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FULL PAPER

Physicochemical and sensory properties of bread incorporated with Melon Manis Terengganu (*Cucumis melo* var Inodorus cv. Manis Terengganu 1) peel powder

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Abstract

Melon Manis Terengganu (MMT) is one of the commonly cultivated melon in Terengganu. However, little study has been reported on value-added products from MMT and its by-product. This study aimed to determine the physicochemical and sensory properties of bread incorporated with Melon Manis Terengganu (MMT) peel powder. The MMT peels were dried in a drying oven and sieved, prior to the determination of its proximate analysis. The MMT peel powder (MMTPP) was then incorporated into the bread formulation at four different levels (0% (control), 3%, 6%, 9%, 12%). All bread samples were analysed for physicochemical and sensory properties. It was found that MMTPP contained 12.13% moisture, 5.89% ash, 2.17% crude fat, 6.86% crude protein, 36.76% crude fibre and 36.18% carbohydrate. The incorporation of MMTPP in bread formulation increased the crude fibre (6.12 – 8.7%) and the moisture content (31.98 – 33.39%) while decreasing the crude protein (6.86-6.04%) and the carbohydrate content (50.44 - 46.45%). However, the ash content only increased after a 9% MMTPP incorporation level and there was no significant difference ($p>0.05$) in the crude fat content. Besides, the lightness of crust colour increased while the crumb colour decreased with increasing level of MMTPP. However, the yellowness for both the crust and the crumb colour increased with increasing MMTPP substitution. Next, the hardness of bread increased while the springiness and the resilience decreased with the addition of MMTPP. It was also found that the volume and the specific volume of bread decreased significantly with increasing MMTPP incorporation. In addition, the sensory analysis showed that the most acceptable bread was control bread, followed by bread with 3% MMTPP.

1. Introduction

Melon Manis Terengganu (MMT) or its scientific name of *Cucumis melo* var Inodorus cv. Manis Terengganu 1 is a type of melon available commercially in Malaysia. MMT is usually consumed fresh or processed into products such as juice and ice cream due to the high nutritional contents of fruit (Utusan Malaysia, 2017). The unique properties of MMT are its crunchiness and its sweet taste with Brix between 12-15%. However, MMT peels are currently not utilized for any commercial purposes. Peels are the major by-products left over after the fruits or vegetables are processed or consumed, thereby creating ‘waste’ (Nurliyana *et al.*, 2010). It is normally used as animal feed, and it may lead to environmental problems if not managed properly. However, fruit peels are rich in dietary fibre and antioxidant compounds and they can incorporate into functional foods (Wachirasiri *et al.*, 2009). Consumption of dietary fibre gives benefits for consumers to prevent constipation and control diabetes (Kranz *et al.*, 2012). This is because foods that contain high soluble dietary fibre are classified as low glycemic index (GI) foods. Besides, low GI foods slow down the rate of glucose release into the blood and reduce insulin resistance, thus reducing the possibility of developing risk factors of degenerative diseases such as hypertension and obesity. Thus, in recent years, fruit peels have attracted many researchers to study their potential as a dietary fibre and antioxidant source (Ibrahim *et al.*, 2018).

The global bread market is projected to increase by 1.43% annually from 2019 to 2024 (Mordor Intelligence, 2021). The popularity of bakery products has contributed to increased demand for ready-to-eat, convenience food products, such as bread, biscuits and other pastry products (Maaruf *et al.*, 2006). In most countries, bread has always been a staple food and its constituents are

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most the vital sources of nutrients such as proteins, fibres, minerals and vitamins (Kamaljit *et al.*, 2010). Since loaves of bread are consumed in large quantities daily, they provide a convenient medium for delivering dietary fibre and other health compounds to consumers. In recent years, many studies have added natural foodstuffs waste containing beneficial ingredients to bread, to develop healthy functional foods (Sangnark and Noomhorm, 2004). Furthermore, many food ingredients have been included in bread formulation to increase its diversity, nutritional value and product appeal. Previous studies have been reported on the incorporation of fruit peel in bread including from watermelon rind (El-Badry *et al.*, 2014), pumpkin peel (Staichok *et al.*, 2016), banana peel (Bandal *et al.*, 2014), pomegranate peel (Sulieman *et al.*, 2016) and orange peel (Okpala and Akpu, 2014). However, until now no study has been reported on the proximate analysis of Melon Manis Terengganu peel powder as well as its incorporation on the physicochemical and sensory properties of bread. Thus, the aim of this study was to determine the effect of incorporating Melon Manis Terengganu (MMT) peel powder in the physicochemical and sensory properties of bread incorporated with.

2. Materials and methods

2.1 Materials

A total of 20 kg of whole mature fresh Melon Manis Terengganu (MMT) were purchased from a local farmer in Manir, Kuala Terengganu. Each MMT fruit weighed between 1 – 1.5 kg. Ingredients for bread making include all-purpose flour (MFM Cap Rose, 9% protein content), instant dry yeast (Mauripan brand), salt (Adabi brand), castor sugar (Prai brand), non-fat milk powder (HOI Bakers brand) and shortening (Adela brand) were purchased from a local grocery store in Kuala Terengganu. All chemicals and reagents used were of analytical grades.

2.2 Methods

In this study, MMT peel was dried and ground into powder form. Then the MMT peel powder was analyzed for its proximate analysis. Next, MMT peel powder was incorporated at different levels (3-12%) in bread formulations. The resulting bread was analysed for its physical properties, chemical properties and sensory acceptance.

