

# Structural, Morphological, Thermal, and Pasting Properties of Starches From Diverse Indian Potato Cultivars

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Starches from 42 diverse Indian potato cultivars are evaluated for diversity in structural (amylose content and amylopectin chain length distribution), morphological (granules size distribution), thermal, and pasting properties. Amylose content varied between 6.5 and 32.2% while the proportion of short (DP 6–12), medium (DP 13–18), and long (DP 19–30) amylopectin chains varied in the range from 37.2 to 45.4%, 35.6 to 39.1%, and 17.8 to 24.5%, respectively. Starches with higher transition temperature showed lower enthalpy of gelatinization. The proportion of small granules (<10 μm) correlated negatively to short amylopectin chains (DP 6–12), peak viscosity, and breakdown viscosity. Transition and pasting temperature related negatively to the proportion of short and medium chains of amylopectin (DP 6–12 and 13–18, respectively), while positively to that of long chains (DP 19–30). Peak viscosity and breakdown viscosity has a negative relation while the final and setback viscosity have a positive relation with long amylopectin chains.

properties of potatoes and potato products.<sup>[2]</sup> Potato starch is preferred in many food applications over commercial starches because of its low gelatinization temperature, high paste viscosity, and formation of translucent paste.<sup>[1]</sup> Potato starch granules are oval and irregular or cuboidal in shape with a size of approximately 10–100 μm in diameter. The potato starch granules are composed of amylose and amylopectin. Amylose content of potato starch varies from 23 to 31%. The content of amylose in potato starch varies among varieties; and is affected by climatic conditions and soil types during growth.<sup>[3]</sup> Amylopectin is branched polymer of glucose with an average degree of polymerization (DP) of 21–28.<sup>[4]</sup> The variations in physicochemical characteristics of starches influence their functionality in various applications, for example, starches with low amylose content

gelatinize easily and produce clear pastes suggesting its usefulness in paper manufacturing industries whereas those with high amylose content would be source of nutritionally desirable carbohydrates (slowly digestible and resistant starch) in particular for diabetics and obese persons. The properties of potato starches were reported to vary with genotypes and cultural practices.<sup>[5]</sup> Alvani et al.<sup>[6]</sup> revealed some differences among the starches from Scottish potato cultivars with protein ranging from 0.30 to 0.34%, amylose 25.2 to 29.1%, and phosphorus 52.6–66.2 mg 100 g<sup>-1</sup>. Hase and Plate<sup>[7]</sup> found that total starch and starch phosphorus contents, as well as granule size distributions of starch from different cultivars of potatoes, showed significant variation due to genotype and environment factors, while amylose contents of starch were very consistent.

The interest in new value-added starch products has spurred researches toward investigating physicochemical and functional properties of starches from diverse cultivars and botanical sources. Although, numerous cultivars of potato are grown in India, there have just been few studies (involving fewer cultivars) on diversity in structural, thermal, and pasting properties of starches. Therefore, the present study was undertaken to evaluate diversity in structural (amylose content and amylopectin chain length distribution), morphological (granule size distribution), thermal, and pasting properties of potato starches from diverse 42 Indian potato cultivars.

## 1. Introduction

Potato is the fourth most important vegetable crop of the world after rice, wheat, and maize. It can be cultivated in various climates and soil types, and are a relatively inexpensive source of calories.<sup>[1]</sup> About 80% of potato tuber is water and major constituent of potato dry matter is starch. The chemical composition of potato dry matter such as starch, non-starch polysaccharide, sugar, and protein influences the functional

