ELSEVIER

Food Chemistry 83 (2003) 387–393

Food Chemistry

www.elsevier.com/locate/foodchem

Physicochemical, rheological and cookie making properties of corn and potato flours

Jaspreet Singh[a], Narpinder Singh[a,*], T.R. Sharma[b], S.K. Saxena[c]

[a]*Department of Food Science and Technology, Guru Nanak Dev University, Amritsar-143 005, India*
[b]*Regional Horticultural Research Station, Mashobra (H.P), India*
[c]*Food Research and Analysis Center, New Delhi, India*

Received 5 September 2002; received in revised form 20 February 2003; accepted 20 February 2003

Abstract

The physicochemical and rheological properties of corn flour and flours made from three potato cultivars (Kufri Jyoti, Kufri Badshah and Pukhraj) were studied. Potato flour showed higher amylose content, water absorption index and solubility than corn flour. The rheological properties (G', G'', η' and tan δ), measured using a dynamic rheometer, of corn and potato flours differed significantly. Potato flours showed higher G', G'' and η' than corn flour. The potato flours made from different cultivars also showed significant differences in various rheological parameters. Kufri Jyoti flour showed the highest G', G'' and η' among the potato flours. The effects of blending corn flour and potato flours at different levels (2, 4 & 6%) with wheat flour on cookie-making properties were also studied. The addition of both corn and potato flours improved the cookie spread factor and lowered cookie fracture force. However, the effect of potato flours on cookie spread and fracture force were higher than corn flour. Colour parameters (L*, a*, b*) of cookies were measured using a Hunter colorimeter. L* value of cookies decreased while a* and b* values increased with increase in level of both corn flour and potato flours. The addition of potato flours brought greater changes in L*, a* and b* values than corn flour at corresponding levels.

Keywords: Corn flour; Potato flour; Physicochemical; Morphological; Thermal; Rheological; Texture analysis; Cookies

1. Introduction

Potato flour is the oldest commercial potato product and is widely used in the baking industry. Potato flour has long been associated with the baking of bread. It is well known that small amounts of added potato solids help to retain the freshness of bread and also impart a distinctive, pleasing flavour and improved toasting qualities (Willard & Hix, 1987). The most simple and widely used procedure consists of dehydrating potatoes in the form of slices and then grinding to make flour (Srivastava, Singh, & Verma, 1973). Roy Choudhuri, Joseph, Narayana Rao, Swaminathan, Sreenivasan and Subramanyan (1963) suggested a faster way of drying the slices by using a kiln or a flow drier for large-scale production of potato flour. Pant and Kulshreshta (1995) prepared potato flour from six potato varieties by pressure cooking the potatoes at 10 lb/cubic inch for 22 min, cooling under running water to room temperature within 3 min and further drying in a cabinet drier at 60 °C. Treadway, Willits, Heisler, Ross, and Osborne (1950) reported the average percentage composition of flour (carbohydrates 77–79%, protein 9–11%, ash 4–4.5%, crude fiber 1.17–1.18% and fat 0.1–0.2%) from different American potato cultivars. Potato flour is used for its characteristics, which differ significantly from those of flour from other plant sources (Willard & Hix, 1987). Identification and screening of potato genotypes is required for desired functionality and unique properties. The physicochemical properties of potato flours vary with genotype and cultural practices (Pant & Kulshrestha, 1995; Willard & Hix, 1987). Willard and Englar (1959) studied the viscosity of potato flour using a Brookfield viscometer as well as viscoamylograph and reported that the viscosity increased as the screen size decreased. Bielawny (1980) showed that the viscosity of potato flour suspensions in water increased as ash, sodium, potassium and

* Corresponding author.
E-mail address: narpinders@yahoo.com (N. Singh).

0308-8146/03/$ - see front matter © 2003 Elsevier Ltd. All rights reserved.
doi:10.1016/S0308-8146(03)00100-6

phosphorus concentrations increased, but decreased with increasing calcium concentration. The starch present in the potato flour may significantly affect the physicochemical properties. Hopkins and Gormley (2000) reported the rheological properties of pastes and gels made from starch isolated from different Irish potato cultivars. Kim, Wiesenborn, Orr, and Grant (1995) and Wiesenborn, Orr, Casper, and Tacke (1994) reported the starch paste behaviour from various potato genotypes and correlated the physicochemical characteristics with functional properties. Starch transition temperatures and gelatinization enthalpies by differential scanning calorimetry (DSC) may be related to characteristics of the starch granule, such as degree of crystallinity (Krueger, Knutson, Inglett, & Walker, 1987). Kim et al. (1995) have studied the thermal properties of 42 potato cultivars and correlated these properties with physicochemical characteristics. Exploratory studies were undertaken to study (1) the physicochemical, dynamic rheological and retrogradation properties of corn and potato flours and (2) the suitability of corn flour and flour prepared from different potato cultivars for cookie making properties.