2.2.1 Preparation of Melon Manis Terengganu peel powder

Preparation of Melon Manis Terengganu peel powder (MMTPP) was carried out using a method described by Potter *et al.* (2006). Whole MMT fruits were washed, peeled and separated into pulp and peel. Then, the MMT peels were cut into small pieces (1 cm × 1 cm) and dried in a cabinet dryer (model FDS-380, Protech, Chemesis Sdn Bhd) at 50°C for 48 hrs. Next, the dried peels were ground at 2850 rpm/min into powder form (250 µm) using a basic grinder (model SK100, Retsch, Retsch GmbH). Then the MMTPP was stored in an airtight container at room temperature (25°C) for further use.

2.2.2 Proximate analysis

Proximate analysis of MMTPP and bread was determined using AOAC methods (AOAC, 2005). Moisture content was determined using the oven drying method, while crude fat content was determined using the Soxhlet method. For crude protein, the Kjeldahl method was used, while ash content was determined using dry ashing. For crude fibre, it was determined after chemical digestion and solubilization of other materials present. The carbohydrate content was determined by difference (AOAC, 2005). However, for crude protein content calculation, the conversion factor of the nitrogen to the protein content of 5.7 was used for bread samples, while 6.25 was used for MMTPP.

2.2.3 Preparation of bread

The formulation of bread was modified from Gisslen (2009) as shown in Table 1. Dry ingredients including bread flour, instant yeast, non-fat milk powder, castor sugar, salt and MMTPP followed by mixing in a stand mixer (model 5KPM50, KitchenAid, Whirpool Corporation, USA). Then, water was added at a continuous pace of mixing until the dough was formed (speed 2 for 15 mins). After that, shortening was added. Then, the dough was kneaded for 20 mins until a smoother dough was formed, followed by fermentation of dough for 30 mins in a dough proofer (model PH 1826 -15+, Food Warming Equipment Co. Inc., USA) at relative humidity (RH) setting of 3 (to avoid skin formation on dough surface) and temperature of 30°C. After 30 mins, the bread was punched, kneaded and rounded for 5 mins. After that, the dough was brought to rest for another 10 mins. After resting, the dough was rolled and folded to fit into the greased bread mould (400 g per mould). Next, the dough was proofed in the dough proofer for 15 mins. The proofed dough was baked at 170°C for 30 mins. The resulting pieces of bread were then analysed for their physicochemical and sensory properties.

2.2.4 Physical analysis

2.2.4.1 Specific volume

Determination of specific volume was performed according to the method described by Mohamed *et al.*

Table 1. Formulation of bread incorporated with MMTPP

Ingredients	Formulation				
	A (0% MMTPP)	B (3% MMTPP)	C (6% MMTPP)	D (9% MMTPP)	E (12% MMTPP)
MMTPP %	0	3	6	9	12
MMTPP (g)	0	12	24	36	48
Bread flour (g)	400	388	376	364	352
Water (g)	240	240	240	240	240
Salt (g)	10	10	10	10	10
Instant yeast (g)	5	5	5	5	5
Castor sugar (g)	20	20	20	20	20
Non-fat milk powder (g)	15	15	15	15	15
Shortening (g)	15	15	15	15	15

Source: Modified from Gisslen (2011)

(2010). The determination of bread volume was performed by the rapeseed displacement method after the bread was cooled to room temperature. Mung bean was used to replace rapeseed. A container with a known volume that is bigger than the bread volume was used. The final bread volume was determined as the amount of mung bean displaced (mL) by the bread in the container. Next, the bread was weighed using an electronic balance (model TX3202L, Shimadzu, Shimadzu Corp.). The specific volume (mL/g) of the bread was determined by using the following formula:

$$\text{Specific volume (mL/g)} = \frac{\text{Loaf volume of bread}}{\text{Weight of bread}}$$

2.2.4.2 Texture profile analysis

Texture analysis of bread was determined according to the Texture Profile Analysis (TPA) method by using a texture analyzer, T.A.X.T Plus Texture Analyzer (Stable Micro System Ltd., UK) with a 75 mm cylinder probe (P/75R) (Arora and Saini, 2016). After baking, the bread was left to cool before texture analysis was carried out. Then the central part of the bread was cut into a dimension of 3×3×2 cm. The TPA was conducted under these specifications; pre-test speed: 1.0 mm/s, test speed: 1.0 mm/s, post-test speed: 5.0 mm/s, strain: 60%, trigger type: auto-5 g, tare mode: auto, data acquisition rate: 250 pps. The texture characteristics analysed were hardness, springiness and resilience.

2.2.4.3 Colour profile analysis

The colour of the crust and crumb were measured by using the Konica Minolta colorimeter. L* (brightness: 0 = black, 100 = white), a* (+ value = red, - value = green) and b* (+ value = yellow, - value = blue). The illuminant used was D_{25} and the values of L*, a* and b* values of white standard tile were used as references for calibration purposes. Average of three values of three different standard points on bread crust and crumbs were calculated and compared (Hamzah and Wong, 2012).

2.2.5 Sensory analysis

The affective test (acceptance test) was carried out by 40 untrained panels from Universiti Malaysia Terengganu. This test was carried out for all formulations of bread to evaluate different sensory attributes which were crust colour, crumb colour, odour, shape, crumb texture, taste and overall acceptability. The samples were sliced into a standard size of 30×15×30 mm and were packed in transparent plastic packaging and sealed. All samples were coded with 3-digit codes and were permute before it was served to the participants in the tray. All panels were asked to evaluate the bread samples using a 7 points hedonic scale with 7 = extremely like, 6 = like very much, 5 = like, 4 = neither like nor a dislike, 3 = dislike, 2 = dislike very much, 1 = extremely dislike (Julianti *et al.*, 2015).

