PLANT SCIENCE TODAY
ISSN 2348-1900 (online)
Vol x(x): xx–xx
https://doi.org/10.14719/pst.2117

HORIZON
e-Publishing Group
HePG

RESEARCH ARTICLE

Nutrient content and biochemical analysis of papaya (*Carica papaya* L.) hybrids grown in central Kenya

Christinah Matsuane[1,3*], Agnes M. Kavoo[1], Beatrice N. Kiage[2] ,Josephine Karanja[1] & Fredah K. Rimberia[1]

[1]Department of Horticulture and Food Security, Jomo Kenyatta University of Agriculture and Technology, P.O Box 62000-00200,Nairobi,Kenya
[2]Department of Human Nutrition Sciences, Jomo Kenyatta University of Agriculture and Technology, P.O Box 62000-00200, Nairobi, Kenya
[3]Department of Crop and Soil Sciences, Botswana University of Agriculture and Natural Resources, Private Bag 0027, Gaborone, Botswana

*Email: cmatsuane@gmail.com

OPEN ACCESS

ARTICLE HISTORY
Received: 12 September 2022
Accepted: 21 November 2022
Available online
Version 1.0 : 04 February 2023

Check for updates

Additional information

Peer review: Publisher thanks Sectional Editor and the other anonymous reviewers for their contribution to the peer review of this work.

Reprints & permissions information is available at https://horizonepublishing.com/journals/index.php/PST/open_access_policy

Publisher's Note: Horizon e-Publishing Group remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Indexing: Plant Science Today, published by Horizon e-Publishing Group, is covered by Scopus, Web of Science, BIOSIS Previews, Clarivate Analytics, NAAS etc.
See https://horizonepublishing.com/journals/index.php/PST/indexing_abstracting

CITE THIS ARTICLE
Matsuane C, Kavoo A M, Kiage B N, Karanja J, Rimberia F K. Nutrient content and biochemical analysis of papaya (*Carica papaya* L.) hybrids grown in central Kenya. Plant Science Today (Early Access).
https://doi.org/10.14719/pst.2117

Abstract

Papaya (*Carica papaya* L.) is a known powerhouse of nutrients and biochemicals which have health benefits necessary in a human diet. Mineral and vitamin deficiencies, like stunting, wasting and underweight in children, are common in Kenya yet available fruits like papaya can provide those nutrients. This study evaluated the nutritional and biochemical compositions, sugars and the 2,2-diphenyl-1-picryl hydrazyl (DPPH) radical scavenging activities of 2 newly developed papaya hybrids (JKUAT 7 and JKUAT 8) grown in Kenya and Solo variety, as control; in a completely randomised design which were subjected to one way ANOVA at $p<0.05$. Results from this study showed significant differences for JKUAT 8 with zinc, iron, potassium and vitamin C contents at 3.28, 3.62, 1145.10 and 448.30 mg/100 g respectively. Solo variety had significantly higher β-carotene (68.75 mg/100 g), lycopene (25.47 mg/100 g) and flavonoid (0.0178 g/100 g) contents. JKUAT 7 had more phenolic and tannins contents at 0.4434 g/100 g and 81.65 mg/100 g respectively. The DPPH activities ranged from 20 to 80 mg/mL with JKUAT 7 having the highest activity at 20 mg/mL and the least, Solo at 80 mg/mL. JKUAT 7 also exhibited higher total sugar contents in a range of 4.86 to 11.57%: with glucose and fructose at 5.74 and 5.83 % respectively. Our results suggested high nutritional and biochemical profiles of the newly developed JKUAT 7 and JKUAT 8 compared to Solo, the commercial variety. The high nutritional and biochemical contents recorded in the study papayas can be utilised in enhancing human nutrition and health thereby reducing metabolic disorders.

Keywords

Carica papaya hybrids, mineral, radical scavenging activity, sugars, vitamin

Introduction

Papaya (*Carica papaya* L.), which belongs to the Caricaceae family, is a popular fruit native to the tropical America (1). It is grown and produced in most world regions along the tropical climacteric areas like Africa where there are warmer temperatures and adequate rainfall. The top papaya producing countries in Africa are Nigeria, Democratic Republic of Congo and Kenya at 929.8, 214.3 and 136.3 thousand metric tons (2) respectively. Papaya is one popular fruit crop grown in Kenya for its nutritional and health benefits. Papaya was introduced in Kenya over 50 years ago where it is mostly grown for domestic and commercial purposes mostly by the small-scale farmers (3). Other important fruits produced in Kenya are bananas, pineapples, avocadoes, oranges, watermelons, passion fruits and tamarillos.

