Physico-chemical, microbial and sensory properties of *kunu zaki* beverage sweetened with black velvet tamarind (*Dialium guineense*)

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Summary

This work determined the physicochemical, microbial and sensory characteristics of *kunu zaki* sweetened with black velvet tamarind (*Dialium guinnense*) flour. The outer covering and seed of black velvet was removed while the pulp was pulverized to obtain the flour. The tamarind pulp was analysed for its proximate and sugar contents. *Kunu zaki* was prepared according to standard method and 10, 20, 30, 40 and 50 g of the black velvet pulp was added to 1000 ml each of *kunu zaki* along with a control sample. The *kunu zaki* samples were stored at refrigeration temperature (4 ºC) for a period of 5 days. The physico-chemical properties (pH, ºbrix, total titratable acidity), color, beta-carotene and vitamin C, microbial load and sensory attributes of the *kunu zaki* were analysed. The black velvet tamarind pulp had 42.01 g/100 g of total solid. The addition of black velvet tamarind (*Dialium guinnense*) to *kunu zaki* lowered the pH, thereby improving the keeping quality of the *kunu zaki* samples. The pH of kunu zaki ranged from 2.69-4.15 while the titratable acidity ranged from 5.44-10.06 %, the beta-carotene and vitamin C content were high with a range of 3.10–36.6 mg/100 g and 4.73–47.25 mg/100 g respectively. The bacterial count ranged from 1-8.8 × 10^3 cfu/mL and a fungal count of 1-4.9 × 10^3 cfu/mL. *Kunu zaki* with 50 g of black velvet tamarind was the most preferred in terms of taste, appearance, aroma and general acceptability.

Keywords: Black velvet tamarind, beverage, colour, *kunu zaki*, sorghum, sensory properties

Introduction

Kunu-zaki is a traditional non-alcoholic fermented beverage widely consumed in the northern part of Nigeria. Obadina et al. (2008) observed that *kunu zaki* is now widely consumed in the Southern parts among low and middle income workers who cannot afford industrial beverages. The beverage is characterized by sweet-sour taste, creamy, refreshing quality as well as its flowing consistency (Obadina et al., 2008). They may exist as liquid or thin gruel preparation with high water content which supplies the body with water sufficient to maintain health (Oguntimein, 1994). *Kunu* is the generic name for all kinds of non-alcoholic beverages that are cereal based with specifications usually attached to denote the base cereal grain (Sowonola et al., 2005, Nahemiah et al., 2014). There are various types of kunu processed and consumed in Nigeria. These include *kunu zaki, kunu gyada, kunu akamu, kunu tsamiya, kunu baule, kunu jiko, ashamu* and *kunu gzakimba*. Of these, *kunu zaki* is the most widely produced and consumed (Inatimi et al., 2011). *Kunu zaki* are made from sorghum, maize, millet, guinea corn or rice (Odunfa and Adeyeye, 1985, Adebayo et al., 2010). Spices such as ginger, alligator pepper, red pepper and black pepper are added as flavour and taste improver (Adebayo and Idowu, 2003). The process of cleaning, steeping, wet milling, sieving, settling, decantation and slurry recovery were applied in the preparation (Adebayo et al., 2010). *Kunu zaki* is acceptable to all age groups and is being served at home and public places as a refreshing drink and complimentary food for infants. It can also be consumed in the morning as breakfast by adults and children, serve as appetizer to entertain guests in rural and urban settings (Onuorah et al., 2005). Akoma et al. (2006) reported that *kunu zaki* have immense social, economic and medicinal importance to its numerous consumers. It is relatively cheap and nutritious when compared to carbonated drinks (Adejuyitan et al., 2008). It contains all the essential nutrients such as carbohydrates, fat, protein, minerals and vitamins (Ugwuanyi et al., 2015). According to Elmahmood et al. (2007), *kunu zaki* is produced at village technology level, its production protocols, packaging and distribution are not yet standardized. *Kunu-zaki* stored at ambient temperature (28 ± 2 °C) has a shelf life of about 24 h (Adeyemi and Umar, 1994). Attempts have been made to improve the shelf life of *kunu zaki* by using pasteurization method coupled with refrigeration storage (Osuntogun and Aboada, 2004) and the use of sodium benzoate treatment followed by refrigeration method (Olasupo et al., 2000). With these methods, the keeping qualities of *kunu zaki* beverage were prolonged.

Black Velvet tamarind (*Dialium guineense*) is a woody plant that occurs in the rain forest region of West Africa. Velvet tamarind fruit is most valued for its high ascorbic acid content, minerals and sugar. However, it has been earlier shown that the fruit could be processed into

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beverages, soft drinks, alcoholic drinks, syrup/concentrate and jams (Okafor, 1975). Since the fruit is high in ascorbic acid and most people (children and adult) consume the beverage *kunu zaki*, the addition of black velvet tamarind (Awin-Yoruba, Tsmaiya Kurm-Hausa) to *kunu zaki* could improve the nutritional value of *kunu zaki*. The use of black velvet tamarind as a sweetener in *kunu zaki* could also be a good source of natural sweetener for people allergic to artificial sweeteners. The objective of the study was to determine the effect of black velvet tamarind on the physicochemical, microbial and sensory properties of *kunu zaki*.

