Physicochemical, thermal and pasting properties of starches separated from different potato cultivars grown at different locations

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Abstract

The starch separated from 21 different Indian potato cultivars from four locations was evaluated for physicochemical, thermal and pasting properties. The relationships between the different properties of starches were determined using Pearson’s correlation analysis. Amylose content was positively correlated to hot paste viscosity (r = 0.460, P ≤ 0.05) and negatively correlated to transmittance measured after storage of 0, 24 and 72 h (r = −0.509, −0.480, −0.453, P ≤ 0.05). Hot paste viscosity showed significant positive correlation with cold paste viscosity, pasting temperature, T p and T c (r = 0.985, 0.607, 0.654, 0.628, P ≤ 0.005) and negative correlation with transmittance measured after 0, 24 and 72 h (r = 0.539, −0.570, −0.451, P ≤ 0.05). Breakdown viscosity showed highly negative correlation with pasting time (r = −0.766, P ≤ 0.005) and positive correlation with transmittance measured after 0, 24 and 72 h (r = 0.533, 0.558, 0.570, P ≤ 0.05). Pasting temperature showed highly positive correlation with transition temperatures T o, T p, T c (r = 0.740, 0.846, 0.734, P ≤ 0.005) and negative correlation with transmittance measured after 0, 24 and 72 h (r = −0.418, −0.468, −0.476, P ≤ 0.05). T o showed the highest positive correlation with T p and T c (r = 0.924, 0.755, P ≤ 0.005). The results revealed that temperature during tuber growth affects granule size, pasting temperature and transition temperature. Lower temperature prevailed during tubers growth resulted into starch with higher granule size and lower pasting and transition temperatures.

Keywords: Potato starch; Location; Amylose; Thermal; Rapid visco analysis; Swelling

1. Introduction

Starch has been extensively studied and discussed in the literature over the last two centuries, although the history of starch usage by man has been variously described for thousands of years. The ancient Egyptians (~4000 BC) and later the Romans used this substance as an adhesive whilst the ancient Greeks also used it in medical preparations. The popularity of starch grew in Europe around the 14th century, owing to its use for stiffening linen and starch was subsequently adopted for cosmetic purposes. Roots and tuber crops are grown throughout the world in hot and humid regions. Roots and tubers contain 70–80% water, 16–24% starch and trace quantities (<4%) of proteins and lipids. Potato starch has been extensively studied in pure and applied studies. Starch properties depend on the physical and chemical characteristics such as mean granule size, granule size distribution, amylose/amylopectin ratio and mineral content (Singh, Singh, Kaur, Sodhi, & Gill, 2003). Different reviews (Hoover, 2001; Tester & Karkalas, 2002) have discussed the unique physicochemical properties of potato starch, especially in terms of extensive phosphorylation of amylopectin molecules. Starch contributes greatly to the textural
properties of many foods and has many industrial applications as a thickener, colloidal stabilizer, gelling agent, bulking agent, water retention agent and adhesive. A large number of techniques such as differential scanning colorimetry (DSC), X-ray diffraction, small angle neutron scattering and Kofler hot stage microscopy are being used to study the gelatinization behaviour of starches. Starch transition temperatures and gelatinization enthalpies, measured by DSC, may be related to crystallinity (Krueger, Knutson, Inglett, & Walker, 1987). However, it has been shown (NMR and X-ray diffraction) that enthalpic transition is primarily due to loss of double helical order rather than crystallinity (Cooke & Gidley, 1992). Rheological and thermal techniques have been applied to study the aging of starch gels. Starch exhibits unique viscosity behaviour with change of temperature, concentration and shear rate (Nurul, Azemi, & Manan, 1999). The Brabender visco-amylograph, rapid visco-analyzers (RVA) have been extensively used for measuring starch paste viscosity (Wiesenborn, Orr, Casper, & Tacke, 1994). Laser light scattering has been used to characterize granule diameter based on the assumption that granules are spherical but this technique may not be accurate for granule diameter based on the assumption that granules are slightly oblong, irregular or cuboidal (Wiesenborn et al., 1994). Starch properties have been reported to be significantly influenced by the cultivars and environmental factors (Cottrell, Duffus, Paterson, & George, 1995; Kaur, Singh, & Sodhi, 2002; Singh & Singh, 2001). The information on the comparison of properties from potato cultivars grown at different locations is reported in Table 1. Uniform size tubers were selected from each cultivar and washed thoroughly.

