

NUTRITIONAL COMPOSITION AND ANTIOXIDANT PROPERTIES OF GOLDEN LILY AND CHOKANAN MANGO (*Mangifera indica*) PEELS

JING WEN KOK¹ AND TENGKU ROZAINA TENGKU MOHAMAD^{1,2*}

¹Faculty of Fisheries and Food Science, Universiti Malaysia Terengganu, 21030 Kuala Nerus, Terengganu, Malaysia.

²Institute of Tropical Biodiversity and Sustainable Development, Universiti Malaysia Terengganu, 21030 Kuala Nerus, Terengganu, Malaysia

*Corresponding author: trozaina@umt.edu.my

Abstract: Mango is one of the popular fruits in Malaysia and has been used in the jam, puree and drinks production. Production of food products using mango pulp has generated by-products such as peel and kernel. Disposal of these by-products will cause environmental pollution if not properly treated. Mango peel contains high nutritional composition and antioxidant properties and can be utilised as food ingredients. The objectives of this study are to determine the nutritional composition and antioxidant properties of the peels of two selected mango varieties, namely Golden Lily and Chokanan. Analysis of proximate composition, minerals, total phenolic compounds, carotenoids, and antioxidant activity (DPPH and ABTS) were carried out in this study. Results of the proximate analysis showed that the peels of both mango varieties were a good source of fibre, which were 14.45% for Golden Lily and 14.89% for Chokanan. The crude fat, crude protein, and total carbohydrate of Chokanan peel (2.62%, 4.67% and 57.74%, respectively) were higher than the Golden Lily peel (1.13%, 2.90% and 53.16%, respectively). Contrastingly, the moisture content of the Golden Lily peel (24.67%) was higher than the Chokanan peel (16.61%). Potassium was the main mineral found in both Golden Lily and Chokanan mango peels (8802.10 mg/kg and 8443.60 mg/kg, respectively). The total phenolic compounds in the peels of both mango varieties were not significantly different. The Chokanan peel contained a higher carotenoids content (35.26 µg/g) than the Golden Lily peel (15.03 µg/g). The ABTS value for Chokanan peel was higher (1406.00 µmol TE/g) than Golden Lily peel (1314.00 µmol TE/g). This study showed that Chokanan and Golden Lily mango peels have the potential to be utilised as ingredient in food products due to their high fibre content.

Keywords: Mango peel, proximate composition, fibre, minerals, antioxidants

Introduction

Mango (*Mangifera indica* L.), which belongs to family Anacardiaceae, is one of the most cultivated fruit in the world (Ashoush & Gadallah, 2011). According to FAO (2014), the production of mango ranked fifth after bananas, citrus, grapes, and apples in the global market. Until 2016, there was about 5,816.4 hectare of mango cultivation in Malaysia with 17,429.7 metric tonnes of products worth more than RM57 million (Department of Agriculture, 2016). The edible tissue (flesh), peel and kernel of mango represent 60-75%, 11-18% and 14-22% of the mango fruit, respectively (Mitra *et al.*, 2013).

Mango has been processed into many food products such as jam, candy, juice, puree, pickles, and others. Production of food products from mango generates by-products such as peel and kernel. The waste generated from the mango processing industry is increasing over the years and this solid waste materials cause serious environmental problems (Gupta *et al.*, 2015). According to Dhillon *et al.* (2013), the waste of the fruit processing industry could facilitate the growth of undesirable bacteria, mice and pest that might result to the spread of plague if the waste is not properly disposed.

According to Baddi (2015), high content of polyphenols and dietary fibre are the special characteristics of mango peel which is found to

be higher than apple peel, orange peel, wheat bran and oat bran. Another study by Kumar *et al.* (2012) showed that mango peel is a rich source of dietary fibre, starch, pectin, minerals, and phytochemicals. Furthermore, Serna-Cock *et al.* (2016) also reported that mango peels contain a noticeable amount of dietary fibre and antioxidants. According to Kim *et al.* (2010), mango peels contain antioxidant compounds and phenolic compound along with anticancer effect. Other than that, mango peels also contained a considerable amount of minerals such as calcium, zinc, iron and manganese (Romelle *et al.*, 2016).

Previous studies (Berardini *et al.* 2005; Ajila & Rao, 2013) showed that the fibre from the mango peels can be used as a food ingredient. Aslam *et al.* (2014) reported that the mango peels are used as a common ingredient for flavour and colourant in functional foods. In Aziz *et al.* (2012) study, they found that the flour processed from mango peel contained superior qualities of total phenolic, carotenoids, anthocyanins, flavonoids, vitamin C, and antioxidant activities than the flour of mango pulp.