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## 2. Experimental Section

The potatoes of 42 cultivars, that is, Kufri (K.) Ashoka, K. Arun, K. Anand, K. Alankar, K. Bahar, K. Badshah, K. Chamtekar, K. Chipsona-1, K. Chipsona-2, K. Chipsona-3, K. Dewa, K. Frysona, K. Giriraj, K. Girdhari, K. Khashigiri, K. Kundan, K. Kanchan, K. Kuber, K. Kcm, K. Kumar, K. Khayati, K. Jeevan, K. Jyoti, K. Jawaher, K. Himalini, K. Himsona, K. Muthu, K. Neela, K. Naveen, K. Pukhraj, K. Purpkar, K. Red, K. Swarna, K. Suttlej, K. Surya, K. Sherpa, K. Sadabhar, K. Shailja, K. Sindhuri, K. Lalima, K. Sheetman, and K. Safed were procured from Central Potato Research Institute, Shimla, India. Uniformly sized potatoes were selected from each cultivar and starch was isolated following the method described elsewhere.<sup>[8]</sup> The isolated starch samples were then packed in air-tight containers.

### 2.1. Granule Size, Amylose Content, and Amylopectin Chain Length Distribution

Granule size distribution of isolated starch were determined using a laser-light particle size analyzer (S3550, Microtrac Inc., USA) equipped with delivery system for wet samples (Microtrac SDC, Microtrac Inc., USA).<sup>[8]</sup>

Amylose content was determined following the method of Williams et al.<sup>[9]</sup> Exactly 20 mg starch was dispersed in 10 ml KOH (0.5M) and made up to 100 ml with distilled water. To an aliquot (10 ml) of the dispersion, 5 ml HCl (0.1M), and 0.5 ml iodine (0.1%) were added and made up to 50 ml. Absorbance was measured at 625 nm using a UV/Vis spectrophotometer (Lambda 25 UV/VIS, Perkin Elimer, Switzerland). The quantity of amylose was determined from a standard curve developed using blends of amylose and amylopectin from potato starch.

Amylopectin unit chains distribution between DP 6 and 30 were analyzed using fluorophore-assisted capillary electrophoresis as described previously.<sup>[10]</sup> Starch was debranched with isoamylase and labeled with 8-amino-1, 3, 6-pyrenetrisulfonic acid.<sup>[11]</sup> The labeled sample was diluted with distilled water and electrophoresis was conducted on an ABI PRISM 3100 genetic analyzer (Applied Biosystems, Foster City, CA, USA). The POP-6 polymer and 36-cm capillary (Applied Biosystems) were used. Electrophoresis was performed with a genetic analyzer buffer (Applied Biosystems) at 15 kV for 2 h, and then data was collected and analyzed using Genescan 3.7 software (Applied Biosystems).

### 2.2. Thermal Properties

Thermal characteristics were studied by using DSC (DSC-821, Mettler Toledo, Switzerland) equipped with thermal analysis data station. Starch ( $\approx 3.5$  mg, dry wt.) was loaded in a 40  $\mu$ L capacity aluminum pan Mettler, ME-27331 and distilled water was added with the help of Hamilton micro syringe to sieve a starch water suspension containing 70% water. Samples were hermetically sealed and allowed to stand for 4 h at room temperature before analysis. DSC analyzer was calibrated using indium and empty aluminum pan was used as reference sample pan were heated at the rate of 10°C min<sup>-1</sup> from 40 to 100°C. Thermal transition of starch samples were defined as  $T_o$  onset

temperature,  $T_p$  peak temperature, and  $T_c$  endset temperature and  $\Delta H_{gel}$  enthalpy of gelatinization.

### 2.3. Pasting Properties

The pasting properties of starches were evaluated using Rapid Visco Analyzer (RVA-4, Newport Scientific, Warriewood, Australia) as described earlier.<sup>[12]</sup> Viscosity profiles of the starch suspensions (starch/water, 3.0:25.0 g) were recorded. Pasting temperature (PT), peak viscosity (PV), trough viscosity (TV), final viscosity (FV), breakdown viscosity (BV), and setback viscosity (SB) were recorded.

### 2.4. Statistical Analysis

The data reported is the average of triplicate observations. The data was subjected to analysis of variance (ANOVA) by Duncan's test ( $P < 0.05$ ), Pearson's correlation and Principal Component Analysis (PCA) using Minitab Statistical Software (State College, PA, USA).