Papaya is a nutraceutical fruit which has a high nutritive value and powerful antioxidants (1). Papaya is mostly consumed for its nutritional benefits as it is a rich source of nutrients and antioxidants such as polyphenols, vitamins and carotenoids (4). Studies have revealed that papaya contains 144% of the daily recommended value per serving of Vitamin C (5) which is great as an infection fighter as well as a free radical-scavenging antioxidant. Its main carbohydrates are glucose, fructose, and sucrose (6) with a range between 10 and 13% (7) after ripening and the fruit protein content at approximately 5% (8).

Papaya has been traditionally used as medicine due to its anti-inflammatory, anticancer, anti-hypertensive and antibacterial properties, gastrointestinal related disorders and hypoglycemic effects (6). Previous research has shown that papaya contain important nutrients and antioxidants (4) necessary in a human diet which could contribute to a healthy immune system due to their medicinal properties which can reduce malnutrition effects. Malnutrition is a serious public health problem and highly prevalent in Kenya (9) due to poor diets and access to nutritional foods despite the government strategies to implement nutrition services in communities to improve the diet and feeding practices of mothers, infants and young children (10). The prevalence of malnutrition is mostly critical in rural areas, drought-stricken areas and poor households (11) where estimates for children are 35% stunting, 7% wasting and 16% underweight. Results from this study could be important in improving individual and/or household nutrition and considered beneficial on overall health through papaya consumption hence this study was conducted to determine the nutrient content and biochemical analysis of papaya grown in Kenya.

Materials and Methods

The study was conducted in February 2022 at the Food Biochemistry laboratory in the Food Science and Technology Department, at the Jomo Kenyatta University of Agriculture and Technology (JKUAT). Papaya hybrids (JKUAT 7 AND JKUAT 8) and Solo variety were collected from Meru County, Kenya, where they were grown under similar cultivation practices. Other papaya hybrids are currently available; but these 2 were chosen due to their good performance on growth and productivity in different agro-ecological zones of Kenya. Meru is located on the Upper Highlands in the eastern Kenya at an elevation of 1600 m above sea level, which has an average temperature and rainfall of 20.1°C and 550 mm respectively. The papaya fruits were harvested ripened based on their 75% yellow skin colour. The fruits were kept for two days at the laboratory where they were deseeded and blended into a homogenous state a day before analysis.

Determination of nutritional composition of papaya

Mineral quantification was done by dry ashing using the atomic absorption spectroscopy (AAS) (Shimadzu AA-7000, Shimadzu Corp., Kyoto, Japan) method (12). The minerals were determined by measuring sample ash solution mixed with 0.5N HNO_3 against the standard solutions of zinc (Zn), iron (Fe), magnesium (Mg) and potassium (K) using AAS.

Determination of vitamin C and Carotenoids

The ascorbic acid content of papaya was determined by High-performance liquid chromatography (HPLC) method (13) using a Shimadzu UV-VIS (Shimadzu Corp., Kyoto, Japan) detector. The β-carotene and lycopene contents of papaya were determined using a chromatographic procedure (14). An HPLC (Model LC-10AS, Shimadzu Corp., Kyoto, Japan) machine was used to determine the ß-carotene contents of the papaya varieties.

Determination of flavonoids, phenolic and tannins contents

The bioactive secondary metabolites of the papaya pulp extract were analysed using the standard ultra-violet spectrophotometric (Shimadzu model UV –VIS 1800, Shimadzu Corp., Kyoto, Japan) method, and the results were expressed in dry weight basis. The total flavonoid content of the papaya was quantified using the standard method (15). The fruit extract was mixed with 5 % sodium nitrite solution, 0.3 mL of 10 % aluminium chloride and 2 mL of 1 M sodium hydroxide at different times. Absorbance was measured at 415 nm and the number of total flavonoids was calculated from the calibration curve of standard prepared from quercetin. Methods described by (16) were used to determine the total phenolic and tannins contents of the papaya pulp which was mixed with 10% Folin-Ciocalteau reagent to form a blue coloured colour. Absorbance was read at 725 nm and phenolic results were calculated as gallic acid equivalent (GAE). Absorbance for tannin contents was read at 500 nm and calculated as % catechin equivalent (CE) using the standard calibration curve.