Chokanan is one of the popular mango varieties that is commonly consumed in Malaysia (Aziz *et al.*, 2012). According to Aziz *et al.* (2012), Chokanan variety is recommended for commercial planting, direct consumption and food products such as jams and candies due to its pleasant flavour and unique taste. Meanwhile, Golden Lily or also known as Namdokmai is the main export variety of Thailand (Watanawan *et al.*, 2014). Kim *et al.* (2007) stated that the popularity of mangoes depends on their bright colour, characteristic, taste, and nutritional composition.

Information on the bioactive compounds derived from fruit wastes has increased the application of the fruit wastes as ingredients in the food products. Previous studies on Chokanan were concentrated on Chokanan pulp and peel flour (Aziz *et al.*, 2012) and Chokanan juice (Santhirasegaram *et al.*, 2013; 2015). However, to our knowledge, information on the nutritional composition of Golden Lily peel and

antioxidant properties of Chokanan and Golden Lily peels are still lacking. Taking this into account, thus the objectives of the present study are to determine the nutritional composition and antioxidant properties of Chokanan and Golden Lily mango peels. Data gained from this study will be useful in the development of food products incorporated with mango peels from these two mango varieties.

Materials and Methods

Sample Preparation

Fifteen (15) kg of Chokanan and Golden Lily mango varieties were purchased from Kuala Bikam, Perak. The maturity index of the mango used was index 5 according to FAMA (2006) maturity index. The mango were washed and allowed to dry at room temperature (28°C). The peels were removed using a sharp knife. The fresh peels were washed with 30% chlorinated water to ensure the mango peels were free from pests. The peels were dried at 50°C in an oven (Memmert, Malaysia) for 48 hours and then grounded into a powder. The mango peel powders were packed in a sealed plastic bag and stored at -20° C until further analysis.

Proximate Analysis

Analysis of proximate composition (moisture, crude protein, crude fat, crude fibre and ash) of Chokanan and Golden Lily mango peels was carried out according to AOAC (2005) methods. Carbohydrate content of the sample was calculated using the following equation:

$$\text{Carbohydrate (\%)} = 100\% - [\text{moisture content (\%)} + \text{ash (\%)} + \text{fat (\%)} + \text{protein (\%)} + \text{crude fibre (\%)}]$$

Mineral Analysis

A 2 g of mango peel powder was weighed into a crucible and heated in a muffle furnace at 500°C for 5-7 hours. The ash was cooled and then mixed with 2 ml of concentrated hydrochloride acid (HCl; Merck, Germany). Afterwards, 10 ml

of 20% nitric acid (HNO₃; Merck, Germany) was added into the mixture. The crucible was heated at 60°C in a water bath for 1 hour. The mixture was transferred into a 100 ml volumetric flask and distilled water was added to the mixture to make up the volume. The final mixture was filtered using Whatman No. 42 filter paper. Determination of minerals in the sample was carried out using Inductively Coupled Plasma-Optical Emission Spectrometry (ICP-OES) (Optima 8300; Perkin Elmer, USA) according to Akpinar-Bayazit *et al.* (2010) method.

Sample Extraction for Antioxidant Analysis

The sample extraction for antioxidant was determined according to the modified Rusak *et al.* (2008) method. 5 g of mango peel powder was mixed with 50 ml of 95% ethanol (Emsure, Germany). The mixture was homogenised using a homogeniser (KIA, Malaysia) for 15 min. The mixture was then left for 1 hour in the dark followed by centrifugation (Hettich Zentrifugen, Malaysia) at 3000 rpm. The extract was filtered using a Whatman No. 1 filter paper and evaporated at 35°C using a rotary evaporator (Buchi, Malaysia).

Analysis of Total Phenolic Content

The total phenolic content (TPC) of the sample extract was determined according to a modified Du *et al.* (2009) and Liu *et al.* (2017) methods. A 0.025 ml of the extract, 2.0 ml of Folin-Ciocalteu reagent (diluted 10 times with distilled water in advance) and 5.975 ml of distilled water were mixed in a test tube. The mixture was incubated for 5 min at room temperature. After that, 2 ml of 20% sodium carbonate (Bendosen, Malaysia) was added to the mixture and the mixture was left to react in the dark for 30 min at room temperature. The absorbance of the mixture was read at 765 nm using a UV/Vis spectrophotometer (Shimadzu, Japan). Gallic acid was used as a standard for the calibration curve purposes.

