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Impact of steaming and blanching on the nutritional composition of kuini (*Mangifera odorata)* waste

Noor Fadilah, M. B.*, Tun Norbrillinda, M., Arif Zaidi, J. and Hadijah, H.

Food Science and Technology Research Centre, MARDI Headquarters, 43400 Serdang, Selangor, Malaysia

Abstract

Kuini (*Mangifera odorata*), an underutilised fruits have gained interest due to its delicious taste and strong aroma smell. To date, there is a lack of information available on the benefit of this fruit, particularly the kernel seed and peel (Kuini waste). This study was carried out to determine impact of steaming and blanching on the level of anti-nutritional factors and sugar composition of Kuini wastes. Both anti-nutritional factors (tannins and phytic acid) shown high reduction in kernel seed and peel (above 50%) where compounds were recorded at 0.027 – 0.243 mg/100 g and 0.207 – 0.295 mg/100 g, respectively after exposed to blanching and steaming. The sugar composition in our sample were also altered by the heat treatment. Fructose and glucose level of both Kuini kernel seed and peel was found increase, but the sucrose level was decreased after heat treatment. Experiment conducted on nutritional composition of the waste was also shown affected by the heat treatments. The heat treatments increased insoluble dietary fibre in kernel seed to 22.71 – 33.59 g/100 g.

Keywords: *steaming, blanching, kuini (Mangifera odorata), anti-nutritional factors, nutritional composition*

Introduction

Kuini *(Mangifera odorata)* is an underutilised fruits that has strong smell and bright colour. It was believed that this fruit commonly cultivated in Peninsular Malaysia and belong to the family of mango (*Mangifera)* (Kozai et al. 2004). This fruit is categorized in family *Anacardiaceae*, which comprises of 73 genera and about 830 species (Mirfat et al. 2015). Among the species, *M. odorata* is less attention compared to *M. indica* due to lack of information regarding its physio-chemical characteristics and potential benefits. Campbell 2007 described Kuini as a fruit with average weight of 325 g and the colour change from green to canary yellow when reach maturity stage and possess sweet flavour with intense and earthy aroma. This fruit is commonly consume its delicious flesh and discard the other inedible parts, which are kernel seed and its peel.

Mango (Mangifera species) in general, has been widely reported as a good source of high nutritional value and phytochemicals compounds. According to Fowomola 2010, mango fruit is available in size and colour. Its tree can reached up to 35 – 40 m in height and its fruit is widely exploited for food, juice, flavour and colour. Maldano-Celis et al. 2019 has reported the benefit compounds of mango which comprised of macronutrients (carbohydrate, lipid, fatty acids etc), micronutrients (vitamins and minerals) and phytochemicals (polyphenols, pigments and volatile constituents). Several studies have been performed on the functional characteristics, antioxidant properties and antimicrobial activities of Kuini (Mirfat et al. 2015; Lasano et al. 2019; Adnan et al. 2018). Kuini has various beneficial compounds such as polyphenols, carotenoids and ascorbic acid which contribute to high antioxidant activities. Some phenolic compounds such as gallic acid, kampherol, quercetin and mangiferin presents in Kuini, which confers to its strong antimicrobial activities (Adnan et al. 2018 and Barreto et al. 2008). All these studies indicated the potential of Kuini as a good source of food ingredients with the presence of multiple health benefit compounds.

Preliminary study conducted by Khoo et al. 2008 reported three types of Mangifera species namely Bambangan, Bacang and Kuini contain isoflavone. This phytoestrogen may serve as health promoting compounds in our diet. The level of daidzen and genistein, phytoestrogen in Kuini was 9.94 and 1.16 mg/100 g.

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Author's full names: Noor Fadilah Mohd Bakri, Tun Brillinda Mokthar, Arif Zaidi Jusoh and Hadijah Hasan
Corresponding author: fadilah@mardi.gov.my

Few types of carotenoids which are alpha carotene and beta caratone were reported found in underutilizsed fruit including Kuini. These compounds have pro Vitamin A activity and antioxidant properties.

There are several studies around the globe focus on the utilisation of agricultural wastes. Valuable compounds can be found abundantly in parts like pulp, core, and skin, which are mostly left out during the processing (Begum et al. 2014). This agricultural waste or by- products not only provide a good material source to enhance the economic value of finished products but could tackle environmental problem due to the dumping of excessive of these unwanted materials that created environment pollution. A process of reinserting wastes from agricultural products in food system may provide a novel solution to value-add agriculture by- product that are safe and healthy for human consumption (Lin et al. 2013). For instance, waste like kernel seed and peel can be a good source of food ingredients based on their nutritional composition. Mango kernels contain good amount of nutrients especially crude protein, crude fat and carbohydrate in the range of (6.24 – 8.19%), fat (5.92 – 13.50%), and carbohydrate (75.02 – 83.04%) according to Kayode et al. 2013. This finding justifies the potential of mango by products as an energy source and could be utilise into food ingredients.

Tannins and phytic acid have been categorised as anti-nutritional factors that exist naturally in plant. Anti-nutritional factors are compound that presence naturally in plants in the form of defense metabolite that protect plants from various threats in the environment (Bora 2014). These compounds have specific biological effect that impact consumption of beneficial macro-and micronutrients into the body. Saponin, oxalate, cynogenic glycosides, alkaloids are among compound that listed as anti-nutritional factors others than tannin and phytic acid.

