Functional properties of pectin from dragon fruit (Hylocereus polyrhizus) peel and its sensory attributes

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Abstract
This study was aimed to add value to the disposed dragon fruit peel from the juice industry. Pectin was extracted from the fruit peel and functional properties of pectin and its application in jam processing were investigated. Hunter ‘L*’, ‘a*’, and ‘b*’ values of the dragon fruit peel pectin were 39.95, 34.87 and 20.18 respectively, which showed light red in colour compared to the commercial apple and citrus pectin. In terms of textural properties, the dragon fruit peel pectin showed several characteristics which were similar to apple and citrus pectin. Water holding capacity of the pectin was similar to apple pectin which was 5.50 and 5.45 g/g respectively. Its oil holding capacity and swelling capacity also showed no significant difference (p >0.05) from that of citrus pectin. It was successfully applied in pineapple jam but at a high percentage of up to 2% to make it well set. For sensory attributes, no significant (p <0.05) differences were observed between the mean scores of the jam produced using dragon fruit peel pectin and apple pectin except for the colour attribute. It is therefore recommended to use this pectin as a thickener in food products such as low viscous food and beverages.

Keywords: dragon fruit peel pectin, functional properties, hydration properties, sensory attributes

Introduction
Pectin is categorised as high methoxyl (HM) or low methoxyl (LM), with degree of esterification (DE) value of >50 and <50% respectively. HM pectin forms a gel through a combination of hydrogen bonding and hydrophobicity, which is irreversible upon heating (DaSilva and Rao 1995). Generally, HM pectin will gel only in the presence of sugar or co-solutes at sufficiently low pH. Panchev et al. (1988) concluded that the optimal strength of the gel is achieved when pectin has a DE value of 57 – 58%. However, Gregory (1986) reported that pectin with molecular weight of more than 100 kda resulted in higher strength gels in dairy products. Rascon-Chu et al. (2009) studied the pectin from ‘Golden Delicious’ apples with a DE value of 57% and suggested the use of the pectin as a potential texturing agent for food industry.

In previous study, pectin was successfully extracted from dragon fruit peel using hot acid solution with a high yield of 51.44% and DE value of 88% (Nur Izalin et al. 2012). The pectin exhibited heterogenous
molar mass distributions with respect to
molecular weight which was 87 kDa and can
be considered as medium molecular weight,
and an estimated RMS radius average of
about 30 nm.

Dragon fruit (*Hylocereus polyrhizus*)
gains wide popularity in many Asian
countries including Malaysia. The peel of
the fruit is a waste from the fruit industry
and is traditionally used as fertiliser. The
peel has high dietary fibre. High amounts
of betacyanins, flavonoids and phenolic
acids are also found in both flesh and
peels (Tenore et al. 2012). Thus, dragon
fruit can be considered as a good source
of antioxidant with health benefits for
human. Several studies have also been
done on the peel (Esquivel et al. 2007;
Wybraniec et al. 2007; Jamilah et al. 2011)
in terms of pigment profiles and betacyanins
content, however, no research has been
found on pectin from dragon fruit peel and
its application.

Following the previous study about
extraction of pectin from dragon fruit peel
and its physico-chemical characteristic,
this study was carried out to investigate
the behaviour of this pectin in terms of
functional properties and organoleptic
characteristics in jam preparation.

**Materials and methods**

All chemicals including analytical grade
of apple pectin was purchased from the
Sigma-Aldrich while commercial food
grade citrus pectin was obtained from
G. K. Ingredients (M) Sdn Bhd. The raw
material was prepared by separating the
peel from the flesh. The peel was dried in
an air-circulated oven (Venticell, Medcenter
Einrichtungen GmbH, Germany) at 55 °C
until constant weight was obtained. The
dried peel was then ground by using an
electrical miller (CyclotecTM 1093, FOSS
Analytical AB, Sweden). The powder
obtained was stored at 4 °C prior to analysis.
All chemicals used in this experiment were
of analytical grade and were purchased from
Sigma-Aldrich.