Analysis of ABTS⁺ Scavenging Activity

Analysis of ABTS⁺ scavenging activity of the sample extract was carried out according to Re *et al.* (1999) method with slight modification. 3 ml of 7 mM 2, 2'-azino-bis-3-ethylbenzothiazoline-6-sulfonic acid (ABTS; Sigma-Aldrich, USA) solution was mixed with 3 ml of 2.45 mM potassium persulphate (Emsure, Germany). The mixture was kept in the dark for 16 hours at room temperature. The mixture was mixed with 80% methanol (Merck, Germany) to attain absorbance of 0.700 ± 0.020 at 734 nm. The ABTS working solution (3 mL) was mixed with 30 µl of sample extract and the absorbance was measured at 734 nm using a UV/Vis spectrophotometer (Shimadzu, Japan). 80% methanol was used as a blank and calibration standard curve was prepared using Trolox (Sigma-Aldrich, USA) solution.

Analysis of DPPH Scavenging Activity

Analysis of DPPH scavenging activity of the sample extract was conducted according to Mon *et al.* (2011) method. The diluted working solutions of the extracts were prepared in methanol, while BHT and α-tocopherol (Sigma-Aldrich, USA) were used as the standards. A 1 ml of the sample extract was mixed with 2 ml of 0.1 mM of 2, 2-diphenyl-1-picrylhydrazyl (DPPH; Sigma Aldrich, Germany) solution in methanol. The mixture was kept in the dark at room temperature for 30 min and then measured at 518 nm using a UV/Vis spectrophotometer (Shimadzu, Japan). The mixture of 1 mL of methanol and 2 ml of 0.1 mM DPPH solution was used as blank. The absorbance was recorded and the percentage of inhibition (%) was calculated using the following equation:

DPPH free radical scavenging activity (%)

$$= \frac{A_c - A_s}{A_c} \times 100$$

Where, A_c = absorbance of control

A_s = absorbance of the sample

Analysis of Carotenoids

Analysis of carotenoids of mango peel powder was conducted according to Sogi *et al.* (2013) method. 1 g of mango peel powder was extracted three times with 10, 5 and 5 ml of hexane:acetone (7:3) solution. The extracts were combined in a separating funnel and washed twice with sodium sulphate solution (5 g/100 mL). The non-aqueous phase was collected, and hexane was added to the collected solution to make up the volume to 25 ml. The mixture absorbance was read at 450 nm using a UV/Vis spectrophotometer (Shimadzu, Japan). Total carotenoids were measured as β -carotene equivalent using a pure β -carotene standard curve.

Statistical Analysis

All analyses were carried out in triplicate and data were reported as mean \pm standard deviation (SD). Statistical analyses of data were performed using a Tukey test in the IBM SPSS version 20 software for significant differences between samples at $p < 0.05$.

Results and Discussion

Proximate Composition of Mango Peels

The moisture, ash, crude fat, crude fibre, crude protein, and total carbohydrate contents of Golden Lily and Chokanan mango peels are shown in Table 1. The mango peel powder of both mango varieties was significantly different ($p < 0.05$) from each other in term of moisture, crude fat, crude protein and total carbohydrate contents.

Table 1: Proximate composition of Golden Lily and Chokanan mango peels

Proximate Analysis	Golden Lily (%)	Chokanan (%)
Moisture	24.67 \pm 0.19 ^a	16.61 \pm 1.13 ^b
Ash	3.69 \pm 0.20 ^a	3.49 \pm 0.24 ^a
Crude fat	1.13 \pm 0.06 ^b	2.62 \pm 0.02 ^a
Crude protein	2.90 \pm 0.17 ^b	4.67 \pm 0.17 ^a
Crude fibre	14.45 \pm 0.16 ^a	14.89 \pm 1.13 ^a
Total carbohydrate	53.16 \pm 0.31 ^b	57.74 \pm 2.16 ^a

All values are reported as dry weight basis; mean \pm standard deviation from three replicates ($n = 3$). Values with a different superscript letter in the same row are significantly different at $p < 0.05$.

The moisture content of the Golden Lily mango peel was significantly higher than Chokanan mango peel ($p < 0.05$). The moisture content of Chokanan mango peel in the present study was higher than Chokanan mango peel flour (6.20%) in Aziz *et al.* (2012). The difference in the moisture contents of Chokanan mango peel in the present study and Aziz *et al.* (2012) was due to method differences in the determination of moisture content. According to Seremet *et al.* (2016), different drying methods would influence moisture content due to differences in technological efficiency for every method.