The DPPH (2,2-diphenyl-1-picrylhydrazyl) radical scavenging activity

The ability of papaya pulp to scavenge DPPH was determined (17). DPPH solution (0.1 mm) was added to extract samples and measured at 517 nm absorbance after 30 minutes of dark incubation. Vitamin C was used as the antioxidant standard at concentrations of same the amount as the extract concentrations while a mixture of methanol and extracts was used as a blank. The concentration of the extract necessary to decrease the initial concentration of DPPH by 50% (IC_{50}) was calculated from a plot of % inhibition of DPPH versus concentration of extract.

Determination of papaya sugars (fructose, glucose and sucrose)

The total and/or individual sugar contents were analysed using a high-performance liquid chromatography (Model LC-20AS, Shimadzu Corp., Kyoto, Japan) (18). Ethanol was added to the blended fruit samples, refluxed for one hour and filtered using 42 mm Whatman filter paper. Rotary evaporation of the solutions to dryness was done at 60 °C and finally 5 ml of 50% acetonitrile was added and micro-filtered.

Data analysis

The experiment was laid out in a completely randomised design with 3 replications. Nutritional and biochemical papaya results were presented as means in a one way analysis of variance using GenStat statistical software package. Where statistical differences were detected, Turkey's multiple range test was used to compare means at p≤0.05.

Results & Discussion

Nutritional analysis

Nutritional composition of Solo, JKUAT 7 and JKUAT 8 papaya varieties resulted in significant differences (P<0.05) in Zn, Fe and K contents while Mg had non-significant results (Table 1). JKUAT 8 hybrid had the highest Zn, Fe and K contents of 3.28, 3.62 and 1145.10 mg/100 g respectively while Solo and JKUAT 7 varieties had statistically similar (P<0.05) contents. The papaya pulp contains most of the nutrients which play an important part in biological processes especially during fruit ripening (6); and are required for bodily functions. Similar results higher in Mg, calcium, Fe and Zn contents were reported in papaya while Mg amounts showed non-significant results in this study (19). Papaya is rich in iron and calcium (1) which are necessary for expectant mothers as they can help with the proper functioning of haemoglobin and alleviate micro-nutrient deficiency in a human diet. Magnesium plays an important role in the cardiovascular system by influencing myocardial metabolism, Ca^{2+} homeostasis and endothelium-dependent vasodilation, and also acts as an antihypertensive, antidysrhythmic, anti-inflammatory and anticoagulant agent (20) while calcium contents in plants play vital roles like carbohydrate metabolism and binding of cell walls (21). Potassium has been as an essential nutrient which promotes sugar translocation in plants, thus its application increases the sugar contents as well as total soluble solids in the papaya fruit and decreases its titratable acidity (22).

Table 1. Nutritional composition of papaya hybrids grown in central Kenya

Variety	Zn (mg/100 g)	Fe (mg/100 g)	Mg (mg/100 g)	K (mg/100 g)
Solo	1.18±0.012^{b}	2.29±0.081^{b}	114.40±4.186^{a}	688.00±20.331^{b}
JKUAT 7	0.95±0.006^{b}	2.14±0.050^{b}	112.60±1.464^{a}	646.90±21.614^{b}
JKUAT 8	3.28±0.151^{a}	3.62±0.114^{a}	120.10±1.827^{a}	1145.10±49.263^{a}

Means within each column followed by a different letter differ significantly at P≤0.05 while means with a similar letter in different columns do not differ using Tukey's test. Mean±S.E. measured in triplicates

Vitamin C and carotenoid contents

Statistical differences (P<0.05) were observed for vitamin C, β-carotene and lycopene contents in the different papaya hybrids. JKUAT 8 hybrid had significantly higher vitamin C content of 448.30 mg/100 g followed by JKUAT 7 and Solo. Results for β-carotene and lycopene contents were highest in Solo variety of 68.75 and 25.47 mg/100 g respectively (Table 2).Papaya vitamins are essential for the metabolic reactions and for normal body growth and health maintenance. These components are not synthesized by the body and therefore must be supplied through a proper diet. Papaya is a good source of vitamin C and its amount varies between maturity stages, varieties (19) and increases during the ripening stage (6). Results from this study revealed a difference from the varieties as JKUAT 8 significantly had a higher vitamin C content at 448.30 mg/100 g. Similar results were reported between 2 local papaya varieties at different maturation stages (19). In a study, guava and papaya were reported to be the only fruits that had a higher ascorbic acid content than that of orange (67 ± 9 mg/100 g) (23). A higher papaya vitamin C content resulted in lower β-carotene and lycopene contents and vice versa.

