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Nutritional composition of dried noodle incorporated with Mango peel powder

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Noodle is one of the staple foods among Asians other than rice. Due to its high consumption, the demands for highly nutritious noodle products are growing rapidly. Mango peel is one of the major by-products in mango processing industry that resulted in increased food waste. Nevertheless, mango peel contains polyphenols and other nutrients with high antioxidant activity which may be beneficial in the production of highly nutritious food. Thus, it leads to the increasing study and research in the utilization of this waste into wealth. This study was conducted in order to investigate the effect of mango peel powder incorporation on the sensory and nutritional composition of noodle. Cleaned mango peel was dried by using vacuum drying and ground into powder form before being used in the production of noodle. Sensory analysis was conducted in order determine the best formulation for mango peel incorporated noodle. The nutritional content of the mango peel incorporated noodle with the best sensorial score was then analysed such as proximate analysis, total phenolic content (TPC) and total carotenoids. Antioxidant activity analysis such as the DPPH free radical scavenging activity and β-carotene/linoleic acid bleaching assay was also carried out. From the results obtained, it was determined that mango peel incorporated noodle was highly preferred by the panels with the highest score showed for samples containing 6% of mango peel powder. The addition of mango peel powder also improves the nutritional content of noodle with the dietary fibre content of 7.26±0.33% as compared to 0% for control sample. An increase in the antioxidant content and activity were also observed with 73.65±1.47 mg GAE/L of total phenolic content and 6.13±0.01 µg/g of total carotenoids. In conclusion, mango peel powder can be utilized as an added ingredient in the production of highly nutritional noodle.

Keywords: Mango peel, Noodle, Nutritional content, Food waste, Antioxidant

INTRODUCTION

The industrial production of noodle is growing rapidly especially in the production of instant noodle. It is estimated that 30-40% of wheat flour in Asian countries was used for noodle production (Kruger et al. 1996). Therefore, there is a high market potential for the production of noodle products with high nutritional value. In addition, the increasing market demand for noodle products especially instant noodle has encouraged an extensive effort in the research and development of high nutritional noodle products to fulfil consumer demands for healthy alternatives. Several examples of the studies conducted on the development of highly nutritional noodles are the development of instant fried noodles with oat bran flour containing β- glucan (Reungmaneepaitoon et al. 2006) and the development of instant noodle and pasta products with rice flour that are high in iron (Reungmaneepaitoon and Sikkhamondhol, 2008; Reungmaneepaitoon et al. 2008). Other than that, studies on the enrichment of noodle and pasta products with vegetable purees and powder were also conducted such as soy and carrot powder- enriched noodles with increased antioxidant content (Adegunwa et al. 2012), pasta made with carrot and beet root purees (Rekha et al. 2013) and the development of functional and nutritional-enhanced noodles with spinach purees (Ramu et al. 2018; Shere et al. 2018). Besides that, several reviews have also been published that discussed the effects of fibre and protein fortification on noodle products (Udachan et al. 2018) and the use of non-conventional ingredients such as fruit waste, legumes and cereals to enhance the nutritional content of noodle products (Nilusha et al. 2019).

Mango peel is one of the major by-products from mango processing other than kernel. The production of mango-based product such as puree, juice, fruit leather, pickles and canned slices contributed to the significant increase in solid waste that may be harmful to the environment. Thus, studies has been focusing on increasing the potential use of these waste into valuable products (Ajila et al. 2007a; Berardini et al. 2005; Jahurul et al. 2015). According to previous studies, mango peel has a high potential to be incorporated into food products in order to enhance its nutritional values such as in the production of biscuits (Ajila et al. 2008), macaroni (Ajila et al. 2010) and yellow alkaline noodle (Nur Azura et al. 2020). It has been reported that the addition of mango peel powder in these products helped in increasing its nutritional and antioxidant properties. It can also be utilized as a source of dietary fibre. In addition, several studies also reported on the application of mango peel powder extract as a natural antioxidant in food replacing artificial food additives such as butylated hydroxytoluene (BHT) and butylated hydroxyanisole (BHA) (Nisha and Bhatnagar, 2020).

Mango peel extract contains polyphenols and carotenoid with high antioxidant activity (Ajila et al. 2007a). The phenolic content found in mango peel extract were syringic acid, quercetin, mangiferin, kaempferol, ellagic acid, gallic acid and benzoic acid (Ajila and Prasada Rao, 2013; Coelho et al. 2019) whereby these compounds have been associated with the prevention of several degenerative diseases such as cancer, diabetes and cardiovascular diseases. Some of the major carotenoids compounds found in mango peel were β-carotene, lutein and violaxanthin (Ranganath et al. 2018) which are responsible for its distinctive colour.

Mango (*Mangifera indica L.*) variety of *Carabao* is one of the main varieties of mangoes in the world. It is cultivated in the Philippines and in Malaysia, it can be found mostly in east Malaysia. it is one of the highly consumed variety of mango and has been reputed internationally due to its unique taste and sweetness. The 1995 edition of the Guinness Book of World Records has listed the *Carabao* variety of mango as the sweetest fruit in the world which has caused a surge in demands (Castillo-Israel et al. 2015). Therefore, this variety of mango is chosen in this study.

Although various studies have been conducted previously, further studies are still required in the production of dried noodles with mango peel as it is still scarce. The production of dried or instant noodles usually requires low-cost ingredients as they were classified as an affordable and easily obtained food products. Due to this, the development of healthy and affordable nutritious noodle can be challenging. The reported benefits of mango peel increase its potential as an added ingredient in the production of nutritious noodle products. However, the production of dried or instant noodles requires drying process that may affect the nutritional content of the produced product. Therefore, a study on the effect of mango peel powder incorporation on the nutritional quality of dried noodle may provide further insight on the application of mango peel powder as a beneficial ingredient in food products.