The ash contents of Chokanan mango peel was not significantly different from the Golden Lily mango peel. The ash content of Chokanan mango peel in the present study was comparable to Aziz *et al.* (2012) on Chokanan mango peel flour (3.20%), Romelle *et al.* (2016) on Alphonso mango peel (3.24%) and Madalageri *et al.* (2017) on Alphonso and Tatapuri mango peels (3.41% and 3.32%, respectively). On the other hand, the ash content of Golden Lily mango peel in the present study (3.69%) was similar to the Kesar mango peel (3.75%; Madalageri *et al.*, 2017).

The crude fat content of Chokanan mango peel was significantly higher than the Golden Lily ($p < 0.05$). According to Imran *et al.* (2013), differences in species variation, soil type, environment and climate condition may contribute to the compositional variations. The crude fat content of Chokanan mango peel in the present study was similar to the Badami variety from India in Ajila *et al.* (2007; 2.66%) study. Meanwhile, the crude protein content of Chokanan peel was also significantly higher than the Golden Lily peel ($p < 0.05$). This finding was not in accordance with Aziz *et al.* (2012) study on the protein content in the Chokanan peel flour (1.80%). The differences in the crude protein content between the previous and present studies probably due to the different source of the Chokanan mango. Palafox-Carlos *et al.* (2011) stated that soil, climate, and environmental condition will affect the mango composition. Furthermore, climatic conditions, agronomic practices and varietal are among the factors that will affect the phytonutrients of mango by-product or waste (Tavarini *et al.*, 2007; Manzoor *et al.*, 2012). The crude protein content of the Chokanan mango peel in the present study was similar to the Alphonso mango peel from India (5.00%; Romelle *et al.*, 2016). Meanwhile, the crude protein content of the Golden Lily mango peel was higher than the Papparanda (1.93%), Julie (2.13%) and Peter (2.48%) mango peels in Onuh *et al.* (2017).

The crude fibre content of Golden Lily mango peel was not significantly different with Chokanan variety. According to Aziz *et al.* (2012), the crude fibre content of Chokanan mango peel flour was 14.50% which was similar to the present study. The crude fibre content of mango peels of both Golden Lily and Chokanan varieties were almost similar to Papparanda, Julie and Peter varieties (15.40%, 13.79% and 15.45%, respectively) (Onuh *et al.*, 2017) and Alphonso mango peel (15.43%; Romelle *et al.*, 2016).

The total carbohydrate content of the peel of Golden Lily was significantly lower than Chokanan variety ($p < 0.05$). The carbohydrate

content in the Chokanan mango peel in the present study was lower than the Chokanan (71.00%; Aziz *et al.* 2012) and Alphonso (63.80%; Romelle *et al.* 2016) mango peels. The lower value of the total carbohydrate obtained in the present study might be due to the high value of the fibre content. This is because fibre is also one of the categories of carbohydrate (Slavin & Carlson, 2014).

Mineral Composition of Mango Peels

Minerals composition in the Golden Lily and Chokanan mango peels in the present study are shown in Table 2. The minerals composition of the Golden Lily mango peel was significantly different with Chokanan mango peel except for potassium. The results showed that the potassium contents in the present study were higher than the Chaunsa (187.80 mg/kg), Desi (187.6 mg/kg), Anwar Rasool (177.30 mg/kg), Dusahri (171.60 mg/kg) and Langra (162.10 mg/kg) mango varieties in Imran *et al.* (2013) study. The huge difference may be explained by the ability of the plant to take up the metals and the deposition of metals in the environment as reported by Sharma *et al.* (2006) and Sharma *et al.* (2009).

Table 2: Minerals composition of Golden Lily and Chokanan mango peels

Minerals	Golden Lily (mg/kg)	Chokanan (mg/kg)
Potassium	8802.10 ± 95.90 ^a	8443.60 ± 364.90 ^a
Calcium	1712.40 ± 6.12 ^a	1474.30 ± 4.45 ^b
Phosphorus	1264.00 ± 3.53 ^b	2042.00 ± 21.80 ^a
Magnesium	806.57 ± 7.00 ^b	978.07 ± 3.10 ^a
Sodium	159.08 ± 0.13 ^a	148.47 ± 3.02 ^b
Manganese	56.77 ± 0.19 ^a	54.04 ± 0.62 ^b
Zinc	27.55 ± 0.11 ^b	50.94 ± 0.85 ^a
Iron	16.84 ± 0.10 ^b	21.19 ± 0.28 ^a
Copper	15.85 ± 0.17 ^a	7.43 ± 0.01 ^b

All values are reported as mean ± standard deviation from three replicates (n = 3). Values with a different superscript letter in the same row are significantly different at $p < 0.05$

The calcium content of the Golden Lily mango peel was significantly higher than the Chokanan mango peel ($p < 0.05$). The finding in the present study was not in the agreement to Imran *et al.* (2013; 750.80 - 874.60 mg/kg) and Madalageri *et al.* (2017; 177.60 - 185.70 mg/kg). The differences in the calcium contents in the present and both previous studies probably due to the differences in the instruments used to analyse the calcium content. ICP instrument was used in the present study, while Atomic Absorption Spectrophotometry (AAS) was used in both previous studies.