## 3. Result and Discussion

### 3.1. Physicochemical Properties

#### 3.1.1. Granule Size

The granular size of starches from different potato cultivars is presented in **Table 1** and **Figure 1**. The starches from different cultivars were divided into three categories on the basis of granules size viz. small (<10  $\mu$ m), medium (11–50  $\mu$ m), and large (>50  $\mu$ m). Medium granules contributed to the highest proportion of starch whereas small granules were present in the lowest proportion. The relative proportion of small, medium and large granules varied from 4.4 to 6.9%, 60.5 to 86.4% and 6.5 to 34.8%, respectively. The variations in genetic architecture among different cultivars may be attributable to the differences in granular size distribution of the starches.

#### 3.1.2. Amylose Content and Amylopectin Chain Length

Amylose content of starches from different potato cultivars showed a wide variation between 6.5 and 32.2% (Table 1). The lowest amylose content was observed for K. Kanchan while K. Swarna showed the highest. Majority of cultivars showed amylose content in the range from 16 to 26%. Amylose content of potato starch had been reported to vary between 16.6 and 20.4%.<sup>[12]</sup> The differences in amylose content among starches from different cultivars/sources have been attributed to various factors like genotype, environment and storage conditions, cultural practice, etc. As all cultivars were grown at the same place, the differences in amylose content may be due to genotypic differences.

The starches from different potato cultivars also differed significantly for amylopectin chain length distribution (Table 1).

**Table 1.** Amylose content, amylopectin chain length (degree of polymerization, DP), and particle (granular) size distribution in starches from different potato cultivars.

Cultivars	Amylose content (%)	DP 6–12 (short chains)	DP 13–18 (medium chains)	DP 19–30 (long chains)	Particle size <10 μm (%)	Particle size 11–50 μm (%)	Particle size >50 μm (%)
Kufri Ashoka	23.4	40.73	38.21	21.09	6.94	86.42	6.45
Kufri Arun	25.9	42.34	37.60	20.04	5.56	70.42	23.88
Kufri Anand	16.7	41.58	37.15	21.26	5.44	75.79	18.62
Kufri Alankar	25.8	41.66	37.27	21.06	5.05	73.23	21.55
Kufri Bahar	19.0	38.47	38.01	23.52	5.94	70.76	23.05
Kufri Badshah	24.0	39.13	38.95	21.91	5.46	74.45	19.93
Kufri Chamtekar	25.3	37.24	38.29	24.45	5.72	69.34	24.68
Kufri Chipsona1	9.5	41.99	38.30	19.72	5.15	75.29	19.34
Kufri Chipsona2	16.0	44.99	35.65	19.38	4.89	75.88	19.04
Kufri Chipsona3	26.3	42.86	39.13	18.00	5.61	77.15	17.02
Kufri Dewa	20.9	39.00	37.47	23.53	5.18	76.97	17.71
Kufri Frysona	18.2	42.30	37.45	20.24	5.36	83.27	11.10
Kufri Giriraj	17.7	43.29	37.14	19.54	4.98	73.24	21.56
Kufri Girdhari	16.3	42.46	37.15	20.39	4.97	81.22	13.58
Kufri Khashigiri	18.9	42.80	37.72	19.49	4.85	73.50	21.40
Kufri Kundan	10.4	42.84	36.35	20.82	5.93	83.62	10.19
Kufri Kanchan	6.5	44.36	36.61	19.03	5.24	83.42	11.12
Kufri Kuber	21.3	42.01	36.80	21.18	5.48	78.46	15.88
Kufri Kcm	14.9	43.38	36.38	20.23	4.35	72.54	22.92
Kufri Kumar	19.2	41.10	36.90	21.99	5.60	80.20	14.04
Kufri Khayati	24.5	37.74	37.93	24.33	5.46	78.32	16.02
Kufri Jeevan	16.0	39.21	38.02	22.77	4.83	69.30	25.72
Kufri Jyoti	27.1	42.30	38.18	19.51	5.25	77.47	17.06
Kufri Jawaher	17.7	43.57	36.26	20.18	4.98	76.17	18.63
Kufri Himalini	16.1	42.37	37.68	19.95	5.80	74.40	19.54
Kufri Himsona	20.8	44.40	37.28	18.31	5.40	84.22	10.16
Kufri Muthu	16.0	45.36	36.81	17.80	5.31	80.07	14.42
Kufri Neela	9.9	42.41	37.37	20.22	5.38	80.61	13.86
Kufri Naveen	19.0	43.63	37.19	19.20	4.95	71.42	23.43
Kufri Pukhraj	19.1	43.53	38.27	18.18	5.14	75.29	19.38
Kufri Purpkar	25.9	42.85	37.11	20.05	5.42	77.56	16.84
Kufri Red	28.8	42.26	37.30	20.42	6.11	75.13	18.60
Kufri Swarna	32.2	41.34	36.97	21.70	5.05	70.89	23.90
Kufri Sutlej	25.6	42.75	37.48	19.74	4.98	72.89	21.91
Kufri Surya	19.9	42.56	35.63	21.84	6.53	76.82	16.34
Kufri Sherpa	23.4	40.66	37.11	22.23	4.86	71.87	23.07
Kufri Sadabahar	10.4	39.46	37.44	23.08	5.57	68.28	25.91