MATERIALS AND METHODS

Materials

The ingredients used for the preparation of dried noodle samples such as wheat flour, salt and sodium carbonate were purchased from a local store in Kota Kinabalu, Sabah. The mango peel powder (MPP) was prepared by obtaining mangoes (*Mangifera indica L.*) variety of *Carabao* from a local market in Kota Kinabalu, Sabah at the maturity index of 5. The cleaned peels were vacuum dried 50±1℃ and 500 mmHg of pressure. The mango peels were dried to a moisture content of 8.27±0.5% and were ground into powder form with an electric blender. The prepared powder was then sieved through a 150 µm sieve and kept in an airtight container before being used for the dried noodle production.

Experimental design and noodle preparation

The formulations for mango peel incorporated noodle were developed based on Kamaruddin et al. (2012) with some modifications. Preliminary experiments were conducted in order to determine basic formulations for the noodle and the formulations were developed by using a factorial design of 2X3 according to Box and Draper (1987). The amount of flour which is the main ingredient and mango peel powder were varied. A total of six formulations were developed as presented in Table 1.

A control sample without the addition of mango peel powder was developed according to the basic formulation of noodle production by MARDI (2008). The mango peel noodle was prepared by mixing the flour with mango peel powder and sieved. The mixture was then mixed with salt, sodium carbonate and water and was evenly mixed with an electrical mixer (Kenwood Major Classic, New Zealand) until a dough was formed. The dough was then flattened to 3±0.01 mm of thickness and extruded into noodle by using a pasta machine (Marcato Ampia 150, Italy). The extruded noodle samples were then cooked by steaming it for 30 minutes before drying with a drying oven (Electrolux, Sweden) at 50±1℃ for 90 minutes**.**

Sensory evaluation of noodle samples

Sensory evaluation tests were conducted in order to identify the best formulation for the development of mango peel incorporated noodle. The dried noodle samples were cooked in boiled water for 3 minutes prior to the test. A total of two sensory analysis tests were conducted which are the BIB ranking test (Balance incomplete block design) followed by hedonic test. The ranking BIB test with Friedman's analysis was conducted in order to choose the best three formulations whereby the samples were divided into small blocks and evaluated (Cochran and Cox, 1957). All of the six formulations were served in difference arrangements according to the block design and were given equal chances to be compared with other formulations. 3 samples were served in each block where the best sample was ranked as 1 while the least favourable sample was ranked as 3. Then, the best three samples were further evaluated by hedonic test whereby the attributes of the sample such as colour, texture, aroma, taste and overall acceptance were evaluated.

The degree of liking for each of the attribute were evaluated with the 7-point hedonic scale whereby: 1= strongly disliked, 2= moderately disliked, 3= slightly disliked, 4= Neutral, 5= slightly liked, 6= moderately liked and 7= strongly liked. A total of 40 panelists among students of Universiti Malaysia Sabah were chosen for the sensory test. The panelists were instructed to clean their palate in between each sample with the provided mineral water.

Proximate analysis

Proximate analysis was conducted on the sample that received the best score on sensory evaluation and was compared to control sample. Moisture, ash, crude fiber, protein and fat content were determined according to AOAC methods 2000 while dietary fiber content was analyzed according to AOAC method 985.29 (Prosky et al. 1985).

Table 1: List of formulations for noodle preparation

<table>
<tr><th>Formulations</th><th>Mango peel powder (%)</th><th>Mango peel powder (g)</th><th>Wheat flour (g)</th><th>Water (g)</th><th>Sodium carbonate (g)</th><th>Salt (g)</th></tr>
<tr><td>Control</td><td>0</td><td>0</td><td rowspan="4">647</td><td rowspan="7">300</td><td rowspan="7">17</td><td rowspan="7">16</td></tr>
<tr><td>F1</td><td>6</td><td>60</td></tr>
<tr><td>F2</td><td>4</td><td>40</td></tr>
<tr><td>F3</td><td>2</td><td>20</td></tr>
<tr><td>F4</td><td>6</td><td>60</td><td rowspan="3">617</td></tr>
<tr><td>F5</td><td>4</td><td>40</td></tr>
<tr><td>F6</td><td>2</td><td>20</td></tr>
</table>

Carbohydrate estimation was calculated by using the following equation (FAO, 2003):

Carbohydrate (%) = 100 – (%∑ moisture + ash + fat + protein + crude fiber)

Solvent extraction of bioactive compounds

The extraction process was conducted according to Ajila et al. (2010). The dried noodle was ground into powdered form by using mortar and pestle prior to the extraction. The extraction process was conducted at room temperature with 80% of acetone. 20 ml of 80% acetone and 1.00±0.01 g of powdered noodle sample was homogenized for 1 hour by using a vertex mixer. The sample was then centrifuged at 8000 x g for 15 minutes and filtered with Whatman No. 1 filter paper. The supernatant was then collected and was analyzed for total phenolic content, total carotenoids, DPPH free radical scavenging assay and β-carotene/linoleic acid bleaching assay.

Total phenolic content

Folin-Ciocalteu technique was used for the determination of total phenolic in the samples according to Singleton et al. (1999) with some modifications. In brief, 200 µl of sample extract was mixed with 1 ml of Folin-Ciocalteu reagent (1:10 diluted in distilled water) in a test tube. The mixture was then left to stand for approximately 5 minutes at room temperature. 800 µl of 7.5% (w/v) of sodium carbonate solution was then added into the mixture and was shaken thoroughly. The solution was then incubated at 40°C for 30 minutes in a dark condition. After the incubation, the absorbance of the sample was measured at 765nm against a reagent blank. Gallic acid was used as standard curve and the total phenolic content for each sample were determined as gallic acid equivalents (mg GAE/g) of samples.

