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Physicochemical, Mineral, and Sensory Properties of Masuku (*Uapaca kirkiana*) Beverages

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ABSTRACT

Masuku (*Uapaca kirkiana*) are wild fruits that are in abundance from December to March. Masuku are highly perishable fruits hence they have to be processed into other products to extend their shelf life. The main objective of this study was to determine the physiochemical, nutritional, and sensory properties of the masuku juices. Two formulations of masuku juice were prepared, one batch involved peeling the masuku and obtaining the pulp, while in the other batch, they were not peeled. The masuku were just washed and squeezed to obtain the pulp. The resulting pulp was used for juice processing. The juices were analyzed for physiochemical and mineral properties. Themasuku fruit had high pH content than that recommended for juice making and juice from unpeeled masuku was more acidic than juice from peeled masuku. Juice from unpeeled Masuku had high magnesium content as compared to juice from peeled masuku. While on paired preference test, the results showed that there was a significant difference in preference between the two batches ($p<0.05$) where the juice from peeled Masuku was most preferred over the juice from unpeeled masuku. In conclusion, masuku raw pulp acid content should be balanced with additional acids when making juices. Masuku juice can be used as a rich source of magnesium and zinc. There are traces of magnesium in the skin of masuku fruits hence squeezing the whole fruit when pulping can help to utilize the fruit fully.

Keywords: Masuku beverages, Physiochemical properties, Mineral, Sensory properties

INTRODUCTION

Masuku (*Uapaca kirkiana*), also known as wild loquat, is one of the indigenous fruits in Malawi that grow wildly throughout the country. For example, they are available in all three regions of Malawi (Southern region e.g. Blantyre, Central region e.g. Lilongwe, and Northern region e.g. Mzuzu). Other examples of local fruits include malambe (Adansonia Digitate), mpoza (Annona Senegalensis), matowo (Azanza Garckeana), bwemba (Tamaringus Indica), and masawu (Zizyphus Mauritiana) (World Agroforestry Center, 2020). Masuku tree is mainly distributed in semi-dry and dry areas. It produces fruits that repine from October to February (Kadzere et al., 2001). Masuku is important fruit because they are rich in minerals such as iron, calcium, magnesium, phosphorus, potassium, sodium, and zinc(Ngulube et al.,1996) and contribute to snack foods when in season.

Masuku is also important because they become available when other fruits are not in season. During this period, they contribute to the diet and nutrient intake since fruits are part of the six food groups in Malawi. Masuku are naturally available for the poor when they are in abundance and are consumed as raw fruits. Some of the fruits are sold along the roads, contributing to the rural areas' economy.

Masuku can be considered as one of the underutilized fruits. No company processes them to add value and as a result, a large quantity of them get wasted when plentiful, thereby depriving the majority of the poor from vitamins and minerals they need to remain healthy. Masuku are in abundance when they are in season (from December to March) and wastage is due to a lack of processing techniques and knowledge on the part of rural communities and households. Like any other fruits, masuku are perishable and lack of processing and value-addition techniques means that they are not available when they are not in season e.g. from March to September. Since most rural households cannot manage to buy other fruits regularly, which denies them a readily available source of vitamins and minerals that they get from natural fruits like masuku.

Despite its abundance, not much research has been done on masuku in Malawi but elsewhere like in Asia (Hughes and Haq, 2003), Zambia (Moombe et al., 2014), and Tanzania (Ndabikunze et al., 2010). In Malawi, Saka et al (2007) have documented a study on physicochemical and organoleptic characteristics of Uapaca Kirkiana, Strychnos Cocculoides, Adensonia Digitate, and Mangifera Indica fruit products).

As it has been revealed by other researchers, masuku are rich in nutrients such as vitamins and minerals such as magnesium and zinc. Magnesium is becoming a mineral of concern in Malawi hence there is a need to start searching for it in our locally available foods such as masuku fruits and amounts of these nutrients in juices can be affected by processing procedures hence there is a need to do a nutritional assessment (mineral analysis) of the processed products from masuku such as the juice.

Until up to date, there is a lack of processed products from masuku and this means that processors do not understand the fruit due to lack of research and this leaves several questions unanswered.

Processing masuku into juice and other products can be one way of commercializing the fruit and making it available for a longer period so that families can continue to diversify their diets. Therefore, this research aims at determining the physiochemical, nutritional, and sensory properties of masuku beverages which will promote dietary diversity and commercialization of the fruit in Malawi.

