Comparison Properties of Adlay (Coix lachryma-jobi L.) Flour and Starch
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Abstract
Adlay (Coix lachryma-jobi L.) was extracted for flour and starch. Two cultivars of adlay (black and white) were chosen to determine for their physical, chemical and physicochemical properties. After extraction, starches (black and white) have higher whiteness index than flours. The morphology of starches appeared spherical and polygonal with some dents on their surfaces. However, flour samples showed that starch granules were aggregated by protein matrix with the protein bodies attached to the granule surfaces. Both adlay cultivars showed similarly A-type patterns with different degrees of crystallinity. Furthermore, the amylose contents of black and white adlays were different (29.22% and 11.55% respectively). When compared the viscosity profiles of two cultivar starches, the results showed that the peak viscosity and breakdown of white were higher than black adlay. On the other hand, the final viscosity of black adlay starch was higher than white adlay starch. In addition, the peak viscosity of black adlay flour appeared duplet and the viscosity profile of black adlay was lower than that of white adlay flour. The gelatinization temperature ranges of both cultivars were similar. However, the gelatinization enthalpy of white adlay was higher than that of black adlay.

Keywords: Adlay, starch, flour, physical, chemical and physicochemical properties.

Introduction
Adlay or Job’s Tears (Coix lachryma-jobi L.) commonly known as coix, is relative of maize and sorghum in the sub family panicoideae (Tatham et al., 1996) widely grown as a grain crop in Asia. It is used in food, forage and the predominant in nutritive medicines. Recently, it has been reported that composition in adlay kernel can possess antitumor and anticancer activity moreover it has an effect against viral infection (Hidaka et al., 1992) and reduce plasma lipid concentration (Huang et al., 2005). In addition, the adlay was high protein content that can not cause coeliac disease. However, the information about adlay characteristic is still limited. In order to reinforce the utilization in food industry, the investigation of physical, chemical and physicochemical properties of adlay flour and starch was carried out. Therefore, the objective of this study was to investigate physical, chemical and physicochemical properties of adlay flours and starches.

Materials and Methods
Materials
Two Adlay (coix) varieties; Black Adlay (BA) and White Adlay (WA) were obtained from Loie province in Thailand.
Adlay flour preparation
Adlay flour was prepared by using dry milling method and pass through a 100 mesh sieve.
Starch Isolation
Adlay starch was isolated by followed Sira and Amaiz method (2004).

Physical properties
Color of flour and starch: The sample color was measured by using a minolta spectrophotometer (model geneys 10S Thermoelectron corporation, USA) then recorded L*, a*, b* values in Hunter Lab system. The values were used to calculate whiteness index (Li and Lee, 1996).

Morphology of starch and flour: Starch and flour morphology were observed by scanning electron microscope (model JSM-5600LV, JEOL, Japan).
Crystalline and degree of crystalline: X-ray diffractometer (model JDX-353, JEOL, Japan) was used to determine the crystalline pattern and the degree of crystalline of sample.

Chemical properties
The chemical compositions of adlay flours and starches were determined, by using A.O.A.C. method (2000). In addition, the amylose content was also analyzed by following Juliano (1971).

Physicochemical properties
Swelling Power and Solubility: Swelling power (SP) and water soluble index (WSI) of flour and starch were determined according to Li and Yeh (2001).

Pasting properties: The pasting profiles of adlay flours and starches were analyzed by Rapid Visco-Analyzer (RVA) (model RVA3D, Newport Scientific Instrument and Engineering, Australia).

Thermal property: Differential scanning calorimetry (model Pyris, Perkin-Elmer, USA) was used to determine the gelatinization temperature and the enthalpy change of sample.

Statistical Analysis
All measurements were analyzed by using a SPSS program. Duncan new’s multiple range test was used to compare mean difference (p< 0.05).

Results and Discussion
Physical properties
The shapes of both adlay cultivars were similar to tear’s drop. However, the color white adlay kernel (WA) was range from matt light brown to dark brown color; while that of black adlay kernel was shiny-black. After decortications, both adlay cultivars appeared to have brownish surface with groove.