Total carotenoids content

The total carotenoids content of the noodle samples were determined according to Dere et al. (1998). The absorbance of the acetone extracts was measured at 400-700 nm by using a spectrophotometer. The absorbance for chlorophyll a and b were measured at 663 nm and 646 nm respectively. For total carotenoid, the absorbance was measured at 470 nm and the total of these pigments were calculated according to Lichtenthaler and Wellburn (1983). The total carotenoids were calculated as shown in the following equation:

Chlorophyll a (C_a) = 12.25 $A_{663.2}$ – 2.79 $A_{646.8}$
Chlorophyll b (C_b) = 21.50 $A_{646.8}$ – 5.10 $A_{663.2}$
Total Carotenoids = 1000 A_{470} – 1.82 C_a – 85.02 C_b/198

DPPH free radical scavenging activity

The free radical scavenging activity of the samples was determined according to Duan et al. (2007) with some modifications. In brief, 2.0±0.01 ml of the acetone extract was added to 2 ml of methanol-DPPH solution (0.1 Mm). The mixture was then vortexed for 1 minute and was incubated in a dark condition for 30 minutes at 25 °C. The absorbance was then measured at 517 nm and the scavenging activity was determined by using the following equation:

Scavenging activity (%) = [1-(A_{sample} – A_{blank})/$A_{control}$] x 100

Where A_{sample} is the absorbance of sample extract with DPPH solution, A_{blank} is the absorbance of sample extract only and $A_{control}$ is the absorbance of DPPH solution only.

ß-carotene/linoleic acid bleaching assay

This assay was conducted in order to determine the capacity of the antioxidant in decreasing the oxidation of ß-carotene in the ß-carotene/linoleic acid system. This assay was conducted according to Ikram et al. (2009). 2.00±0.01 mg of β-carotene was dissolved in 10 ml of chloroform in order to prepare the β-carotene solution. 1.0 ml of the prepared β-carotene solution was then mixed with 20 µl of linoleic acid, 200 µl of Tween 20 and 200 µl of the sample extract in a round bottom flask. The mixture was then evaporated with a rotary evaporator at 30 ℃ for 20 minutes in order to remove the chloroform. The mixture was then added with 50 ml of distilled water and was vigorously agitated in order to form an emulsion. 2.0 ml of this emulsion was then transferred into a test tube and was placed in a water bath at 50±1 ℃ for 2 hours. The absorbance of the sample was measured by using a spectrophotometer and the antioxidant activity was determined with the equation below:

Antioxidant activity (%) = (A_0 – A_1)/A_0 x 100

Where A_0 is the absorbance of the sample at time 0 while A_1 is the absorbance of the sample at 2 hours.

Statistical analysis

All of the analysis were conducted in triplicates and the data obtained were analysed with Excel (Microsoft inc.) in order to calculate the mean and standard deviation. The data for BIB rank test were analysed by using Friedman's test with least significance difference (LSD). The data were also analysed with T-test for comparing two means while One-Way ANOVA with Tukey-HSD was conducted for comparing several means. The statistical analysis was conducted by using IBM statistical software (SPSS) version 23 where the means were considered as significantly different at P<0.05.

RESULTS

Sensory analysis of mango peel incorporated noodle

Ranking BIB test

The ranking test was conducted by using the *Balanced Incomplete Block* method. The samples were arranged into several small blocks and were evaluated according to (Cochran and Cox, 1957). This test was conducted in order to determine the three most preferred formulation for mango peel incorporated dried noodle. Friedman's analysis was conducted on the data obtained from the sensory evaluation test. In this analysis, the total score of the samples were arranged in order and the Friedman value was determined where P<0.05 indicated significant difference between the samples. From the analysis, the T-value obtained was 19.25 and was higher than the $X^2_{5,0.05}$=11.1 from the upper α probability points of X^2 distribution of Meilgaard et al. (1999). This indicated that there are significant different between the samples tested. LSD test was also conducted in order to determine differences between formulations as shown in Figure 1. The LSD value was 10.51 at 95%. The formulations were arranged accordingly from highest to the lowest rank and differences in value of more than 10.51 indicated significant different between the samples.

According to Figure 1, no significant different was observed between samples F1 to F4. In addition, no significant different was also observed between F2, F3, F4 and F5 samples. Significant different was only observed for sample F6 as compared to F1, F2, F3 and F4 samples. F1, F2 and F3 has the lowest rank scores which indicated highest preference as compared to the other samples while sample F6 with the highest rank score indicated the least preferred sample.

Hedonic test

The best three formulation from the BIB ranking test, F1, F2 and F3 was chosen to undergo the hedonic scale sensory test. In this test, the seven hedonic scale was used in order to rate the attributes of the noodle such as colour, aroma, taste, texture and overall acceptance. The test was conducted to determine the best formulation for the production of mango peel incorporated noodle. The overall results were presented in Figure 2 and the results for the One-way ANOVA test of the samples were presented in Table 2.

According to Table 2, a significantly high score (P<0.05) of appearance (colour) was observed for sample F3, with the lowest MPP percentage as compared to sample F1 and F2 of higher MPP percentage. A significant different (P<0.05) was observed between sample F1 and both of sample F2 and F3 while no significant different (P>0.05) was observed between sample F2 and F3 in terms of aroma. F1 sample showed a significantly higher preference score for taste as compared to sample F2 and F3. For texture, a significant different was only observed between sample F2 and F3 while for the overall acceptance of the samples, sample F3 showed a significantly lower score as compared to sample F1 and F2. The F1 sample showed the highest score for most of the attributes which indicates highest preference as compared to other samples.