The objectives of this study were to determine the physiochemical, minerals, and sensory properties of masuku beverages.

MATERIALS AND METHODS

Sample Collection

Thirty (30) kg of Masuku fruits were purchased from the Waka-waka market in Lilongwe.

Juice Processing

Ripen masuku fruits were sorted and graded to have good quality fruits. This was followed by washing the fruits to remove the dust and any adhering to the masuku fruits. In the first batch, masuku fruits were peeled and then the seeds were removed to obtain the pulp. In the second batch, the masuku fruits were placed in a perforated basket and squeezed to release the pulp through the basket without peeling the masuku first. 4 cups of water were added to one cup of pulp and 200g of sugar was added to 1 cup of pulp to maintain the original brix level. The juice was then boiled to 90ºC for 15 minutes to pasteurize the juice and then 0.05% of sodium benzoate was added as a preservative. The juices were cooled to 25-32ºC and then they were bottled and refrigerated.

Physiochemical Analysis

pH determination

A pH meter was used to determine the pH of the juices. pH meter was standardized using pH 7.0 and 4.0 buffers. 10 ml of the sample juice was measured using a pipette and then transferred into a beaker. Then the pH meter was immersed into the sample juice until a steady reading was reached and the reading was recorded. The procedure was repeated 3 times.

Titratable acidity determination

Three drops of phenolphthalein indicator were added into a 50 ml Erlenmeyer flask containing 10 ml of the sample juice or raw fruit pulp. This mixture was titrated with Sodium Hydroxide (NaOH) until pink color appears. The volume used to titrate the juice was recorded and the procedure was repeated 3 times.

Calculations of %titratable acidity

$$\%acid\left(\frac{wt}{vol}\right) = \frac{N \times V1 \times EqWt}{V2 \times 1000} \times 100$$

Where:

N is Normality

Eqwt is the Equivalent weight of the predominant acid

V1 is the volume of the titrant

V2 is the volume of the sample

1000 is the factor relating mg to grams (mg/g)

Nutritional Analysis (Mineral Analysis)

Determination of Ash by gravimetric method

Five grams (W2) of the sample was weighed by difference into a pre-dried, pre-weighed crucible (W1). Then the sample was incinerated in a furnace at 525°C. The temperature of the furnace was decreased to 180°C and the crucibles were transferred into a desiccator and cooled for 15-30 minutes and weighed (W3). The ash content was calculated by the following method.

Calculations of ash content

$$Ash, (g\ per\ 100g = \frac{(W3 - W1)}{(W2 - W1)} \times 100$$

Sample Preparation for mineral analysis

One milliliter of water and 5 ml of concentrated HCL was added to the ash and then the mixture was boiled to dryness. The dried sample was moistened with 3 ml of 6N HCL and then 6 drops of concentrated Nitric acid was added. Five milliliters of warm water was added and covered with a watch glass and then the sample was boiled for 2 minutes. The sample was cooled and quantitatively transferred into a 100ml volumetric flask and filled to the mark with distilled water then mixed well. The mixture was kept in polyethylene bottles pending analysis.

Magnesium analysis

Sample preparation for Magnesium

Lanthanum chloride weighing 13.369g was transferred into a beaker. This was followed by adding concentrated HCl solution slowly until the material dissolved. The resulting solution was transferred into a 100 ml volumetric flask and distilled water was added to fill up to the mark. 6 ml of this solution was pipetted into a 100 ml volumetric flask containing 10 ml of the previously prepared sample from the ash. Distilled water was then added to fill up to the mark.

Determination of Magnesium

The prepared sample was transferred into polyethylene bottles. To determine the amount of magnesium in the sample, an AS100 spectrophotometer was used. A sucking tube of the spectroscopy was immersed into the sample and then the machine reads the absorbance of the sample which was then displayed on a computer. The standard curve for the standard solution was plotted. From the standard curve, the concentration of the sample was determined.

Calculation of Magnesium

$$Mg\ content\ gMg\ per\ 100g\ sample = \frac{C \times D \times 10}{W}$$

Where:

C is the concentration of the sample solution in ppm read off the standard curve

DF is the dilution factor

W is the Sample weight in grams

Determination of Zinc

The prepared sample was transferred into polyethylene bottles. To determine the amount of zinc in the sample, an AS100 spectrophotometer was used. A sucking tube of the spectroscopy was immersed into the sample and then the machine reads the absorbance of the sample which was then displayed on a computer. The standard curve for the standard solution was plotted. From the standard curve, the concentration of the sample was determined.