2. Materials and methods

2.1. Materials

The tubers of *Solanum tuberosum* L. cv. Kufri Anand, Kufri Ashoka, Kufri Bahar, Kufri Badshah, Kufri Chandarmukhi, Kufri Chipsona-1, Kufri Chipsona-2, Kufri Jyoti, Kufri Lalima, Kufri Lauvkar, Kufri Pukraj and Kufri Sindhuri grown in different locations (Gwalior, Jalandhar, Modipuram and Patna) were procured from Central Potato Research Institute (CPRI), Shimla from 2003 harvest. The maximum and minimum temperature of different locations is reported in Table 1. Uniform size tubers were selected from each cultivar and washed thoroughly.

2.2. Methods

2.2.1. Starch isolation

Starch was isolated from different potato cultivars as described previously (Singh & Singh, 2001).

2.2.2. Physicochemical properties of starches

Moisture content (%) of starches was determined using Halogen Moisture Analyzer (Mettler Toledo, Greifensee, Switzerland). Ash content (%) was determined using the standard AACC method (1995). Amylose content (%) was determined using the method of Williams, Kuzina, and Hlynka (1970). Swelling power (g/g) and solubility (%) were determined using method of Leach, McCowen, and Schoch (1959).

Light transmittance (%) were measured by Craig, Manning, Seib, and Hoseney (1989). An aequorin suspension of starch (1%) near neutral pH from each potato cultivar was heated in a water bath at 90 °C for 1 h with constant stirring. The suspension was cooled and held for 1 h at 30 °C. The sample was then stored for 5 days at 4 °C in a refrigerator and transmittance was measured after every 24 h at 640 nm using a Lambda 25 UV/VIS spectrometer (Perkin–Elmer, Switzerland).

2.2.3. Thermal properties

Thermal properties of potato starches were analyzed using a DSC-822° (Mettler Toledo, Greifensee, Switzerland) as described earlier (Singh & Singh, 2001). The gelatinization temperature parameters: onset temperature (*T*<sub>o</sub>); peak temperature (*T*<sub>p</sub>); conclusion temperature (*T*<sub>c</sub>); enthalpy of gelatinization (*ΔH*<sub>gel</sub>) and gelatinization temperature range (*R*) were calculated.

2.2.4. Pasting properties by rapid visco-analyzer (RVA)

The pasting properties of potato starches were evaluated with a rapid visco analyzer (RVA-4, Newport Scientific, Warriewood, Australia). Starch (3 g, 14% mb) was weighed directly in the aluminium RVA sample canister, and distilled water was added to a total weight of 28 g. The samples were held at 50 °C for 1 min, heated to 95 °C in 3.7 min, held at 95 °C for 2.5 min and holding at 50 °C for 2 min. The pasting temperature (*P*<sub>temp</sub>); peak viscosity (PV); hot paste viscosity (HPV); cool paste viscosity (CPV); breakdown (BD); setback (SB) were recorded. HPV = minimum viscosity at 95 °C, CPV = final viscosity at 50 °C, BD = PV − HPV and SB = CPV − HPV.

2.2.5. Statistical analysis

The data reported are average of triplicate determinations. Pearson’s correlation coefficients (r) were calculated for various starch properties using Minitab Statistical Software (Minitab Inc., State college, USA).

### Table 1

<table>
<thead>
<tr>
<th>Temperature</th>
<th>Modipuram</th>
<th>Jalandhar</th>
<th>Gwalior</th>
<th>Patna</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max (°C)</td>
<td>18.1−36.8</td>
<td>18.3−31.9</td>
<td>30.8−32.8</td>
<td>17.6−34.5</td>
</tr>
<tr>
<td>Min (°C)</td>
<td>4.7−19.4</td>
<td>1.4−18.2</td>
<td>10.4−18.1</td>
<td>7.6−24.5</td>
</tr>
</tbody>
</table>
3. Results and discussion