According to Rose *et al.* (2001), ICP-related techniques produce better results than AAS. Furthermore, the variation in the minerals content may be due to the mango varieties, soil composition and climate condition as suggested by Shad (2001). Contrastingly, the phosphorus content of the Golden Lily mango peel was significantly lower than Chokanan mango peel. The findings in the present study were lower than Madalageri *et al.* (2017) study on Alphonso (209.50 mg/kg), Kesar (190.60 mg/kg) and Totapuri (194.40 mg/kg) mango peels.

The magnesium contents of Golden Lily and Chokanan mango peels were 806.57 mg/kg and 978.07 mg/kg, respectively. The magnesium content in Paparanda, Julie and Peter mango peels were 948.30, 1091.50 and 1122.00 mg/kg, respectively (Onuh *et al.*: 2017). Both the Golden Lily and Chokanan mango peels in the present study have lower sodium content compared to Imran *et al.* (2013) study on Chaunsa (180.70 mg/kg), Anwar Ratool (177.70 mg/kg), Langra (172.30 mg/kg), Dushari (165.00 mg/kg) and Desi (170.20 mg/kg). This could be due to the different instrument used to analyse the mineral content where Flame Photometer-410 technique was used in the Imran *et al.* (2013) on analysis of sodium content. According to Dipietro *et al.*

(1988), the lower result of sodium and potassium will be obtained if ICP-AES was used to analyse both minerals compared to flame photometry method.

The manganese content of the peels of Golden Lily was significantly higher than Chokanan variety ($p < 0.05$). The manganese contents in the mango peels in the present study were comparable to Ngowe (48.50 mg/kg; Njiru, 2014) and Alphonso (47.70 mg/kg; Romelle *et al.*, 2016) mango peels. Meanwhile, the zinc content of the Golden Lily mango peel was significantly lower than Chokanan mango peels. A lower zinc content was reported in the Alphonso (6.60 mg/kg; Romelle *et al.*, 2016) and Kesar (2.90 mg/kg; Madalageri *et al.*, 2017) mango peels. The differences in the zinc contents in mango peels are probably due to the differences in the growing area of the mango trees.

The iron content of both Golden Lily and Chokanan mango peels were relatively low compared to the mango peels in Romelle *et al.* (2016; 127.90 mg/kg), Onuh *et al.* (2017; 104.80 – 135.00 mg/kg) and Imran *et al.* (2013; 53.46 – 95.96 mg/kg) studies. According to Romelle *et al.* (2016), differences in the mineral content might be due to the differences between the mango cultivars. Meanwhile, the copper content in the Golden Lily mango peels was significantly higher (15.85 mg/kg) than the Chokanan variety (7.43 mg/kg; $p < 0.05$). The copper concentration of Golden Lily mango peel in the present study was similar to the mango peel of Apple variety (15.00 mg/kg; Njiru, 2014). On the other hand, the copper content of Chokanan peel was similar to Van dyke mango peel (7.00 mg/kg; Njiru 2014).

Antioxidant Properties

The antioxidants properties (total phenolic, carotenoid, ABTS and DPPH scavenging activities) of Golden Lily and Chokanan mango peels are shown in Table 3. Imran *et al.* (2013)

reported that the total phenolic content of Chaunsa, Anwar Ratoool, Langra, Dusahri and Desi mango peels were 8.76, 8.10, 7.95, 7.72 and 7.52 mg GAE/g, respectively. The findings of the total phenolic content of Imran *et al.* (2013) study were higher than the Golden Lily and Chokanan mango peels in the present study. This probably due to the factors of maturity stage, agronomic practices and cultivar types that will greatly affect the total phenolic content in mango peels as suggested by Onuh *et al.* (2017).

The total carotenoid content of Golden Lily mango peel was significantly different from Chokanan mango peel ($p < 0.05$). This is probably due to the differences in the colour of the mango peels. According to Sogi *et al.* (2013), the colour of the peels during ripening is one of the factors that affect the carotenoid content in the mango peels.