Pectin from dragon fruit peel was
extracted using hot citric acid extraction at
67.5 °C for 70 min and pH 2.0. After that,
the slurries were cooled to room temperature
(25 °C) and filtered through a Buchner
funnel connected to the vacuum pump.
Following that, the filtrate was concentrated
to half of its volume using vacuum glass
evaporator at 52 ± 1 °C (Faravash and
Ashtiani 2007) before precipitation with two
volumes of 96% w/w ethanol, filtered again
and washed three times with 50, 75 and
100% ethanol. Lastly, the polysaccharide
was dried in an air-circulated oven at 50 °C
for 15 hand milled to get the pectin powder.

Colour of the pectin powder was
examined using Minolta Chroma Meter
(CR-300, Japan) with the L*, a* and b*
colour scale. L* is defined as lightness
(ranging from 0, black to 100, white), a*
which is the positive value for reddish
colours and negative values for greenish
colours, and b* which is the positive value
for yellowish colours and negative for bluish
colours. The colorimeter was standardised
with the reference white plates before each
measurement was taken.

Pectin gels were prepared according
to Rascon-Chu et al. (2009) at 3%
concentration by adding sucrose and the
pH was adjusted to 2.7. The solution was
boiled for 30 min to get 60 °Brix of syrup.
The solution was allowed to set for 12 h
(overnight) at 4 °C and the gel strength
(g) was measured using TA-XT2 Texture
Analyser (Stable Micro Systems, England)
using 0.5” cylinder probe (P/0.5) at
1.0 mm/s up to 15 mm depth. After
conditioning, the sample was positioned
centrally under the standard probe and
the penetration test was commenced.
The parameters of hardness, springiness,
cohesiveness, gumminess, chewiness and
resilience were recorded.

Water holding capacity (WHC)
was determined using the method
described by Massiot and Renard (1997).
One hundred mg of dragon fruit peel
pectin powder was added to 25 ml of
distilled water in a 50 ml centrifuge tube and incubated overnight at 4 °C. Then the mixture was centrifuged at 13 °C, 600 g for 20 min. The supernatant was removed and the slurry was dried at room temperature for 2 h. The wet sample was weighed again and dried for 2 h at 120 °C. Lastly, the dried sample was weighed to get the weight of dry residue. Water holding capacity was expressed as:

\[ \text{WHC} = \frac{\text{g of water}}{\text{g of pectin powder}} \]

Oil-holding capacity (OHC) was measured using a method described by Caprez et al. (1986). One hundred mg of pectin was added to 10 ml of corn oil in a 50 ml centrifuge tube. The content was stirred, then the tubes were centrifuged at 1500 g for 30 min. The supernatant was weighed and OHC was expressed as:

\[ \text{OHC} = \frac{\text{g of supernatant}}{\text{g of pectin powder}} \]

Swelling capacity (SC) was measured using a method described by Weightman et al. (1995). Sample of 100 mg was weighed in cone-shaped plastic tube. Then 5 ml of distilled water was added, mixed carefully and left overnight. Swelling capacity was calculated as:

\[ \frac{\text{SC}}{\text{g of pectin powder}} = \frac{\text{ml of swollen material}}{\text{g of pectin powder}} \times 100\% \]

Pineapple jam was prepared using dragon fruit peel pectin at different concentration of 0.2, 0.5, 0.7, 1 and 2%. To prepare the jam, the pineapple puree was heated at 60 – 70 °C. After that, half of the sugar was added, while the remaining sugar was blended with the pectin. Following that, the remaining sugar with pectin was incorporated and the mixture was continuously stirred to make sure the pectin was fully dissolved. When the mixture reached 68 °Brix, citric acid was added prior to the end of heating process. The solution of the jam was poured into glass container and kept in room temperature to set. Table 1 shows the formulation of jam making using dragon fruit peel pectin.