(Continued)

**Table 1.** (Continued)

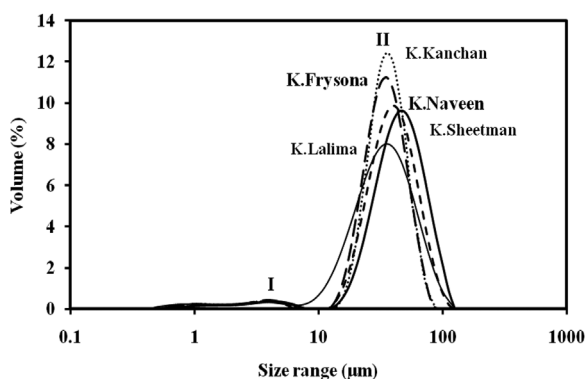
Cultivars	Amylose content (%)	DP 6–12 (short chains)	DP 13–18 (medium chains)	DP 19–30 (long chains)	Particle size <10 μm (%)	Particle size 11–50 μm (%)	Particle size >50 μm (%)
Kufri Shailja	21.7	41.28	37.07	21.66	5.50	78.83	15.51
Kufri Sindhuri	20.4	43.99	36.96	19.05	5.31	78.39	16.09
Kufri Lalima	16.8	41.85	39.04	19.09	6.02	68.64	25.11
Kufri	12.7	44.29	36.28	19.43	4.58	60.48	34.82
Sheetman							
Kufri Safed	11.6	43.20	37.06	19.71	4.90	68.43	26.50
Pooled SD	0.70	0.92	0.91	0.74	0.18	0.60	0.15

Starches from all cultivars showed a smooth polymodal distribution with the peak maxima at DP 12. It was consistent with that reported earlier for potato,<sup>[12]</sup> chickpea,<sup>[13]</sup> wheat,<sup>[14]</sup> and amaranth starches.<sup>[15]</sup> To ascertain the relation of amylopectin structure with functional properties of potato starch the amylopectin chains were grouped as short (DP 6–12), medium (DP 13–18), and long chains (DP 19–30). The proportion of short, medium, and long amylopectin chains varied in the range of 37.2–45.4%, 35.6–39.1%, and 17.8–24.5%, respectively. The starches with greater proportion of short chains had lesser proportion of long and medium amylopectin chains as DP 6–12 correlated negatively with DP 13–18 and DP 19–30 ( $r = -0.490$  and  $-0.906$ , respectively, and  $P < 0.005$ ). Rice bean starches were reported to contain DP 6–10, DP 11–20, and DP 21–30 in the range of 19.85–28.42%, 60.69–65.05%, and 8.67–15.67%, respectively,<sup>[16]</sup> against 23.13–34.13%, 57.33–62.05%, and 7.9–14.85%, respectively, for amaranth starches.<sup>[15]</sup> PCA also provided an overview of the interrelationships among different properties. The properties whose curves lay close to one another on PCA loading plot (Figure 2) were positively related, while those whose curves ran in opposite directions were negatively related.<sup>[17]</sup> PCA revealed a strong positive relation of amylose with long amylopectin chains and negative with short chains (Figure 2). PCA also revealed a negative relation of short amylopectin chains with the proportion of small and medium granules and positive with large granules, while inverse was observed for medium and long chains (Figure 2). This reflected that small and medium potato starch