3.1. Amylose content and swelling power (SP)

The physicochemical parameters (amylose content and swelling power) of starches from different potato cultivars are shown in Table 2. The amylose content of starches ranged between 15.0% and 23.1%, and differed significantly among different potato cultivars. The lowest amylose content of 15.0% for Kufri Ashoka (Patna) and the highest of 23.1% for Kufri Badshah (Jalandhar) starch were observed. The results for amylose content are consistent with those reported by Wiesenborn et al. (1994), Singh and Singh (2001), Kaur et al. (2002), Singh and Kaur (2004) and Singh et al. (2003). The difference in amylose content among starches from different potato cultivars may be due to different factors such as genotype, environmental conditions, cultural practice etc. (Cottrell et al., 1995; Kim & Wiesenborn, 1995). SP indicates the ability of starch to hydrate under specific cooking conditions (90°C/30 min). Kufri Sindhuri (Modipuram) showed the lowest SP (26.2 g/g) whereas Kufri Sindhuri (Patna) showed the highest (48.6 g/g). The difference in SP among starches from different potato cultivars indicate variation in the strength of associative bonding forces with granules (Leach et al., 1959). The solubility (%) of starches ranged between 2.5% and 36.9%, and differed significantly among different potato cultivars. The lowest solubility of 2.5% for Kufri Chandarmukhi (Modipuram) and the highest of 36.9% for Kufri Sindhuri (Modipuram) starch were observed. The higher SP and solubility of starches from different potato cultivars are probably due to higher content of phosphate groups on adjacent chains, which increase hydration by weakening the extent of bonding within the crystalline domain (Galliard & Bowler, 1987). The difference in amylose content and starch granular properties may also have affected the SP and solubility of starches (Singh & Singh, 2001). SP of starches was reported to be affected by the presence of lipids (Swinkels, 1985). These may have no or little effect on SP in our study as very low lipid content in potato starches has been reported (Swinkels, 1985).

3.2. Pasting properties

Pasting properties of different potato starches are reported in Table 3. PT of different potato starches ranged from 64.5 to 69.5°C, the highest for Kufri Sindhuri (Patna) and the lowest for Kufri Bahar (Jalandhar). PT range from 66.7 to 70.3°C has been reported earlier (Noda et al., 2004). PV was found to be the lowest for Kufri Chandarmukhi (Gwalior) and the highest for Kufri Lalima (Jalandhar). The starch separated from the potato cultivars grown in Jalandhar showed lower PT as compared to starch from those grown in other locations. This is consistent with the transition temperatures measured using DSC. The increased viscosity with increasing temperature has been attributed to the removal of water from the exuded amylose by the granules on the swelling of starches (Ghiasi, Varriano-Marston, & Hoseney, 1982). HPV ranged between 1950 and 3204 cP, the lowest for Kufri Chandarmukhi (Modipuram) and the highest for Kufri Chandarmukhi (Gwalior) and the highest for Kufri Badshah (Jalandhar). Starch granules become increasingly susceptible to shear disintegration as they swell, and starches with lower amylose content swell more than those with higher amylose content. BD showed negative relation with amylose content, however, this was statistically non-significant. The starch with lower amylose

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Table 2
Physicochemical properties of potato starch from different cultivars