Materials and methods

Sorghum (Sorghum bicolour), black velvet tamarind (*Dialium guineense*), dried sweet potato chips and dried ginger were obtained at Ipata market Ilorin metropolis, Kwara state.

Production of black velvet tamarind powder

Eight hundred gram (800 g) of the black velvet tamarind fruits was sorted and cleaned. The black shells of the fruits were dehulled which weighed about 250 g to expose the orange pulp. The pulp was subsequently separated from the seeds (300 g) mechanically with a knife. The size of the pulp was reduced by blending and sieving to give a fine powder of about 250 g (Fig. 1).

Production of kunu zaki

The *kunu zaki* drink was produced as described by Akoma et al. (2002), with some modifications (Fig. 2). The process involved cleaning and steeping 500 g of sorghum in 1000 ml tap water (1:2, w/v) for 24 h at 30-32 °C.

Black velvet tamarind fruit

↓

Cleaning/sorting

↓

Separation of pulp from seed

↓

Blending and sieving of the pulp

↓

Fine Pulp Powder

Fig. 1. Production of black velvet tamarind pulp

The water in the steeped grains was decanted off and washed with more tap water before wet milling with dried sweet potatoes and ginger with the addition of 1000 ml of tap water to form a wet paste/ slurry. The paste was divided into two unequal portions (1:3 v/v). To the larger portion of paste, hot water was added to gelatinize it, it was then cooled to 40 °C and added to the ungelatinized portion to form *kunu zaki* slurry. The *kunu zaki* was stirred vigorously for about 2 min and then allowed to stand and fermented for 8-12 hours. The fermented *kunu zaki* was sieved through 350 μm diameter mesh and sweetened with the black velvet tamarind powder at different concentrations (10 g, 20 g, 30 g, 40 g, and 50 g) each into 1000 ml of *kunu zaki* (Fig. 2).