2.2.6 Data analysis

The results of the analysis were stated as mean and standard deviation. The data analysis was carried out by using Minitab 19 software. The data were subjected to a one-way analysis of variance (ANOVA) to test the significant differences between bread formulations. The differences between ranges of the properties were determined by using the Least Significant Differences (LSD) tests at a 95% confidence level ($p<0.05$).

3. Results and discussion

3.1 Proximate composition of Melon Manis Terengganu peel powder

It was found that the total weight of MMTPP obtained was 58.61 g from 1 kg of fresh MMT peel. Table 2 shows the results of the proximate composition of MMTPP. The moisture content (12.13%) was relatively moderate for powder/flour. For wheat flour, the low moisture content will extend the shelf life of flour, with a maximum moisture content of 14% (Nasir *et al.*, 2003). The moisture content of MMTPP was in a similar range to other fruit peel/by-products (ranging from 6.28% for pineapple pomace and 16.95% for melon peel (*Maazoun* variety) (Wu and Shiau, 2015; Mallek-Ayadi *et al.*, 2017). The moisture content of fruit peel is affected by the drying process being carried out.

Table 2. Proximate analysis of MMTPP

Component	Content (%)
Moisture	12.13±0.12
Ash	5.89±0.07
Crude fat	2.17±0.20
Crude protein	7.53±0.16
Crude fiber	36.76±0.11
Carbohydrate	35.51±0.12

The protein content of MMTPP (7.53%) was in a similar range to those of melon peel (*Maazoun* variety) (7.48%), mangosteen rind (7.48%), carrot pomace (6.5%) and apple pomace (6%) (Winuprasith and Suphantharika, 2013; Bchir *et al.*, 2014; Nagarajaiah and Prakash, 2015; Mallek-Ayadi *et al.*, 2017). However, it is higher than those of mango peel (1.56-2.47%) (Noor Aziah *et al.*, 2011; Ibrahim *et al.*, 2018), apple pomace (2.06%) (Sudha *et al.*, 2007), jackfruit rind (4.52%) (Feili *et al.*, 2013), banana peel (Suresh *et al.*, 2014) (2.14%) and pineapple pomace (5.74%) (Wu and Shiau, 2015). However, higher protein has been reported for watermelon rind (8.70%) (El- Badry *et al.*, 2014), Sharlyn melon peel (9.07%) (Al- Sayed and Ahmed, 2013), pomegranate peel (18.24%) (Gül and Şen, 2017), tomato pomace (16.31% dry basis) (Isik and Topkaya, 2016), orange peel (16.51%) (Adewole *et al.*, 2014), grape pomace (11.49% dry basis) (Bender *et al.*, 2016) and pumpkin peel (12.5%) (Mala and Kurian, 2016). The protein content is different between different fruit peels due to the difference in species and varieties of fruits as well as the external factor such as climate and soil conditions.

Table 2 shows that MMTPP contained 36.76% crude fibre. This value was higher than those of mango peel (11.40%) (Ibrahim *et al.*, 2018), banana peel (21.51%) (Suresh *et al.*, 2014), sharlyn melon peels (29.59%) (Al-Sayed and Ahmed, 2013), orange peel (12.47%) (Adewole *et al.*, 2014), pumpkin peel (13.91%) (Mala and Kurian, 2016), and watermelon rinds (16.8%) (Al-Sayed and Ahmed, 2013). However, it was lower than those of grape pomace (67.95% dry basis) (Bender *et al.*, 2016).

Besides, the ash content of MMTPP (5.89%) in this study is quite similar to those of jackfruit rind (5.91%) (Feili *et al.*, 2013), orange peel (5.21%) (Adewole *et al.*, 2014), carrot pomace (5.12%) (Nagarajaiah and Prakash, 2015) and pumpkin peel (6.04%) (Mala and Kurian, 2016). However, MMTPP has higher ash content than mango peel (2.5-2.92%) (Noor Aziah *et al.*, 2011; Ibrahim *et al.*, 2018), apple pomace (0.50%) (Sudha *et al.*, 2007), pineapple pomace (3.18%) (Wu and Shiau, 2015), pomegranate peel (3.21%) (Gul and Sen, 2017), apple pomace (1.4%) (Bchir *et al.*, 2014), tomato pomace (3.49% dry basis) (Isik and Topkaya, 2016), dragon fruit peel (0.1%) (Jamilah *et al.*, 2011), mangosteen rind (4.47%) (Winuprasith and Suphantharika, 2013), Melon peel (*Maazoun* variety) (3.67%) (Mallek-Ayadi *et al.*, 2017). However, higher ash content was reported in grape pomace (10.53% dry basis) (Bender *et al.*, 2016), watermelon rind (12.93%) (El- Badry *et al.*, 2014), sharlyn melon peel (11.09%) (Al- Sayed and Ahmed, 2013) and banana peel (12.93%) (Suresh *et al.*, 2014).

Furthermore, the amount of total carbohydrates of MMTPP (36.18%) is higher compared to those of mango peel (73.57%-76.82%) (Noor Aziah *et al.*, 2011; Ibrahim *et al.*, 2018), dragon fruit peel (6.20%) (Jamilah *et al.*, 2011) and grape pomace (1.4% dry basis) (Bender *et al.*, 2016). However, it is lower than those of watermelon rinds (56.02%) (El- Badry *et al.*, 2014), and mango peels (73.57%) (Noor Aziah *et al.*, 2011), jackfruit rind (79.32%) (Feili *et al.*, 2013), orange peel (40.47%) (Adewole *et al.*, 2014), banana peel (50.26%) (Suresh *et al.*, 2014), pumpkin peel (55.61%) (Mala and Kurian, 2016), mangosteen rind (81.60%) (Winuprasith and Suphantharika, 2013) and Melon peel (*Maazoun* variety) (69.77%) (Mallek-Ayadi *et al.*, 2017).