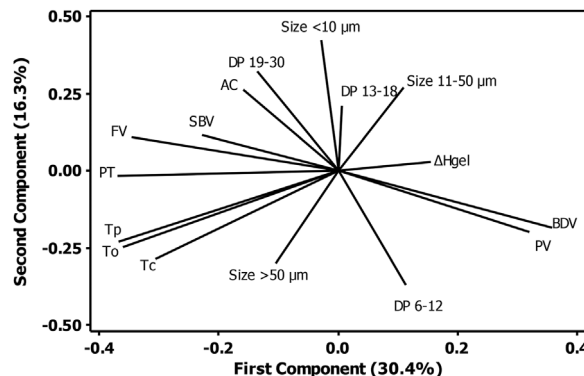
granules contained higher proportion of amylopectin chains with DP 13–30 and lower of short chains of DP 6–12 while large granules had higher proportion of short amylopectin chains and lower of chains with DP between 13 and 30.

### 3.2. Thermal Properties

Transition temperatures ( $T_o$ ,  $T_p$ , and  $T_c$ ) varied in the range from 60.0 to 64.3 °C, 63.0 to 67.7 °C, and 67.3 to 74.0 °C, respectively, and  $\Delta H_{gel}$  varied between 11.0 and 18.6 J g<sup>-1</sup> (Table 2). Starches from majority of cultivars showed  $T_o$ ,  $T_p$ ,  $T_c$ , and  $\Delta H_{gel}$  in the range from 60.5 to 63.0 °C, 64.0 to 65.5 °C, 68.0 to 71.0 °C and 15 to 16 J g<sup>-1</sup>, respectively. Earlier,  $T_o$ ,  $T_p$ , and  $T_c$  of starches from different Indian potato cultivars were reported to range from 55.4 to 59.6 °C, 58.8 to 62.4 °C, and 65.2 to 68.1 °C, respectively.<sup>[12]</sup> Transition temperatures represent initiation of starch gelatinization at which the granules start imbibing water and undergo transition from semi-crystalline to gel state. PCA revealed that  $T_o$ ,  $T_p$ , and  $T_c$  related negatively to the proportion of short and medium chains of amylopectin while positively to that of long chains (Figure 2). This indicated that amylopectin chains of DP 6–12 might get disrupted by heat at relatively lower temperatures whereas long chains (DP 19–30) unraveled at higher temperature, hence contributed to increased gelatinization temperature of starches, and the probable reason may be the formation of stronger crystalline network within the starch



**Figure 1.** Granule size distribution starches from different potato cultivars.



**Figure 2.** Principal component analysis loading plot indicating relationships among starches from different potato cultivars. DP, degree of polymerization; AC, amylose content; PT, pasting temperature; PV, peak viscosity; FV, final viscosity; BDV, breakdown viscosity; SB, setback viscosity).