Carotenoids are strong antioxidants which play an important role in human health and nutrition. These carotenoid compounds are usually associated with the fruit cultivar together with its preharvest and postharvest handling factors (24). They contribute to the reddish colour of the papaya pulp, especially lycopene, whereas β-carotene is mostly converted to vitamin A by the body. Different carotenoids levels were observed in our study for the papaya hybrids; with the highest found in Solo. Weather conditions, ripening stage, variety or group cultivar, geographical area and season of the year have been reported to have an effect on thecarotenoid levels in fruits (25). High amounts of β-carotene contents are reported in this study with similar results reported where the β-carotene content in red-fleshed papaya was significantly higher (p < 0.0001) than that in yellow-fleshed papaya (26). High lycopene contents were also reported in red fleshed papaya by (14, 25, 27).

Table 2. Vitamin C and carotenoid composition of papaya hybrids grown in central Kenya

Papaya hybrid	Vitamin C (mg/100 g)	β-Carotene (mg/100 g)	Lycopene (mg/100 g)
Solo	212.60±5.401^{c}	68.75±1.328^{a}	25.47±0.529^{a}
JKUAT 7	314.60±10.448^{b}	26.04±1.488^{b}	10.95±0.521^{b}
JKUAT 8	448.30±7.004^{a}	20.39±0.370^{c}	11.63±0.237^{b}

Means within each column followed by a different letter differ significantly at P≤0.05 while means with a similar letter in different columns do not differ using Tukey's test. Mean±S.E. measured in triplicates

Total flavonoid, phenolic and tannin contents

Flavonoid, phenolic and tannin compounds, which are naturally found in plants and plant products, are known to have antioxidant potentials necessary for anti-oxidative stress which can result in the development of health disorders, infections and/or chronic diseases. Significant differences (P<0.05) were observed for the total papaya flavonoids, phenols and tannins. Solo variety and JKUAT 8 hybrid had the highest and statistically similar total flavonoids contents (TFC) while JKUAT 7 had the least quercetin equivalents (QE) of 0.0085 g/100 g (Fig. 1). Flavonoids have free radical scavenging activities in plant foods and have significant vitamin C sparing activity (24). As evaluated, significant differences in TFC were observed in this study where JKUAT 7 had the least quercetin equivalents of 0.0085 g/100 g. These results were higher than the content (28) on papaya (8.40 mg QE/100 g) for a freeze-dried papaya.

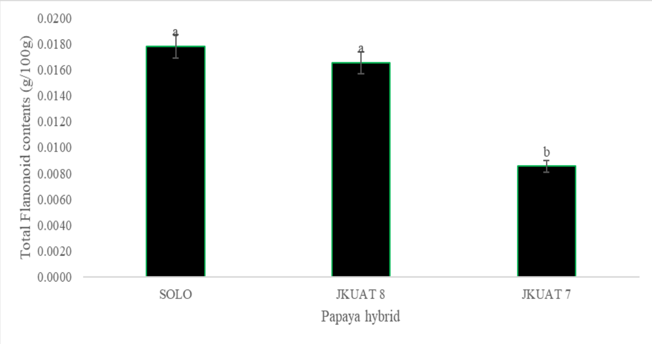

Fig. 1. Total flavonoid contents of papaya hybrids grown in central Kenya.

JKUAT 7 had the highest significant total phenol contents (TPC) ($P<0.05$) of 0.4434 g/100 g. Statistically similar phenol contents (GAE) were observed for both JKUAT 8 hybrid and Solo variety (Fig. 2). Phenolic compounds are important fruit constituents which act as antioxidants because of their ability to donate hydrogen or electrons and by generating stable radical intermediates (24). In a study by (23) the TPC in papaya fruit was 28±6 mg GAE /100 g FW which was lower than the highest TPC found in JKUAT 7 of 0.4434 g/ GAE/100 g. (29)

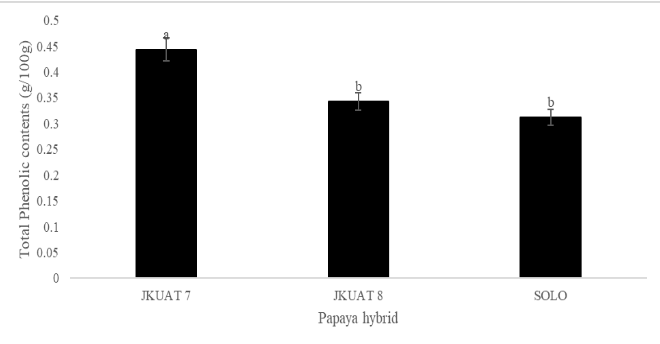

Fig. 2. Total phenolic contents of papaya hybrids grown in central Kenya

reported a TPC of 54 mg GAE/100 g FW of fresh papaya cultivated in Thailand.