Tannins, part of polyphenols group that could be found in various part of the plants. This compound displays anti-nutritional characteristic by forming complexes with major and minor elements in plant like carbohydrate and vitamins, and enzyme that involved in the digestion of proteins and pectin in body, which turn the beneficial compound unattainable to be adsorbed. This process in turn decreasing the nutritional quality of food. On the other hand, the unique structure of phytic acid strengthen its ability to chelate with minerals like magnesium, zinc and copper and made these micronutrients hardly to be adsorbed by animals (Kumar et al. 2010). Phytic acid could decrease protein availability and enzyme activities by altering the protein structure once it consumes and bring a negative affect into food components.

Numerous techniques in food processing have been developed to reduce the amount of these undesirable components in food products. This pre-treatment process is necessary to mitigate its destructive effect and enhance nutritional quality of food ingredients. Heat treatments including soaking, cooking, germination, and fermentation are among the efforts taken by the industries to overcome this problem. Bethapudi et al. 2023, mentioned that heat treatment process for example soaking could result in destruction of seed membranes which led to release of significant amount of soluble sugars, fibres and anti-nutritional component into the medium and ultimately lowered level of anti-nutritional compounds from the food ingredients.

Despites these techniques, lack of study has been conducted to evaluate the effect of steaming and blanching to these anti-nutritional compounds in plant by-products, specifically in Kuini. Most of the recent studies only highlighted the good quality of Kuini and beneficial effect of its flesh. There is still uncertainty about its waste, particularly the kernel seed and peel. The aim of this study is to determine the effect of heat treatment which are steaming and blanching on the chemical composition of Kuini by waste, particularly on the anti- nutritional factor and sugar composition content. Steaming and blanching has been chosen as heat treatment in our study due to the simplicity technique and low-cost processing, which can be applied by food industries.

Materials and method

Preparation of sample

Fresh Kuini fruit (*Mangifera odorata*) were obtained from MARDI Sintok, Kedah. Approximately 30 kg of Kuini at maturity stage were washed manually and divided into 3 groups according to treatment control, blanching (10 mins) and steaming (10 mins). The duration of both treatments was chosen based on preliminary study where there is no significant different of physicochemical properties between different duration of process (data not shown). The kernel seed and peel were separated from fruit and sliced simultaneously in smaller piece before dried in oven (Memmert, Germany) at 60 °C until reached the moisture content of 5% using air forced oven. The dried kernel seed and peel were chopped manually into small pieces and grinded into powder prior to analysis (Waring, USA).

Determination of antinutrient factors

Determination of phytic acid

Determination of phytic acid procedure was conducted as described by Latta and Erskin 1980. A total of 0.5 g of dried sample was weighed into 250 mL conical flask. The initial extraction was done with 25 ml HCl (2.4%, v/v) and the sample was shaken in orbital shaker (Labwit ZHWX-304 Orbital Shaker, Australia) for an hour at room temperature. Then, the sample was centrifuged at 3000 rpm for 30 mins (Sigma 2-16K Sartorius Centrifuge, UK). Three milliliter (3 mL) clear supernatant was transferred into test tube for the phytate analysis, followed by adding 1 mL of Wade reagent (0.03% solution of $FeCl_6H_2O$ containing 0.3% sulfosalicylic acid in water) and vortex for a minute. Sample was read at 500 nm absorbance (Microplate Reader EON, Biotek, UK). Phytate was quantified from a standard calibration curve of phytic

acid (2 to 10 mg/mL). Result was expressed as phytic acid equivalent (mg/100 g).

Determination of tannin

The determination of tannin was done according to Azeez et al. 2015 with slight modifications. Dried (finely ground sample, 0.2 g) was soaked in 25 mL of 70% acetone in 25 mL beaker and then incubated in an iced ultrasonic water bath (RS Pro Ultrasonic, Malaysia) for 20 mins ultrasonic treatment (2 times 10 mins ultrasonic with 5 mins break in between). The supernatant was centrifuged for 10 mins at approximately 3000 rpm under 4 °C condition (Sigma 2-16K Sartorius Centrifuge, UK) and then filtered using Whatman No 1 filter paper and continue kept in chilled condition. Three concentration of filtrate (0.02, 0.05 and 0.1 mL) were taken, made up to 0.5 mL with distilled water, followed by adding 500 µL of Folin-Ciocalteau reagent. Lastly, 1.5 mL of Na_2CO_3 was added into the mixture, continued vortexed and incubated for 40 mins at room temperature. Absorbance of sample and tannin standards was read against blank at 725 nm. Result was expressed as tannic acid equivalent (mg/100g).

Determination of sugar composition

Sugar profile of the samples was analysed based on Wilson et al. 1981. Sample preparation was initiated by dissolving 250 mg of grind sample with 25 mL distilled water and shake for 30 mins in shaker (Labwit ZHWX-304 Orbital Shaker). From the mixture, 10 mL of aliquot was removed and mixed with 10 mL of methanol, followed by centrifugation at 43,000 rpm for 5 mins (Sigma 2-16K Sartorius Centrifuge). Sample was then filtered through 0.45 µL

Regenerated Cellulose (RC) filter and store in vial until further analysis. Sugar compositionof sample was separated by a carbohydrate column (Waters Spheriscorb 5 µm NH_2 4.0 x 250 mm) using HPLC (Waters 2996, USA) equipped with Evaporative Light Scattering Detector (ELSD) Beckman, US. The isocratic gradient mobile phase comprised of Acetonitrile: water (85:15,v/v) with the flow rate maintained at 1.0 ml/min. Ten microliter of the samples was injected into the HPLC. Identification and quantification of major sugar components present in the samples were achieved by comparing each peak retention time and peak area with those of the sugar standards. Sugar standards were made for glucose, fructose, and sucrose and each sugar standard curve was prepared by injecting different concentrations of the respective sugar solution and plotting HPLC peak areas versus sugar concentrations in the standards.