To evaluate the effect of pectin from dragon fruit peel on food product, sensory evaluation and consumer acceptance of pineapple jam was studied. Sensory evaluation was conducted on the best selected pineapple jam of dragon fruit peel pectin (Table 1) and was compared to the jam containing commercial apple pectin. A total of 30 panels with experience in sensory evaluation from MARDI were requested to analyse the sensory qualities using 9-point hedonic scale as follows: (1) dislike extremely; (2) dislike very much; (3) dislike moderately; (4) dislike slightly; (5) neither like nor dislike; (6) like slightly; (7) like moderately; (8) like very much and (9) like extremely.

Table 1. Formulations used in pineapple fruit jam preparation using pectin from dragon fruit peel

<table>
<thead>
<tr>
<th>Ingredient (%)</th>
<th>F1</th>
<th>F2</th>
<th>F3</th>
<th>F4</th>
<th>F5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pectin</td>
<td>0.2</td>
<td>0.5</td>
<td>0.7</td>
<td>1.0</td>
<td>2.0</td>
</tr>
<tr>
<td>Sugar</td>
<td>56.2</td>
<td>56.0</td>
<td>55.9</td>
<td>55.7</td>
<td>55.2</td>
</tr>
<tr>
<td>Pineapple paste</td>
<td>36.0</td>
<td>35.9</td>
<td>35.8</td>
<td>35.7</td>
<td>35.4</td>
</tr>
<tr>
<td>Water</td>
<td>7.2</td>
<td>7.2</td>
<td>7.2</td>
<td>7.2</td>
<td>7.1</td>
</tr>
<tr>
<td>Citric acid</td>
<td>0.4</td>
<td>0.4</td>
<td>0.4</td>
<td>0.4</td>
<td>0.4</td>
</tr>
</tbody>
</table>

**Statistical analysis**

Data was expressed as means ± standard deviations (SD) of three replicated determinations. Statistical calculation by Minitab Version 14 software (Minitab Inc., State College, PA, USA) was carried out. Analysis of variance (ANOVA) was
Pectin from dragon fruit for jam preparation

Results and discussion

Colour determination

Hunter color values of dragon fruit peel, apple and citrus pectins were determined and presented in Table 2. There are significant differences \((p < 0.05)\) between all the samples for \(L^*\) values. Citrus pectin has the highest value for brightness \((67.70 \pm 0.47)\), followed by apple pectin \((52.54 \pm 0.97)\) and dragon fruit peel pectin \((39.95 \pm 0.16)\). For \(a^*\) and \(b^*\) values, both apple and citrus pectins show no significant differences \((p > 0.05)\). However, dragon fruit peel pectin shows greater values for both redness and yellowness compared to apple and citrus pectins. This is because dragon fruit peel, which has darker and redness appearance, causes a more redness pectin product to be produced.

Texture profile analysis of pectin gel

The texture profile analysis of the pectin gels was determined using TA-XT2 texture analyser (Table 3). This empirical technique allows the determination of parameters such as hardness, springiness, cohesiveness, gumminess, chewiness and resilience.

Overall, there are significant differences \((p < 0.05)\) between the gels made from dragon fruit peel, apple and citrus pectins for all the textural properties. At 3\% concentration, the gel prepared from dragon fruit peel pectin has the lowest hardness compared to apple and citrus pectins. The dragon fruit peel pectin had the highest value of resilience among the three samples but similar springiness and cohesiveness properties with that of citrus pectin. For gumminess properties, dragon fruit peel pectin shows the lowest value. As for chewiness, citrus pectin gives the lowest value \((25.05 \pm 0.61)\), followed by dragon fruit peel pectin \((39.11 \pm 0.38)\) and apple pectin \((44.59 \pm 0.52)\). Therefore, it can be concluded that the springiness and cohesiveness of dragon fruit peel pectin was similar to that of citrus and apple pectin, while the chewiness characteristics was close to that of apple pectin.

