents, mango contains several 3 to 6 carbons organic acids (Elsheshetawy et al., 2016). Other important chemical components of mango include carotenoid, anthocyanin, chlorophyll and phenols that contribute to the overall nutritional properties of the fruit. These chemical properties vary according to maturity,

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harvest season, variety and processing techniques. In juice production, there must be an appropriate combination of high-quality raw materials and operational procedures. For instance, wrong time-temperature combination may adversely affect overall quality of thermally treated mango juice. These factors constitute important parameters that must be carefully adjusted for maximum juice quality. Being a commonly relished fruit in the tropic coupled with the desire to achieve five serving target of fruits and vegetables per day (WHO, 2003), there is a great incentive in exploring some quality-determining factors in mango and its products.

There are several studies on the influence of processing parameters, conditions and treatments, cultivar and varietal differences on the physicochemical, sensory and microbial stability of mango and mango products. The study of Wibowo et al. (2015) evaluated the quality and storage stability of pasteurized mango juice using targeted and non-targeted multivariate analytical approaches, with remarkable results. Similarly, the study of Oliveria et al. (2012) assessed the significance of temperature and time in sensorial changes in mango juice. While, these studies were only on thermal treatment of mango juice, the studies of Santhirasegaram et al. (2015) evaluated the qualitative differences between ultraviolet-irradiated and thermally treated mango juice. In the same vein, Naresh et al. (2015) and Guan et al. (2016) evaluated the microbial stability and desirable attributes of irradiated and non-thermally treated mango juice; all with significant novel outputs. There are other studies focusing on the changes in physicochemical properties of mango juice obtained from different cultivars. Elsheshetawy et al. (2016) and Ribeiro et al. (2008) comparatively evaluated the physical, chemical and sensorial differences among mango cultivars. There are no studies in the literature where combined effects of variety and thermal holding time were examined on the chemical, sensorial and microbial attributes of mango juice. Hence, the study can suggest appropriate processing conditions suitable for different mango varieties.

MATERIAL AND METHODS

Sources of Raw Materials: Fifty pieces of mango from each variety (Mado, Julie and Kent) were supplied by NIHORTS (National Institute of Horticultural Study of Nigeria, Abeokuta) at relatively optimum maturity. The samples were cleaned and sorted for uniformity and wholesomeness. Mango juice were produced according to general full factorial Design with two factors (variety and pasteurization time) in a laboratory scale juice extractor (Sayona, Stainless Steel Electric Juicers SJ – 828). A total of 18 samples were obtained bottled, corked and held at 95 ^{o}C using electrical water bath (Memmert, China) for 15, 30 and 60 seconds, in accordance with the method described by Shahid et al. (2015). Samples were allowed to cool and stored at refrigeration temperature prior to analysis.

Determination of pH: The acidity or alkalinity level of the juice samples were determined with a Digital Handheld Thermal Orion 868 pH meter (Thermo Fisher Scientific, Inc., Massachusetts, USA) at room temperature. The pH meter was calibrated prior to the actual measurement, with buffers at pH 7.0 and 4.0

Determination of acidity: Titratable acidity was determined by titrating diluted samples against sodium hydroxide (0.1 N) with phenolphthalein as indicator and the result was expressed as percentage equivalent of malic acid.

Determination of soluble solid: A hand-held refractometer (Atancon, Japan) was used to measure total soluble solid of the samples, reported in ^{o}Brix.

Optical colour density determination: This colour density was determined spectroscopically according to the method described by Wroistad, (1993). Mango juice of 2 mL was made up to mark with 15 mL methanol and mixed continuously for 30 min so as to extract the colour. The mixture was centrifuged after 10 min. The colour intensity of the supernatant was determined by measuring the absorbance at two wavelengths; 420 and 520 nm using UV-VIS spectrophotometer (Shimadzu UV- 1800, Kyoto, Japan). Average of three replicate was taken and sum of the absorbances were recorded as colour intensity by using equation 1.