Table 1 shows the color of flours and starches as well as the whiteness index. Both flour cultivars appeared to have darker color compared to starches. It might be due to the fact that during the starch isolation, the impurity such as protein and ash was isolated from starch fraction.

<table>
<thead>
<tr>
<th>Sample</th>
<th>L*</th>
<th>a*</th>
<th>b*</th>
<th>Whiteness index</th>
</tr>
</thead>
<tbody>
<tr>
<td>BAF</td>
<td>77.93 ± 0.39</td>
<td>0.72 ± 0.05</td>
<td>8.98 ± 0.18</td>
<td>76.16 ± 0.43</td>
</tr>
<tr>
<td>WAS</td>
<td>91.60 ± 0.14</td>
<td>-0.20 ± 0.04</td>
<td>2.58 ± 0.16</td>
<td>91.21 ± 0.18</td>
</tr>
</tbody>
</table>

Mean (n = 3) with different letters within column were significantly different (p< 0.05)
Morphology of flour and starch
The scanning electron micrographs of adlay flours revealed that the starch granules were embedded in the protein matrix with the protein bodies on their surfaces (figure 1). After starch extraction, the starch granules appeared smooth and their shapes were spherical and polygonal with some dents. Flours and starches from both cultivars had similar characters.

Fig. 1 Scanning electron micrographs of black and white adlay flour and starch. (PB: protein body, PM: Protein matrix and SG: Starch granule)

Crystallinity of flour and starch
X-ray diffraction patterns of flours and starches from black and white adlay showed similar pattern with different intensity. The crystalline peaks were observed at 15, 17, 18 and 23 degree, 2θ (figure 2) corresponded to A-type pattern of cereal starch (Cheetham and Tao, 1998). From the area of intensity, the degree of crystalline was calculated as shown in table 2. The result shows that the degree of crystalline of starch was higher than that of flour compare within the same cultivar. The degree of crystalline might be affected by the other components such as protein in flour (Mousia et al., 2004).

Chemical properties
The chemical compositions of adlay flours and starches were illustrated in table 3. The results show that black adlay flour (BAF) had protein; fat as well as ash than white adlay flour (WAF) but had carbohydrate content lower than WAF. When comparing the chemical compositions of starches, the protein content of black adlay starch (BAS) was higher than that of white adlay starch (WAS). Furthermore the amylose content of BAS (29.22%) was higher than that of WAS (11.55%).

Physicochemical properties
Swelling power (SP) and water soluble index (WSI)
The swelling power and water soluble index were increased with increasing temperature, as shown in figure 3. The higher SP of WAF and WAS compared to BAF and
BAS might be due to the higher amylopectin content in WAS (Ratnayake and Jackson, 2006; Oates, 1997 and Aguilera and Stanley, 1999).

### Table 2: Degree of crystalline of flours and starches from both adlay cultivars

<table>
<thead>
<tr>
<th>Sample</th>
<th>Crystal pattern</th>
<th>Degree of crystalline (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>BAF</td>
<td>A</td>
<td>16.30 ± 1.68</td>
</tr>
<tr>
<td>WAF</td>
<td>A</td>
<td>18.15 ± 0.10</td>
</tr>
<tr>
<td>BAS</td>
<td>A</td>
<td>22.50 ± 1.31</td>
</tr>
<tr>
<td>WAS</td>
<td>A</td>
<td>26.76 ± 0.05</td>
</tr>
</tbody>
</table>

Means (n = 3) with different letters within column were significantly different (p< 0.05).