Statistical analysis

All data collected were expressed in triplicate and reported as mean ± standard deviation (SD). Statistical analyses were performed using Statistical Analysis Software (SAS) package (version 9.1.4 of SAS Institute, Inc. Cary, NC, 2008). Means were determined by One Way Analysis of Variance (ANOVA) and the Duncan Multiple Range Test (DMRT) was performed to determine significant differences at the $p < 0.05$.

Results and discussion

Effect of blanching and steaming process on phytic acid content in Kuini kernel seed and peel

The presence of anti-nutritional factor i.e. phytic acid and tannins have been reported in Mango. This study investigates effect of heat treatment on these anti-nutrients in Kuini by- products (seed and peel). Data on the effect of blanching and steaming are demonstrated in *Table 1*.

Phytic acid (myoinositol, 1, 2, 3, 4, 5, 6 hexakis-dihydrogen phosphate) and phytate (salts of phytic acid) was widely reported found in plant seed grains, tubers and legumes (Rasha et al. 2011). Phytic acid was detected at 1.498 mg/100 g and 0.401 mg/100 g in kernel seed and peel respectively. This finding was similar to study reported by Fowomola 2010 and Bethapudi et al. 2023 where level of phytate in mango (*Mangifera indica*) was at 1.44 mg/100 g and 0.48 mg/100 g. It is fundamental to note that level of phytic acid was significantly different ($p < 0.05$) between raw and treatment samples. In sample of kernel seed, it was found that this compound decreased drastically (more than 80%) after exposed to high temperature. Blanching and steaming process effectively lowered level of phytic acid to 0.243 mg/100 g and 0.232 mg/100g respectively. The same phenomenon was observed in Kuini peel, whereby both heat treatments (blanching and steaming process) also decreased the phytic acid content significantly ($p < 0.05$).

Blanching and steaming reduced up to 48% of phytic acid content, given final reading of phytate at 0.207 mg/100 g and 0.208 mg/100 g, respectively. This study correlates favourably well with work done by Embaby 2010; Addo et al. 2018 and Bala et al. 2013 and further support the concept of significant reduction of phytic acid in all heat treatment (microwave, boiling, autoclaving and roasting). Embaby 2010 discovered boiling method was efficient to reduce 3.8 to 11.8% phytic acid in the peanut and sesame seeds samples. The samples undergone longer time of heat treatment resulted lower content of this antinutrient. Experiment carried out by Addo et al. 2018 confirmed the roasting process at 160 °C for 30 mins, could reduce 58 to 76% phytate in watermelon seeds and highlighted different processing techniques could affect the ratio of antinutrients in the watermelon seeds. Soaking method, another pre- treatment was reported able to reduce the antinutrient in raw mango kernel at the range of 80 to100% in all mango varieties (Bala et al.2013). Phytic acid is relatively heat-stable, hence, significant, and prolonged inputs of energy are required for its destruction (Rasha Mohamaed etal. 2011). The chemical structure, thermal stability at high temperature and water solubility, are among the important factors that may affect the anti-nutrients compounds such

Table 1. Antinutritional factor in Kuini (*Mangifera odorata*) kernel seed and peel

	Kernel seed (mg/100g)		Peel (mg/100g)	
	Phytic acid	Tannic acid	Phytic Acid	Tannic acid
Raw	1.498 ± 0.01[a]	0.366 ± 0.02[a]	0.401 ± .01[a]	0.446 ± 0.03[a]
Blanch	0.232 ± 0.01[b]	0.080 ± 0.01[b]	0.207 ± 0.01[b]	0.25 3 ± 0.01[c]
Steam	0.243 ± 0.01[b]	0.027 ± 0.01[c]	0.208 ± 0.01[b]	0.295 ± 0.03[b]

Data was expressed as mean ± standard deviation(n = 3)
Means within sample with different letter are significantly different at (p <0.05)

as phytic acid (Larrosa and Otero 2021). The wet thermal processing such as soaking and blanching will leach out the phytic acid, thus reduce its content in the samples.

Effect of blanching and steaming on tannins content in Kuini kernel seed and peel

The same trend changes were detected for tannins level in both blanching and steaming process for the kernel seed and peel samples. The level of tannins in raw kernel seed and peel were 0.336 mg/100 g and 0.446 mg/100 g respectively. We found much lower value of tannin than reported by Fowomola 2010 (1.03 mg/100 g) in Mango (*Mangnefira Indica*). But our result was similar with work done by Bethapudi et al. 2023 (0.25 mg/100 g). In the study on effect of blanching and steaming on level of tannin, we found that both treatments gave significant different (p <0.05) in lowering the tannins content in Kuini kernel seed and peel. The high reduction was seen in kernel seed part, where the blanching treatment diminished the anti-nutrient compound up to 78% and reduced to 0.080 mg/100 g. While, steaming treatment caused about 92% reduction in kernel seed with the tannins content of 0.027 mg/100 g. For Kuini peel, both heat treatment also reduced tannins up to 48% and 34% respectively. Tannin was quantified at 0.253 mg/100 g and 0.295 mg/100 g, after blanching and steaming pre-treatments respectively. Our experiments corroborate with the previous result (Bala et al. 2013).