Determination of pigments content: Total chlorophyll and carotenoid (pro-vitamin A) were determined using a modified method of

Harborne (1980). Mango juice (2 mL) was diluted with 20 mL acetone (80%), and centrifuged at 1107 x g for 10 min. Supernatant was dissolved in 20 mL ethanol (80%) and the absorbance was taken at 480, 645 and 662 nm using UV-VIS spectrophotometer (Shimadzu UV-1800, Kyoto, Japan). Total chlorophyll and carotenoids contents were calculated using the extinction equations 2 and 3, where A: absorbance at a corresponding wavelength, V: volume of chlorophyll extract in 80% acetone, W: weight of the sample.

Determination of vitamin C content: The method of Ordóñez-Santos et al. (2017) was adapted to determine ascorbic acid content of the samples. Briefly, 5 mL of the sample was extracted 100 mL of cold water. A portion of the extract (2 mL) was disolved in 25 mL gacial acetic and the mixture was titrated against 2.6-dichloroindophenols (0.05g/100 mL) dye solution. Pure ascorbic acid was used as standard, and the result were calculated as equation 4 indicated.

$$\text{Colour density} = \text{A420nm} + \text{A520nm} \quad (1)$$

$$\text{Total carotenoid content (mg/L)} = \frac{4 * \text{A.}_{480\text{nm}} * \text{V} * 1000}{\text{Sample weight}} \quad (2)$$

$$\text{Total chlorophyll content (mg/L)} = \frac{[(20.2 * \text{A.}_{645\text{nm}} + 8.02 * \text{A.}_{663\text{nm}}) * \text{V}]}{1000 * \text{Sample weight}} \quad (3)$$

$$\text{Ascorbic acid (mg/100 mL)} = \frac{\text{Titre value * dye factor * volume (100 ml)}}{\text{aliquot of extract * volume of sample}} \text{ x } 100 \quad (4)$$

Determination of total phenol contents: Total phenol content (mgGAE/L) content of the juice was determined following the Folin-Ciocalteu method described by Singleton & Lamuela-Raventos, (1999). To 0.5 mL juice extract, 1mL of Folin (10%) and 2 mL sodium carbonate (20%) were added and the mixture was incubated at 30 ºC for 60 min. The clear bluish colour developed was measured spectroscopically (UV-Visible spectrophotometer, Shimadzu, 1800, USA) at 760 nm absorbance of the sample was measured at 760 nm using UV-Visible spectrophotometer (Shimadzu, 1800, USA). Total phenol content of as miligram equivalent of gallic acid (mgGA) per 100 mL of sample, was calculated using gallic acid standard curve.

Total flavonoid content determination: Total flavonoid content of the juice was estimated using a slightly modified method of Quettier, (2000). Briefly, 2 mL of centrifuged mango juice was mixed with equal volume of 2% aluminium trichloride. After 10 min, the absorbance of the resultant clear solution was measured spectroscopically (UV-Visible spectrophotometer, Shimadzu, 1800, USA) at 430 nm. The flavonoid content was calculated as milligram equivalent of quercetin per 100 mL of the juice.

Determination of total tannin content. This was determined using the method of Makkar and Goodehild, (1996). In brief, the mixture of 0.2 g sample and 10 mL acetone (70%) was covered and mixed in a cold bath for 2 hr. The mixture was centrifuged, and 0.2 mL of the supernatant was mixed with water (0.8 mL), 0.5 mL Folin reagent and 2.5 mL sodium carbonate (20%). The mixture was properly vortexed and allowed to incubate for 40 mins at room temperature. The absorbance of the solution was measured spectroscopically (UV-Visible spectrophotometer, Shimadzu, 1800, USA) at 725 nm and tannin content was calculated in milligram per liter using tannic acid standard curve.

Microbial quality assessment: Morton, (2001) standard plate method of microbiological evaluation was used to determine total plate count (TPC) of the samples. The sample (25 mL) was mixed with 225 mL sterile peptone water and serially diluted. Pour plate method of inoculation was done on the surface of sterile agar ((PCA, 70152 Sigma-Aldrich, Germany) using 10^{-1} and 10^{-2} dilutions. The experiment was conducted in duplicate and the plates were incubated for 24 hr at 37 ºC. The number of colonies on the place were counted and expressed as colony forming units (CFU). The method of Harrigan and MacCance, (1976) was used to enumerate mould and yeast growths using Potato dextrose agar (PDA) incubated at 25 ºC for 72 hr.