Tannins are plant phenolic compounds with biological activities which act as phytochemicals with antioxidant effects in the body. Results on total tannin contents (TTC) of the papaya hybrids revealed that JKUAT 7 had statistically ($P<0.05$) higher tannins of 81.65 mg CE/100 g followed by Solo and JKUAT 8 at 35.72 and 6.74 mg/100 g respectively (Fig. 3). Higher total tannins content was observed for JKUAT 7 at 81.65 mg/100 g compared to Solo and JKUAT 8 (35.72 and 6.74 mg/100 g respectively). These results were comparably higher than the freeze-dried ripe papaya extracts which showed significantly higher tannin content (9.58 and 6.0 mg CAE/g fresh weight of sample in ethanol and aqueous extracts respectively (28).

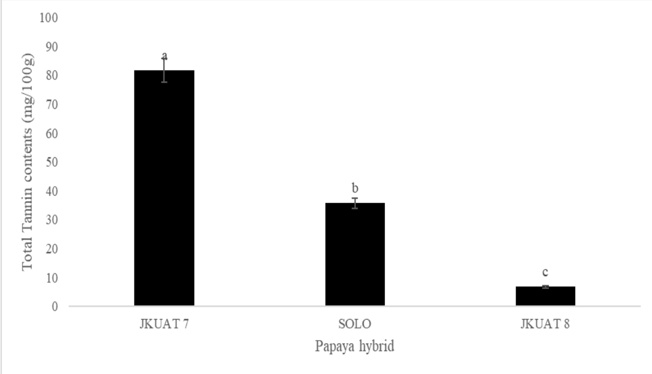

Fig. 3. Total tannin contents of papaya hybrids grown in central Kenya.

The DPPH (2,2-diphenyl-1-picrylhydrazyl) radical scavenging activity

The DPPH radical scavenging method is commonly used to determine the capability of an extract to scavenge free radicals, with the highest scavenging obtained at a lower IC_{50} value. The half inhibitory concentration (IC_{50}) of the different papaya fruits ranged from 20 mg/mL to 80 mg/mL compared with 2.5 mg/mL of the vitamin C standard as presented in Fig. 4 and Table 3. Papaya hybrid, JKUAT 7, had the highest radical scavenging activities of 20 mg/mL followed by JKUAT 8 at 30 mg/mL and Solo having the least at 80 mg/mL (Table 3). The different antioxidant activities in the different papaya hybrids could be a result of different synthesis and accumulation of bioactive compounds (30). A high correlation between vegetable/fruit polyphenols and their IC_{50} values has been observed in some studies; an IC_{50} of 3.5 ± 0.9 mg/mL for Solo papaya was reported in a study which was higher compared to 80 mg/mL found in this study (23).

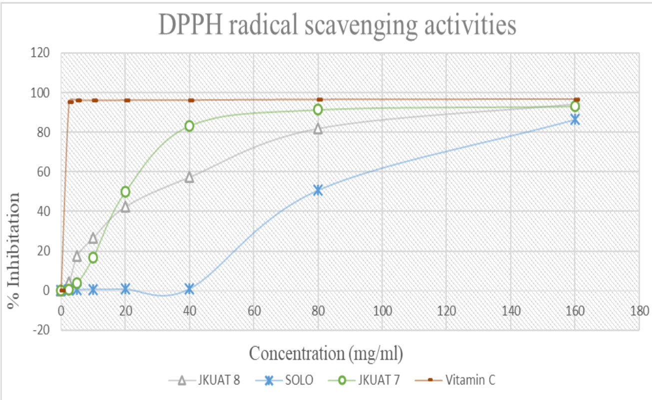

Fig. 4. DPPH (2,2-diphenyl-1-picrylhydrazyl) radical scavenging activities of papaya hybrids grown in central Kenya

Table 3. DPPH (2,2-diphenyl-1-picrylhydrazyl) scavenging activity of papaya hybrids grown in central Kenya