<table>
<thead>
<tr>
<th>Variety</th>
<th>Location</th>
<th>Mean granule size (µm)</th>
<th>Ash (%)</th>
<th>Amylose (%)</th>
<th>SP (g/g)</th>
<th>Solubility (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>K. Chandarmukhi</td>
<td>Gwalior</td>
<td>36.90</td>
<td>0.15</td>
<td>15.67</td>
<td>43.95</td>
<td>16.25</td>
</tr>
<tr>
<td>K. Jyoti</td>
<td>Gwalior</td>
<td>36.22</td>
<td>0.29</td>
<td>19.12</td>
<td>44.52</td>
<td>9.30</td>
</tr>
<tr>
<td>K. Lauvkar</td>
<td>Gwalior</td>
<td>32.37</td>
<td>0.28</td>
<td>17.45</td>
<td>45.43</td>
<td>7.33</td>
</tr>
<tr>
<td>K. Badshah</td>
<td>Jalandhar</td>
<td>38.51</td>
<td>0.22</td>
<td>23.10</td>
<td>46.49</td>
<td>4.91</td>
</tr>
<tr>
<td>K. Bahar</td>
<td>Jalandhar</td>
<td>33.44</td>
<td>0.15</td>
<td>16.26</td>
<td>45.16</td>
<td>5.69</td>
</tr>
<tr>
<td>K. Jyoti</td>
<td>Jalandhar</td>
<td>37.24</td>
<td>0.17</td>
<td>20.84</td>
<td>46.42</td>
<td>6.78</td>
</tr>
<tr>
<td>K. Chandarmukhi</td>
<td>Jalandhar</td>
<td>40.63</td>
<td>0.06</td>
<td>20.25</td>
<td>42.09</td>
<td>10.96</td>
</tr>
<tr>
<td>K. Lalima</td>
<td>Jalandhar</td>
<td>38.62</td>
<td>0.42</td>
<td>17.98</td>
<td>37.78</td>
<td>7.32</td>
</tr>
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<td>Jalandhar</td>
<td>32.60</td>
<td>0.29</td>
<td>17.70</td>
<td>45.76</td>
<td>7.12</td>
</tr>
<tr>
<td>K. Sindhuri</td>
<td>Jalandhar</td>
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<td>0.30</td>
<td>17.00</td>
<td>45.51</td>
<td>4.15</td>
</tr>
<tr>
<td>K. Anand</td>
<td>Modipuram</td>
<td>40.63</td>
<td>0.28</td>
<td>15.59</td>
<td>44.75</td>
<td>12.31</td>
</tr>
<tr>
<td>K. Bahar</td>
<td>Modipuram</td>
<td>32.41</td>
<td>0.29</td>
<td>19.75</td>
<td>46.17</td>
<td>4.17</td>
</tr>
<tr>
<td>K. Chipsona-1</td>
<td>Modipuram</td>
<td>38.72</td>
<td>0.45</td>
<td>16.86</td>
<td>34.64</td>
<td>17.41</td>
</tr>
<tr>
<td>K. Chipsona-2</td>
<td>Modipuram</td>
<td>42.05</td>
<td>0.27</td>
<td>17.24</td>
<td>45.17</td>
<td>34.67</td>
</tr>
<tr>
<td>K. Jyoti</td>
<td>Modipuram</td>
<td>35.80</td>
<td>0.43</td>
<td>19.73</td>
<td>44.46</td>
<td>7.89</td>
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<tr>
<td>K. Chandarmukhi</td>
<td>Modipuram</td>
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<td>48.08</td>
<td>2.59</td>
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<td>0.34</td>
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<td>29.20</td>
</tr>
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<td>26.29</td>
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<td>K. Ashoka</td>
<td>Patna</td>
<td>37.37</td>
<td>0.24</td>
<td>15.00</td>
<td>45.25</td>
<td>11.27</td>
</tr>
<tr>
<td>K. Jyoti</td>
<td>Patna</td>
<td>39.14</td>
<td>0.22</td>
<td>21.37</td>
<td>45.11</td>
<td>8.39</td>
</tr>
<tr>
<td>K. Sindhuri</td>
<td>Patna</td>
<td>37.72</td>
<td>0.28</td>
<td>18.06</td>
<td>48.61</td>
<td>19.25</td>
</tr>
</tbody>
</table>
content was being more susceptible to shear. SP and BD showed negative relation with each other, however, this was statistically non-significant. CPV increased upon cooling which may be due to the aggregation of the amylose molecules (Miles, Morris, Orford, & Ring, 1985). CPV and setback viscosity varied from 2351 to 3606 and 224 to 436 cP, respectively. Setback value is the recovery of the viscosity during cooling of the heated starch suspension. The difference in setback among different starches may be due to the amount and the molecular weight of amylose leached from the granules and the remnant of the gelatinized starch (Loh, 1992). Pasting properties of starches separated from different potato cultivars differed significantly (Table 5). Kufri Jyoti (Jalandhar) showed the highest \( T_p \) and \( T_o \) of 76.98°C, followed by Kufri Lauvkar (Modipuram) showed lower \( H_{gel} \) (10.6, 11.3 and 11.89 J/g, respectively). Kufri Jyoti (Jalandhar) showed the lowest \( T_c \) (76.98°C), while it was the lowest for Kufri Ashoka (Patna) starch (66.63°C). \( T_p \) and \( T_o \) of starch from different cultivars ranged between 61.60–66.75°C and 58.26–62.21°C, respectively. Kufri Sindhuri (Patna) starch showed the highest \( T_p \) and \( T_o \) while Kufri Chipsona-1 (Modipuram) showed the least R-value. Double helical and crystalline structures are disrupted in starches during gelatinization. This order–disorder phase transition showed melting of crystals, which was illustrated by DSC endotherms in the range of 60–95°C for various native starches (Jacobs, Eerlingen, Claouwaert, & Delcour, 1995). The \( H_{gel} \) reflected primarily the loss of molecular double-helical order (Cooke & Gidley, 1992).