Sensory properties determination: Variations in the sensorial characteristics of the samples were

carried according to Wang et al. (2014). A total of 30 panelists (15 male and 15 female) who are Food Science and Technology Departmental members or students with prior knowledge of food sensory evaluation, were selected from the Department of Food Science and Technology. Changes in sensory parameters (taste, favour, appearance, and general acceptability) with respect to the factors considered were measured objectively.

Statistical Data Analysis: A univariate statistical analysis (ANOVA) was applied to determine main factors and interaction effect of variety and thermal holding time on the measured variables, at 95% significant level, using Minitab Statistical Package (Minitab 16.0, Minitab Inc., State College, USA). In order to have a comprehensive overview of the underlying relationship between factors and variables, a principal component analysis (PCA) model was built on the data. It is the most commonly applied statistical tools with the ability to transform data matrix linearly into a reduced dimension using its eigen values (principal components - PCs), for better visualization. The dimensional reduction of the data matrix enables maximum preservation of variances in the original data set (Jolayemi et al., 2016). PCA model output includes: score and loading plots that show the position of the samples with respect to the variable predictors. Data matrix of size 18 x 16 consisting of 18 mango juice samples (observations) and 16 variables was analyzed. The variables include: vitamin C, total carotenoid, total phenol, total flavonoid, tannin contents, pH, titratable acidity, °Brix, colour density and six sensory parameters. SIMCA software (ver. 15.0.2. Umerics Umea, Sweden) was used for the PCA. The clustering pattern of observations and variables (score and loading plots), total percentage explained variance and number of PCs revealed the performance of the model

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RESULTS AND DISCUSSIONS

Variations in the physicochemical properties

The pH, TTA, and TSS constitute intrinsic quality attributes of juice that could influence the acceptability of the products to end-users. As shown in Table 1.

pH was significant with respect to variety alone and Mado had the highest pH (4.48 – 5.60) (Table 2). The pH range corresponds with that of 'low-acid food' and set the probability for microbial growth and enzyme activities than juice from other varieties. Juice of Kent variety was next to Mado in pH and Julie was the most acidic (3.38 – 3.63) of the three varieties.

Table 1. Statistical significance of variety and thermal holding time on chemical and sensory properties of mango juice

Variables	Variety	THT	Variety + THT
Physicochemical properties			
pH	0.00	0.32	0.24
Titratable acidity (%)	0.01	0.23	0.16
Total soluble solid (°Brix)	0.03	0.14	0.10
Colour Density	0.01	0.02	0.01
Chlorophyll (µg/100g)	0.00	0.04	0.03
Vitamin C (mg/kg)	0.02	0.01	0.02
Total carotenoid (µg/100g)	0.00	0.00	0.00
Total phenol content (mg/100g)	0.01	0.01	0.00
Total flavonoid content (mg/100g)	0.01	0.01	0.01
Tannin (mg/L)	0.02	0.15	0.04
Sensory properties			
Taste	0.15	0.62	0.85
Flavour	0.83	0.59	0.45
Odour	0.79	0.39	0.69
Mouthfeel	0.24	0.90	0.40
Appearance	0.05	0.90	0.95
Acceptability	0.03	0.81	0.23

P-value < 0.05 is significantly different; THT: Thermal Holding Time

The same trend but in an inverse manner was true for TTA. Similarly, only varietal difference affected the TSS contents of the juices, with Mado variety having the highest values (12.50 – 13.70 ºBrix). There was no observable variation in these parameters with respect to thermal holding time. This agrees with the results of Guan et al. (2016). Similarly, Igual et al. (2010) showed that temperature-time combination have no significant effect on pH and Brix of pasteurized juice. These quality parameters constitute important stability indices for many phytochemicals in fruits and fruit (Sánchez-Moreno et al., 2006). Both variety and THT had significant ($P < 0.05$) effects on the juice colour density. Juice of Mado variety had highest colour densities (0.08 – 0.15) and this is related to the slightly higher level of pigmentation of the variety (as will be seen later). There was a linear decrease in colour intensity with THT in all the varieties, which is partially in agreement with Cruz-Cansino et al. (2015) who observed an increased colour stability in minimally processed pear juice at holding time > 30s. Similarly, colour intensity has been used as an indicator to predict quality degradation as a function of thermal treatment in fruits and vegetables (Xiao et al., 2017).