| Table 2. Colour values \((L^*, a^*, b^*)\) of pectin powder from different sources |
|------------------|------------------|------------------|
|                 | \(L^*\)         | \(a^*\)          | \(b^*\)          |
| Apple pectin    | 52.54 ± 0.97b    | 0.35 ± 0.00b     | 0.35 ± 0.00b     |
| Citrus pectin   | 67.70 ± 0.47a    | 0.34 ± 0.00ab    | 0.35 ± 0.00b     |
| Dragon fruit peel pectin | 39.95 ± 0.16c | 34.87 ± 0.21a | 20.18 ± 0.29a |

\(a\) All the given values are means of three determinations ± standard deviations
Means within columns with different letters are significantly different at \(p < 0.05\)

| Table 3. Comparison of texture properties of three different gels |
|------------------|------------------|------------------|
|                  | Dragon fruit pectin | Apple pectin  | Citrus pectin |
| Hardness         | 22.63 ± 0.21c     | 32.86 ± 0.69a   | 23.81 ± 0.05b |
| Springiness      | 2.57 ± 0.06a      | 2.38 ± 0.02b    | 2.56 ± 0.03a  |
| Cohesiveness     | 0.43 ± 0.1abc     | 0.56 ± 0.02b    | 0.66 ± 0.01ab |
| Gumminess        | 9.33 ± 0.35c      | 16.50 ± 0.17a   | 15.63 ± 0.35b |
| Chewiness        | 39.11 ± 0.38ab    | 44.59 ± 0.52a   | 25.05 ± 0.61cc|
| Resilience       | 1.15 ± 0.17a      | 0.11 ± 0.02c    | 0.25 ± 0.01bc |

All the given values are means of three determinations ± SD
Means within the rows with different letters are significantly different at \(p < 0.05\)

applied to determine significant difference at \(p <0.05\).
As shown in Table 4, WHC and OHC of dragon fruit peel pectin were compared to that of apple pectin and citrus pectin. The WHC of dragon fruit peel pectin (5.50 g/g) has no significant difference \((p < 0.05)\) from that of apple pectin (5.45 g/g). Also, dragon fruit peel pectin show no significant differences \((p < 0.05)\) from citrus pectin for OHC and SC. Thus, dragon fruit peel pectin produced in this research has a characteristic of WHC as good as apple pectin, while OHC and SC were comparable to that of citrus pectin. In previous study, Kosmala et al. (2010) reported that WHC of apple pomace with ethanol extraction is 5.2 g/g, which can be considered as having low ability to hold water compared to other polysaccharides (Grigelmo-Miguel and Martin-Belloso 1999; Ubando et al. 2005; Vergara-Valencia et al. 2007).

In this study, dragon fruit peel pectin has better SC than citrus pectin, thus it will give better hydrodynamic volume when dissolve in water. Alongside its hydration properties, OHC of dragon fruit peel pectin is lower than apple pectin, but similar than that of citrus pectin and other polysaccharides (Grigelmo-Miguel and Martin-Belloso 1999; Ubando et al. 2005; Vergara-Valencia et al. 2007). High OHC is required in ground meal formulation, meat replacers and extenders, baked goods and soups. Thus, dragon fruit peel pectin has potential to be used in the production of hydrated food products. Further study is needed to improve the hydration properties of this dragon fruit peel pectin.

### Sensory evaluation of pineapple jam incorporated with dragon fruit pectin

In this study, pineapple jam was chosen as a model for sensory evaluation to see if the panellists might find any differences between the jam made from dragon fruit peel pectin and apple pectin. The formulation (Table 1) varies in terms of the amount of pectin and other ingredients percentage, while maintaining the citric acid. From the formulation trials, it was found that jam with 2% pectin from dragon fruit peel (F5) was selected as the best jam by the panels (data not shown) in terms of the sensory attributes and the hardness of the jam. Generally, the amount of apple pectin used in making fruit jam was about 0.2 – 0.5%, however, 2% dragon fruit peel pectin was required to set the pineapple jam. On the other hand, jam prepared with dragon fruit peel pectin at 0.2, 0.5, 0.7 or 1% was not set or weakly set. Thus, jam with 2% dragon fruit peel pectin was further evaluated for its organoleptic properties.