### 3.4. Thermal properties

The transition temperatures \((T_o, T_p, T_c)\), gelatinization temperature range \((R)\) and enthalpies of gelatinization \((\Delta H_{gel})\) of the starches from different potato cultivars differed significantly (Table 5). Kufri Jyoti (Jalandhar) showed the highest \( \Delta H_{gel} \) of 17 J/g whereas Kufri Lalima (Jalandhar), Kufri Jyoti (Patna) and Kufri Bahar (Modipuram) showed lower \( \Delta H_{gel} \) (10.6, 11.3 and 11.89 J/g, respectively). Kufri Jyoti (Jalandhar) showed the lowest \( T_c \) (76.98°C), followed by Kufri Lauvkar (Jalandhar) starch (71.62°C) while it was the lowest for Kufri Ashoka (Patna) starch (66.63°C). \( T_p \) and \( T_o \) of starch from different cultivars ranged between 61.60–66.75°C and 58.26–62.21°C, respectively. Kufri Sindhuri (Patna) starch showed the highest \( T_p \) and \( T_o \) and R-value while Kufri Chipsona-1 (Modipuram) showed the least R-value. Double helical and crystalline structures are disrupted in starches during gelatinization. This order–disorder phase transition showed melting of crystals, which was illustrated by DSC endotherms in the range of 60–95°C for various native starches (Jacobs, Eerlingen, Claouwaert, & Delcour, 1995). The \( H_{gel} \) reflected primarily the loss of molecular double-helical order (Cooke & Gidley, 1992).

### 3.3. Transmittance

The transmittance value decreased progressively during refrigerated storage of pastes from different potato starches (Table 4). The decrease in transmittance with storage duration was the highest for Kufri Lauvkar (Jalandhar) and the lowest for Kufri Chandarmukhi (Modipuram). This may be due to the presence of less granule remnants in the starch paste that in turn depends on the morphological structure of starch granules. The low light transmittance exhibited by some starches may be due to high refraction of light by swollen granule remnants (Craig et al., 1989).
(1996) have postulated that DSC parameters (\(T_o\), \(T_p\), \(T_c\) and \(\Delta H_{gel}\)) are influenced by molecular architecture of the crystalline region which corresponds to the distribution of amylopectin short chains and not by the proportion of the crystalline region, which corresponds to amylose/amylopectin ratio. Kim and Wiesenborn (1995) and Jane et al. (1999) observed \(\Delta H_{gel}\) value in the range between 17.3 and 18.2 J/g for potato starches. Granules shape, proportion of large and small granules and presence of phosphate esters have been reported to affect \(\Delta H_{gel}\) of starches. Yuan, Thompson, and Boyer (1993) observed that \(\Delta H_{gel}\) decreased with decreasing granule size. Peak height index (PHI) is the ratio \(\Delta H_{gel} / (T_p - T_o)\) of the gelatinization range (\(R\)) and is a measure of uniformity of gelatinization. PHI ranged between 2.74 and 9.62 J/g/°C for Kufri Badshah (Jalandhar) and Kufri Anand (Modipuram) starches, respectively. The difference in PHI may be due to the difference in chemical composition and granule structures among the various starches (Singh & Singh, 2001). The difference in the \(R\)-value among