Table 2. Physicochemical properties of Mango juice of different varieties and thermal holding time

Sample	pH	TTA (%)	Brix (º)	Colour Density	Chlorophyll (µg/100g)	Tannin (mg/L)
Mado variety						
15s	5.50±0.05	6.70±0.28	12.80±0.15	0.12±0.03	9.00±0.00	1.36±0.02
30s	4.55±0.07	6.70±0.28	12.70±0.20	0.70±0.01	14.51±0.35	1.31±0.06
60s	4.55±0.07	7.30±0.42	13.42±0.28	0.10±0.02	13.40±0.42	1.48±0.00
Julie variety						
15s	3.45±0.07	23.30±0.42	10.50±0.05	0.08±0.00	3.15±0.35	1.15±0.06
30s	3.55±0.07	23.65±0.35	10.20±0.25	0.06±0.00	5.85±0.35	1.38±0.06
60s	3.55±0.08	24.00±0.71	10.90±0.14	0.01±0.00	4.00±0.00	1.33±0.05
Kent variety						
15s	3.60±0.00	19.40±0.14	10.50±0.10	0.10±0.00	6.20±0.85	1.34±0.01
30s	3.65±0.07	20.00±0.00	9.70±0.20	0.07±0.00	6.10±0.28	1.31±0.03
60s	3.60±0.14	19.2±0.28	9.50±0.35	0.01±0.00	7.35±0.71	1.27±0.00

Values are means ± SDs

Variations in Vitamin and Pigments contents

Variety, THT and their interactions significantly affected vitamin C, chlorophyll and carotenoids (Pro-vitamin A) contents of the mango juice (Table 1). The pattern of change in vitamin C with respect to THT was similar among different varieties. However, quantitatively, juice of Julie variety had the highest vitamin C (19.65 – 23.04 mg/kg) content, followed by Kent (13.67 – 18.69 mg/kg) and Mado (4.47 – 6.79 mg/kg) was the least. This observation is in pal with the study of Ellong et al. (2015). Similarly, Elsheshetawy et al. (2016) and Naresh et al. (2015) have earlier confirmed the significance of varietal and cultivar differences in ascorbic contents of mango. Nutritionally, it is not likely to obtain a correct link between servings of fruits and vegetables and quantity of vitamin C derived. However, the standard 400g/day of fruits and vegetable according to FAO/WHO guidelines (FAO&WHO, 2004) aimed at providing sufficient vitamin C to prevent chronic disease. Therefore, consumption of adequate amount of juice of Julie variety could be highly beneficial to human health. Ascorbic acid degradation or loss in fruits and vegetables has been linked to many processing parameters among which temperature-time combination, is the most studied (Xiao et al., 2017; Jolayemi et al., 2018). This explained the linear decrease in vitamin C with THT in all the varieties. Kadakal et al. (2017) experienced a first-order linear reduction of ascorbic acid with thermal holding time in rosehip nectar. In the same vein, the study of Munyaka et al. (2010) showed the temperature-time dependency of ascorbic acid in broccoli.

The pigments composition of the juice was found significant with respect to the main effects (variety and THT) and their interaction. The pigments contribute to the brilliant colour of mango skin and pulp. Nutritionally, carotenoids are best known for their pro-vitamin A activity in addition with many other biological functions which include: antioxidant properties, cell signaling, enhanced immunity, skin protection, and prevent damages due to photo-oxidation (Van de Berg et al., 2000). Mado juice had more than double-fold of chlorophyll and carotenoid (pro-vitamin A) contents of other varieties. This explains the higher colour density in Mado

mango juice as stated earlier. However, chemical changes such as isomerization of carotenoid caused by prolonged exposure to high temperature pasteurization may explain the decrease in carotenoids with thermal holding time (Figure 1B). This is consistent with the observation of Santhirasegaram et al. (2015) who compared the carotenoid contents mango juice between thermal and ultrasonic treatments. It is noteworthy to mention the reduced stability effect of low pH on carotene according to Ariviani et al. (2015) which explains why Mado maintained higher carotene than other varieties. The changes in chlorophyll due to THT did not follow a linear sequence as observed in carotenoid. THT of 30 s better retained more chlorophyll in Mado and Julie varieties while 60 s was better for Kent.