Tannins reduction was discovered in mango kernel at the range of 61.54 to 76.3% after exposed to hot soaking water at 80 °C for a duration of 4 days. Another research done by Embaby 2010 and Addo et al. 2018 also confirmed both roasting and boiling method also significantly reduced tannins at approximately 16.6 to 37.0% for brown and white sesame seeds and 15.09 to 23.85% in watermelon seeds. Decreasing of tannins may be due to the factor that the interaction between this compound with other chemical components like protein to form insoluble complexes. During heat treatment, this process escalates its degradation, resulting loss of tannins (Embaby 2010). This finding extends our knowledge that heat treatment could reduce tannins efficiently in any part of sample.

The usage of heat treatment for sample preparation led to membrane disruption which allow release of different types of compounds from samples (Bethapudi et al. 2023). Both blanching and steaming decreased content of phytic acid and tannin into acceptable range. This method seems promising in converting the samples which are Kuini by-products into nutritious and more suitable food ingredient.

Effect of blanching and steaming on sugar profile in Kuini kernel seed and peel

Fruit is a well-known source of natural sugar and other carbohydrates. Fructose, sucrose, glucose and maltose are among listed types of sugars that could be found in fruits. *Figure 1* summarizes the comparison of sugar profile between raw and pre-treatment of Kuini kernel seed and peel samples. Analysis of sugar profile in both part of Kuini detected the presence of fructose, sucrose and glucose. These types of sugar were reported earlier by Bello-Pérez et al. 2007 on various mango cultivars. In Kernel seed, level of fructose, sucrose and glucose were reported at 2.4, 4.41 and 2.19% respectively. For the peel sample, higher level of these sugar was recorded at 5.31, 6.48 and 3.66% (fructose, sucrose and glucose respectively). From the sugar profile analysis, it was revealed that there was a significant different (p <0.05) in the level of sucrose between raw and pre- treatment in kernel seed and peel sample. Sucrose, the predominant sugar presents in both kernel seed and peel was found reduced drastically during heat treatment process.

The level of sucrose in raw kernel seed was decreased to 33.5 – 37.6% after exposed of blanching and steaming process. The final reading of sucrose after pre-treatment was 2.75 and 2.98% for steaming and blanching respectively. On the contrary, our data showed that level of fructose was increased from 2.40% (w/w) in raw kernel seed to 2.51% and 2.74% (w/w) respectively after blanching and steaming. The glucose level of raw kernel seed also increased significantly from 2.19% (w/w) to 3.29% and 4.12% (w/w) after steaming and blanching process respectively. The same trend of changes also observed in the sucrose, fructose and glucose level in Kuini peel. Level of sucrose in Kuini peel was 6.48% (w/w) and then degraded to 55.6 – 65.4% after subjected to both steaming and blanching process. Kuini peel samples exhibited an increase level of fructose level from 5.31% to 6. 01% and 5.94% (w/w) after exposed to heat treatment. Glucose content in Kuini peel also observed increased from 3.66% (w/w) and then escalated to 3.82% and 4.12% (w/w) after steaming and blanching process respectively. However, the study conducted by Liu et al. 2016 recorded no significantly different (p >0.05) for sugar level in high pressure heat treatment either with or without blanching treatment. The same author highlighted

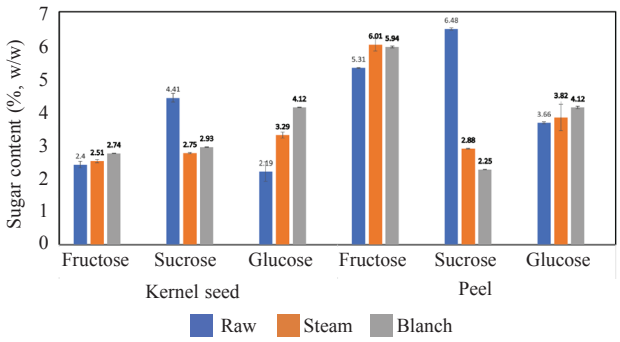

Figure 1. Effect of steaming and blanching on sugar content from kuini (Mangifera odorata) kernel seed and peel

that glucose and fructose content can be increased by the inversion reaction of sucrose but can also decreased by Maillard reaction. Another work done by Mongi and Ngoma 2022 were also reported, substantial amount of sugar was maintained and concentrated in all dried samples, with no significant different between fresh and dried sample. Their study was conducted to evaluate effect of difference drying technique – cabinet and tunnel dryer to physicochemical properties of various mango types. Further study by Abud and Narain 2012 indicated drying temperature of above 55 °C diminished the amount of reducing sugars in acerola fruits due to non-enzymatic degradation. Maillard reaction is also responsible for the degradation of monosaccharides during heating treatment like blanching (Cao et al. 2012). Interestingly, from this finding, it shown that both treatments could preserve the quality of two types of sugar in kuini waste. By conserving these two types of sugar, both kernel seed and peel could be applied as a source of sugar in food ingredients. Furthermore, from this experiment, its demonstrate that blanching and steaming were a capable pre-treatment to prolong the shelf life of Kuini waste.