### Table 4
Transmittance value for cooked starch suspensions from different potato cultivars

<table>
<thead>
<tr>
<th>Variety</th>
<th>Location</th>
<th>0 h</th>
<th>24 h</th>
<th>48 h</th>
<th>72 h</th>
<th>96 h</th>
<th>120 h</th>
</tr>
</thead>
<tbody>
<tr>
<td>K. Chandarmukhi</td>
<td>Gwalior</td>
<td>14.72</td>
<td>14.50</td>
<td>12.81</td>
<td>11.51</td>
<td>10.01</td>
<td>9.06</td>
</tr>
<tr>
<td>K. Jyoti</td>
<td>Gwalior</td>
<td>14.54</td>
<td>14.70</td>
<td>12.78</td>
<td>10.83</td>
<td>11.78</td>
<td>10.28</td>
</tr>
<tr>
<td>K. Bahar</td>
<td>Jalandhar</td>
<td>17.25</td>
<td>16.05</td>
<td>14.41</td>
<td>13.35</td>
<td>12.25</td>
<td>11.20</td>
</tr>
<tr>
<td>K. Jyoti</td>
<td>Jalandhar</td>
<td>16.05</td>
<td>15.76</td>
<td>14.61</td>
<td>11.35</td>
<td>9.20</td>
<td>7.20</td>
</tr>
<tr>
<td>K. Lalima</td>
<td>Jalandhar</td>
<td>19.50</td>
<td>20.50</td>
<td>19.35</td>
<td>18.15</td>
<td>17.20</td>
<td>18.09</td>
</tr>
<tr>
<td>K. Lauvkar</td>
<td>Jalandhar</td>
<td>13.50</td>
<td>11.08</td>
<td>9.53</td>
<td>7.75</td>
<td>6.25</td>
<td>5.02</td>
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<tr>
<td>K. Sindhuri</td>
<td>Jalandhar</td>
<td>19.04</td>
<td>17.66</td>
<td>16.02</td>
<td>15.98</td>
<td>14.25</td>
<td>13.20</td>
</tr>
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<td>Modipuram</td>
<td>17.81</td>
<td>16.81</td>
<td>15.47</td>
<td>14.88</td>
<td>13.48</td>
<td>12.45</td>
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<td>K. Chipsona-1</td>
<td>Modipuram</td>
<td>19.52</td>
<td>18.70</td>
<td>17.86</td>
<td>16.48</td>
<td>15.60</td>
<td>14.64</td>
</tr>
<tr>
<td>K. Chipsona-2</td>
<td>Modipuram</td>
<td>24.20</td>
<td>23.70</td>
<td>23.05</td>
<td>22.00</td>
<td>21.10</td>
<td>20.10</td>
</tr>
<tr>
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<td>Modipuram</td>
<td>11.21</td>
<td>10.21</td>
<td>9.30</td>
<td>8.31</td>
<td>7.32</td>
<td>6.21</td>
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<tr>
<td>K. Ashoka</td>
<td>Patna</td>
<td>17.30</td>
<td>16.14</td>
<td>15.40</td>
<td>13.51</td>
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<td>10.21</td>
<td>11.10</td>
<td>10.26</td>
<td>9.26</td>
</tr>
</tbody>
</table>

\(T_o = \) onset temperature; \(T_p = \) peak temperature; \(T_c = \) conclusion temperature; \(R = \) gelatinization range \(2(T_p - T_o)\).

\(\Delta H_{gel} = \) enthalpy of gelatinization; PHI = (peak height index)=\(\Delta H_{gel} / (T_p - T_o)\).