Table 3: Antioxidant properties of Golden Lily and Chokanan mango peels

Parameter	Golden Lily	Chokanan
TPC (mg GAE/g)	3.54 ± 0.12 ^a	3.49 ± 0.04 ^a
Carotenoid (µg/g)	15.03 ± 0.13 ^b	35.26 ± 1.47 ^a
ABTS (µmol TE/g)	1314.00 ± 6.00 ^b	1406.00 ± 4.70 ^a
DPPH (%)	73.51 ± 0.55 ^a	76.89 ± 3.53 ^a

All values are reported as mean ± standard deviation from three replicates (n = 3). Values with a different superscript letter in the same row are significantly different at $p < 0.05$

The ABTS activity of the mango peels of Golden Lily and Chokanan were 1314 µmol TE/g and 1406 µmol TE/g, respectively. Adetuyi *et al.* (2016) reported that the ABTS scavenging activity of the mango peels in their study was between 430-620 µmol TE/g which were lower than the ABTS scavenging activity of the mango peels in the present study. This might be due to the differences in the ripeness of the mango used in both studies. The mango peels used by the previous study was obtained from the freshly harvested mango, while for the present study, the mango was ripe in the desired ripeness. According to Adetuyi *et al.* (2016), the phenolic

content and antioxidant activity of mangoes are affected by their psychological and ripening process.

The DPPH scavenging activity of Golden Lily and Chokanan mango peels were lower than the DPPH scavenging activity of BHT (82.31%) and α-tocopherol (96.56%) standards. According to Umamahesh *et al.* (2016), the DPPH scavenging activity of Sindhura mango peel was 89.24% which was higher than the mango peels in the present study.

Conclusion

There were some significant differences between the nutritional composition and antioxidant properties of Golden Lily and Chokanan mango peels. The crude fat, crude protein and total carbohydrate of Chokanan mango peel were significantly higher than the Golden Lily mango peel. Contrastingly, the moisture content of Golden Lily mango peel was significantly higher than Chokanan mango peel. Both mango peels in the present study contained a high percentage of fibre. There were significant differences in the minerals contained in the peels of both mango varieties except for potassium probably due to the variation of the mango variety. The total phenolic content of Golden Lily mango peel was not significantly different from Chokanan mango peel. Meanwhile, the ABTS scavenging activity and carotenoid content of Chokanan mango peel were higher than the Golden Lily mango peel. The results of the present study showed that both Golden Lily and Chokanan mango peels are a good source of fibre and can be incorporated into functional food products. Information on the nutritional composition and antioxidant properties of both mango varieties in the present study will be useful to food manufacturers in designing their products.

Acknowledgements

The authors would like to thank the laboratory staff of the Faculty of Fisheries and Food Science, Universiti Malaysia Terengganu for their technical assistance in this study.