Nutritional composition of Kuini waste in blanching and steaming samples

It is interesting to highlight that pre-treatment study not only improvise the quality of waste by decreasing the antinutrients content, but it also contributes to the level of macro and micronutrients the samples. From the proximate analysis, it is intriguing to find that both kernel seed and peel part contain good level of nutritional composition. Protein content of raw kernel seed and peel were reported 5.17 and 4.07 g/100 g respectively. These values correlated well with Nwafor et al. 2022 (4.82% in seeds) and Romelle et al.'s 2016 studies (5.00 g/100 g in peels). Level of protein in raw kernel seed was decreased at 4.90 g/100 g after went through blanching process. Protein can easily interact with other food component when the temperature rises; thus caused the changes in solubility, texture and nutritional value (Lee et al. 2019). It is also sensitive to non-enzymatic degradation, resulting in reduction of protein quality and quantity (Bonnazi and Dumouli 2011).

The fat content of raw kernel seed and peel was determined at the level of 7.97 and 1.06 g/100 g respectively. This finding was similar with the study done by Abdalla et al. 2007 and Lebaka et al. 2021 whereby Kuini kernel seed contain 7.1 to 15% crude fat on dry basis. According to Maldonado-Celis et al. 2019, nutritional composition of Kuini samples was dependent on few factors namely maturity stage, location, variety and climatic production region. From our study, the result showed no significant different (p >0.05) between raw and heat treatment samples and it not affected by the pre-treatments due to its heat stable characteristic (Tun Norbrillinda et al. 2022). Mongi and Ngoma 2022 observed a reduction in fat content of the dried mango sample after undergone the solar drying method. The decreasing of fat content was happened due to the oxidation process. Mango seed fat has attracted scientist to explore due to its unique triglycerides profile and fatty acids composition (Jahurul et al. 2015). According to their report, the crude fat from mango seed has similar properties with commercial coco butter. This information exhibits the potential to explore fat profile of this waste as natural food ingredients.

Interestingly, a high content of insoluble dietary fibre was determined from both Kuini kernel seed and peel parts. The dietary fibre has been recognised as an important functional food that possess lots of beneficial effects related to human health like reducing risk of obesity and coronary heart disease (Rymbai et al. 2013). As describe by Jia et al. 2019, dieatry fibre is categorized into soluble dietary fibre and insoluble dietary fibre, depend on capability of this compound to form a solution in water. Soluble dietary fibre was more favoured due to its unique characteristic i.e oil/water holding capability and its potential in binding with various molecules. While insoluble dietary fibre is important for our body due to its significant role in regulating digestion and also relieving constipation.

From our experiment, it shown that kernel seed mainly consists of insoluble dietary fibre (13.52 g/100 g). This value has been found to be higher than Mutua et al. 2017, where the crude fibre in their mango seed kernel from different location were in the range of 2.64 to 3.71%. Research conducted by Lahutiya and Yadav, 2023 also disclosed lower level of mango kernel seed which was 2.4%. Dissimilarity of finding in our sample could be suggested due to various factor such as harvest stage of the fruits, different variety of mango and also location of planting area. Study on the effect of blanching and steaming in level of dietary fibre in kernel seed exhibit higher level of this compound after the heat treatment. Insoluble dietary fibre of kernel seed recorded at 33.59% and 22.71% for blanching and steaming respectively and total dietary fibre increased more than 70% in total dietary fibre after steaming (the final result was 33.59% and 24.99% for blanching and steaming respectively). This trend correlates favorably well with Akter et al. 2010 in their work to investigate effect of blanching and drying temperature in physicochemical properties of persimmon

peel powder. They found that dried blanched peels had higher dietary fibre composition than those unblanched samples. A dramatically increased (16.7%) of total dietary fibre was discovered after the blanching process. They also highlighted that blanching and drying method were common practise to obtain higher dietary fibre in fruits waste. Report by Wolf 2010 stated that glycosidic bond was ruptured by high temperature and this action released oligosaccharides, indirectly may increase the quantity of soluble dietary fibre. Another research by Dong et al. 2019 indicated that various heat treatment, namely steaming, and microwave escalated the dietary fibre of the oat sample significantly at the p <0.05. Result on the dietary fibre of peel sample, recorded level at 18.05, 40.44 and 58.47 g/100 g for soluble dietary fibre, insoluble dietary fibre and total dietary fibre respectively. The total dietary fibre was higher in peel sample compared to kernel seed. This finding was in agreement with work reported by Ajila et al. 2007, where fresh mango peel contain 45 to 78% of total dietary fibre. However,total dietary fibre in our sample was higher than Vergara-Valencia et al. 2007 and Romelle et al. 2016 (58.47 g/100 g compared to 28.1 g/100 g and 15.43 g/100 g). Ajila et al. 2007 also emphasised that mango peel contains higher level of dietary fibre than other fruits like apple waste (23%) and orange waste (36%). For the study on effect of heat treatment in level of dietary fibre, result for the peel samples showed contrast finding from previous finding in kernel seed. Our data presented that blanching and steaming process caused a reduction in the level of all types of dietary fibre. Soluble dietary fibre lower 10% after blanching (16.08 g/100 g) and only accelerated 6% after the steaming process. Both the heat treatment lessened up to 20% in total dietary fibre (47.91 and 42.89 g/100 g for steaming and blanching respectively and the decreased observed up to 30% in insoluble dietary fibre (28.16 and 26.80 g/100 g for steaming and blanching respectively). Dietary fibre which is cell wall polysaccharides, will easily dissolve with the presence of heat. The increasing temperature ruptured the weak bonds between the polysaccharides and resulting the solubilisation and loss of the of the compounds. This finding concurs well with Galib et al. 2022 and support previous finding in report by Wennberg and Nyaman 2004. In study done by Wennberg and Nyaman 2004 it was revealed that proportion of soluble fibre was reduced at higher temperature in their cabbage sample. In comparison made by Galbi et al. 2022, dry oven method exhibits lower mango fibre concentration significantly (p <0.5) compared to other dry method. The author discussed that discoloration, food shrinkage and losses of compounds might happen when high temperature applied in drying technique of fibre. Therefore, choosing the suitable processing condition and cultivar is important to control the dietary fibre of product. This fact was supported by Ozyurt and Ötles 2016 mentioned that different processing technology could modify fibre composition and microstructure, which could affect the nutritional and functional properties of dietary fibre.