### Table 5
Thermal properties of starches separated from different potato cultivars

<table>
<thead>
<tr>
<th>Variety</th>
<th>Location</th>
<th>(T_o) (°C)</th>
<th>(T_p) (°C)</th>
<th>(T_c) (°C)</th>
<th>(\Delta H_{gel}) (J/g)</th>
<th>PHI (J/g°C)</th>
<th>(R) (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>K. Chandarmukhi</td>
<td>Gwalior</td>
<td>58.90</td>
<td>67.77</td>
<td>66.80</td>
<td>13.33</td>
<td>4.64</td>
<td>5.74</td>
</tr>
<tr>
<td>K. Jyoti</td>
<td>Gwalior</td>
<td>61.11</td>
<td>64.25</td>
<td>69.44</td>
<td>13.27</td>
<td>4.21</td>
<td>6.28</td>
</tr>
<tr>
<td>K. Lauvkar</td>
<td>Gwalior</td>
<td>61.31</td>
<td>64.39</td>
<td>69.80</td>
<td>14.71</td>
<td>4.77</td>
<td>6.16</td>
</tr>
<tr>
<td>K. Badshah</td>
<td>Jalandhar</td>
<td>59.56</td>
<td>64.08</td>
<td>70.50</td>
<td>12.42</td>
<td>2.74</td>
<td>9.04</td>
</tr>
<tr>
<td>K. Bahar</td>
<td>Jalandhar</td>
<td>58.27</td>
<td>61.60</td>
<td>67.45</td>
<td>13.48</td>
<td>4.04</td>
<td>6.66</td>
</tr>
<tr>
<td>K. Jyoti</td>
<td>Jalandhar</td>
<td>59.13</td>
<td>63.03</td>
<td>76.98</td>
<td>17.00</td>
<td>6.92</td>
<td>7.8</td>
</tr>
<tr>
<td>K. Chandarmukhi</td>
<td>Jalandhar</td>
<td>58.30</td>
<td>61.8</td>
<td>66.70</td>
<td>13.69</td>
<td>4.51</td>
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<td>K. Lalima</td>
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<td>64.79</td>
<td>70.12</td>
<td>10.60</td>
<td>7.00</td>
<td>7.2</td>
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<tr>
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<td>Jalandhar</td>
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<td>71.62</td>
<td>13.21</td>
<td>3.22</td>
<td>8.18</td>
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<tr>
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<td>Jalandhar</td>
<td>59.45</td>
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<td>67.78</td>
<td>13.08</td>
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<td>K. Anand</td>
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<td>68.62</td>
<td>13.05</td>
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<tr>
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<td>68.56</td>
<td>11.89</td>
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<tr>
<td>K. Chipsona-1</td>
<td>Modipuram</td>
<td>61.22</td>
<td>64.06</td>
<td>68.50</td>
<td>13.37</td>
<td>4.70</td>
<td>5.68</td>
</tr>
<tr>
<td>K. Chipsona-2</td>
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<td>64.26</td>
<td>70.62</td>
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</tr>
<tr>
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<td>64.32</td>
<td>70.42</td>
<td>12.47</td>
<td>3.63</td>
<td>7.26</td>
</tr>
<tr>
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<td>Modipuram</td>
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<td>61.90</td>
<td>67.76</td>
<td>14.01</td>
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</tr>
<tr>
<td>K. Pukraj</td>
<td>Modipuram</td>
<td>60.34</td>
<td>64.34</td>
<td>70.38</td>
<td>16.90</td>
<td>4.22</td>
<td>8.0</td>
</tr>
<tr>
<td>K. Sindhuri</td>
<td>Modipuram</td>
<td>62.09</td>
<td>65.58</td>
<td>71.20</td>
<td>13.15</td>
<td>3.76</td>
<td>6.98</td>
</tr>
<tr>
<td>K. Ashoka</td>
<td>Patna</td>
<td>58.26</td>
<td>62.53</td>
<td>66.63</td>
<td>13.25</td>
<td>4.20</td>
<td>8.54</td>
</tr>
<tr>
<td>K. Jyoti</td>
<td>Patna</td>
<td>61.35</td>
<td>64.50</td>
<td>69.95</td>
<td>11.30</td>
<td>3.58</td>
<td>6.3</td>
</tr>
<tr>
<td>K. Sindhuri</td>
<td>Patna</td>
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<td>66.75</td>
<td>71.56</td>
<td>14.39</td>
<td>3.16</td>
<td>9.08</td>
</tr>
</tbody>
</table>
starch from different potato cultivars may be due to the presence of crystalline regions within a starch granule composed of small crystallites having slightly different crystal strength (Banks & Greenwood, 1975). The thermal parameters were affected by the size of the starch granules. The starch separated from the potato cultivars grown in Jalandhar showed lower $T_w$, $T_p$ and $T_c$ as compared to starch from those grown in other locations. The results revealed that small-granule fractions gelatinized at slightly higher temperatures than their counterpart large-granule fractions. Vasanthan and Bhatty (1996) and Peng et al. (1999) have reported similar results for barley and wheat starches.

3.5. Granule size

Potato starch showed the presence of exceptionally large size granules (Table 2). The granules showed the size between 32.37 and 42.05 μm. Kufri Lauvkar (Gwalior) starch showed presence of smaller size granules and Kufri Chipsona-2 (Modipuram) showed larger granules. The mean granule size between 25.5–46.8 μm (Noda et al., 2004), 38.7–53.8 μm (Wiesborn et al., 1994) and 16.5–27.5 μm (Murakami, Asama, & Itoh, 1978) has been reported earlier. The starch separated from the potato cultivars grown in Jalandhar showed higher granule size as compared to those grown in other locations. This may be attributed to difference in temperature of the locations during tubers growth. A comparison between the temperatures during tubers growth at different locations revealed that the temperature range, especially minimum temperature, was lower at Jalandhar compared to the other three locations. Large granule size observed in starch separated from potatoes grown in Jalandhar could be attributed to lower temperature prevailed during tubers growth. A decrease in granule size with increase in growth temperature has been reported earlier (Cottrell et al., 1995; Tester, Debon, Davies, & Gidley, 1999).