**Table 2.** Thermal properties (transition temperatures and enthalpies) of starches from different potato cultivars.

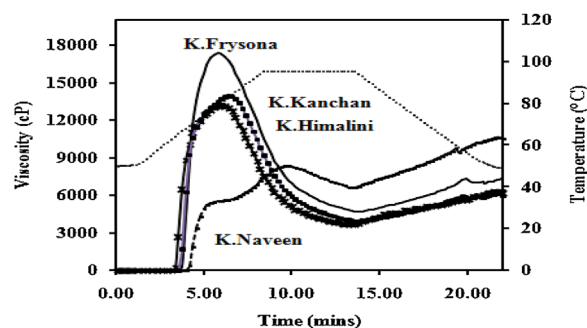
Variety	$T_o$ (°C)	$T_p$ (°C)	$T_c$ (°C)	$\Delta H_{gel}$ (J g <sup>-1</sup> )
Kufri Ashoka	61.6	65.1	69.7	14.09
Kufri Arun	63.6	66.7	70.7	12.88
Kufri Anand	63.1	66.5	70.9	15.40
Kufri Alankar	61.7	64.9	69.0	13.49
Kufri Bahar	62.3	65.7	70.2	17.64
Kufri Badshah	62.0	65.3	69.9	15.67
Kufri Chamtekar	62.6	66.7	69.0	15.30
Kufri Chipsona 1	63.0	66.2	70.5	17.75
Kufri Chipsona 2	61.4	64.8	69.5	15.66
Kufri Chipsona 3	62.6	65.4	69.1	15.52
Kufri Dewa	63.4	67.0	71.0	15.06
Kufri Frysona	61.3	64.4	68.4	15.33
Kufri Giriraj	61.8	65.0	69.3	18.55
Kufri Girdhari	62.3	65.5	69.4	15.14
Kufri Khashigiri	62.1	65.6	70.4	15.66
Kufri Kundan	63.0	66.3	70.5	15.42
Kufri Kanchan	60.0	63.0	67.3	16.35
Kufri Kuber	62.7	66.1	69.9	15.19
Kufri Kcm	60.7	63.9	68.2	15.93
Kufri Kumar	61.2	64.5	68.4	15.78
Kufri Khayati	61.8	64.8	68.7	15.43
Kufri Jeevan	63.2	65.7	69.4	15.51
Kufri Jyoti	61.5	64.5	68.6	15.87
Kufri Jawaher	63.9	67.5	74.0	11.00
Kufri Himalini	60.3	64.0	69.0	15.86
Kufri Himsona	62.0	64.6	68.4	15.38
Kufri Muthu	62.0	64.9	68.8	14.71
Kufri Neela	61.5	65.2	70.0	15.93
Kufri Naveen	64.3	67.7	71.7	16.51
Kufri Pukhraj	62.0	65.4	70.0	15.00
Kufri Purpkar	61.9	65.4	69.7	16.33
Kufri Red	62.1	65.4	69.5	15.53
Kufri Swarna	60.9	64.1	68.8	14.71
Kufri Sutlej	61.8	65.1	69.3	15.74
Kufri Surya	61.9	65.2	69.5	15.20
Kufri Sherpa	61.8	64.9	68.7	15.72
Kufri Sadabahar	60.3	63.5	68.0	15.72
Kufri Shailja	61.3	65.2	69.9	16.53
Kufri Sindhuri	62.4	65.7	70.2	14.89
Kufri Lalima	61.2	64.2	68.1	15.01
Kufri Sheetman	64.0	67.2	71.4	15.20
Kufri Safed	61.3	64.6	68.9	15.38
Pooled SD	0.25	0.29	0.30	0.23

granules. High transition temperatures result from a higher degree of crystallinity which provides structural stability to the granules hence make them more resistant toward

gelatinization.<sup>[18]</sup> Negative correlation of transition temperatures with extremely short chains of amylopectin was reported previously.<sup>[19,20]</sup> However, at the same time, the contribution of amylose can not be denied, as it also related positively to transition temperatures (Figure 2). Earlier, Vasanthan et al.<sup>[21]</sup> demonstrated that starches with higher transition temperatures and enthalpy would require higher heat for solubilization. Contrarily, in the present study, the starches with high transition temperatures showed lower  $\Delta H_{gel}$  as  $T_o$ ,  $T_p$ , and  $T_c$  related negatively to  $\Delta H_{gel}$  on the PCA loading plot (Figure 2).