3.3 Proximate analysis of bread incorporated with Melon Manis Terengganu peel powder

Four formulations of bread incorporated with MMTPP were prepared using different levels of MMTPP (excluding control). Then the pieces of bread were analysed for proximate analysis (Table 3).

Table 3 shows that the range of moisture content in bread obtained was from 31.98-33.39%. The range of moisture content in this study was in a similar range with bread incorporated with watermelon rind (36.61-43.77 %), pumpkin flour (32.02-35.32%) (See *et al.*, 2007), cake incorporated with mango peel (35.38-35.91) (Noor Aziah *et al.*, 2011) and muffins incorporated with apple skin (31.39-30.39%) (Rupasinghe *et al.*, 2008). Table 3 shows that the moisture content of the bread incorporated with MMTPP increased with an increasing amount of MMTPP in bread formulation, but not all differences were significant ($p<0.05$). Control bread gave the lowest moisture content compared to other samples incorporated with MMTPP ($p<0.05$). Moisture content for bread with 3% and 6% of MMTPP and also bread with 9% and 12% of MMTPP was not significantly different between them ($p>0.05$). This finding is supported by Felli *et al.* (2018), whereby the moisture content of bread incorporated with jackfruit rind powder also increased with the increasing

Table 3. Proximate analysis of the breads incorporated with different amount of MMTPP

Component (%)	0% MMTPP	3% MMTPP	6% MMTPP	9% MMTPP	12% MMTPP
Moisture	31.98±0.12^{c}	32.28±0.10^{b}	32.44±0.11^{b}	33.18±0.11^{a}	33.39±0.12^{a}
Ash	1.92±0.08^{c}	1.95±0.08^{c}	2.01±0.05^{c}	2.16±0.04^{b}	2.37±0.01a
Crude fat	2.63±0.13^{a}	2.76±0.185^{a}	2.84±0.21^{a}	2.87±0.20^{a}	2.90±.0.15^{a}
Crude protein	6.86±0.05^{a}	6.69±0.10^{ab}	6.53±0.06^{b}	6.29±0.09^{c}	6.04±0.08^{d}
Crude fiber	6.12±0.07^{e}	6.84±0.12^{d}	7.73±0.08^{c}	8.33±0.03^{b}	8.70±0.10^{a}
Carbohydrate	50.44±0.09^{a}	49.49±034^{a}	48.43±0.24^{b}	47.15±0.57^{c}	46.45±0.59^{c}

Values are presented as mean±standard deviation of three replications. Values with the same supersripts within the same row are not significantly different (p>0.05), between samples.

level of jackfruit rind powder. Similar findings have been reported by Eshak (2016) and Salgado *et al.* (2011) and were increased the substitution level of cupuassu peel and banana peel powder increased the moisture content of the bread. Higher moisture content could be due to the addition of fibre from MMT peel in bread formulation where fibre has a higher water holding capacity than starch (Kethireddipalli *et al.*, 2002). Furthermore, the moisture content of bread is highly dependent on the flour composition which gives an effect the water absorption and also on the yield of the dough (Buksa *et al.*, 2010).

Ash content is an indicator of the presence of minerals in flour (Adejuyitan *et al.*, 2009). Table 3 shows the ash content of the bread incorporated with different levels of MMTPP was from 1.92% to 2.37%. The ash content of pieces of bread in this study is in a similar range with bread incorporated watermelon rind (1.18-2.75%) and cupuassu peel (1.61-1.66%) (Salgado *et al.*, 2011; El- Badry *et al.*, 2014). Table 3 shows there was no significant difference in ash content of bread samples for control bread, 3% and 6% incorporation of MMTPP (p>0.05). However, bread with 12% of MMTPP gave higher ash content than that of 9% of MMTPP and the rest of the bread samples. The ash content of MMTPP was 5.89%, while the ash content of wheat flour was only 0.78% (Feili *et al.*, 2013). Since MMTPP has higher ash content than wheat flour, higher levels of MMTPP substitution would increase the ash content in bread, but only above 9% incorporation of MMTPP (p<0.05). Previous studies also found that the addition of watermelon rind powder (WRP) in bread gave higher ash content compared with the control bread, due to WRP containing 12.93% ash while wheat flour only contained 0.73% ash (El- Badry *et al.*, 2014). Similar findings have also been reported for bread incorporated with pomegranate peel and orange peel (Babiker *et al.*, 2013; Sayed-Ahmed, 2014).

According to Ballad (2009), fat in the bread plays a role in increasing the size of the loaf and the colour of the bread is more evenly distributed and also helps it to prolong the bread shelf life by acting as an anti-stalling agent. Table 3 shows that the range of crude fat content in bread was between 2.63% to 2.90%. A similar range of fat content has been reported in bread incorporated with pumpkin flour (2.59-2.44%) and jackfruit rind (2.21 -2.63%) (See *et al.*, 2007; Felli *et al.*, 2018). However, there was no significant difference in the crude fat content of all bread samples (p>0.05). The crude fat content of wheat flour is about 0.72% (Feili *et al.*, 2013) while that of MMTPP was 2.17%. However, incorporation of up to 12% MMTPP did not change the crude fat content of bread significantly. Similar findings have been reported by Al-Sayed and Ahmed (2013) for cake incorporated with sharlyn melon peel powder whereby there was no significant difference in fat content with the increasing amount of melon peel powder. However, Costa *et al.* (2018) reported a significant increase in fat content of bread incorporated with 30% pumpkin seed flour (7.72-9.39%) as compared to that of control (6.17%).