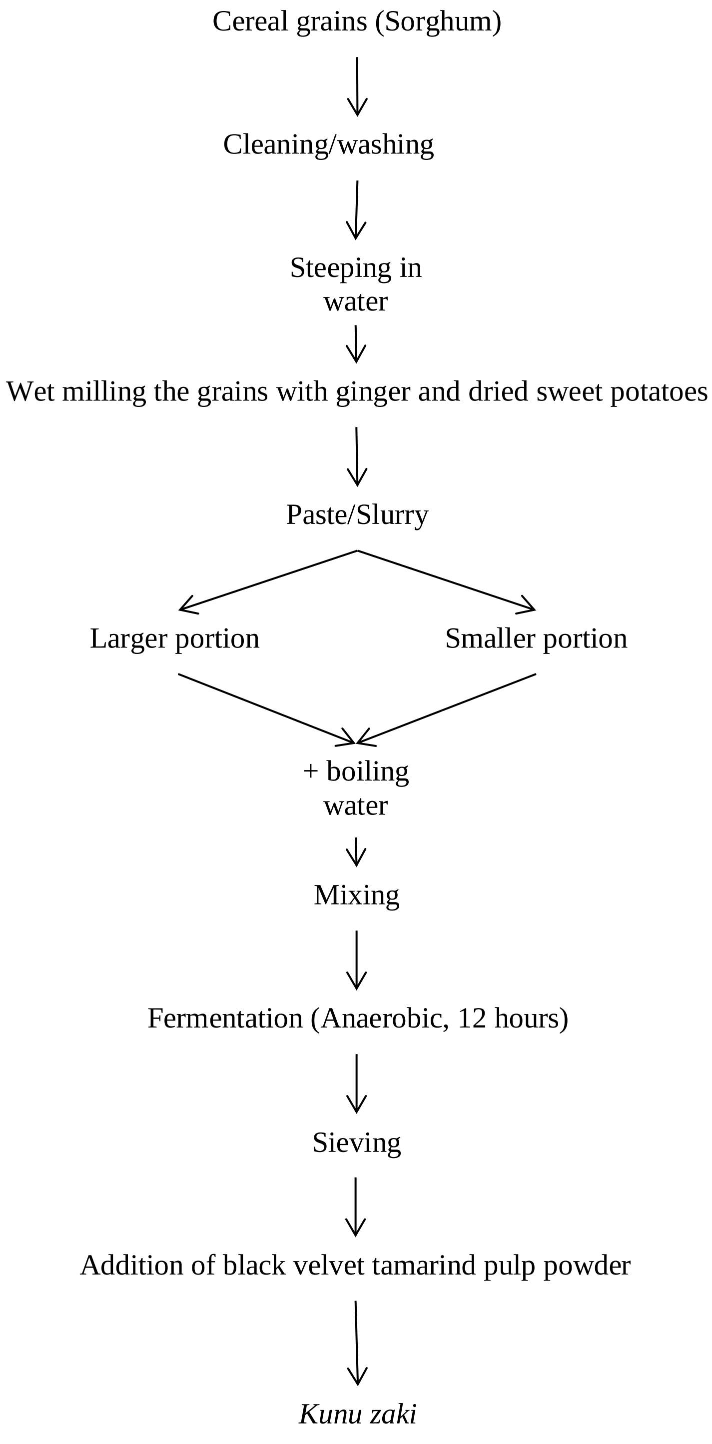

Fig. 2. K*unu zaki* production (Gaffa and Ayo, 2002; Akoma et al., 2002)

Analyses

Proximate composition of black velvet tamarind, sugar, vitamin C and physicochemical analyses of black velvet tamarind and *kunu zaki* beverage were determined using AOAC method (AOAC, 2005). Refractometer was used to determine the total soluble solid. Beta-carotene was done according to method of Kumar et al. (2011). The colour of *kunu zaki* samples was evaluated by measuring L*, a*, b* parameters by means of a reflectance colourimeter (CR 300 Chroma-metter, Minolta, Japan). Colour was expressed in CIE-Lab parameters as L* (whiteness/darkness), a* (redness/greenness), and b* (yellowness/blueness) (Ugarčić-Hardi et al., 2007). Microbiological analysis of the *kunu zaki* samples were carried out using total plate count on nutrient agar (NA) while fungi isolation was carried out using potato dextrose agar (PDA). The counts were expressed in colony forming unit per millilitre (cfu/mL) (Fawole and Oso, 2007).

Sensory evaluation

Sensory analysis of the *kunu zaki* samples was carried out by selecting 20 trained panelists among the students and Lecturers of Department of Home Economics and Food Science, University of Ilorin, Kwara State, Nigeria. The panelists were requested to examine the *kunu zaki* samples and score according to their degree of likeness with a 9-point hedonic scale ranging from 1 (dislike extremely) to 9 (like extremely). The parameters evaluated were the taste, appearance, aroma and general acceptability.

Statistical analysis

Analyses were carried out in triplicates and the data collected were evaluated for significant differences in their means with Analysis of Variance (ANOVA) ($p \leq 0.05$). Mean separation was carried out using Tukey's as packaged by SPSS 17.0 software.

Results and discussion

Proximate composition of black velvet tamarind (Dialium guineense)

The proximate composition of *D. guineense* is shown in Table 1. Moisture content of black tamarind was 10.53 % similar to the report of Osanaiye et al. (2013). Higher moisture content (30 %) was observed in the black tamarind pulp by Adamu et al. (2015). Lower moisture content is desirable in flour as this improve the storability of the pulp and prevents susceptibility to microbial attack. The ash value obtained from the pulp was 12.55 % and was found to be higher than the values 9.7-12.52 % obtained by Attah-Krah et al. (1986), Osanaiye et al. (2013) and Adamu et al. (2015) respectively. The lipid content of the pulp was 5.39 %. The value was slightly higher than 5.34 % reported by Osanaiye et al. (2013). The fat content was within the range for flour. High fat content could lead to rancidity thereby causing deterioration in the pulp. Lower protein content was observed in the pulp of black tamarind pulp, as compared to that reported by Osanaiye et al. (2013), Adeola and Aworh (2012), Gnansounou et al. (2014) and Adamu et al. (2015). The variation in the protein contents observed may be due to the cultivar of fruit. According to the reports, black tamarind pulp could not be regarded as a proteineous food due to low amount of protein contents. The crude fibre value (1.01 %) obtained was similar to the value (1.05 %) obtained by Osanaiye et al, (2013). Black tamarind pulp generally had low fibre contents however, this had been reported to aid digestion process and help in bowel movement. The carbohydrate value of the pulp was 67.32 %. This value was lower than the value (79.0 %) reported for carbohydrate content of black velvet by Adepoju (2009) but higher than 58.65 % reported by Osanaiye et al. (2013). The carbohydrate contents could be in form of glucose, fructose, sucrose etc. Due to high carbohydrate content, black velvet pulp is regarded as energy giving food. The variations in the proximate composition of black velvet pulp could be due to the species, geographical, climatic and seasonal variations.

Table 1. Proximate composition of *Dialium guineense* pulp

Parameter (%)	Black Velvet Pulp
Moisture	10.53±0.01
Ash	12.55±0.01
Crude Fat	5.39±0.02
Crude Fibre	1.01±0.01
Protein	3.2±0.01
Carbohydrate	67.32±0.01

Sugar composition of black velvet tamarind (Dialium guineense)

Table 2 showed the sugar compositions of black velvet tamarind pulp. The total soluble solid of black velvet tamarind (*Dialium guineense*) was 41.86 g/100 g similar to the values 42.20 g/100 g obtained by Ayessou et al. (2014). Glucose (20.03 g/100 g) and fructose (18.01g/100g) were the predominant sugars in the fruit. The high values of the total soluble solid/ sugar components of the black velvet tamarind (*Dialium guineense*) support its use as a sweetener in *kunu zaki* production.