### 3.3. Pasting Properties

Pasting properties represent changes in viscosity of starch suspensions during heating, holding, and cooling (Figure 3). PT, the temperature at which viscosity of starch suspensions began to rise steeply during heating due to the absorption of water and loss of starch structure, varied between 66.6 and 72.7 °C (Table 3). Starches from majority of cultivars showed PT in the range of 67.7–70.4 °C. PT related positively to transition temperatures of starches, amylose content, and the proportion of long amylopectin chains (Figure 2). This supported the contribution of amylose and long amylopectin chains toward granular integrity leading to high gelatinization temperatures. Starches with high amylose and longer chains have been reported to show high gelatinization temperatures.<sup>[22]</sup> PV of the starches varied between 7259 and 17 320 cP, being the lowest for K. Girdhari and the highest for K. Frysona. PV represents the point of maximum granular swelling during the heating of starch suspension. Majority of cultivars showed high values of PV (>9000 cP), reflecting high ability of granules to swell freely before their physical breakdown due to the presence of esterified phosphate groups which got ionized when heated and resulted in slight coulombic repulsion causing opening of branched amylopectin molecules, leading to high swelling and PV.<sup>[23]</sup> PV showed a negative correlation with amylose content ( $r = -0.343$ ,  $P < 0.05$ ) which was consistent with that reported earlier for starches from different wheat types/cultivars<sup>[18,24]</sup> and indicated suppression of granular swelling in the presence of high levels of amylose. This relationship was also observed on PCA loading plot. PCA also revealed a positive relation of PV with the proportion of short amylopectin chains while negative with that of long amylopectin chains (Figure 2). This suggested that starches with high proportion of long amylopectin chains swelled to a lesser extent than the starches with high



**Figure 3.** Pasting curves of starches from some representative potato cultivars.

**Table 3.** Pasting properties of starches from different potato cultivars.

Cultivars	Peak viscosity (cP)	Breakdown viscosity (cP)	Final viscosity (cP)	Setback viscosity (cP)	Pasting temperature (°C)
Kufri Ashoka	9471	4920	7646	3095	69.1
Kufri Arun	9721	3234	10 430	3943	70.3
Kufri Anand	10290	4672	6484	866	70.5
Kufri Alankar	11910	6710	9117	3917	69.0
Kufri Bahar	8380	3334	7910	2864	69.2
Kufri Badshah	10020	3814	9435	3229	70.2
Kufri Chamtekar	13 480	8339	7785	2644	70.2
Kufri Chipsona1	15 760	11 151	7746	3137	67.8
Kufri Chipsona2	13 510	8930	7292	2712	69.0
Kufri Chipsona3	11 190	6185	6358	1353	69.0
Kufri Dewa	10 180	5587	7612	3019	69.2
Kufri Frysona	17 320	12 673	7389	2742	67.7
Kufri Giriraj	15 700	12 044	6085	2429	67.5
Kufri Girdhari	7259	2406	8613	3760	70.2
Kufri Khashigiri	13 570	9023	6681	2134	70.2
Kufri Kundan	10 190	4282	9352	3444	69.9
Kufri Kanchan	13 860	9992	5875	2007	66.6
Kufri Kuber	10010	4719	8792	3501	71.5
Kufri Kcm	10690	6792	6576	2678	67.7
Kufri Kumar	8613	2156	9892	3435	69.0
Kufri Khayati	10770	6296	7763	3289	69.2
Kufri Jeevan	9509	5398	9013	4902	70.2
Kufri Jyoti	13 400	8296	8699	3595	67.7
Kufri Jawahar	11 470	6879	7470	2879	67.8
Kufri Himalini	13 120	9500	5932	2312	67.8
Kufri Himsona	13 590	8978	7018	2406	67.4
Kufri Muthu	10690	6792	6576	2678	69.0
Kufri Neela	13 760	9614	6624	2478	68.1
Kufri Naveen	8313	1699	10 170	3556	72.7
Kufri Pukhraj	10 730	5315	8593	3178	69.8
Kufri Purpkar	8315	3982	7484	3151	69.1
Kufri Red	11 340	5011	9013	2684	70.2
Kufri Swarna	9073	4218	7408	2553	67.7
Kufri Sutlej	10850	5409	8334	2893	69.0
Kufri Surya	7711	2182	9036	3507	69.0
Kufri Sherpa	13 380	9160	6545	2325	69.4
Kufri Sadabahar	14 790	10 484	7361	3055	67.7
Kufri Shailja	10 700	5017	8708	3025	68.9
Kufri Sindhuri	9719	4660	8271	3212	68.8
Kufri Lalima	14 680	10 075	8093	3488	67.8
Kufri Sheetman	12 100	6149	9102	3151	70.4
Kufri Safed	13 560	9252	6971	2663	67.5
Pooled SD	54	35	88	29	0.4