The effect of mango peel on the nutritional composition of dried noodle

Proximate analysis was conducted on mango peel incorporated dried noodle prepared with F1 formulation (6% MPP) and was compared with control sample (0% MPP). The data were analysed with T-test.

According to Table 3, significant difference was observed between the control dried noodle sample containing 0% of MPP and the mango peel incorporated dried noodle with 6% of MPP for all of the nutrient component except for the carbohydrate content. The mango peel incorporated noodle had a significantly (p<0.05) higher content of ash, crude fibre, protein and dietary fibre as compared to the control sample. On the other hand, a lower content of moisture, fat and carbohydrate was observed for mango peel incorporated noodle as compared to the control sample.

The total phenolic, carotenoids and antioxidant activity of mango peel incorporated dried noodle

The effect of mango peel incorporation on total phenolic and carotenoid content was determined in order to study the potential use of mango peel powder in enhancing the nutritional value of dried noodle products (Table 4). The antioxidant analysis of the samples was conducted in order to determine its ability to scavenge free radical (DPPH free radical scavenging activity) and in preventing the oxidation process of lipid (B-carotene/linoleic acid bleaching assay). The data obtained were analyzed with T-test and comparison was made between mango peel incorporated noodle (6% MPP) and the control noodle sample containing 0% of MPP (Table 4). From the results obtained, it was determined that the addition of MPP caused a significant increase in total phenolic, carotenoids and antioxidant activity in dried noodle.

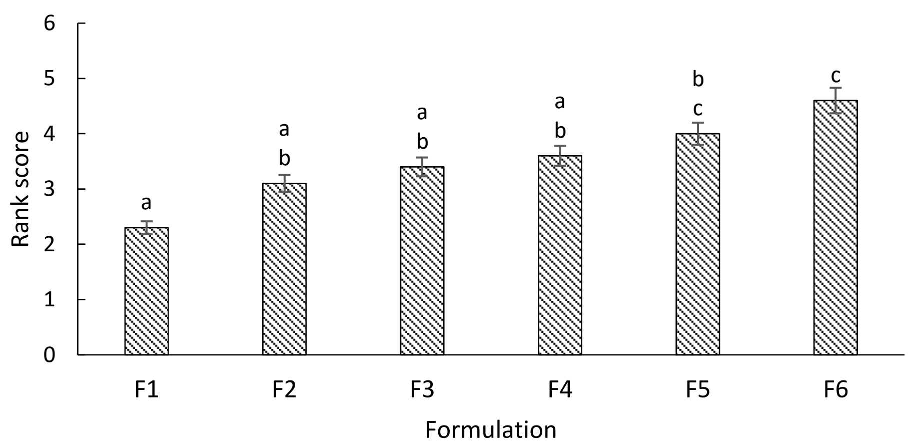

Figure 1: Total score for mango peel incorporated noodle formulations. Total score with different letters^{a-c} was significantly different at 5% (LSD_{rank}=10.51)

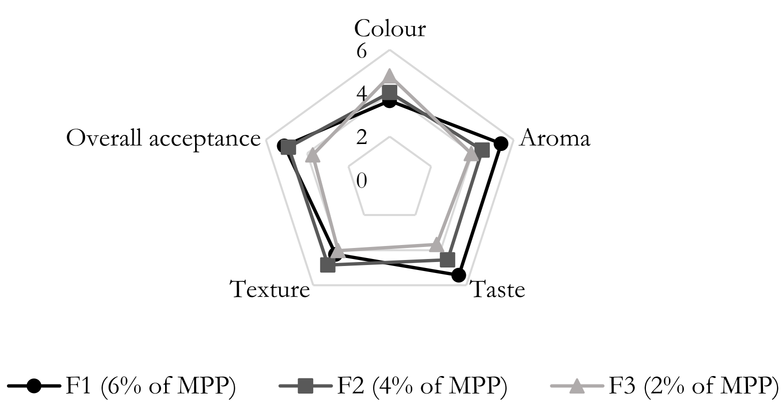

Figure 2: Sensory evaluation (hedonic test) of mango peel incorporated dried noodles.

Table 2: Mean score of the acceptance values for colour, aroma, taste, texture and overall acceptance of mango peel incorporated dried noodle.

Attributes	Sample		
	F1	**F2**	**F3**
Appearance (Colour)	$3.65^{a} \pm 1.12$	$4.03^{a} \pm 1.23$	$4.80^{b} \pm 1.44$
Aroma	$5.40^{a} \pm 1.03$	$4.48^{b} \pm 1.11$	$3.95^{b} \pm 1.09$
Taste	$5.43^{a} \pm 1.22$	$4.55^{b} \pm 1.28$	$3.68^{c} \pm 0.97$
Texture	$4.25^{ab} \pm 1.30$	$4.85^{a} \pm 1.00$	$4.03^{b} \pm 1.12$
Overall acceptance	$5.10^{a} \pm 0.96$	$4.90^{a} \pm 1.08$	$3.73^{b} \pm 1.04$

Mean scores with different letters^{a-c} within the same row are significantly different at $P<0.05$.