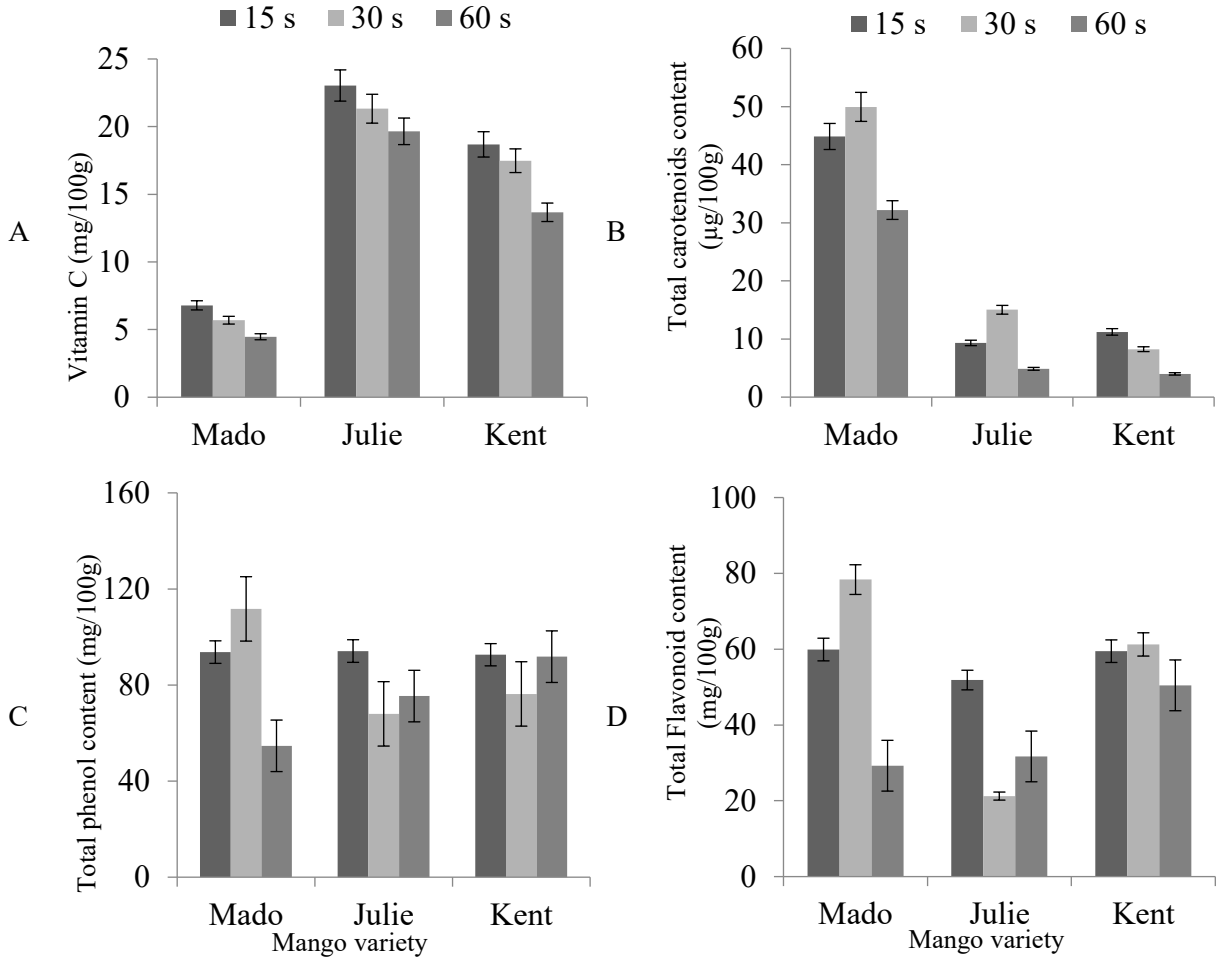

Figure. 1. Variation in (A) Vitamin C, (B) total carotenoids (C) total phenol (D) total flavonoid contents of mango juice with respect to variety (Mado, Julie and Kent) and thermal holding time (15 s, 30 s and 60 s) (Data are presented as mean of three replicates ± standard deviation).