Effect of sweetener black velvet tamarind on the colour of kunu zaki

Colours of *kunu zaki* sweetened with black velvet tamarind are shown in Table 3. Sample A (control sample) had the highest value tending towards lightness/whiteness (38.23) than other samples. The treated samples have lower values in decreasing order of lightness/whiteness with sample B (37.27), C (36.11), D (34.85), E (34.58) and F (33.32) respectively. This showed that the *kunu zaki* became deeper in colour with addition of black velvet pulp. The a^* values revealed increase in redness with addition of black velvet pulp. Sample F with 50 g black velvet tamarind pulp was significantly different ($p<0.05$) from other samples in a^*. Likewise, b^* (yellowness) values increased with addition of black velvet pulp. The control had the least yellowness value (8.05) while sample F had higher value (13.42). The change in colour parameters observed could be attributed to impact of the orange-red color of the black velvet tamarind on the *kunu zaki* samples.

Physicochemical properties of kunu zaki (pH, titratable acidity and Brix)

The results of the pH, titratable acidity and brix content of *kunu zaki* are presented in Table 4, 5 and 6 respectively. The pH values obtained for all the treated *kunun zaki* samples ranged from 2.95 to 4.15 on the first day of production. The pH results obtained were lower than 4.70-5.75 obtained by Gaffa and Ayo (2002), Akoma et al. (2006) and Amusa and Ashaye (2009). However, the pH was similar to the results (3.3-4.3) obtained by Elmahmood and Doughari (2007). Over the period of storage at 4 ºC, the pH values was reduced on the third day with a range of 2.8 - 3.95, and 2.69-3.45 on the fifth day of storage.

Table 2. Sugar content of black velvet tamarind *(Dialium guineense)* pulp

Sugar	Weight(g/100 g)
Glucose	20.03 ± 0.01
Fructose	18.01 ± 0.02
Saccharose	3.40 ± 0.01
Glycerol	0.38 ± 0.01
Sorbitol	0.04 ± 0.03
Total Soluble Sugars	41.86 ± 0.01

Table 3. Effect of black velvet tamarind on the colour of *kunu zaki*

Sample	L^*	a^*	b^*
A	$38.23{\pm}0.04^{a}$	$3.14{\pm}0.05^{f}$	$8.05{\pm}0.10^{f}$
B	$37.27{\pm}0.07^{b}$	$4.85{\pm}0.07^{e}$	$8.60{\pm}0.11^{e}$
C	$36.11{\pm}0.08^{c}$	$5.28{\pm}0.06^{d}$	$10.7{\pm}0.08^{d}$
D	$34.85{\pm}0.10^{d}$	$6.03{\pm}0.11^{c}$	$11.22{\pm}0.04^{c}$
E	$34.58{\pm}0.07^{e}$	$6.24{\pm}0.13^{b}$	$11.51{\pm}0.03^{b}$
F	$33.32{\pm}0.04^{f}$	$7.45{\pm}0.05^{a}$	$13.42{\pm}0.14^{a}$

Values in the same column with different superscript are significantly different ($p>0.05$). Values with the same letter in the column are not significantly different ($p<0.05$), L^* Lightness, a^* chromaticity on a green (-) to red (+) axis and b^* chromaticity on a blue (-) to yellow (+) axis. A-Control (1000 ml of kunu zaki), B-1000 ml of *kunu zaki* + 10 g of Black velvet tamarind pulp (v/w), C-1000 ml of *kunu zaki* + 20 g of Black velvet tamarind pulp (v/w), D-1000 ml of *kunu zaki* + 30 g of Black velvet tamarind pulp (v/w), E-1000 ml of *kunu zaki* + 40 g of Black velvet tamarind pulp (v/w), F-1000 ml of *kunu zaki* + 50 g of Black velvet tamarind pulp (v/w)

The acidity of *kunu zaki* beverage has been noted to be as a result of lactic acid production by some bacteria during fermentation (Ashiru et al., 2003) and thus, the drink becomes sour in taste and organoleptically unacceptable with time as observed in the control sample. However, the pH of the treated samples was low and acidic with increase in concentration of the velvet tamarind pulp. The pH of the treated samples were significantly different (p>0.5) from the control sample.