Conclusion

Our work has led us to conclude that blanching and steaming process could reduce significantly (p <0.05) level of anti-nutrients factor namely phytic acid and tannins in Kuini (*Mangifera odorata*) by-products. Based on discussion in the previous section, the reduction was happened up to 80% for both pretreatments. Blanching and steaming were also altered sugar profile in kernel seed and peel. Major loss of sucrose was reported in heated samples, but slight increase of fructose and glucose was detected. Increasing of total dietary fibre was also recorded in steaming samples, suggesting that this process may efficiently increase the total dietary fibre of Kuini waste. Pre heat treatments offer a promising technique to increase the dietary fibre of kuini waste. Therefore, it could help to produce better quality dietary supplement for the food industry. Given all these points, Kuini waste can provide as a potential ingredient for value-added product development. Future study will focus on the metabolite's properties of Kuini wastes with more evidence and information to support the utilisation of these agro wastes in food application.

Table 2. The nutritional composition in Kuini *(Mangifera odorata)* kernel seed and peel

	Kernel seed (g/100 g)			Peel (g/100 g)		
	Raw	Blanch	Steam	Raw	Blanch	Steam
Protein	5.17 ± 0.02^{a}	4.90 ± 0.04^{b}	5.21 ± 0.04^{a}	4.07 ± 0.02^{a}	4.20 0.10^{a}	4.23 ± 0.00^{a}
Fat	7.97 ± 0.35^{a}	6.63 ± 0.55^{b}	7.28 ± 0.33^{a}	1.06 ± 0.30^{a}	1.18 ± 0.09^{a}	1.45 ± 0.0^{a}
Ash	2.89 ± 0.11^{b}	3.14 ± 0.20^{a}	2.98 ± 0.13^{b}	5.87 ± 0.18^{a}	4.65 ± 0.01^{b}	4.65 ± 0.01^{b}
Moisture	3.77 ± 0.37^{b}	5.78 ± 0.09^{a}	6.09 ± 0.09^{a}	7.39 ± 0.10^{b}	9.70 ± 0.45^{a}	8.02 ± 0.03^{b}
Carbohydrate	83.97 ± 0.06^{a}	85.33 ± 0.50^{a}	84.47 ± 0.40^{a}	89.00 ± 0.41^{a}	89.670.06^{a}	89.67 ± 0.06^{a}
Energy value	428.14 ± 2.84^{a}	420.29 ± 2.83^{a}	424.32 ± 0.71^{a}	381.71 ± 0.71^{a}	389.791.42^{a}	388.67 ± 0.7^{a}
Soluble dietary fibre	nd	nd	<3	18.03 ± 1.51^{a}	16.08 ± 2.01^{a}	19.25 ± 1.28^{a}
Insoluble dietary fibre	13.52 ± 1.33^{c}	33.59 ± 1.23^{a}	22.71 ± 1.47^{b}	40.44 ± 0.86^{a}	26.80 ± 0.15^{b}	28.16 ± 0.61^{b}
Total dietary fibre	13.52 ± 1.33^{c}	33.59 ± 1.23^{a}	24.99 ± 2.02^{b}	58.47 ± 2.37^{a}	42.89 ± 2.16^{b}	47.41 ± 1.89^{b}

nd : Not detected

Data was expressed as mean± standard deviation (n = 3)

Means within sample with different letter are significantly different at (p <0.05)

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References

Abdalla, A. E. M., Darwish, S. M., Ayad, E. H. E., & El-Hamahmy, R. M. (2007). Egyptian mango by-product 1. Compositional quality of mango seed kernel. *Food Chemistry.* 103(4), 1134–1140

Abud, A. K. S. & Narain, N. (2012). Characterization and alternatives to use acerola residue. III International Symposium on Medicinal and Nutraceutical Plants and III Conference of National Institute of Science and III Conference of National Institute of Science and 1198, 145–154

Addo, P. W., Agbenorhevi, J. K. & Adu-Poku, D. (2018). Antinutrient contents of watermelon seeds. *MOJ Food Processing and Technology*. 6(2): 237–239.

Adnan, H., Ali, M. S. M., Hassan, H., Manan, M. A., Ghazali, M. N., & Ramli, N. S. N. (2018). Bioassay-guided of fresh and fermented kuini (Mangifera odorata) extracts against bacterial activity. *International Journal of Agriculture, Forestry and Plantation.7*, 27–32

Ajila, C. M., Bhat, S. G. & Rao, U. J. S. P. (2007). Valuable components of raw and ripe peels from two Indian mango varieties. *Food Chemistry*. 102(4), 1006–1011

Akter, M. S., Ahmed, M., & Eun, J.-B. (2010). Effect of blanching and drying temperatures on the physicochemical characteristics, dietary fiber composition and antioxidant-related parameters of dried persimmons peel powder. *International Journal of Food Sciences and Nutrition*, *61*(7), 702–712.