Table 3: Difference in nutritional composition of mango peel incorporated noodle with control sample

Component	Control sample	Mango peel incorporated noodle
Moisture (%)	$9.60^{a} \pm 0.04$	$8.41^{b} \pm 0.04$
Ash (%)	$2.20^{b} \pm 0.02$	$2.93^{a} \pm 0.01$
Crude fibre (%)	0.00^{b}	$0.94^{a} \pm 0.04$
Protein (%)	$9.80^{b} \pm 0.03$	$10.11^{a} \pm 0.04$
Fat (%)	$1.10^{a} \pm 0.01$	$0.42^{b} \pm 0.03$
Carbohydrate (%)	$77.30^{a} \pm 0.07$	$77.19^{a} \pm 0.03$
Dietary fiber (%)	0.00^{b}	$7.26^{a} \pm 0.33$

Mean values with different letters ^{a,b} within the same row are significantly different ($P<0.05$).

Table 4: Difference in total phenolic, carotenoid and antioxidant activity of mango peel incorporated noodle with control sample

	Control sample	**Mango peel incorporated noodle**
Total phenolic content (mg GAE/L)	$6.13^{b} \pm 0.01$	$73.65^{a} \pm 1.47$
Total carotenoids (µg/g)	$1.65^{b} \pm 0.03$	$6.47^{a} \pm 0.06$
DPPH free radical scavenging activity (%)	$5.63^{b} \pm 0.04$	$67.63^{a} \pm 1.12$
Β-carotene/linoleic acid bleaching assay (%)	$7.14^{b} \pm 0.01$	$85.58^{a} \pm 1.15$

Mean values with different letters^{a-b} within the same row were significantly different at $p<0.05$.

DISCUSSION

Referring to the results obtained from sensory analysis, F1 sample with the lowest rank score contained the highest mango peel percentage of 6% whereas sample F6 with the highest rank contained the lowest percentage of mango peel with 2% (Figure 1). These results indicated that the mango peel incorporated dried noodle was highly preferred by the panel whereby F1 was the best formulation for the production of mango peel incorporated noodle. Although F1 was determined as the best formulation according to the ranking test, it does not explain the reason for the high acceptance of the sample. Therefore, a rating test such as hedonic test is required in order to determine the attributes that played a significant role and therefore help in optimizing the formulation.

Based on the hedonic test of the three best formulations, in terms of colour, the scores recorded for all samples were 3.65 to 4.80 which indicates 'slightly like' to 'slightly dislike' preferences. The relatively low preference is due to the difference in colour between the dried mango peel incorporated noodles with the usual yellow colour of dried noodles in the market whereby brownish colour was observed for mango peel incorporated noodles. According to Nur Azura et al. (2020), the addition of MPP in yellow alkaline noodles resulted in brown coloured noodles and reduces the preferable bright yellow colour. The brown colour intensifies with increase in MPP percentage whereby samples containing the highest percentage of 30% recorded the acceptance score of lower than 5. The brown colour of the MPP resulted in red hue for samples containing 10% of MPP. Meanwhile, the study conducted by Ajila et al. (2010) on macaroni samples showed no significant different in the colour preference between sample containing the highest amount (7.5%) of MPP as compared to control sample. According to Ajila et al. (2008), the addition of mango peel powder in biscuits also resulted in a decrease in the yellowness colour and it was attributed to the oxidation of polyphenols in the mango peel by polyphenol oxidase and peroxidase that changes its colour from yellow to brown. The dried noodle in the present study showed brown colour at a lower mango peel powder percentage of 6% as compared to previous studies that resulted in a lower preference score.

This is due to the hot air drying process of the noodle that increases the oxidation process of the polyphenols and intensifies the brown colour of the noodle (Larrauri et al. 1997). For aroma, the preference score increased with increase in the percentage of MPP due to the fragrant odour of the MPP. Volatile compounds such as aldehydes and terpenes are abundant in the peel as compared to any other part of mango which may contribute to the aroma (Lalel et al. 2003).

The results also showed an increase in preference in terms of taste with increase in MPP percentage. This result is in contradictory with the result obtained previously by Ajila et al. (2010) on macaroni whereby an increase in MPP percentage reduces the preference score for taste while Nur Azura et al. (2020) also reported a less preference score in terms of taste for yellow alkaline noodle with high percentage of MPP. This is mainly due to the difference in the type of mango used between the studies in which it has been reported that the mango peel from different sources contains different chemical composition that may contribute to difference in taste (Maldonado-Celis et al. 2019). In addition, the high acceptance of aroma for sample with high MPP percentage may also affect the taste of the noodle due to the interaction between taste and aroma (Noble, 1996). In terms of texture, sample F2 with 4% of MPP showed the highest preference score as compared to sample F1 and F3. This is due to the presence of high MPP in F1 resulted in noodle with hard texture while sample with the lowest MPP percentage of 2% caused the texture to be too soft and break easily. These result is in agreement with (Nur Azura et al. 2020) whereby an increase in MPP percentage up to 20% causes an increase in hardness. Overall, the results obtained indicates a high preference for mango peel incorporated noodle with F1 as the best formulation.

Referring to the results obtained from proximate analysis, the moisture content of the sample is in contrary with the study conducted by Nur Azura et al. (2020) whereby the replacement of wheat flour with MPP increases the moisture content of noodle which was attributed to the water holding capacity of pectin in the MPP. However, in the present study, the amount of MPP incorporated in the noodle was not as high as compared to the previous study by Nur Azura et al. (2020) in which 30% of MPP was substituted in the noodle and the noodle produced was not subsequently dried. The result was consistent with the study conducted by Adegunwa et al. (2012) whereby the enrichment of dried noodle with cassava, soy and carrot powder reduces the moisture content of the noodle. The reduction in the moisture content can be attributed to the increase in solid content by the addition of MPP that aid in the drying process of the noodle. According to Phisut (2012), the drying process of juices can be improved by concentrating juice prior to drying process in order to increase its solid content and reduces the amount of water to be evaporated. The reduction in moisture content also help in improving the shelf life of the noodle by reducing water activity and prevent the growth of microorganism. This characteristic is crucial for dried noodle products as they were usually stored at room temperature (Sivasankar, 2002).