Variety	EC_{50} (mg/mL)
Solo	80
JKUAT 7	20
JKUAT 8	30
Vitamin C standard	2.5

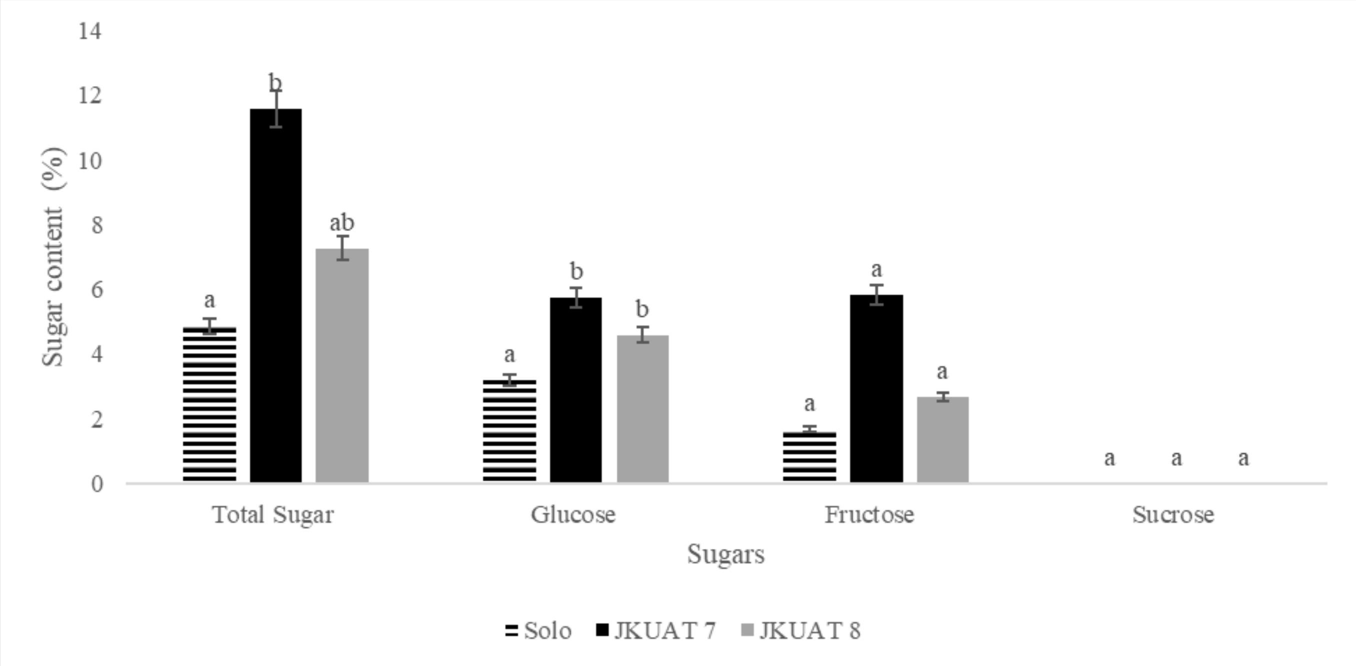

Fig. 5. Sugar contents (%) of papaya hybrids grown in central Kenya.

Papaya sugars

Papaya hybrid, JKUAT 7, had the highest significant (P<0.05) total sugar contents (11.57%) compared to both Solo variety and JKUAT 8 hybrid (Fig. 5). Solo variety had the lowest total sugar (4.86%) and glucose (3.18%) contents while JKUAT 7 and JKUAT 8 had statistically similar glucose contents. No significant differences (P<0.05) were observed for sucrose contents as all the papaya varieties had minute and/no sugar content. Papaya sugars determine the final fruit quality, especially its sweet taste. Sugar contents increase during the ripening stage due to an enzymatic reaction which breaks simple sugars into fructose, glucose and sucrose (31). Glucose and fructose are mostly available while sucrose content declines during the period, suggesting that there is sucrose *de novo* synthesis during ripening of the detached papaya (32). A portion of glucose is mostly used as a precursor of antioxidants like vitamin C (31), especially under stressful environmental conditions. The total sugar contents of the papaya hybrids in this study ranged from 4.86 and 11.57% which was similar to an earlier study (7).

Conclusion

The results of this study showed significant differences on the nutritional and biochemical profiles of the papaya hybrids. JKUAT 8 hybrid performed better nutritionally with higher minerals, vitamin C, lycopene, phenol and tannin contents while JKUAT 7 had more of β-carotene, flavonoids, DPPH and total sugar contents. These papaya hybrids can have a positive impact in human nutrition and health by reducing metabolic disorders.