proportion of short chains. Long amylopectin chains are involved in more than one cluster hence have lesser tendency to be dispersed because of entanglement with other amylopectin molecules,<sup>[25]</sup> whereas short chains promote swelling by destabilizing lamellar

structure.<sup>[26]</sup> Starch swelling and pasting is also influenced by granular size, and wheat starch suspensions with high proportion of large granules were more viscous than those having higher proportion of small granules.<sup>[14,18,24]</sup> This relation was also observed

for potato starch in the present study as PV related negatively with the proportion of small granules that had particle size less than 10 µm (Figure 2). BDV, indicating the susceptibility of swollen starch granules to disintegrate, varied between 1699 and 12 763 cP, being the lowest for K. Naveen and the highest for K. Frysona; while majority of cultivars showed BDV in the range of 4660 and 9992 cP. BDV correlated positively to PV ( $r = 0.968$ ,  $P < 0.005$ ), indicating that starches capable of swelling to a high degree were less resistant to disintegrate on cooking hence exhibited greater breakdown in viscosity after reaching the maximum value.<sup>[18]</sup> A positive correlation between PV and BDV has been observed earlier for starches from potato cultivars grown at different locations.<sup>[27]</sup> PCA also revealed that PV and BDV related positively to one another while negatively to the proportion of long amylopectin chains and starch gelatinization temperatures. This suggested that starches with long amylopectin chains might have swollen to a lesser degree hence disintegrated to a lesser extent on cooking than the starches with short chains. However, the contribution of high amylose to granular integrity and retardation of swelling can not be denied as amylose content also related negatively to PV and BDV (Figure 2). The viscosity of heated starch pastes increased on cooling due to amylose re-association and gel network formation.<sup>[18]</sup> FV and SBV ranged from 5875 to 10 430 cP and 866 to 4902 cP, respectively, among different cultivars. However, majority of the cultivars showed FV and SBV in the range of 6085–9892 cP and 2312–3943 cP, respectively. FV and SBV represent the tendency of gelatinized starches to retrograde on cooling. PCA revealed that FV and SBV related positively with amylose content and the proportion of long amylopectin chains while negatively with that of short amylopectin chains (Figure 2). This further supported the contribution of amylose and long amylopectin chains toward retrogradation in potato starch pastes. Earlier, higher level of amylose has been attributed to lower PV and BDV but higher SBV of potato starches.<sup>[28]</sup> Generally, the pasting viscosities of starches are related to the contents of amylose and amylopectin as former inhibits whereas the later contributes to granular swelling and pasting.<sup>[29]</sup> However, the present study revealed that not only amylopectin content but also their structure influence pasting properties of potato starches.

#### 4. Conclusion

Starch from different potato cultivars showed significant diversity in physicochemical, structural, and functional properties. Starches with high amylose content had greater proportion of long chains and lesser proportion of short and medium amylopectin chains. Long amylopectin branches and amylose contributed to high gelatinization temperatures and retrogradation rate as the starch with higher proportion of amylopectin chains with DP 19–30 and amylose content showed higher PT, DSC transition temperatures, FV and SBV. The results also revealed that small starch granules contributed to lower PV and BDV as negative relations between these were observed.

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#### Conflict of Interest

The authors have declared no conflict of interest.

#### Keywords

amylopectin, fine structure, functional, potato starch

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