Azeez, S. O., Lasekan, O., Jinap, S. & Sulaiman, R. (2015). Physico-chemical properties, amino acid profile and antinutritional factors in seeds of three Malaysian grown jackfruitcultivars. *Journal of Food, Agriculture & Environment.* 13(2), 58–62

Bala, S. M., Ameh, D. A., Omage, J. J., Bugaje, S. M., Makeri, M. U., Dikko, H. & Usman,

M. S. (2013). Influence of processing method on the nutrients and antinutrients contentof kernels of three Nigerian local mango (*Mangifera indica* L.*)* varieties. *Journal of Applied Agricultural Research*. 5(1), 203–213

Barreto, J. C., Trevisan, M. T. S., Hull, W. E., Erben, G., De Brito, E. S., Pfundstein, B., Würtele, G., Spiegelhalder, B. & Owen, R. W. (2008). Characterization and quantitation of polyphenolic compounds in bark, kernel, leaves, and peel of mango (Mangifera indica L.). *Journal of Agricultural and Food Chemistry.* 56(14), 5599–5610

Begum, R., Aziz, M. G., Uddin, M. B. & Yusof, Y. A. (2014). Characterization of Jackfruit (Artocarpus Heterophyllus) Waste Pectin as Influenced by Various Extraction Conditions. *Agriculture and Agricultural Science Procedia*. *2*, 244–251.

Bello-Pérez, L. A., García-Suárez, F. J. & Agama-Acevedo, E. (2007). Mangocarbohydrates. *Food*. 1(1), 36–40.

Bethapudi, S. S., Hamid, K. N., Khatri, B., & Sharma, K. (2023). Effect of Various Pretreatments on Anti-nutrients of Mango Seed Kernel and its Utilization in Preparation of Pasta. *J Food Chem Nanotechnol*, *9*, S398–S407.

Bonazzi, C. & Dumoulin, E. (2011). Quality Changes in Food Materials as Influenced byDrying Processes. *Modern Drying Technology*. 3,1–20

Bora, P. (2014). Anti-nutritional factors in foods and their effects. *Journal of Academia and Industrial Research*, *3*(6), 285–290.

Campbell, R.J. (2007). The Potential of New Mangifera Species in Florida. *Proc. Fla. State Hort. Soc*. 120,11–12

Cao, X., Bi, X., Huang, W., Wu, J., Hu, X. & Liao, X. (2012). Changes of quality of high hydrostatic pressure processed cloudy and clear strawberry juices during storage. *Innovative Food Science & Emerging Technologies*. 16, 181–190.

Dong, J.-L., Yang, M., Shen, R.-L., Zhai, Y.-F., Yu, X. & Wang, Z. (2019). Effects of thermal processing on the structural and functional properties of soluble dietary fiberfrom whole grain oats. *Food Science and Technology International.* 25(4), 282–294

Embaby, H. E.-S. (2010). Effect of heat treatments on certain antinutrients and in vitro protein digestibility of peanut and sesame seeds. *Food Science and Technology Research.* 17(1), 31–38

Fowomola, M. A. (2010). Some nutrients and antinutrients contents of mango (Magnifera indica) seed. *African Journal of Food Science*, *4*(8), 472–476.

Jahurul, M. H. A., Zaidul, I. S. M., Ghafoor, K., Al-Juhaimi, F. Y., Nyam, K.-L., Norulaini,

N. A. N., Sahena, F. & Omar, A. K. M. (2015). Mango (Mangifera indica L.) by- products and their valuable components: A review. *Food Chemistry*. 183, 173–180.

Jia, M., Chen, J., Liu, X., Xie, M., Nie, S., Chen, Y., Xie, J., & Yu, Q. (2019). Structural characteristics and functional properties of soluble dietary fiber from defatted rice bran obtained through Trichoderma viride fermentation. *Food Hydrocolloids*, *94*, 468–474.

Lasano, N. F., Hamid, A. H., Karim, R., Pak Dek, M. S., Shukri, R. & Ramli, N. S. (2019). Nutritional composition, anti-diabetic properties and identification of active compounds using UHPLC-ESI-orbitrap-MS/MS in Mangifera odorata L. peel and seed kernel. *Molecules*. 24(2), 320

Latta, M. & Eskin, M. (1980). A simple and rapid colorimetric method for phytate determination. *Journal of Agricultural and Food Chemistry*. 28(6), 1313–1315

Lahutiya, V., & Yadav, S. P. S. (2023). Systematic analysis of nutritional contents in mango seed kernel (msk) after application of different processing techniques. *Malaysian Journal of Halal Research (MJHR)*, *6*(1), 9–12.

Kayode, R. M. O., Sani, A., Apata, D. F., Joseph, J. K., Olorunsanya, O. A., Annongu, A. A., & Obalowu, M. A. (2013). Physico-chemical and anti-nutritional characterization of the kernels of some mango (Mangifera indica) cultivars grown in Western parts of Nigeria. *Food Science and Quality Management*, *22*, 1–8.

Khoo, H. E., Ismail, A., Mohd-Esa, N., & Idris, S. (2008). Carotenoid content of underutilizedtropical fruits. *Plant Foods for Human Nutrition*, *63*, 170–175.