The protein content is an important criterion in producing quality bread due to the development of gluten protein which is composed of gliadin and glutenin, which is responsible for the strength and structure of bread (Gisslen, 2007). Table 3 shows that the crude protein content in bread samples was from 6.86% to 6.04%. Table 3 also shows that in general, there was a decreasing trend of crude protein content with an increasing percentage of MMTPP incorporation. However, bread with 3% MMTPP was not significantly different (p>0.05) from control bread and that with 6% MMT incorporation. Eshak (2016) also reported a similar study with an increasing amount of banana peel powder incorporated into the bread. The decreasing trend in protein content of bread incorporated with MMTPP is due to higher protein content in wheat flour (9%) compared to MMTPP (7.53%). Wu and Shiau (2015) reported a similar trend in this study where pineapple peel powder (5.74%) had lower protein content than wheat flour. Besides, higher gluten content will have a higher ability to trap more air in bread (Annett *et al.*, 2007).

Generally, crude fibre covers the insoluble fractions of fibre, which are cellulose, hemicelluloses and lignin. Table 3 shows that the range of crude fibre in bread was from 6.12% to 8.70%. There was an increasing trend in the crude fibre content of bread with increasing levels of MMTPP substitution. All bread samples gave significantly different crude fibre ($p<0.05$) between them. Sayed-Ahmed (2014) reported a similar finding for crude fibre content in bread incorporated with pomegranate peel powder also gave a significant difference with the increasing level of substitution.

Table 3 shows that the carbohydrates content of bread samples ranged from 50.44% to 46.45%. Table 3 shows that carbohydrate content decreased with increasing incorporation of MMTPP, however, some changes were not significantly different ($p<0.05$). There was no significant difference in carbohydrate content of control bread and bread with 3% MMTPP and those of 9% and 12% MMTPP ($p>0.05$). El-Badry *et al.* (2014) reported a similar trend where increased substitution of watermelon rind powder in bread will decrease the carbohydrate content in bread. A similar result was reported by Noor Aziah *et al.* (2011) where the increased level of mango pulp powder decreased the carbohydrates content in cake. The increased crude fibre content serves a crucial role in reducing the total available carbohydrate, thus lowering calories in bread. Significant increase in moisture and ash content ($p<0.05$) also contributes to the significant ($p<0.05$) decrease in total available carbohydrates. A similar study has been reported in Eshak (2016), whereby increased crude fibre content of balada flatbread substituted with banana peel flour caused a significant ($p<0.05$) decrease in carbohydrate content.

3.4 Physical properties of bread incorporated with Melon Manis Terengganu peel powder

Loaf volume is regarded as the most important bread characteristic since it provides a quantitative measurement of baking performance (Tronsmo *et al.*, 2003). The range of loaf volume in bread was obtained from 2826 mL (control bread) to 2791 mL (12% of MMTPP). Table 4 shows that the loaf volume of bread incorporated with MMTPP decreased with the increasing level of MMTPP. The increasing level of MMTPP in bread is expected to further reduce the loaf size of the bread, however, some changes were not significant ($p<0.05$). Bread with 0% and 3% MMTPP gave the highest loaf volume of all the samples. Lee *et al.* (2019) also reported that as more fibre in corn cob flour was substituted in the bread, a pronounced decrease in volume was observed. At higher fibre incorporation, the lower protein network occurs because there is a weak interaction between starch and gluten. The high fibre content of the bread can reduce the effectiveness of gluten proved in the bread, affecting the optimal gluten matrix formation during mixing, fermentation and baking. Hence it cannot stretch and rise (Pomeranz *et al.*, 1977). A similar study was reported by Fendri *et al.* (2016) for the incorporation of bread with pea pod powder and Sudha *et al.* (2007) for the incorporation of cake with apple pomace powder.

Specific volume is widely accepted as a more reliable method to measure the loaf size. Table 4 shows the specific volume of bread incorporated with different levels of MMTPP substitution. The range of specific volume obtained in this study was 4.25 mL/g (control bread) to 4.06 mL/g (12% of MMTPP). The range of specific volume in this study was in a similar range compared to bread incorporated with mango peel (4.24-2.57) (Ibrahim *et al.*, 2018). Table 4 shows a decrease in a specific volume of bread with an increasing level of MMTPP. It is significantly different ($p<0.05$) in the specific volume of all the samples except for those of 9% and 12% MMTPP. Similar results were reported by Sudha *et al.* (2007), where the increased substitution of wheat flour with apple pomace powder in cake formulation has decreased the volume of cake. In addition, Wu and Shiau (2015) also reported similar

Table 4. Physical properties of breads incorporated with different amount of MMTPP