The titratable acidity (TTA) of *kunu zaki* ranged between 5.44 to 9.16 g/L on day 0 and 8.05 to 10.06 g/L on the fifth day of storage. There were significant differences (p>0.05) in the titratable acidity of the control and treated samples. The control had the least value while the highest value was at 50 g black velvet tamarind pulp. The titratable acidity increased with addition of black velvet tamarind. Titratable acidity of all the samples was lower in day 0 than the stored *kunu zaki*. The values increased with storage days. The acidity of the samples can be attributed to the acidic nature of the black velvet tamarind fruit and the presence of some bacteria like *lactobacillus, Acidophilus* and *Saccharomyces cerevisiae* which helped in acid fermentation of *kunu zaki*. The ºBrix values ranged from 6.15 to 7.85 on the first day of production. However, the ºBrix value of sample with the 50 g black velvet tamarind (sample F) was higher (7.85) compared to ºBrix 3.0-15.0 observed for powdered *kunu zaki* by Omowaye-Taiwo and Oluwamukomi (2015). This can be attributed to the presence of glucose, fructose and higher total soluble solids in black velvet tamarind pulp. This also corroborates the report of Ogungbenle (2003). The presence of these sugars supports the use of black velvet tamarind pulp as a sweetener in *kunu zaki*.

However, over the storage period there were decrease in the ºBrix value of the *kunu zaki* samples this could be attributed to the breakdown of sugar during the period of storage as fermentation occurred. The microorganisms present in the *kunu zaki* samples converted the fermentable sugars being utilized for growth and afterwards produce organic acids which were further converted to produce ethanol and carbondioxide (Okafor, 1972). This finding agrees with the observation of Igue (1995).

Table 4. pH value of the *kunu zaki* samples.

Sample	Day 0	Day3	Day5
A	4.15± 0.06 ^{a}	3.95 ± 0.06^{a}	3.45± 0.06 ^{a}
B	3.65± 0.06 ^{b}	3.35 ± 0.06^{b}	3.25± 0.06 ^{b}
C	3.58± 0.1 ^{c}	3.28 ± 0.06 ^{c}	3.25± 0.06 ^{b}
D	3.46 ± 0.1 ^{c}	3.25 ± 0.05 ^{c}	3.13± 0.13 ^{c}
E	3.05±0.06 ^{d}	2.93± 0.1 ^{d}	2.83 ± 0.1 ^{d}
F	2.95± 0.06 ^{d}	2.80± 0.0 ^{e}	2.69 ± 0.05 ^{e}

Values in the same column with different superscript are significantly different (p>0.05). A-Control (1000 ml of *kunu zaki*), B-1000 ml of *kunu zaki* + 10 g of Black velvet tamarind pulp (v/w), C-1000 ml of *kunu zaki* + 20 g of Black velvet tamarind pulp (v/w), D-1000 ml of *kunu zaki* + 30 g of Black velvet tamarind pulp (v/w), E-1000 ml of *kunu zaki* + 40 g of Black velvet tamarind pulp (v/w), F-1000 ml of *kunu zaki* + 50 g of Black velvet tamarind pulp (v/w).

Table 5. Titratable acidity (g/L) of *kunu zaki* samples

Sample	Day 0	Day3	Day5
A	5.44±0.0 ^{f}	6.15±0.01 ^{f}	6.19±0.06^{f}
B	6.45±0.0 ^{e}	7.05±0.06 ^{e}	7.75±0.06^{e}
C	7.16±0.01^{d}	7.85±0.06 ^{d}	8.27±0.42^{d}
D	7.9±0.01^{c}	8.45±0.06 ^{c}	9.27±0.01^{c}
E	8.56±0.01^{b}	9.01±0.01 ^{b}	9.55±0.01^{b}
F	9.16±0.01^{a}	9.9±0.01 ^{a}	10.06±0.01^{a}

Values in the same column with different superscript are significantly different (p>0.05). A-Control (1000 ml of *kunu zaki*), B-1000 ml of *kunu zaki* + 10 g of Black velvet tamarind pulp (v/w), C-1000 ml of *kunu zaki* + 20 g of Black velvet tamarind pulp (v/w), D-1000 ml of *kunu zaki* + 30 g of Black velvet tamarind pulp (v/w), E-1000 ml of *kunu zaki* + 40 g of Black velvet tamarind pulp (v/w), F-1000 ml of *kunu zaki* + 50 g of Black velvet tamarind pulp (v/w).

Table 6. ºBrix value of the *kunu zaki* Samples

Sample	Day 0	Day3	Day5
A	6.15 ± 0.06^{e}	5.85 ± 0.06^{e}	4.40 ± 0.12^{d}
B	6.42 ± 0.02^{d}	6.16 ± 0.05^{d}	5.80 ± 0.01^{c}
C	6.44 ± 0.04^{cd}	6.23 ± 0.03^{d}	5.91 ± 0.12^{c}
D	6.95 ± 0.06^{c}	6.80 ± 0.11^{c}	6.55 ± 0.0^{b}
E	7.45 ± 0.06^{b}	7.12 ± 0.17^{b}	6.53 ± 0.35^{b}
F	7.85 ± 0.06^{a}	7.65 ± 0.06^{a}	7.43 ± 0.04^{a}

Values in the same column with different superscript are significantly different (p>0.05). A-Control (1000 ml of *kunu zaki*), B-1000 ml of *kunu zaki* + 10 g of Black velvet tamarind pulp (v/w), C-1000 ml of *kunu zaki* + 20 g of Black velvet tamarind pulp (v/w), D-1000 ml of *kunu zaki* + 30 g of Black velvet tamarind pulp (v/w), E-1000 ml of *kunu zaki* + 40 g of Black velvet tamarind pulp (v/w), F-1000 ml of *kunu zaki* + 50 g of Black velvet tamarind pulp (v/w).