References

- Adetuyi, F. O., Makinde, A., Adeyemi, I., & Timothy, Y. (2016). Bioactive components, antioxidative properties and inhibition of Fe²⁺ induced lipid peroxidation of mango peel as affected by the storage of mango fruit. *International Journal of Food Studies*, 5, 131-145.
- Ajila, C. M., Bhat, S. G., & Prasada Rao, U. J. S. (2007). Valuable components of raw and ripe peels from two Indian mango varieties. *Food Chemistry*, 102, 1006-1011.
- Ajila, C., & Rao, P. (2013). Mango peel dietary fibre: Composition and associated bound phenolics. *Journal of Functional Foods*, 5, 444-450.
- Akpınar-Bayazit, A., Turan, M.A., Yılmaz-Ersan, L., & Taban, N. (2010). Inductively Coupled Plasma Optical - Emission Spectroscopy determination of major and minor element in vinegar. *Notulae Botanicae Horti Agrobotanici Cluj- Napoca*, 38(3), 64-68.
- AOAC. 2005. "Official Methods of Analysis" Association Official Analytical Chemists of the 16th Ed. International, Washington D.C., U.S.A.
- Ashoush, I. S., & Gadallah, M. G. E. (2011). Utilization of mango peels and seed kernels powders as sources of phytochemicals in biscuit. *World Journal of Dairy & Food Sciences*, 6(1), 35-42.
- Aslam, H. K. W., Raheem, M. I. U., Ramzan, R., Shakeel, A., Shoaib, M., & Sakar, H. A. (2014). Utilization of mango waste material (peel, kernel) to enhance dietary fiber content and antioxidant properties of biscuit. *Journal of Global Innovation Agriculture Social Sciences*, 2(2), 76-81.
- Aziz, N. Z. A., Wong, L. M., Bhat, R., & Cheng, L. H. (2012). Evaluation of processed green and ripe mango peel and pulp flours (*Mangifera indica* var. Chokanan) in terms of chemical composition, antioxidant compounds and functional properties. *Journal of Science Food Agriculture*, 92, 557-563.
- Baddi, J., Vijayalakshmi, D., Durgannavar, N. A., & Chandru, R. (2015). Mango peel: A potential source of natural bioactive phytonutrients in functional food. *Asian Journal of Dairy & Food Research*, 34(1), 75-77.
- Berardini, N., Knödler, M., Schieber, A., & Carle, R. (2005). Utilization of mango peels as a source of pectin and polyphenolics. *Innovation Food Science and Emerging Technology*, 6, 442-452.
- Department of Agriculture. (2016). *Fruit Crops Statistic of Malaysia 2016*. Putrajaya, Malaysia.
- Dhillon, G.S., Kaur, S., & Brar, S. K. (2013). Perspective of apple processing wastes as low-cost substrates for bioproduction of high value products: A review. *Renewable and Sustainable Energy Reviews*, 27, 789-805.
- Dipietro, E. S., Bashor, M. M., Stroud, P. E., Smarr, B. J., Burgess, B. J., Turner, W. E., & Neese, J. W. (1988). Comparison of an inductively coupled plasma-atomic emission spectrometry method for the determination of calcium, magnesium, sodium, potassium, copper and zinc with atomic absorption spectroscopy and flame photometry methods. *Science of The Total Environment*, 74, 249-262.
- Du, G., Li, M., Ma, F., & Liang, D. (2009). Antioxidant capacity and the relationship with polyphenol and Vitamin C in Actinidia fruits. *Food Chemistry*, 113(2), 557-562.
- FAMA. (2006). Menuju kearah kualiti Malaysia's best, Siri Panduan Kualiti Mangga.
- FAO. (2014). *FAOSTAT. Food and Agricultural commodities production*. <http://faostat.fao.org/site>
- Gupta, P., Ray, J., Aggarwal, B. K., & Goyal, P. (2015). Food processing residue analysis and its functional components as related to human health: recent developments. *Austin Journal of Nutrition and Food Sciences*, 3, 1068.

- Imran, M., Butt, M. S., Anjum, F. M., & Sultan, J. I. (2013). Chemical profiling of different mango peel varieties. *Pakistan Journal of Nutrition*, 12(10), 934-942.
- Kim, Y., Brecht, J. K., & Talcott, T. S. (2007). Antioxidant phytochemical and fruit quality changes in mango (*Mangifera indica* L.) following hot water immersion and controlled atmosphere storage. *Food Chemistry*, 105, 1327-1334.
- Kim, H., Moon, J. Kim, H., Lee, D., Cho, M., Choi, H., Kim, Y., Mosaddik, A., & Cho, S. (2010). Antioxidant and antiproliferative activities of mango (*Mangifera indica* L.) flesh and peel. *Food Chemistry*, 121, 429-436.
- Kumar, D., Ashfaq, M., Muthukumar, M., Singh, M., & Garg, N. (2012). Production and characterization of carboxymethyl cellulase from *Paenibacillus polymyxa* using mango peel as substrate. *Journal of Environment Biology*, 33, 81-84.
- Liu, Y. G., Zhang, X. M., Ma, F. Y., & Fu, Q. (2017). The antioxidant activities of mango peel among different cultivars. *IOP Conference Series: Earth and Environmental Science*, 61, 012065, 1-7.
- Madalageri, D. M., Bharati, P., & Kage, U. (2017). Physicochemical properties, nutritional and antinutritional composition of pulp and peel of three mango varieties. *International Journal of Educational Science and Research*, 7(3), 81-94.
- Manzoor, M., Anwar, F., Saari, N., & Ashraf, M. (2012). Variations of antioxidant characteristics and mineral contents in pulp and peel of different apple (*Malus domestica* Borkh.) cultivars from Pakistan. *Molecules*, 17, 390-407.
- Mitra, S. K., Pathak, P. K., Devi, H. L., & Chakraborty, I. (2013). Utilization of seed and peel of mango. *Acta Horticulturae*, 992, 593-596.
- Mon, M. M., Maw, S. S., & Oo, Z. K. (2011). Quantitative determination of free radical scavenging activity and anti-tumor activity of some Myanmar herbal plants. *World Academy Science Engineering and Technology*, 75, 524-530.
- Njiru, M. K. (2014). Analysis of essential minerals in residues of *Mangifera indica* L. grown in selected divisions of Mbeere South, Embu County, Kenya. Master thesis, Kenyatta University, Kenya.
- Onuh, J. O., Momoh, G., Egwujeh S., & Onuh, F. (2017). Evaluation of the nutritional, phytochemical and antioxidant properties of the peels of some selected mango varieties. *American Journal of Food Science and Technology*, 5(5), 176-181.
- Palafox-Carlos, H., Ayala-Zavala, J. F., & Gonza'lez-Aguilar, G.A. (2011). The role of dietary fiber in the bioaccessibility and bioavailability of fruit and vegetable antioxidants. *Journal of Food Science*, 76, 6-15.
- Re, R., Pellegrini, N., Proteggente, A., Pannala, A., Yang, M., & Rice-Evans, C. (1999). Antioxidant activity applying an improved ABTS radical cation decolorization assay. *Free Radical Biology Medicine*, 26, 1231-1237.
- Romelle, F. D., Ashwini, R. P., & Manohar, R. S. (2016). Chemical composition of some selected fruit peels. *European Journal of Food Science and Technology*, 1.4, 12-21.
- Rose, M., Knaggs, M., Owen, L., & Baxter, M. (2001). A review of analytical method for lead, cadmium, mercury, arsenic and tin determination used in proficiency testing. *Journal of Analytical Atomic Spectrometry*, 16, 1001-1006.
- Rusak, G., Komes, D., Likic, S., Hirzic, D., & Kovac, M. (2008). Phenolic content and antioxidative capacity of green and white tea extracts depending on extraction conditions and solvent used. *Food Chemistry*, 110, 852-858.