Calculation of Zinc

$$Zn\ content\ gZn\ per\ 100g\ sample = \frac{C \times D \times 10}{W}$$

Where:

C is the concentration of the sample solution in ppm read off the standard curve

DF is the dilution factor

W is the Sample weight in grams

Sensory evaluation

Paired preference test

A panel of 40 untrained assessors was used, two coded samples of Masuku juice were presented to the panelist and they were requested to indicate the sample which they have preferred amongst the two samples and they were also requested to comment on why they have preferred the particular sample.

Statistical analysis

Data collected was entered through the Microsoft Excel version of 2016 and SPSS. The results were analyzed using Statistical Package for Social Science (SPSS) version 20. One-way ANOVA was used to compare the means.

RESULTS AND DISCUSSION

Physiochemical properties

pH and titratable acidity of masuku fruit and masuku juices

Table 1 shows the pH content of masuku raw fruit and masuku juice samples. Raw masuku pulp has an average pH of 4.5±0.14[a], juice from unpeeled masuku has a pH of 3.47±0.27[b] and juice from peeled masuku has a pH of 3.8±0.01[c]. The results agree with the range reported by Ndabikunze et al. (2010) who reported that the pH of masuku juice ranges from 3.23 to 4.22. There was a significant difference in the pH of the samples ($p<0.05$) when run under the LSD test. The difference in pH of the raw pulp to masuku juices might be due to the addition of preservatives (Sodium benzoate) (Makina, 2018).

The pH of the raw pulp is higher than those recommended for juice making (3.0-3.5) hence there is a need to balance the pH with additional acids such as citric acid (Chawafambira *et al.,*2020). The acid content of the ripened fruit pulp affects the biotransformation of nutrients during processing and product stability in juice (FAO, 1999). Table 1.0 also shows the Titratable acidity of masuku fruit and masuku juice. There is a significant difference in titratable acidity between the samples (P<0.05). The TTA value of the raw fruit agrees with the results which were noted by Ndabikunze et al., (2010) (0.59%). Juice from unpeeled masuku had a TTA of 1.1 ± 0.11^{b}% while juice from peeled masuku had TA of 0.88 ± 0.01^{c}%. The TTA of juices agrees with the range which was reported by Saka *et al.,* 2007 (0.85-1.32%). Unpeeled masuku juice had higher TTA as compared to peeled masuku juice. This is due to differences in processing procedures. The masuku skin has tannins that led to an increase in the acidity of the masuku juice and TTA varies directly to acidity (Muchuweti *et al.,*2006). TTA measures the total hydrogen in the juice and it is important because it affects the taste of the juice.

Nutritional Properties of Masuku Fruits and Masuku Juice

Ash content of masuku fruit and masuku juices content

Table 2 shows the ash content of masuku raw fruit and masuku juices. Ash content ranged from 2.7g/100g $\pm$ 0.05^{a}, 2.2g/100g $\pm$ 0.25^{b}, and 2.03g/100g $\pm$ 0.06^{b} for raw masuku pulp, juice from unpeeled masuku and juice from peeled masuku respectively. There is a significant difference in the mean ash content of raw fruits and juice samples (P<0.05). The Ash content of the raw pulp is higher than what was noted by Moombe in 2009. Moombe (2009) noted that ash content was 2.2g/100g but is lower than 3.2g/100g which was reported by Stadlymar *et al.* (2013). The variations might be attributed to differences in varieties and stages of maturity (Nielson, 2014). The raw pulp ash content (2.7g/100g) is higher than those of the juices because no water was added to it and hence minerals were concentrated unlike in the juices where the concentration of minerals was diluted (Dietz, 1999). Ash content varies directly from the mineral content of the sample.