Phenolic Composition of Different Varietal Mango Juice

Fruits and vegetables are the main sources of bioactive phenolic compounds that are capable of exhibiting antioxidant activities via hydrogen or electron donation (Abbasi et al., 2015). The results of total phenol and flavonoid contents of the juice were significant with respect to the two factors while tannin was more influenced by varietal difference and factors interaction as shown in Table 1. Accumulation of phenolic compounds in fruits and vegetables has been attributed to some important agronomical parameters among which variety constitutes the most intriguing one (Kim et al., 2013). Quantitatively, juice of Mado exhibited slightly higher total phenol and flavonoids at 54.70 – 111.70 mg/100g and 29.25 – 78.35 mg/100g, respectively than other varieties. Relatively, this quantity is significantly high enough to be nutritionally vital in case of regular consumption of mango. Amongst the groups of phenols, flavonoids are the most potent antioxidants. According to the study of Abbasi et al. (2015), anthocyanin is the group of flavonoid most common in mango pulp. Being structurally unstable, the slight variation in flavonoid and total phenol with THT may be due to thermal

degradation and other temperature-dependent changes. Tannins are a class of astringenic polyphenols capable of binding and precipitating proteins and various organic compounds (Akharaiyi & Ugberase, 2017). Mado juice of 60 s THT was slightly higher in tannin than others. On average, the contents of tannin were low in all the varieties as shown in Table 2. In addition to the well-known health importance of tannin, it has been showed to possess antibacterial and antifungal activities in mango (Oliveira et al., 2016).

Microbiological Quality Assessment of Different Varietal Mango Juice

The microbiological qualities of the juices were assessed with respect to different mango varieties and THT (Table 3). A general decreasing trend was observed in total viable count of microorganisms with THT. Juice of Mado variety had a TVC of 4.30 x 10^3 CFU/mL after holding for 15 s and the count decreased more than 76% by the end of 60 s pasteurization. A similar trend was observed in other varieties. There was no viable count after 60 s THT in juices of Julie and Kent varieties. Mould growths significantly decreased with THT in all the varieties. Slightly higher microbial loads of juice of Mado variety may be due to its higher pH. The low acidity of the variety may have allowed more microbial proliferation as supported by literature (Batra et al., 2018). Generally, the minimal level of viable microorganisms in the samples may not be solely due to pasteurization time. The sanitary preparatory conditions of the sample may have contributed to the overall microbial quality of the juices. The results were in pal with the observation of Santhirasegaram et al. (2015) who reported a delay in microbial deterioration and extended storage life of thermally treated mango juice. Similarly, Mahgoub & El-Shourbagy (2015) reported total bacteria and yeast/moulds counts between 2.18 – 2.56 CFU/mL in some pasteurized commercial fruit juices.

Sensory Assessment of Different Varietal Mango Juice

The results of sensory evaluation of the mango juices by panelist on taste, flavour, odour, mouthfeel, appearance and overall acceptability were shown in Table 4. The samples did not show any significant difference in all the sensory parameters with respect to variety, THT and their interaction, except for generally acceptability that slightly favoured juice of Julie variety. There was no significant influence of THT on the sensory properties of the juices. On average, Kent ranked slightly better in taste while Mado juice was preferred in taste, flavour and overall acceptability after 30 s THT only. Julie had a slightly better appearance in all the THTs when compared to others. Appearance is recognized as consumers' primary motivation toward food products selection (Fernández-vázquez et al., 2013). Generally, the result showed all the sensory descriptors assessed from the juice samples were reasonably fair as none was scored below 5. In addition, the dependency of organoleptic properties of mango juice on variety and THT were relatively low.