### Table 3: Chemical compositions both black and white adlay cultivars of flour and starch

<table>
<thead>
<tr>
<th>Sample</th>
<th>Moisture</th>
<th>Protein</th>
<th>Fat</th>
<th>Ash</th>
<th>Crude fiber</th>
<th>Carbohydrate</th>
</tr>
</thead>
<tbody>
<tr>
<td>BAF</td>
<td>10.38 ± 0.01</td>
<td>14.88 ± 0.03</td>
<td>3.16 ± 0.07</td>
<td>1.17 ± 0.02</td>
<td>0.61 ± 0.03</td>
<td>69.80 ± 0.11</td>
</tr>
<tr>
<td>WAF</td>
<td>9.90 ± 0.22</td>
<td>13.28 ± 0.28</td>
<td>2.89 ± 0.10</td>
<td>1.12 ± 0.01</td>
<td>0.60 ± 0.04</td>
<td>72.20 ± 0.06</td>
</tr>
<tr>
<td>BAS</td>
<td>11.59 ± 0.40</td>
<td>0.52 ± 0.14</td>
<td>0.16 ± 0.06</td>
<td>1.00 ± 0.00</td>
<td>0.09 ± 0.06</td>
<td>86.63 ± 0.54</td>
</tr>
<tr>
<td>WAS</td>
<td>10.84 ± 1.27</td>
<td>0.25 ± 0.04</td>
<td>0.04 ± 0.01</td>
<td>1.00 ± 0.00</td>
<td>0.17 ± 0.14</td>
<td>87.71 ± 1.28</td>
</tr>
</tbody>
</table>

Means (n = 3) with different letters within column were significantly different (p< 0.05)
In the presence of protein and other composition, it caused the SP of flours lower than that of starch since these compositions might be restricted the swelling volume of starch (Wang and Seib, 1996 and Oates, 1997). The WSI of starch corresponds to the amylose leached out from granules during the heating process (Oates, 1997 and Aguilera and Stanley, 1999). Therefore the BAS, consisted of high amylose content, had higher WSI than WAS. The WSI of flour was higher than that of starch due to the higher soluble components.

*Pasting properties*

The pasting profiles of WAS and BAS show similar trend; however, WAS had higher peak viscosity than BAS. It might be because the higher protein content in BAS (table 3) caused the decrease of swelling volume of starch and led to the lower peak viscosity. The effect of protein was more pronounced when observed the pasting profiles of flours. In the presence of other components such as protein and lipid, it could reinforce the granule strength tremendously since the breakdown viscosity was lower drastically in flour compared to starch.

![Fig. 4 Pasting profiles of black adlay starch and flour and white adlay starch and flour](image)

*Thermal properties*

The presence of other components could affect on the gelatinization enthalpy; while had less affected on the gelatinization temperature (To-Tp-Tc) as compared between flour and starch of the same cultivar (table 4). The onset temperature of BAF and BAS was lower than WAF and WAS, which might be related to the degree of crystalline (table 2). Furthermore, the enthalpy changes (table 4) were in an agreement with the degree of crystalline (table 2). When the degree of crystalline increased, the enthalpy required to breakdown the hydrogen bond increased.

<table>
<thead>
<tr>
<th>Sample</th>
<th>To (°C)</th>
<th>Tp (°C)</th>
<th>Tc (°C)</th>
<th>ΔHgel (J/g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>BAF</td>
<td>67.76 b ±0.26</td>
<td>74.96 b ±0.01</td>
<td>80.70 b ±0.39</td>
<td>6.08 c ±0.92</td>
</tr>
<tr>
<td>WAF</td>
<td>68.81 a ±0.21</td>
<td>76.24 a ±0.34</td>
<td>82.86 a ±0.33</td>
<td>8.93 b ±0.25</td>
</tr>
<tr>
<td>BAS</td>
<td>65.82 c ±0.00</td>
<td>71.75 d ±0.36</td>
<td>81.09 c ±3.70</td>
<td>14.83 a =0.10</td>
</tr>
<tr>
<td>WAS</td>
<td>68.85 b ±0.19</td>
<td>73.37 c ±0.18</td>
<td>80.38 d ±0.33</td>
<td>16.41 a ±1.12</td>
</tr>
</tbody>
</table>

Means (n = 3) with different letters within column were significantly different (p< 0.05)
Conclusion
The shape, color and crystalline pattern of flour and starch from black and white adlay were similar. White adlay had higher degree of crystalline than black adlay and it shows the higher swelling power, peak viscosity and the enthalpy of gelatinization than black adlay. Moreover the other components in flour could restrict the swelling volume as well as increased the granule strength of starch.

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References