Magnesium and Zinc content of masuku fruit and masuku juice

Table 3 shows results of magnesium content for raw masuku fruit and masuku juice which was made from peeled masuku and juice which was made from unpeeled masuku. Magnesium content ranged from 32.65 ± 1.16^{a} to 17.20 ± 0.04^{c} mg/100g. The magnesium content of the raw fruit was significantly different from the juices (P<0.05). This is because in the fruit no water was added and there was a high concentration of minerals unlike in the juices. There is a significant difference in magnesium content among the juices (P<0.05). Juice from unpeeled masuku had higher Magnesium content as compared to juice which was made from peeled masuku. This shows that there are traces of magnesium in the masuku skin which are transferred into the pulp when the whole fruit is squeezed. The value of magnesium for the masuku pulp (raw fruit) is higher compared to the mean value reported by Ndabikunze, Masambu, and Tiisekwa (2010) but agrees with the value noted in the *Uapaca Kirkiana* fruit by Stadlmayr et al. (2013). Saka et al. (2007) also noted that Masuku juice had a high amount of magnesium. The concentration of magnesium in masuku fruit and masuku juice can contribute 30% to recommended dietary allowances for children aged 1 to 9 years (Food and Nutrition Board, 2005). From Table 3.0, the Zinc content of masuku raw fruit is significantly different from the zinc content of the juices ($P<0.05$). Masuku fruit has 0.937 ± 0.03^a mg/100g Zn, this is in agreement with values reported by Chawafambira (2020) but its lower than the values reported by Saka et al. (1992). In this study, it was found that there are no significant differences among the juice samples ($P>0.05$). The Zinc content of the juice samples agrees with Saka et al. (2007). Masuku is a good source of zinc compared to other indigenous fruits (e.g. *A. digitata*; 0.14 mg/100g zinc; *V. infausta*; 0.02 mg/100g zinc) (Amarteifio and Mosase, 2006). Zinc deficiency is a major problem in sub-Saharan Africa (Gadaga et al., 2009) hence the consumption of these juices will help in fighting against this challenge.

Sensory Properties

Paired preference test for Juice from peeled masuku and juice from unpeeled masuku

The results showed that 30 out of 40 assessors preferred Juice from peeled masuku representing 75%. There is a significant difference in preference between the two samples of masuku juices. Juice from peeled masuku is significantly preferred over juice from unpeeled masuku ($p<0.05$). Most of the assessors did not prefer juice from unpeeled masuku because of its bitter/sour aftertaste.

CONCLUSION

From this study, it was noted that the processing procedure affected the nutritional, sensory, and physiochemical properties. There are nutrients in masuku skin (e.g. Magnesium) hence squeezing the whole fruit when pulping helps to utilize the fruit fully. Juice from unpeeled masuku had high magnesium content than juice from peeled masuku fruits. Masuku juice can be used as a rich source of zinc and magnesium. Masuku pulp should be treated with additional acids when processed into juice. Juice from unpeeled masuku was more acidic compared to juice from peeled masuku fruits. Juice from peeled masuku is preferred compared to juice from unpeeled masuku because the juice from unpeeled masuku had a bitter aftertaste.

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Table 1 pH content of masuku raw fruit and masuku juice samples and the titratable acidy of masuku juices

Sample ID	pH content	% Titratable acidity
Raw fruit	4.50 ± 0.14[a]	0.50 ± 0.02[a]
Juice from unpeeled fruits	3.47 ± 0.27[b]	1.10 ± 0.11[b]
Juice from peeled fruits	3.80 ± 0.01[c]	0.88 ± 0.01[c]

Means with different superscripts in the same column are significantly different (P<0.05). (Values represent mean ± standard deviation)

Table 2 Results for ash content of masuku raw fruit and masuku juice samples

Sample ID	Ash content g per 100g
Raw fruit	2.70 ± 0.05[a]
Juice from unpeeled fruits	2.20 ± 0.25[b]
Juice from peeled fruits	2.03 ± 0.06[b]

Means with different superscripts in the same column are significantly different (P<0.05).

Table 3 Magnesium and zinc content of the juices and the raw fruit

Sample ID	Magnesium content (mg/100g)	Zinc content (mg/100g)
Raw fruit	32.65 ± 1.16[a]	0.937 ± 0.03[a]
Juice from unpeeled fruits	17.85 ± 0.03[b]	0.250 ± 0.01[b]
Juice from peeled fruits	17.20 ± 0.04[c]	0.210 ± 0.01[b]

Means with different superscripts in the same column are significantly different (P<0.05). (Values represent mean ± standard deviation)

Table 4 Preference scores for masuku juice samples

Sample ID	Number of assessors
Juice from unpeeled masuku fruits	10[a]
Juice from peeled masuku fruits	30[b]

Key: The value is the number of assessors and different superscript in the same column shows that there was a significant difference (p<0.05)

Figure 1. The process for juice processing