Besides that, the ash and protein content of the MPP incorporated dried noodle was also significantly higher as compared to the control sample. The high amount in ash content was in agreement with the previous study whereby an increase in MPP percentage increases the ash content of the noodle (Nur Azura et al. 2020). The result was also in agreement with the study conducted by Adegunwa et al. (2012) whereby the ash content of the dried noodle was improved with the incorporation of cassava, soy and carrot powder. According to Nielsen (2003), the high ash content indicated a high mineral content and thus, the incorporation of MPP in noodle improves its mineral content. In terms of protein, the result obtained is in contrary with the previous study whereby the substitution of wheat flour with MPP reduces the protein content of the noodle (Nur Azura et al. 2020). The protein content of the noodle was mostly originated from the flour as MPP contains low amount of protein (Ajila et al. 2010; Nur Azura et al. 2020). The improved drying process of the noodle with MPP due to the increase in solid content may have contributed to the protein content retention in the noodle as it minimizes protein denaturation (Shilton, 2003).

In addition, the fat content in mango peel incorporated noodle was significantly ($p<0.05$) lower as compared to control sample which is in agreement with the study conducted by Nur Azura et al. (2020). No significant different was observed in terms of carbohydrate and thus, the addition of mango peel powder does not affect the carbohydrate content of dried noodle. A significant ($p<0.05$) increase in crude and dietary fibre content was observed with the presence of MPP in the noodle. This result is in agreement with the study conducted by Ajila et al. (2010) whereby the addition of MPP in macaroni increases its dietary fibre content. It has been reported previously that mango peel powder was rich in dietary fibre (Ajila et al. 2007a; Ajila and Prasada Rao, 2013; Jahurul et al. 2015) and the fibre content in mango peel were mostly originated from cellulose, hemicellulose and pectin (Sogi et al. 2013). According to the Malaysian Food Act 1983 and Regulation (2020), dietary fibre content of not less than 3g per 100 g of solid food were recognised as a source of dietary fibre whereas for content that was higher than 6g for every 100g of food is considered as high source of dietary fibre. The dietary fibre of mango peel incorporated noodle in the present study was 7.26g per 100g of noodle and therefore can be classified as high in dietary fibre. Overall, the addition of mango peel powder help in the production of highly nutritious noodle.

Mango peel has been reported to contain high amount of total phenolic and carotenoids (Ajila et al. 2007a; Ajila et al. 2007b; Ajila and Prasada Rao, 2013; Suleria et al. 2020; Tokas et al. 2020). According to the study conducted by Suleria et al. (2020) on 20 fruit peels, mango peel has been reported to contain the highest amount of total phenolic content as compared to the other fruit peels such as apple, grapefruit, apricot and banana peel. These characteristics increases the potential of mango peel to be used as an added ingredient in the development of highly nutritious food product. It has been reported that the addition of MPP in biscuit increases the total phenolic content, total carotenoids and antioxidant activity of the sample as compared to control samples (Ajila et al. 2008; Ashoush and Gadallah, 2011). Moreover, Abdul Aziz et al. (2012) also reported a higher total phenolic and total carotenoids content for mango peel flour as compared to mango pulp and wheat flour. However, it is crucial to note that the interaction between phenolic compounds with other chemical component in foods may affect its total phenolic content and antioxidant activity (Nicoli et al. 1999). Besides that, the synergistic effect of phenolic compound with other component such as chelating agents may also affect the antioxidant level of the sample (Siah et al. 2011).

The high total carotenoids in the sample containing MPP can be associated with β-carotene content which is known as the main source of vitamin A. β-carotene is classified as one of more than 600 naturally occurring carotenoids and was also found abundantly in mango peel along with other carotenoid compounds such as lutein and violaxanthine

(Ajila et al. 2010). β-carotene is an important component in our diet as it helps in enhancing the immune system and sight. Therefore, the consumption of food containing this nutrient is important to ensure our health.

The significant increase in antioxidant activity based on the free radical scavenging activity and the ability to prevent lipid peroxidation were associated with the high amount of total phenolic and carotenoids in the samples with the addition of MPP. According to Dorta et al. (2012), there is a significant correlation between the increase in total phenolic and carotenoids of mango peel with the increase in the DPPH free radical scavenging percentage. High correlation was also observed between the increase in total phenolic and carotenoids concentration in the sample with its ability to prevent the peroxidation of β-carotene. In addition, a study by Suleria et al. (2020) on 20 different fruit peels also reported that mango peel shows the second highest percentage of DPPH free radical scavenging activity after grapefruit peel. The result obtained was also in agreement with Ajila et al. (2010) whereby free radical scavenging activity of the macaroni samples improved with the addition of MPP. There are several factors that may affect the antioxidant activity such as the concentration of antioxidant compounds, the medium used for the extraction, the pH and temperature of the medium, the chemical structure and its position within the molecule (Othman et al. 2007). Therefore, the addition of MPP in dried noodle increases the concentration of antioxidant compound and thus, increases its antioxidant activity.

CONCLUSION

The results obtained from this study demonstrated the potential use of mango peel powder in the development of highly nutritious dried noodle with positive consumer acceptance. Sensory evaluation of the developed formulations revealed that dried noodle incorporated with the highest content of MPP (F1, 6% MPP) was the most preferred formulation with highest preference was observed for three of the five attributes tested such as aroma, taste and overall acceptance. The increase in MPP percentage resulted in less preference in terms of appearance (colour) and therefore, future studies should be conducted for improvements. Besides, the addition of MPP also increases the nutritional content of dried noodle with significant increase in dietary fibre and antioxidant activity. As differences in the variety of mangoes may affect the results as observed in the data obtained from this study as compared to the previous studies, the variety of mango used should be put into account for the future development of mango peel-based product. Future studies are also required in order to further explore the application of mango peel powder in other food products and also as an alternative to natural antioxidant food ingredients replacing artificial antioxidants such as butylated hydroxyanisole (BHA) and butylated hydroxytoluene (BHT).