Kozai, N., Keizer, M., dela Cruz, F., Sajise, P. E., & Idris, S. (2004). The marketing channeloftwo underutilized fruit species of Malaysia: Pulasan [Nephelium ramboutan- ake (Labill.) Leech] and Kuini (Mangifera odorata Griff.).

Kumar, V., Sinha, A. K., Makkar, H. P. S. & Becker, K. (2010). Dietary roles of phytateand phytase in human nutrition: A review. *Food Chemistry*. 120(4), 945–959.

Larrosa, A. P. Q. & Otero, D. M. (2021). Flour made from fruit by-products: Characteristics, processing conditions, and applications. *Journal of Food Processing and Preservation.*45(5),1–22

Lebaka, V. R., Wee, Y.-J., Ye, W. & Korivi, M. (2021). Nutritional composition and bioactive compounds in three different parts of mango fruit. *International Journal of Environmental Research and Public Health*. 18(2), 741. doi: 10.3390/ijerph18020741.

Lee, H.-J., Kim, J.-H., Ji, D.-S. & Lee, C.-H. (2019). Effects of Heating Time and Temperature on Functional Properties of Proteins of Yellow Mealworm Larvae (Tenebrio molitor L.). *Food Science Animal Resource.* 39(2), 296–308

Lin, C. S. K., Pfaltzgraff, L. A., Herrero-Davila, L., Mubofu, E. B., Abderrahim, S., Clark, J. H., Koutinas, A. A., Kopsahelis, N., Stamatelatou, K. & Dickson, F. (2013). Food waste as a valuable resource for the production of chemicals, materials and fuels.

Current situation and global perspective. *Energy Environment Science*. 6,426–464

Liu, F., Liao, X., & Wang, Y. (2016). Effects of High-Pressure Processing with or without Blanching on the Antioxidant and Physicochemical Properties of Mango Pulp. *Food Bioprocess Technol*ogy. 9,1306–1316

Maldonado-Celis, M. E., Yahia, E. M., Bedoya, R., Landázuri, P., Loango, N., Aguillón, J., Restrepo, B. & Guerrero Ospina, J. C. (2019). Chemical composition of mango (Mangifera indica L.) fruit: Nutritional and phytochemical compounds. *Frontiers in Plant Science*. 10,1073. doi: 10.3389/fpls.2019.01073

Mirfat, A. H. S., Razali, M., Salma, I. & Kalsum, H. Z. (2015). Antioxidant and nutritional values of selected under-utilised mangifera species in Malaysia. *Indian Journal of PlantGenetic Resources*. 28(1),72–79.

Mongi, R. J. & Ngoma, S. J. (2022). Effect of Solar Drying Methods on Proximate Composition, Sugar Profile and Organic Acids of Mango Varieties in Tanzania. *Applied Food Research*. 2(2),100140.

Mutua, J. K., Imathiu, S., & Owino, W. (2017). Evaluation of the proximate composition, antioxidant potential, and antimicrobial activity of mango seed kernel extracts. *Food Science & Nutrition*, *5*(2), 349–357.

Nwafor, M. N., Anosike, A. C., Onodugo, C. A., Ya'u, M., & Babandi, A. (2022). Antioxidant, phytochemical composition and proximate analysis of Mangifera hadenseeds. *International Journal of Scholarly Research in Chemistry and Pharmacy*. 1(1),011–023

Ozyurt, V. H. and Ötles, S. (2016). Effect of food processing on the physicochemical properties of dietary fibre. *Acta Scientiarum Polonorum Technologia Alimentaria.*15(3),233–245

Rasha Mohamed, K., Abou-Arab, E. A., Gibriel, A. Y., Rasmy, N. M. H. & Abu-Salem, F.

M. (2011). Effect of legume processing treatments individually or in combination ontheir phytic acid content. *Africa Journal Food Science Technology*. *2*,36–46.

Romelle, F. D., Rani, A. & Manohar, R. S. (2016). Chemical composition of some selectedfruit peels. *European Journal of Food Science and Technology*. 4(4),12–21

Rymbai, H., Srivastav, M., Sharma, R. R., Patel, C. R., & Singh, A. K. (2013). Bio-active compounds in mango (Mangifera indica L.) and their roles in human health and plant defence–a review. *The Journal of Horticultural Science and Biotechnology*. 88(4), 369–379.

Tun Norbrillinda, M., Hasri, H., Syahida, M., Norra, I. and Hadijah, H. (2022). Effect of pretreatment on nutrient content and antioxidant properties of Mangifera odorata L. peeland seed kernel powder. *Food Research*. 6(2), 32–42.

Vergara-Valencia, N., Granados-Pérez, E., Agama-Acevedo, E., Tovar, J., Ruales, J. & Bello-Pérez, L. A. (2007). Fibre concentrate from mango fruit: Characterization, associated antioxidant capacity and application as a bakery product ingredient. *LWT-Food Science and Technology.* 40(4),722–729.

Wennberg, M. & Nyman, M. (2004). On the possibility of using high pressure treatment to modify physico-chemical properties of dietary fibre in white cabbage (Brassica oleraceavar. capitata). *Innovative Food Science & Emerging Technologies*. *5*(2),171–177.

Wilson, A. M., Work, T. M., Bushway, A. A. and Bushway, R. J. (1981). HPLC determination of fructose, glucose, and sucrose in potatoes. *Journal of Food Science.* 46(1), 300–301.

Wolf, B. (2010). Polysaccharide functionality through extrusion processing. *Current Opinionin Colloid & Interface Science.* 15(1–2), 50–54.