Properties (%)	0% MMTPP	3% MMTPP	6% MMTPP	9% MMTPP	12% MMTPP
Loaf volume (mL)	2826±2.8[a]	2828.5±2.1[a]	2807±4.2[b]	2801.5±3.5[b]	2791±4.2[c]
Specific volume (mL/g)	4.25±0.009[a]	4.21±0.015[b]	4.16±0.017[c]	4.09±0.012[d]	4.06±0.016[d]
Colour of crust (L* value)	55.56±0.28[c]	63.92±1.48[b]	69.09±2.14[a]	70.4±0.59[a]	71.20±0.10[a]
Colour of crust (a* value)	16.7±0.31[a]	13.1±0.80.31[b]	7.98±1.6[c]	5.53±0.23[d]	1.49±0.46[e]
Colour of crust (b* value)	41.78±0.2[d]	43.7±0.53[c]	44.62±0.29[c]	46.5±1.4[b]	47.95±0.54[a]
Colour of crumb (L* value)	76.6±1.74[a]	75.7±0.85[ab]	74.1.33[b]	70.0±1.00[c]	68.7±0.41[c]
Colour of crumb (a* value)	-4.23±0.08[e]	-3.29±0.43[d]	-2.73±0.12[c]	-2.14±0.21[b]	-1.27±0.14[a]
Colour of crumb (b* value)	26.35±0.73[e]	32.54±0.69[d]	35.55±0.23[c]	37.73±0.41[b]	39.87±0.49[a]
Hardness (g)	1226±207[c]	1571±374[c]	2159±366[b]	2681±366[b]	3258±388[a]
Springiness (%)	0.69±0.05[a]	0.57±0.01[b]	0.54±0.02[b]	0.49±0.05[c]	0.44±0.03[c]
Resilience (%)	0.15±0.008[a]	0.134±0.011[a]	0.11±0.014[b]	0.099±0.016[b]	0.093±0.007[b]

Values are presented as mean±standard deviation of three replications. Values with the same supersripts within the same row are not significantly different ($p>0.05$), between samples.

results in bread incorporated with pineapple pomace powder. The quantity and quality of the protein in the flour as well as the proofing time can control the loaf volume of the bread. According to Shittu *et al.* (2007), the temperature and the baking time also influence the loaf volume and specific volume. Besides that, the reduction of specific volume may occur due to higher levels of fibre content in bread which can increase the water absorption capacity (Chen *et al.*, 1988).

The crust colour is influenced by the physicochemical characteristics of the raw dough such as its water content, pH and reducing amino acid content (Zanoni *et al.*, 1995). It is also influenced by the temperature, airspeed and relative humidity during the operations condition. Table 4 shows the L* value of bread crust incorporated with different levels of MMTPP substitution. The range of L* values obtained was 55.56 to 71.20. This L* of bread crust in this study was quite similar to the bread incorporated with corn cob flour (55.58-70.26) (Lee *et al.*, 2019. Table 4 also shows the a* value of bread crust incorporated with different levels of MMTPP substitution. The range of a* values obtained was 16.67 to 1.49. Amir *et al.* (2013) reported a* values within a similar range to this study for bread incorporated with cocoa pod husk powder (12.23-7.11). Table 4 also shows the b* value of bread crust incorporated with different levels of MMTPP substitution. The range of b* values obtained was 41.78 to 47.95. The b* values in this study were lower compared to those reported by Fendri *et al.* (2016) in bread incorporated with pea pod powder (102.24-54.84).

As shown in Table 4, the L* values (lightness) for crust colour increased with the increasing level of MMTPP incorporation. However, some of the changes were not significantly different. A similar study was reported by Feili *et al.* (2013) where the incorporation of jackfruit rind powder (JRP) in bread had a significant difference between the control sample and 5% of JRP. Next, there was a decreasing trend observed in Table 4 for the a* (redness) of crust colour with increasing MMTPP incorporation. All samples gave significant differences in a* values ($p<0.05$). A similar study was reported by Lee *et al.* (2019) where the bread incorporated with corn cob flour had a significant difference between all samples.

Scanlon *et al.* (1993) reported that the bread crumb colour can be determined by the crumb's cellular structure or its grain. Table 4 shows the L* value of bread crumbs incorporated with different levels of MMTPP substitution. The range of L* values obtained was 76.60 to 68.72, which is quite similar to L* values for the bread incorporated with grape pomace powder (75.01-51.54) (Hayta *et al.*, 2014). The range of a* values obtained was -4.32 to -1.27. Kampuse *et al.* (2015) reported a* values within a similar range to this study for bread incorporated with pumpkin pomace powder (-4.41- -3.42). The b* values of bread crust incorporated with different levels of MMTPP substitution were between 26.35 to 39.87. Lee *et al.* (2019) reported on bread incorporated with corn cob flour found the b* values of 17.42-31.41, which is slightly lower than this study. Table 4 shows the L* value (lightness) for crumb colour decreased with the increasing level of MMTPP incorporation. However, some of the changes were not significantly different. Wu and Shiau (2015) reported that the L* value of pineapple pomace powder had slightly significant differences between all the samples. Furthermore, there was an increasing trend for the a* (redness) and the b* (yellowness) of crumbs with increasing MMTPP incorporation. All samples gave significant differences in a* and b* values ($p<0.05$). A similar study was reported by See *et al.* (2007) where the a* and the b* value of bread incorporated with pumpkin flour had a significant difference between all samples. The trend colour of bread crumbs in this study was similar to the trend reported by Hsu et al (2019) and Amir *et al.* (2013) where an increased level of pitaya peel powder and cocoa pod husk powder in bread will decrease the L* value and increase the a* and the b* value.

The colour change of bread might be related to the fact that colour pigments and phenolic compounds went through the oxidation reaction. This is expected as Gomez *et al.* (2003) also found that the colour of the crumb usually is similar to the colour of fibre added. In addition, the crumb colour changed from white (control) to brown (12% MMTPP) also due to the Maillard reaction of wheat protein and the additional glucose contained in loaves (Jamilah *et al.*, 2011). Similar findings have been reported by See *et al.* (2007), in which the colour of bread crumbs changed from light brown (control) to darker brown (12% pumpkin flour) due to the additional sugar contained in loaves.