CONFLICT OF INTEREST

The authors declared that present study was performed in absence of any conflict of interest.

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AUTHOR CONTRIBUTIONS

The manuscript was written by NSMI and INM. NMM and YH reviewed the manuscript and advised on the antioxidant activity discussion. The experiment was designed by NSMI and MAH. All authors read and approved the final version.

REFERENCES

Abdul Aziz NA, Wong LM, Bhat R, Cheng LH, 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. J. Sci. Food Agric. 92:557–563.

Adegunwa MO, Bakare HA, Akinola OF, 2012. Enrichment of Noodles with Soy Flour and

Carrot Powder. Niger. Food J. 30:74–81.

Ajila CM, Aalami M, Leelavathi K, Rao UJSP, 2010. Mango peel powder: A potential source of antioxidant and dietary fiber in macaroni preparations. Innov. Food Sci. Emerg. Technol. 11:219–224.

Ajila CM, Bhat SG, Prasada Rao UJS, 2007a. Valuable components of raw and ripe peels from two Indian mango varieties. Food Chem. 102:1006–1011.

Ajila CM, Leelavathi K, Prasada Rao UJS, 2008. Improvement of dietary fiber content and antioxidant properties in soft dough biscuits with the incorporation of mango peel powder. J. Cereal Sci. 48: 319–326.

Ajila CM, Naidu KA, Bhat SG, Rao UJSP, 2007a. Bioactive compounds and antioxidant potential of mango peel extract. Food Chem. 105:982–988.

Ajila CM, Prasada Rao UJS, 2013. Mango peel dietary fibre: Composition and associated bound phenolics. J. Funct. Foods 5:444–450.

AOAC, 2000. Official Methods of Analysis. 17th Edition, The Association of Official Analytical Chemists, Gaithersburg, MD, USA.

Ashoush I, Gadallah MG, 2011. Utilization of mango peels and seed kernels powders as sources of phytochemicals in biscuit. World J Dairy Food Sci. 6: 35-42.

Berardini N, Knödler M, Schieber A, Carle R, 2005. Utilization of mango peels as a source of pectin and polyphenolics. Innov. Food Sci. Emerg. Technol. 6: 442–452.

Box GEP, Draper NR, 1987. Empirical model-building and response surfaces. New York: Wiley.

Cochran WG, Cox GM, 1957. Experimental designs. New York: John Wiley and Sons.

Coelho EM, De Souza MEAO, Corrêa LC, Viana AC, Azevêdo LCDe, Lima MDS, 2019. Bioactive compounds and antioxidant activity of mango peel liqueurs (Mangifera indica L.) produced by different methods of maceration. Antioxidants 8:1–11.

Dere S, Güneş T, Sivaci R, 1998. Spectrophotometric Determination of Chlorophyll-A, B and Total Carotenoid Contents of Some Algae Species Using Different Solvents. Turk. J. Botany 22: 13–17.

Dorta E, Lobo MG, González M, 2012. Using drying treatments to stabilise mango peel and seed: Effect on antioxidant activity. LWT - Food Sci. Technol. 45:261–268.

Duan X, Jiang Y, Su X, Zhang Z, Shi J, 2007. Antioxidant properties of anthocyanins extracted from litchi (Litchi chinenesis Sonn.) fruit pericarp tissues in relation to their role in the pericarp browning. Food Chem. 101: 1365–1371.

FAO, 2003. Chapter 2: Methods of Food Analysis. Food energy- methods of analysis and conversion factors. Food and Agriculture Organization. http://www.fao.org/3/y5022e/y5022e03.html. Accessed 20 December 2020.

Ikram EHK, Eng KH, Jalil AMM, Ismail A, Idris S, Azlan A, Mokhtar RAM, 2009. Antioxidant capacity and total phenolic content of Malaysian underutilized fruits. J Food Compos Anal. 22: 388–393.

Jahurul MHA, Zaidul ISM, Ghafoor K, Al-Juhaimi FY, Nyam KL, Norulaini NAN, Mohd Omar AK, 2015. Mango (Mangifera indica L.) by-products and their valuable components: A review. Food Chem. 183: 173–180.

Kamaruddin S, Ahmad SM, Abidin NFIZ, Karuppan J, Din NM, 2012. Pemprosesan mi kuning ditambah serbuk daun ubi keledek. Bil, 2(Buletin Teknologi MARDI), pp. 83–86.

Kruger JE, Matsuo RB, Dick JW, 1996. Pasta and Noodle Technology. American Association of Cereal Chemists.

Lalel HJD, Singh Z, Tan SC, 2003. Distribution of aroma volatile compounds in different parts of mango fruit. J Hortic Sci Biotech 78: 131–138.

Larrauri JA, Rupérez P, Saura-Calixto F, 1997. Effect of Drying Temperature on the Stability of Polyphenols and Antioxidant Activity of Red Grape Pomace Peels. J Agric Food Chem 45: 1390–1393.

Legal Research Board. Food Act (1983) and Regulations (as at 5th January 2020). (2020). Petaling Jaya: International Law Book Services.

Lichtenthaler H, Wellburn A, 1983, Determinations of total carotenoids and chlorophylls a and b of leaf extracts in different solvents. Biochem Soc Trans 11: 591–592.