Principal Component Analysis (PCA) of Mango Juice Quality Properties

PCA was applied to evaluate the distinct quality properties of mango juice of different varieties and THT. It is an unsupervised data clustering technique that reveals the inherent patterns and trends within the data matrix. These patterns and trends are represented by the projection of observations (mango juices) and variables (quality parameters) into a one-dimensional hyperplane called score and loading plots as shown in Figure 2A and 2B respectively.

Table 3. Microbial quality of Mango juice of different varieties and pasteurization holding time

Sample		Total Viable Count (CFU/mL)	Mould Count (sfu/mL)
Mado variety	15s	4.30 x 10^3	3.20 x 10^2
	30s	3.10 x 10^3	2.00 x 10^2
	60s	1.00 x 10^2	NVG
Julie variety	15s	2.30 x 10^3	1.00 x 10^2
	30s	1.00 x 10^2	1.00 x 10^2
	60s	NVG	NVG
Kent variety	15s	3.20 x 10^4	3.10 x 10^2
	30s	1.00 x 10^3	1.30 x 10^2
	60s	NVG	NVG

Values are means of two replicates; CFU: colony forming unit; sfu: spore forming unit, NVG: no viable growth

Table 4. Sensory properties of Mango juice of different varieties and thermal holding time

Samples	Taste	Flavour	Odour	Mouthfeel	Appearance	Overall acceptability
Mado variety						
15s	5.90±0.42	6.40±0.28	6.30±0.14	5.30±0.14	7.00±0.28	6.40±0.28
30s	6.50±0.71	6.90±0.42	6.40±0.28	6.30±0.71	6.70±0.42	6.80±0.28
60s	5.90±0.71	6.10±0.42	6.50±0.14	5.80±0.28	6.70±0.42	6.00±0.57
Julie variety						
15s	5.90±0.71	7.00±0.85	6.00±0.28	6.00±0.00	7.70±0.14	7.20±0.00
30s	5.80±0.85	6.70±1.27	6.90±0.42	6.30±0.42	7.90±0.42	7.10±0.14
60s	5.20±0.28	6.00±0.28	6.10±0.42	6.00±0.00	7.90±0.71	7.30±0.71
Kent variety						
15s	6.20±0.57	6.40±0.28	6.20±0.00	7.20±0.57	7.60±0.28	6.90±0.14
30s	6.60±0.28	6.00±0.29	6.60±0.28	6.10±0.42	7.90±0.14	6.00±0.00
60s	6.60±0.29	6.60±0.85	6.90±0.14	6.30±0.14	7.30±0.42	6.90±0.42