The measurement for the texture profile analysis (TPA) was done to check the textural quality of the bread. The characteristics that had been analysed are hardness, springiness and resilience. Firstly, hardness is defined as the force required to compress the product by a pre-set distance. Hardness is an important characteristic and is commonly used as an index of bread quality (Wang *et al.*, 2007). Table 4 shows the hardness of bread crumbs incorporated with different levels of MMTPP substitution. In this study, the range of hardness obtained was between 1226 and 3258 g. Table 4 also shows that the hardness of bread increased as the level of MMTPP increased, however, not all increments were significant. Bread with 12% MMTPP gave the highest hardness, followed by those of 6% and 9% (which is not significantly different) and finally those of 0 and 3% MMTPP. A similar study reported by Hayta *et al.* (2014) where bread was incorporated with grape pomace powder (GPP) had a significant difference between control and bread with 15% GPP. The trend of hardness in this study was also similar to bread incorporated with mango peel and pitaya peel powder (Pathak *et al.*, 2016; Hsu *et al.*, 2019). Furthermore, an increase in bread hardness could be due to lower protein content (and lower gluten from wheat flour) and higher fibre content in MMTPP, which may affect the development of the gluten network. The hardness of bread in this study is consistent with a lower specific volume in bread with a high amount of MMTPP. In addition, the bread hardness was due to the interaction between gluten and fibrous materials (Gomez *et al.*, 2003). Fibre might cause firmer crumbs by a thickening effect of the walls that surround the air bubbles in the fibre-added dough. Several researchers had reported a similar trend of hardness for baked products with increased substitution of fibre sources (Feili *et al.*, 2013; Wu and Shiau, 2015; Pathak *et al.*, 2016).

According to Abdelghafor *et al.* (2010), springiness indicates the elastic recovery that occurs when the compressive force is removed. While, resilience indicates how a sample recovers from deformation in relation to speed and force derived (Brenda *et al.*, 2005). Both of these characteristics are related to the position recovery of the compressed bread. The range of springiness in bread obtained was 0.69% (control bread) to 0.44% (12% of MMTPP). A similar range of springiness was reported by Pathak *et al.* (2016) in bread incorporated with mango peel powder (0.30-0.55%). Besides, the range of resilience obtained was 0.15 to 0.09%. Sayed Ahmed (2014) and Liu *et al.* (2007) reported higher resilience for bread incorporated with pomegranate peel powder (0.44-0.16) and sweet potato stem powder (0.3-0.29). Table 4 shows that the springiness and resilience of bread demonstrated a decreasing trend with the addition of MMTPP. For springiness, control bread gave significantly ($p<0.05$) higher springiness than other formulations while for the resilience, bread with 0% and 3% MMTPP was significantly ($p<0.05$) resilient compared to the rest of the samples. This study was similar to the cake that incorporated orange waste, carrot pomace, potato peels and green peel powder where the increased level of substitution will decrease the springiness and resilience of the cake (Sharoba *et al.*, 2013). High springiness in control bread can be attributed to gluten formation. Breads incorporated with MMTPP suffer from gluten dilution due to the presence of lower protein content (MTTPP has no gluten) and more fibre in MMTPP. Lower gluten may cause a lower ability to hold gases which results in elasticity reduction and lowered volume in bread (Pyler, 1988).

3.5 Sensory acceptance of bread incorporated with Melon Manis Terengganu peel powder

In this study, sensory evaluation was carried out with six attributes which are colour (crust and crumb), odour, crumb texture, taste and overall acceptability. Table 5 shows the sensory scores for bread samples substituted with different levels of MMTPP.

Table 5 shows the mean score of crust and crumb colour attribute from the sensory evaluation of bread incorporated with different levels of MMTPP substitution. The range of crust colour in this study obtained was 5.6 to 4.68. A similar study reported on the bread incorporated with pitaya peel (5.22-5.48) and pumpkin pomace (5.0-5.3) (Kampuse *et al.*, 2015; Hsu *et al.*, 2019). Next, the range of crumb colour obtained was 5.73 to 4.15. The mean score of crumb colour in this study was within a similar range compared to the bread incorporated with grape pomace (4.35-4.21) (Hayta *et al.*, 2014).

Based on the results obtained, the highest score for the colour of crust attribute was given by control bread and bread incorporated with 3% MMTPP. For the colour of the crumb attribute, the highest score was given by control bread. However, the score of crust colour bread incorporated with 3% MMTPP is not significantly different from control bread and bread with 6% MMTPP. By referring to the results in Table 4, the crust colour of bread was lighter compared to the crumb colour, but it was slightly different between all the samples ($p<0.05$). Next, the darkening of crumb colour with the increase of MMTPP substitution where bread with 12% of MMTPP gave lower acceptability from the panellist. Lee *et al.* (2019) reported that the crust and crumb colour of bread was slightly different between all bread samples incorporated with corn cob flour. Therefore, incorporation of up to 3% MMTPP is acceptable for colour attributes. According to Wrolstad *et al.* (2004), the initial impression of the quality and acceptability of a food product is judged based on its visual appearance. The high score of colour attribute for control bread might be due to consumers being accustomed to the colour of bread available in the market.