Maldonado-Celis ME, Yahia EM, Bedoya R, Landázuri P, Loango N, Aguillón J, Guerrero Ospina JC, 2019. Chemical Composition of Mango (Mangifera indica L.) Fruit: Nutritional and Phytochemical Compounds. Front Plant Sci 10:1073.

MARDI (Institut Penyelidikan dan Kemajuan Pertanian Malaysia), 2008. Latihan amali pemprosesan mi kuning, mi kolok dan mi sanggul. Stesen MARDI Kuching.

Meilgaard M, Civille GV, Carr BT, 1999. Sensory evaluation techniques, CRC Press, Boca Raton, Fla.

Nicoli MC, Anese M, Parpinel M, 1999. Influence of processing on the antioxidant properties of fruit and vegetables. Trends Food Sci Technol 10: 94-100.

Nielsen SS, 2003. Food Analysis (3rd edition), Kluwer Academic/ Plenum Publishers, New York.

Nilusha RAT, Jayasinghe JMJK, Perera ODAN, Perera PIP, 2019. Development of pasta products with nonconventional ingredients and their effect on selected quality characteristics: A brief overview. Int J Food Sci 2019.

Nisha, Bhatnagar V, 2020. Mango Peels: A Potential Source of Nutrients and a Preservative. In M Thakur, VK Modi, eds, Emerging Technologies in Food Science: Focus on the Developing World, Springer Singapore, Singapore, pp. 139–146.

Noble AC, 1996. Taste-aroma interactions. Trends Food Sci Technol 7: 439–444.

Nur Azura Z, Radhiah S, Wan Zunairah WI, Nurul Shazini R, Nur Hanani ZA, Ismail-Fitry MR, 2020. Physicochemical, cooking quality and sensory characterization of yellow alkaline noodle: Impact of mango peel powder level. Food Research 4: 70–76.

Othman A, Ismail A, Abdul Ghani N, Adenan I, 2007. Antioxidant capacity and phenolic content of cocoa beans. Food Chem 100: 1523–1530.

Phisut N, 2012. Spray drying technique of fruit juice powder: some factors influencing the properties of product. Int Food Research J 19: 1297–1306.

Prosky L, Asp NG, Furda I, Devries JW, Schweizer TF, Harland BF, 1985. Determination of Total Dietary Fiber in Foods and Food Products: Collaborative Study. J Assoc Off Anal Chem 68: 677–679.

Ramu L, Basha S J, Jakeer Basha S, Bhasker V, 2018. Physio-chemical analysis of spinach paste fortified instant noodles. Int J Chem Stud 6: 2373–2381.

Ranganath, KG, Shivashankara KS, Roy TK, Dinesh MR, Geetha GA, Pavithra KCG, Ravishankar KV, 2018. Profiling of anthocyanins and carotenoids in fruit peel of different colored mango cultivars. J Food Sci Tech 55:4566–4577.

Rekha MN, Chauhan AS, Prabhasankar P, Ramteke RS, Venkateswara Rao G, 2013. Influence of vegetable purees on quality attributes of pastas made from bread wheat (T. aestivum). CYTA - J Food 11:142–149.

Reungmaneepaitoon S, Sikkhamondhol C, 2008. Development of pasta products from high-iron rice and iron-fortified rice flour. Kasetsart Journal - Natural Science 42:367–375.

Reungmaneepaitoon S, Sikkhamondhol C, Jariyavattanavijit C, Teangpook C, 2008. Development of instant noodles from high-iron rice and iron-fortified rice flour. Songklanakarin J Sci Tech 30:713–721.

Reungmaneepaitoon S, Sikkhamondhol C, Tiangpook C, 2006. Nutritive improvement of instant fried noodles with oat bran. Songklanakarin J Sci Tech 28 (SUPPL. 1):89–97.

Siah WM, Faridah H, Rahimah MZ, Tahir SM, Zain DM, 2011. Effects of packaging materials and storage on total phenolic content and antioxidant activity of Centella asiatica drinks. J Trop Agric Fd Sc 39:1–7.

Shere PD, Devkatte AN, Pawar VN, 2018. Studies on Production of Functional Noodles with Incorporation of Spinach Puree. Int J Curr Microb App Sci 7: 1618–1628.

Shilton N, 2003. Drying: Chemical changes. In: Caballero B, Trugo L, Finglas P Eds., Encyclopaedia of Food and Health. Elsevier Science Ltd., Amsterdam, Netherlands, pp 1947–1950.

Singleton VL, Orthofer R, Lamuela-Raventós RM, 1999. Analysis of total phenols and other oxidation substrates and antioxidants by means of folin-ciocalteu reagent. In Oxidants and Antioxidants Part A (Vol. 299), Academic Press, pp 152–178.

Sivasankar, B, 2002. Food Processing And Preservation. Prentice Hall of India, New Delhi, India.

Sogi DS, Siddiq M, Greiby I, Dolan KD, 2013. Total phenolics, antioxidant activity, and functional properties of “Tommy Atkins” mango peel and kernel as affected by drying methods. Food Chem 141: 2649–2655.

Suleria HAR, Barrow CJ, Dunshea FR, 2020. Screening and characterization of phenolic compounds and their antioxidant capacity in different fruit peels. Foods 9(9).

Tokas J, Punia H, Baloda S, Rn S, 2020. Mango Peel : A Potential Source of Bioactive Compounds and Phytochemicals. Austin Food Sciences 5: 1–7.

Udachan IS, Pakhare KN, Dagadkhair AC, 2018. Enhancement of Nutritional and Functional Characteristics of Noodles by Fortification with Protein and Fiber: A Review. J Pharmacogn Phytochem 7: 351–35