Acknowledgements

This research paper was financially supported by Carnegie Cooperation of New York through a capacity building competitive grant *Training for the next generation of scientists* through the Regional Universities Forum for Capacity Building in Agriculture (RUFORUM), Grant No: RU/2020/GTADRG/016. Special thanks to Botswana University of Agriculture and Natural Resources (BUAN) for providing academic leave to the PhD student and Mr. David Abuga from the Department of Food Science and Technology, JKUAT.

Authors contributions

This research work was part of CM's PhD thesis which was supervised by the other authors. All authors contributed to the whole research work; revised and approved the final manuscript draft to be published.

Compliance with ethical standards

Conflict of interest: Authors do not have any conflict of interests to declare.

Ethical issues: None.

References

1. Parni B, Verma Y. Biochemical properties in peel, pulp and seeds of *Carica papaya*. Plant Arch. 2014; 14(1):565-68.
2. Corral-Aguayo RD, Yahia EM, Carrillo-Lopez A, González-Aguilar G. Correlation between some nutritional components and the total antioxidant capacity measured with six different assays in eight horticultural crops. J Agric Food Chem. 2008; 56(22):10498-504. https://doi.org/10.1021/JF801983R.
3. Compendium S. Fr It Statistical Compendium. 2017.
4. Asudi GO, Ombwara F, Rimberia F, Ateka EM. Collection and documentation of papaya germplasm in Kenya Caroline ndungu View project evaluation of growth, development and yield traits of new papaya hybrid lines in Kenya View project. 2010. https://www.researchgate.net/publication/280319916

5. Ali A, Devarajan S, Waly MI, Essa MM, Rahman MS. Nutritional and medicinal values of papaya (*Carica papaya* L.). In: Proceedings of Natural Products and Their Active Compounds on Disease Prevention. 2012;307-24.

6. Saeed F, Arshad MU, Pasha I, Naz R, Batool R, Khan AA et al. Nutritional and phyto-therapeutic potential of papaya (*Carica papaya* Linn.): An overview. Int J Food Prop. 2014; 17 (7):1637-53. http://dx.doi.org/10.1080/10942912.2012.709210

7. Zhou L, Paull RE. Sucrose metabolism during papaya (*Carica papaya*) fruit growth and ripening. J Amer Soc Hort Sci. 2001; 126(3):351-57. https://doi.org/10.21273/JASHS.126.3.351

8. de Oliveira JG, Vitória AP. Papaya: Nutritional and pharmacological characterization and quality loss due to physiological disorders. An overview. Food Research International. 2011;44 (5):1306-13. https://doi.org/10.1016/J.FOODRES.2010.12.035

9. Kabubo-Mariara J, Ndenge GK, Mwabu DK. Determinants of children's nutritional status in Kenya: evidence from demographic and health surveys. J Afr Econ. 2009; 18(3):363-87. https://doi.org/10.1093/JAE/EJN024

10. Nutrition | UNICEF Kenya. [cited 2022 Aug 29]. Available from: https://www.unicef.org/kenya/nutrition

11. Dhs M, Macro ICF. Kenya. 2008.

12. Singh M, Yadav P, Garg VK, Sharma A, Singh B, Sharma H. Quantification of minerals and trace elements in raw caprine milk using flame atomic absorption spectrophotometry and flame photometry. J Food Sci Technol. 2015; 52(8):5299. https://doi.org/10.1007/S13197-014-1538-9

13. Vikram VB, Ramesh MN, Prapulla SG. Thermal degradation kinetics of nutrients in orange juice heated by electromagnetic and conventional methods. J Food Eng. 2005; 69(1):31-40. https://doi.org/10.1016/J.JFOODENG.2004.07.013

14. de Souza LM, Ferreira KS, Chaves JBP, Teixeira SL. L-ascorbic acid, B-carotene and lycopene content in papaya fruits (*Carica papaya*) with or without physiological skin freckles. Sci Agric. 2008; 65(3):246-50. https://doi.org/10.1590/S0103-90162008000300004

15. Yang X, Yang L, Zheng H. Hypolipidemic and antioxidant effects of mulberry (*Morus alba* L.) fruit in hyperlipidaemia rats. Food Chem Toxicol. 2010; 48(8-9):2374-79. https://doi.org/10.1016/J.FCT.2010.05.074

16. Fiorentini D, Cappadone C, Farruggia G, Prata C. Magnesium: biochemistry, nutrition, detection and social impact of diseases linked to its deficiency. Nutrients. 2021; 13(4): https://doi.org/10.3390/NU13041136.