Table 5 shows the mean score of odour attributes for bread incorporated with different levels of MMTPP substitution. The range of odour obtained was 5.75 to 3.43. This range of odour attributes was similar to the

Table 5. Sensory scores for bread samples substituted with different amounts of MMTPP

Attribute	MMTPP substitution level (%)				
	0	3	6	9	12
Crust colour	5.60±1.39[a]	5.63±1.19[a]	55.08±1.14[ab]	4.75±1.19[b]	4.68±1.42[b]
Crumb colour	5.73±1.38[a]	5.23±1.40[ab]	4.95±1.28[bc]	4.60±1.30[cd]	4.15±1.55[d]
Odour	5.75±1.19[a]	5.03±1.42[b]	4.21±1.34[c]	4.15±1.48[c]	3.43±1.48[d]
Crumb texture	5.3.8±1.39[a]	4.78±1.39[b]	4.45±1.30[b]	4.33±1.23[b]	3.50±1.41[c]
Taste	5.45±1.36[a]	5.00±1.50[a]	4.20±1.56[b]	3.93±1.61[b]	3.25±1.53[c]
Overall acceptability	5.55±1.39[a]	5.18±1.20[a]	4.38±1.35[b]	5.60±1.39[bc]	3.63±1.50[c]

Values are presented as mean±standard deviation of three replications. Values with the same supersripts within the same row are not significantly different (p>0.05), between samples.

bread incorporated with pineapple pomace (4.42-3.57) and grape pomace (4.14-3.64) (Hayta *et al.*, 2014; Wu and Shiau, 2015). Based on the results obtained, there was a decreasing trend in odour scores with an increasing amount of MMTPP incorporated in the bread. There was a significant difference (p<0.05) between all samples except for bread with 6% and 9% MMTPP. The highest odour score was given to control bread. A similar study was reported by Feili *et al.* (2013) where the control bread had the highest odour among all the samples that incorporated jackfruit rind powder. The trend of this study is also similar to the bread incorporated with orange peel powder and cake incorporated with sharlyn melon peel powder (Al- Sayed and Ahmed, 2013; Stoll *et al.*, 2015). Bread produced from MMTPP substitution has an odour and aroma that attracts the panels, but as the level of substitution increases, the odour becomes strong and this becomes a distraction to the panels. This can be concluded that the addition of MMTPP had a negative effect on the aroma of the final product and was least acceptable among panellists.

Table 5 shows the mean score of crumb texture attributes of bread incorporated with different levels of MMTPP substitution. The range of crumb texture scores was 5.38 to 3.50. In this study, there was a similar range of bread incorporated with tomato pomace powder (5.0-4.8) (Majzoobi *et al.*, 2011). Based on the results, the highest score for crumb texture was obtained by control bread. However, bread incorporated with 3%, 6% and 9% MMTPP had similar scores for crumb texture where they were not significantly different (p>0.05). Fendri (2016) reported a similar finding whereby the control bread had a significant difference among all the samples that were substituted with pea pod powder. Besides, panels like the moderate texture. The hardest texture of bread samples is the bread with the 12% of MMTPP substitution and gave the least acceptable formulation among panellists. Increased fibre source would result in a more compact and dense crumb texture, thereby increasing the hardness of bread so the panels needed more energy to chew the bread. A similar study was reported by El-Badry *et al.* (2014) for bread incorporated with watermelon rind powder (WRP).

Table 5 also shows the taste acceptability of bread substituted with different levels of MMTPP substitution. The range of taste scores obtained from this study was 5.45 to 3.25. The range of taste scores in this study was similar to the bread incorporated with pumpkin flour (5.73-4.87) and pumpkin pomace powder (5.0-3.0) (See *et al.*, 2007; Kampuse *et al.*, 2015). Based on the result obtained, it shows a decreasing trend of taste score with increasing incorporation of MMTPP. Furthermore, the control bread and that of 3% MMT gave the highest taste scores compared with all samples. Besides that, some of the panellists gave negative feedback towards the highest formulation (12% MMTPP) where there was a weird taste after consuming the bread. The trend of this study was similar to bread when increased levels of cupuassu peel powder decreased the taste acceptability from the panel (Salgado *et al.*, 2011).

Table 5 shows the overall acceptability for bread incorporated as affected by MMTPP substitution. The range of overall acceptability in this study was 5.55 to 3.63. The overall acceptability scores in this study were similar to the range of bread incorporated with tomato pomace powder (5.0-3.8) (Majzoobi *et al.*, 2011). It was noted that there was a decreasing trend in the overall acceptability of bread with the increasing incorporation of MMTPP. Next, control bread and bread with 3% MMTPP gave the highest overall acceptability (p<0.05) than other bread samples. This study shows that bread with 12% MMTPP substitution gave the least acceptable formulation among the panellists. The trend of this study was similar to the bread incorporated with jack rind powder (Feili *et al.*, 2013), pomegranate peel powder and mango peel powder (Sayed-Ahmed, 2014; Ibrahim *et al.*, 2018).

In short, the bread with 3% MMTPP gave similar acceptability scores for 4 attributes such as crumb colour, crust colour, taste and overall acceptability. However, control bread scored higher for crumb texture and odour. This study shows that the most acceptable bread was the control followed by 3% of MMTPP. Bread with 12% MMTPP was not accepted among the panels. A similar finding was reported for bread prepared with watermelon rind powder (WRP) where the substitution of WRP at 12% was not accepted among panels (El-Badry *et al.*, 2014).

Further study could be carried out on the incorporation of MMTPP into other products such as muffins, doughnuts or cake. Added flavours such as chocolate may mask the undesirable taste of MMT peel powder. Furthermore, the antioxidant properties and compounds in MMT peel powder could be studied as well using water or solvent extraction. Finally, the preparation, characterization and evaluation of nanocellulose from MMT peel powder could be explored as an emulsion stabilizer.

4. Conclusion

This study found that incorporation of 3-12% MMTPP in bread formulation has affected the proximate composition, crumb and crust colour, texture and sensory attributes of bread. The sensory analysis showed that the most acceptable bread was control bread, followed by bread with 3% MMTPP.

Conflict of interest

The authors declare no conflict of interest.

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