Beta carotene (mg/100 g) content of the kunu zaki samples

Table 7 showed the β-carotene contents of treated *kunu zaki.* The β-carotene content of the control sample was 8.71 mg/100 g slightly higher than the value (8.57 mg/100 g) obtained by Ogbonna et al. (2013). There were significant differences (p<0.05) in the β-carotene contents of the control and treated samples. However, the β-carotene content of the treated *kunu zaki* samples increased as the treatment concentration increased and this may be attributed to the β-carotene content of the black velvet tamarind pulp. Also, it was observed that the β-carotene content of the control and treated samples were reduced over the period of storage, however, sample F had the highest value of β-carotene.

Vitamin C (mg/100 g) content of kunu zaki samples

Vitamin C contents of *kunu zaki* sweetened with black velvet tamarind pulp are shown in Table 8. The vitamin C content of the control sample was 28.23 mg/100 g which was higher than that recorded by Olaoye et al. (2016) for *kunu zaki* substituted with tigernut extract. The vitamin C content of the treated samples were higher ranging from 35.00 - 47.25 mg/100 g and more stable during the period of storage, with sample F having the highest value of vitamin C content. According to Adamu et al. (2015), black velvet tamarind pulp have high vitamin C contents (150 mg/100 g) which contributed to the increase in the vitamin C contents of the treated *kunu* samples.

Microbial analysis

Fig. 3 and 4 showed the bacteria and fungi count of the *kunu zaki* samples. On day 0, sample A had the highest growth count (3×10^3 cfu/mL) compared to the treated sample. The growth in the control sample was higher than 2.1×10^3 cfu/mL observed by Mbachu et al. (2014). However, the treated samples C, D, E and F have lower bacterial count than the count recorded by Mbachu et al. (2014). Moreover as the days of storage was extended the bacterial counts of the samples increased but those of the treated samples increased at a slower rate compared to the control sample and lower than the values observed by Mbachu et al. (2014) at the third day of storage which was recorded 'too numerous to count'. Sample F had the least bacterial count. The treated samples had lower count on day 0 and throughout the period of storage unlike the control sample which increased during storage from 3×10^3 cfu/mL to 8.8×10^3 cfu/mL. The decrease in microbial count for the treated samples could be attributed to the acidic nature of the black velvet tamarind. The acidic nature was not favorable for rapid multiplication of microbial organisms. The fungal count on the sample with the highest treatment (50 g/L black velvet tamarind pulp) had low fungal count of 1 to 1.9×10^3 cfu/mL throughout the period of storage.

Sensory analysis of kunu zaki samples

The sensory properties of *kunu zaki* sweetened with black velvet tamarind are shown in Table 9. Sample A had the least value (4.40) in taste while the sample with 50 g/L black velvet tamarind pulp had higher value (7.73) and was more preferred in taste. Although, sample F had higher taste value but there were no significant differences (p>0.05) in the values of sample D to F in taste. However, no significant differences (p>0.05) in the taste, appearance and aroma of the control, sample A and B.

This result of taste indicated that the addition of the velvet tamarind pulp improved the taste of the *kunu zaki* and the treated samples were more acceptable than the control. Sample A and B were similar in taste, this was probably due to the fact that sample B had low amount of the velvet tamarind. In terms of appearance and aroma, sample A was significantly different (p<0.05) from the other samples while samples B, C, D, E and F were not significantly different from each other. When compared with the control sample (A), the velvet tamarind sweetened *kunu zaki* drinks were more preferred. There were increase in the taste preference of *kunu zaki* with increase in concentration of black velvet tamarind but there were no significant differences (p>0.05) in taste of *kunu zaki* sweetened with black velvet tamarind values.

Sample B, C, D, E and F were not significantly different in terms of its general acceptability, with values 5.47, 6.60, 6.87, 7.00, 7.73 respectively. The control sample A, was significantly different in terms of general acceptability. Sample F was the most preferred, this could be as a result of the high concentration of the velvet tamarind pulp it contained.