17. Siddhuraju P, Becker K. Antioxidant properties of various solvent extracts of total phenolic constituents from three different agroclimatic origins of drumstick tree (*Moringa oleifera* Lam.) leaves. J Agric Food Chem. 2003;51(8):2144-55. https://doi.org/10.1021/jf020444+

18. Tolić MT, Jurčević IL, Krbavčić IP, Marković K, Vahčić N. Phenolic content, antioxidant capacity and quality of Chokeberry (*Aronia melanocarpa*) products. Food Technol Biotechnol. 2015;53(2):171. https://doi.org/10.17113/FTB.53.02.15.3833

19. White PJ and Broadley MR. Calcium in plants. Ann Bot. 2003; 92(4):487. https://doi.org/10.1093/AOB/MCG164.

20. Cunniff P. Official methods of analysis of AOAC International. (16. ed.). 5th. rev. AOAC., Washington D.C.; 1999. p. 1-2.

21. Bari L, Hassan P, Absar N, Haque ME, Khuda MIIE, Pervin MM et al. Nutritional analysis of two local varieties of papaya (*Carica papaya* L.) at different maturation stages. Pak J Bio Sci. 2006;9(1):137-40. https://doi.org/10.3923/pjbs.2006.137.140

22. Römheld V, Kirkby EA. Research on potassium in agriculture: needs and prospects. Plant Soil. 2010;335(1):155-80. https://doi.org/10.1007/S11104-010-0520-1

23. Lim YY, Lim TT, Tee JJ. Antioxidant properties of several tropical fruits: A comparative study. Food Chem. (3):1003-08. https://doi.org/10.1016/j.foodchem.2006.08.038

24. Setiawan B, Sulaeman A, Giraud DW, Driskell JA. Carotenoid content of selected Indonesian fruits. J Food Compos Anal. 2001; 14(2):169-76. https://doi.org/10.1006/jfca.2000.0969

25. Chandrika UG, Jansz ER, Wickramasinghe SMDN, Warnasuriya ND. Carotenoids in yellow- and red-fleshed papaya (*Carica papaya* L). J Sci Food Agric. 2003;83(12):1279-82. http://doi.org/10.1002/jsfa.1533

26. Laurora A, Bingham JP, Poojary MM, Wall MM, Ho KKHY. Carotenoid composition and bioaccessibility of papaya cultivars from Hawaii. J Food Compos Anal. 2021;101:103984. https://doi.org/10.1016/j.jfca.2021.103984

27. Rivera-Pastrana DM, Yahia EM, González-Aguilar GA. Phenolic and carotenoid profiles of papaya fruit (*Carica papaya* L.) and their contents under low temperature storage. J Sci Food Agric. 2010; 90(14):2358-65. https://doi.org/10.1002/jsfa.4092

28. Annegowda HV, Bhat R, Yeong KJ, Liong MT, Karim AA, Mansor SM. Influence of drying treatments on polyphenolic contents and antioxidant properties of raw and ripe papaya (*Carica papaya* L.). Int J Food Prop. 2013; 17(2):283-92. http://dx.doi.org/101080/109429122011631248

29. Patthamakanokporn O, Puwastien P, Nitithamyong A, Sirichakwal PP. Changes of antioxidant activity and total phenolic compounds during storage of selected fruits. J Food Compos Anal. 2008;21(3):241-48. https://doi.org/10.1016/j.jfca.2007.10.002

30. Zhang R, Lv J, Yu J, Xiong H, Chen P, Cao H et al. Antioxidant analysis of different parts of several cultivars of papaya (*Carica papaya* L.). Int J Fruit Sci. 2022;22(1):438-52. https://doi.org/101080/1553836220222047138

31. Kamelia M, Supriyadi, Widiani N, Farida, Damayanti I. The analysis of glucose and vitamin C on papaya (*Carica papaya* L.) with different time storage. J Phys Conf Ser. 2019;1338 (1):012026. https://doi.org/10.1088/1742-6596/1338/1/012026

32. Gomez M, Lajolo F, Cordenunsi B. Evolution of soluble sugars during ripening of papaya fruit and its relation to sweet taste. J Food Sci. 2002; 67(1):442-47. https://doi.org/10.1111/J.1365-2621.2002.TB11426.x