Values are means ± SDs

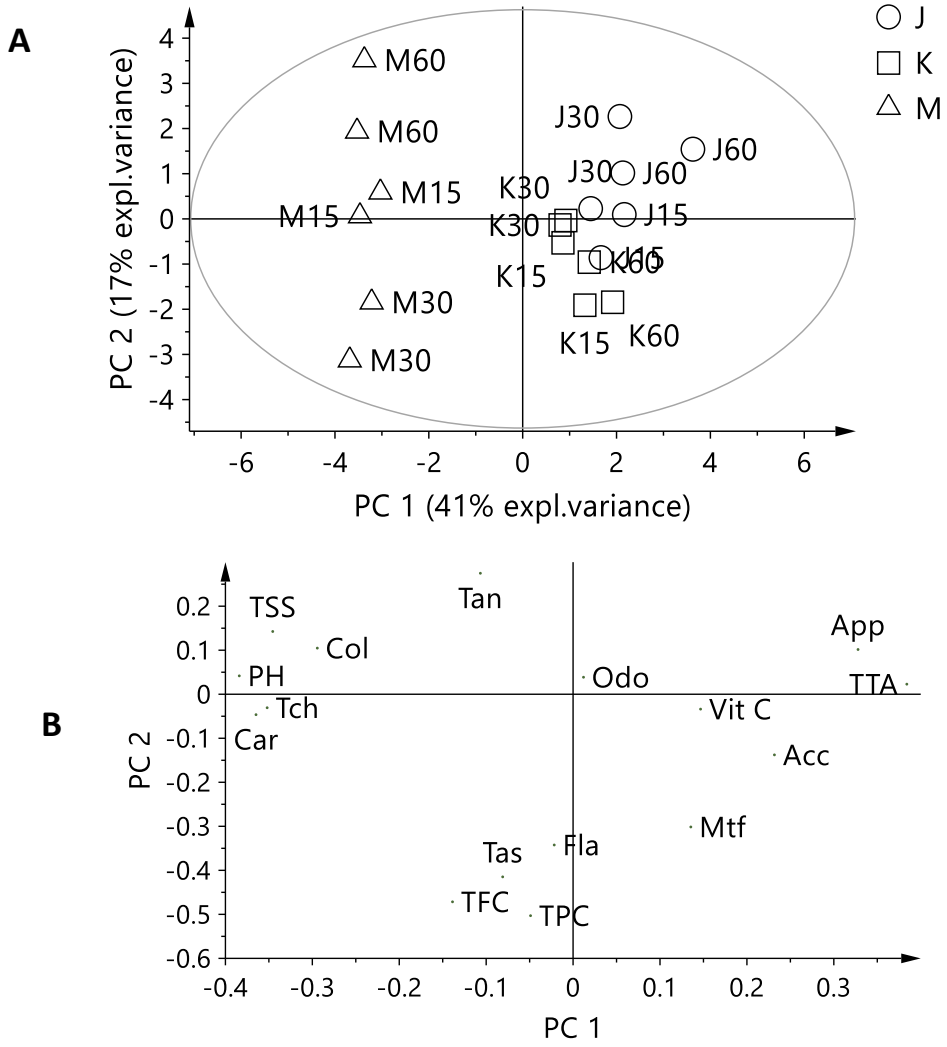

Figure 2. Result of PCA multivariate model: (A) Score plot, (B) Loading plot of Julie (J) Kent (K) and Mado (M) of mango juices thermally held for 15, 30 and 60 s at 95 °C. Car: Carotene (µg/100g), Tch: total chlorophyll (µg/100g), Tan: Tannin (mg/L), Col: Colour, Vit C: Vitamin C (mg/kg), TPC: Total phenol content (mg/100g), TFC: Total flavonoid content (mg/100g); TSS: Total soluble solid, Fla: Flavour, Odo: Odour, Tst: Taste, App: Appearance, Mtf: Mouthfeel, Acc: General Acceptability.

The results of the model with 2PCs and 58% explained variance indicated clearly that the most pronounced factor influencing the clustering of observations was the mango variety. As shown in the score plot (Figure 2B), Juice of Mado variety occupied the left side of the ellipse while Julie and Kent clustered on the right side. Mado mango juices were best described by their comparatively higher pigments (chlorophyll and carotenoids), colour density, tannin, pH, total soluble solid, TPC, TFC and taste. In the case of Julie samples, parameters such as appearance, odour and titratable acidity were responsible for their separation. Variables such as vitamin C, odour, and TTA that lie on the zero plane of the score right hemisphere were properties significant for both Julie and Kent varieties. On the other hands, sensory parameters such as mouthfeel, general acceptability and flavour were more substantial in Kent variety. However, THT had more distinctive influence on Mado juice in terms of quality properties compared to other varieties. At 60 s slightly more tannin, colour density, pH and TSS were obtained in Mado juice, while juice obtained after 15 s had higher chlorophyll and carotenoids and those of 30 s retained more phenolic contents and taste.

CONCLUSIONS

Varietal difference was the most significant factor influencing the physicochemical and quality properties of mango juice obtained from Mado, Julie and Kent varieties. Thermal holding times between 15 and 60 s at constant temperature of 95ºC were found significant on some chemical parameters such as, pigments, vitamin C, total phenol, flavonoids contents as well as microbial quality. Interactions of both factors were also important, indicating the significance of their appropriate combination. Both factors did not substantially affect the organoleptic quality of the juices. However, the longer the thermal holding time, the lower the microbial counts. The result of PCA multivariate clustering technique showed higher total phenolic and pigments contents were peculiar to juice of Mado variety depending on the thermal holding time, while Julie and Kent retained more vitamin C and better sensory properties. The study suggests, a better understanding of thermal processing technologies relative to agronomical parameters such as variety; is necessary to maximize the physicochemical, sensorial properties and microbial safety of mango juice and can also contribute to the effectiveness of mango juice production.

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