Table 7. β-carotene content of *kunu zaki* samples (mg/100 g)

Sample	Day 0	Day 3	Day 5
A	8.71 ± 0.01^{f}	6.28 ± 0.06^{f}	3.10 ± 0.06^{f}
B	20.56 ± 0.03^{e}	15.10 ± 0.06^{e}	11.10 ± 0.06^{e}
C	26.52 ± 0.06^{d}	24.70 ± 0.12^{d}	19.72 ± 0.06^{d}
D	30.60 ± 0.12^{c}	26.60 ± 0.12^{c}	20.40 ± 0.12^{c}
E	34.68 ± 0.05^{b}	30.40 ± 0.12^{b}	22.72 ± 0.01^{b}
F	36.60 ± 0.23^{a}	33.48 ± 0.06^{a}	29.20 ± 0.12^{a}

Values in the same column with different superscript are significantly different (p>0.05). A-Control (1000 ml of *kunu zaki*), B-1000 ml of *kunu zaki* + 10 g of Black velvet tamarind pulp (v/w), C-1000 ml of *kunu zaki* + 20 g of Black velvet tamarind pulp (v/w), D-1000 ml of *kunu zaki* + 30 g of Black velvet tamarind pulp (v/w), E-1000 ml of *kunu zaki* + 40 g of Black velvet tamarind pulp (v/w), F-1000 ml of *kunu zaki* + 50 g of Black velvet tamarind pulp (v/w).

Table 8. Vitamin C values of *kunu zaki* Samples (mg/100 g)

Sample	Day 0	Day 3	Day 5
A	28.23 ± 0.1^{f}	10.15 ± 0.06^{f}	4.73 ± 0.1^{e}
B	35.45 ± 0.06^{e}	30.35 ± 0.06^{e}	25.15 ± 0.06^{d}
C	39.35 ± 0.06^{d}	37.25 ± 0.06^{d}	25.20 ± 0.12^{d}
D	40.15 ± 0.06^{c}	39.45 ± 0.06^{c}	36.65 ± 0.06^{c}
E	44.4 ± 0.12^{b}	42.15 ± 0.06^{b}	39.25 ± 0.06^{b}
F	47.25 ± 0.06^{a}	45.25 ± 0.06^{a}	40.65 ± 0.06^{a}

Values in the same column with different superscript are significantly different (p>0.05). A-Control (1000 ml of *kunu zaki*), B-1000 ml of *kunu zaki* + 10 g of Black velvet tamarind pulp (v/w), C-1000 ml of *kunu zaki* + 20 g of Black velvet tamarind pulp (v/w), D-1000 ml of *kunu zaki* + 30 g of Black velvet tamarind pulp (v/w), E-1000 ml of *kunu zaki* + 40 g of Black velvet tamarind pulp (v/w), F-1000 ml of *kunu zaki* + 50 g of Black velvet tamarind pulp (v/w).

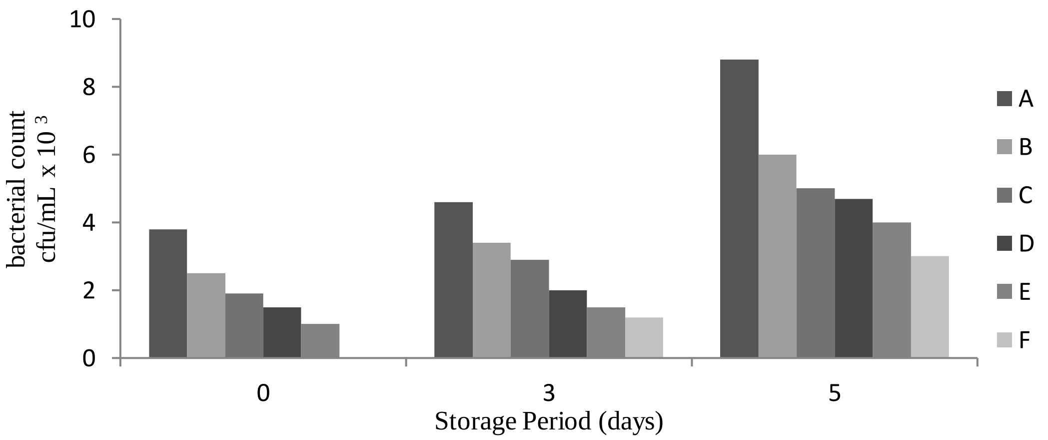

Fig. 3. Bacterial Count of *Kunu zaki* Samples. A-Control (1000 ml of kunu zaki), B-1000 ml of *kunu zaki* + 10 g of Black velvet tamarind pulp (v/w), C-1000 ml of *kunu zaki* + 20 g of Black velvet tamarind pulp (v/w), D-1000 ml of *kunu zaki* + 30 g of Black velvet tamarind pulp (v/w), E-1000 ml of *kunu zaki* + 40 g of Black velvet tamarind pulp (v/w), F-1000 ml of *kunu zaki* + 50 g of Black velvet tamarind pulp (v/w)