- Santhirasegaram, V., Razali, Z., and Somasundram, C. (2013). Effects of thermal treatment and sonication on quality attributes of Chokanan mango (*Mangifera indica* L.) juice. *Ultrasonics Sonochemistry*, *20*, 1276-1282.
- Santhirasegaram, V., Razali, Z., George, D. S., & Somasundram, C. (2015). Comparison of UV-C treatment and thermal pasteurization on quality of Chokanan mango (*Mangifera indica* L.) juice. *Food and Bioproducts Processing*, *94*, 313-321.
- Seremet (Ceclu), L., Botez, E., Nistor, O. V., Andronoiu, D. G., & Mocanu, G. D. (2016). Effect of different drying methods on moisture ratio and rehydration of pumpkin slices. *Food Chemistry*, *195*, 104-109.
- Serna-Cock, L., García-Gonzales, E., & Torres-León, C. (2016). Agro-industrial potential of the mango peel based on its nutritional and functional properties. *Food Reviews International*, *32*(4), 364-376.
- Shad, M.A., Rehman, A., & Daud, K. (2001). Minerals contents of mango seeds kernels. *Journal of Biological Sciences*, *1*, 195-197.
- Sharma, R. K., Agrawal, M., & Marshall, F. M. (2006). Heavy metals contamination in vegetables grown in waste water irrigated areas of Varanasi, India. *Bulletin of Environment Contamination Toxicology*, *77*, 311-318.
- Sharma, R. K., Agrawal, M., & Marshall, F. M. (2009). Heavy metals in vegetables collected from production and market sites of a tropical urban area of India. *Food Chemistry Toxicology*, *47*, 583-91.
- Slavin, J., & Carlson, J. (2014). Carbohydrates. *Advances in Nutrition*, *5*(6), 760-761.
- Sogi, D., Siddiq, M., Greiby, I. & Dolan, K. (2013). Total phenolics, antioxidant activity, and functional properties of 'Tommy Atkins' mango peel and kernel as affected by drying methods. *Food Chemistry*, *141*, 2649-2655.
- Tavarini, S., Innocenti, E. D., Remorini, D., Massai, R., & Guidi, L. (2007). Antioxidant capacity, ascorbic acid, total phenols and carotenoids changes during harvest and after storage of Hayward kiwifruit. *Food Chemistry*, *107*, 282-288.
- Umamahesh, K., Sivudu, S. N. & Reddy, O. V. S. (2016). Evaluation of antioxidant activity, total phenolics and total flavonoids in peels of five cultivars of mango (*Mangifera indica*) fruit. *Journal of Medicinal Plants Studies*, *4*(2), 200-203.
- Watanawan, V., Wasusri, T., Srilaong, V., Wongs-Aree, T., & Kanlayanarat, S. (2014). Near infrared spectroscopic evaluation of fruit maturity and quality of export Thai mango (*Mangifera indica* L. var Namdokmai). *International Food Research Journal*, *21*(3), 1109-1114.