The pineapple jam of apple pectin and dragon fruit peel pectin were evaluated by a panel of 30 untrained people in one batch. Both samples were subjected to a composite scoring test for the evaluation of colour, aroma, taste, texture (spreadable) and overall acceptance. From the scores (Table 5), there are no significant differences \((p > 0.05)\) between the jams with dragon fruit peel pectin and apple pectin except for colour attribute which has significant difference \((p < 0.05)\). However, the colour of the jam produced using dragon fruit peel
Table 5. Hedonic scale scores of sensory attribute

<table>
<thead>
<tr>
<th>Jam</th>
<th>Colour</th>
<th>Aroma</th>
<th>Taste</th>
<th>Texture</th>
<th>Overall</th>
</tr>
</thead>
<tbody>
<tr>
<td>Commercial apple pectin</td>
<td>8.13 ± 0.68a</td>
<td>7.87 ± 0.51a</td>
<td>8.13 ± 0.51a</td>
<td>8.23 ± 0.43a</td>
<td>8.17 ± 0.46a</td>
</tr>
<tr>
<td>Dragon fruit peel pectin</td>
<td>5.67 ± 0.80b</td>
<td>8.07 ± 0.45a</td>
<td>8.07 ± 0.52a</td>
<td>8.10 ± 0.48a</td>
<td>7.98 ± 0.38a</td>
</tr>
</tbody>
</table>

All the given values are means of three determinations ± SD
Means within columns with different letters are significantly different at p <0.05

pectin is still on the positive side of the hedonic scale.

**Conclusion**
The dragon fruit peel pectin powder is light red in colour compared to the commercial apple and citrus pectins. The textural properties of dragon fruit peel pectin has several similar characteristics as apple and citrus pectins. While the WHC values is similar to that of apple pectin. The dragon fruit peel pectin can be used as a gelling and thickening agent and has the potential to be applied in low gel food product. It is therefore recommended to use this pectin as a thickener in food products such as in low viscous food and beverages. Thus, it can be concluded that dragon fruit peel pectin has the potential to be a good hydrocolloid which might be very useful in food industry.

**Acknowledgement**
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**References**


**Abstrak**

Dalam kajian ini, pektin telah diekstrak daripada kulit buah naga dan sifat-sifat berfungsi serta ciri-ciri sensori pektin ini telah dikaji. Bacaan hunter ‘L*’, ‘a*’ dan ‘b*’ bagi pektin kulit buah naga adalah masing-masing 39.95, 34.87 dan 20.18, menunjukkan bahawa pektin yang diekstrak berwarna sedikit merah berbanding dengan pektin komersial. Dari segi sifat tekstur, pektin kulit buah naga menunjukkan beberapa ciri sama seperti pectin epal dan sitrus. Keupayaan pegangan air (WHC) pektin ini adalah sama seperti pektin epal, dengan masing-masing 5.50 dan 5.45 g/g. Keupayaan pegangan minyak (OHC) dan keupayaan mengembang (SC) juga menunjukkan tiada perbezaan ketara (p >0.05) berbanding pectin sitrus. Pektin ini telah berjaya diaplikasikan di dalam jam nanas, tetapi pada peratus yang agak tinggi iaitu 2% untuk menjadikannya set. Untuk penilaian rasa, tiada perbezaan ketara (p >0.05) dilihat antara markah purata jam yang dihasilkan daripada pektin kulit buah naga dan pektin komersial kecuali untuk atribut warna.

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