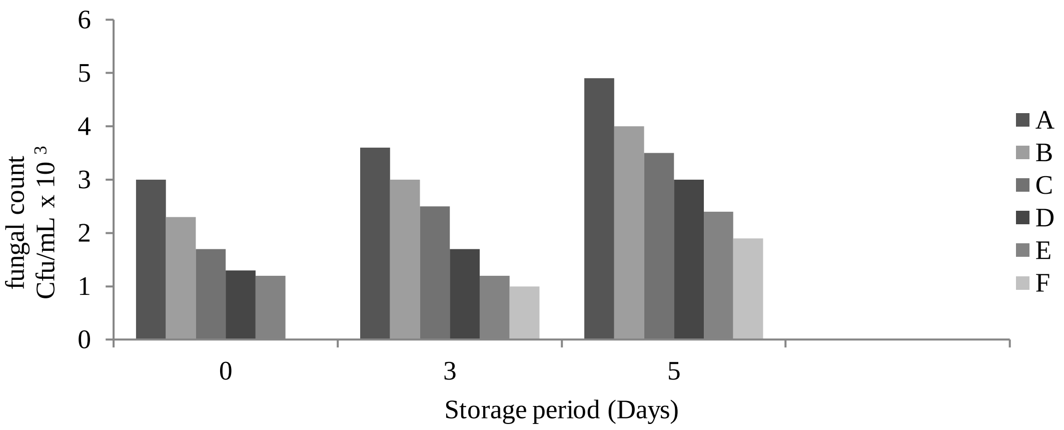

Fig. 4. Fungal Count of *kunu Zaki* Samples. A-Control (1000 ml of *kunu zaki*), B-1000 ml of *kunu zaki* + 10 g of Black velvet tamarind pulp (v/w), C-1000 ml of *kunu zaki* + 20 g of Black velvet tamarind pulp (v/w), D-1000 ml of *kunu zaki* + 30 g of Black velvet tamarind pulp (v/w), E-1000 ml of *kunu zaki* + 40 g of Black velvet tamarind pulp (v/w), F-1000 ml of *kunu zaki* + 50 g of Black velvet tamarind pulp (v/w).

Table 9. Sensory analysis of the *kunu zaki* samples

Sample	Taste	Appearance	Aroma	General Acceptability
A	4.40 ± 1.84^{c}	5.73 ± 1.71^{c}	5.00 ± 0.34^{c}	5.47 ± 1.12^{b}
B	4.80 ± 1.42^{c}	5.40 ± 1.51^{bc}	5.47 ± 1.55^{bc}	5.60 ± 1.30^{ab}
C	6.13 ± 1.46^{b}	6.47 ± 1.60^{ab}	6.53 ± 1.19^{ab}	6.60 ± 1.18^{ab}
D	7.00 ± 0.66^{a}	6.60 ± 1.60^{ab}	6.60 ± 1.19^{ab}	6.87 ± 1.18^{a}
E	7.07 ± 1.62^{a}	7.33 ± 1.24^{a}	6.93 ± 1.22^{a}	7.00 ± 0.93^{a}
F	7.73 ± 1.40^{a}	7.00 ± 1.31^{ab}	7.33 ± 1.23^{a}	7.73 ± 0.93^{a}

Values in the same column with different superscript are significantly different ($p>0.05$). A-Control (1000 ml of *kunu zaki*), B-1000 ml of *kunu zaki* + 10 g of Black velvet tamarind pulp (v/w), C-1000 ml of *kunu zaki* + 20 g of Black velvet tamarind pulp (v/w), D-1000 ml of *kunu zaki* + 30 g of Black velvet tamarind pulp (v/w), E-1000 ml of *kunu zaki* + 40 g of Black velvet tamarind pulp (v/w), F-1000 ml of *kunu zaki* + 50 g of Black velvet tamarind pulp (v/w).

Conclusions

The study determined the effect of black velvet tamarind *(Dialium guineense)* on the physicochemical properties and storage life of *kunu zaki*. It was observed that the addition of the velvet tamarind pulp into *kunu zaki* improved its physico-chemical properties. Also, addition of velvet tamarind pulp to *kunu zaki* extended the keeping quality of the *kunu zaki* drinks. Black velvet tamarind (*Dialium guineense)* is a good source of carbobydrate with high percentage of glucose and fructose. The lightness of the *kunu zaki* decreased with increase in black velvet tamarind (*Dialium guineense)* concentration, while the yellowness and redness increases with black velvet tamarind (*Dialium guineense)* concentration. There was significant increase in the beta-carotene and vitamin C content of the treated *kunu zaki* samples. However, there was a decrease in the values of vitamin C and beta-carotene during storage. The microbial loads of the treated samples were low when compared to the microbial load of the control sample on the first day and during storage. This may be due to the acidic nature of the black tamarind in treated samples which confer a preservative property on the product thereby extending the keeping quality of kunu zaki. In terms of taste, appearance, aroma and general acceptability sample F was more preferred. Black velvet tamarind lower the pH of the beverage thereby making the beverage acidic.

Fig. 5. The entire Black velvet tamarind (*Dialium guineense)* fruit and its different parts. A-Black velvet tamarind (*Dialium guineense)* whole fruit; B-Black velvet tamarind (*Dialium guineense)* deshelled fruit; C-Black velvet tamarind (*Dialium guineense)* seeds

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