3.6. Pearson’s correlation between properties of potato starches

The Pearson’s correlation coefficient for the relationship between various properties of starches separated from different potato cultivars are shown in Table 6. Ash content which mainly represents the phosphorus content in potato starch was positively correlated to HPV, $T_w$ and $T_p$ ($r = 0.507$, $0.621$, $0.585$, $P \leq 0.05$) and negatively correlated with SP ($r = -0.527$, $P \leq 0.05$). The relationship between ash and $T_w$ is shown in Fig. 1. It has been reported that the phosphorus content is highly positively correlated to PV (Noda et al., 2004). Amylose content was positively correlated to HPV ($r = 0.460$, $P \leq 0.05$) and CPV ($r = 0.497$, $P \leq 0.05$). The relationship of amylose content and HPV is shown in Fig. 2. Reddy, Subramanian, Zakudin Ali, and Bhattacharya (1994) also found a positive cor-
relation between amylose content and paste viscosity for rice starch at a paste concentration of >7%. Amylose content was negatively correlated to transmittance measured after storage of 0, 24, and 72 h ($r = -0.508, -0.480, -0.453, P \leq 0.05$). The relationship of amylose and transmittance is shown in Fig. 3. SP showed a significant negative correlation with solubility ($r = -0.656, P \leq 0.005$). Solubility was positively correlated with $T_o$ and $T_p$ ($r = 0.423, 0.434, P \leq 0.05$). PV showed significant positive correlation with BD ($r = 0.924, P \leq 0.005$) and negative correlation with pasting time ($r = -0.546, P \leq 0.05$). The relationship between PV and BD is shown in Fig. 4. HPV showed significant positive correlation with CPV, $P_{temp}$, $T_p$ and $T_c$ ($r = 0.985, 0.607, 0.654, 0.628, P \leq 0.005$) and negative correlation with transmittance measured after 0, 24 and 72 h ($r = -0.539, -0.571, -0.451, P \leq 0.05$). The relationship of HPV with $T_p$ is shown in Fig. 5. CPV showed positive correlation to PT, $P_{temp}$, $T_p$ and $T_c$ ($r = 0.520, P \leq 0.05, 0.624, 0.673, 0.663, P \leq 0.005$) and negative correlation to transmittance measured after 0, and 24 h ($r = -0.591, 0.620, P \leq 0.005$). BD showed highly negative correlation with PT ($r = -0.766, P \leq 0.005$) and positive correlation with transmittance measured after 0, 24 and 72 h ($r = 0.533, 0.558, 0.570, P \leq 0.05$). $P_{temp}$ showed highly positive correlation with transition temper-
atures $T_o$, $T_p$, $T_c$ ($r = 0.740, 0.846, 0.734, P \leq 0.005$). The relationship between $P_{\text{temp}}$ and $T_p$ is shown in Fig. 6 and negative correlation with transmittance measured after 0, 24 and 72 h ($r = -0.418, -0.468, -0.476, P \leq 0.05$). PT showed highly negative correlation with transmittance measured after 0, 24 and 72 h ($r = -0.707, -0.720, -0.679, P \leq 0.005$). The relationship between PT and transmittance is shown in Fig. 7. $T_o$ showed significant positive correlation with $T_p$ and $T_c$ ($r = 0.924, 0.755, P \leq 0.005$) and $T_p$ also showed significant positive correlation with $T_c$ ($r = 0.902, P \leq 0.005$) Singh, Kaur, and Singh (2004). Mean granule size did not correlate significantly with PV, BD and $P_{\text{temp}}$. This is in agreement with the results reported earlier (Noda et al., 2004).

4. Conclusion

The research demonstrates the effect on different properties of potato starch from various cultivars of different locations. Amylose content, pasting properties and thermal properties seem to be more altered than other starch properties. In contrast, no or slight difference in, ash content, and mean granule size were observed. The information obtained in this study could be useful to food and related industries that make use of potato starch.

Acknowledgement

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References