2. Material and methods

2.1. Materials

The potatoes of three cultivars, Kufri Badshah, Kufri Jyoti and Pukhraj, were procured from Sangha Potato Farms, Jalandhar, India from the 2001 harvest. Uniform sized potatoes were selected from each cultivar for flour preparation. Corn flour was a gift from B.N. Flour Mills (Batala, Amritsar). Sodium bicarbonate and sodium chloride of analytical grade were obtained from SD Fine Chemicals (Mumbai). The wheat flour, shortening (hydrogenated vegetable fat, Dalda brand, Hindustan Lever Ltd., Mumbai), and sugar was procured from the local market. The sugar was coarsely ground in a laboratory grinder.

2.2. Potato flour preparation

Potatoes were washed, brushed and peeled. The eyes and all bruises were pitted out. Immediately after peeling, the potatoes were dipped in water containing a small amount of potassium metabisulfite (35 g/100 l). The potatoes were boiled for 30 min in water. The boiled potatoes were shredded and uniformly layered in a tray and dried at a temperature of 50 °C in a hot air cabinet drier. The dried and shredded potatoes were ground to pass through the sieve no. 72 (British Sieve Standards). The powdered potato flour was packed in air-tight containers.

2.3. Amylose content of corn and potato flours

Amylose content of the flours was determined by the method given by Williams, Kuzina, and Hlynka (1970).

2.4. Water absorption index (WAI) and water solubility index (WSI) of corn and potato flours

WAI and WSI of flours were determined by slightly modifying the method of Anderson, Conway, Pfeiffer and Griffin (1969). The ground flour samples (2.5g) were mixed with 30 ml distilled water, using a glass rod, and cooked at 90 °C for 15 min in a water bath. The cooked paste was cooled to room temperature and transferred to centrifuge tubes and centrifuged at $3000\times g$ for 10 min. WAI and WSI were calculated by using the expressions:

$$\mathrm{WAI} = \frac{\text{Weight of sediment}}{\text{Weight of dry solids}}$$

$$\mathrm{WSI} = \frac{\text{Weight of dissolved solids in supernatant}}{\text{Weight of dry solids}} \times 100$$

2.5. Colour characteristics of corn and potato flours

Colour measurements of the flours were carried out using a Hunter colorimeter, model D25 optical sensor (Hunter Associates Laboratory Inc., Reston, VA, USA) on the basis of L^*, a^* and b^*. The instrument (45°/0° geometry, 10° observer) was calibrated against a standard light yellow-coloured reference tile ($L^*=77.14$, $a^*=-1.52$, $b^*=21.88$). A glass cell containing the powdered flour was placed above the light source and covered with a white plate and L^*, a^*, b^* values were recorded.

2.6. Cooking of corn and potato flours

Flour pastes (10 and 6%) were heated from 30 to 90 °C at a rate of 1.5 °C/min, held for 20 min at 90 °C, and then cooled to 50 °C at a rate of 1.5 °C/min in Brabender Viscoamylograph (Brabender OHG Duisburg, Germany). The cooked pastes were used to study rheological and retrogradation properties of corn and potato flours.

2.7. Rheological properties of corn and potato flours

A small amplitude oscillatory rheological measurement was made for corn and potato flours, with a dynamic rheometer (Carri-Med CSL2-100, TA

Instruments Ltd, Surrey, England) equipped with 1.59° steel cone geometry (4 cm diameter). The strain was set at 1.5%. The flour samples were subjected to frequency sweep testing with a range of 0.1–20 Hz at 40 °C. The dynamic rheological properties, such as storage modulus (G'), loss modulus (G''), loss factor (tan δ) and dynamic viscosity (η'), were determined for corn and potato flours. Cooked flour pastes (as described earlier) of 10% (w/w) concentration were loaded on the ram of the rheometer and covered with a thin layer of low-density silicone oil (to minimize evaporation losses).

2.8. Retrogradation properties of corn and potato flours

Cooked flour pastes (as described above) of 6% (w/w) concentration were stored for 4, 6 and 8 days at 4 °C. Syneresis was measured as % water released after centrifugation at $3000\times g$ for 15 min.

2.9. Cookie making and evaluation

Cookie dough was mixed in a single speed pinhead laboratory mixer (National Manufacturing Company, Lincoln, NE) as described in AACC (1995) methods by adding 2, 4, 6% corn and potato flours. The dough was then sheeted to a thickness of 1 cm with the help of a rolling pin. The cookies were cut with a cookie die of diameter 4.5 cm and transferred to a lightly greased baking tray. The cookies were baked at 205 °C for 12 min in a revolving reel oven mixer (National Manufacturing Company, Lincoln, NE). The baked cookies were cooled to room temperature and packed in airtight containers. The spread factor was measured as described in AACC (1995) methods. The fracture force test was conducted on the cookies using and Instron Universal Testing Machine (Instron Limited, High Wycombe, UK). Fracture force was recorded, as force required for shattering the cookies with the help of a blade. The cross head speed was 100 mm/min and span between the two platforms was 40 mm. The average force was calculated for eight cookies and reported as fracture force. The colour parameters of cookies were measured as described earlier for flours. A glass cell containing a single cookie was placed above the light source and covered with a white plate and L^*, a^*, b^* values were recorded.

2.10. Statistical analysis

The data reported in all the tables are averages of triplicate observations. The data in Tables are averages of eight observations. The data were subjected to statistical analysis using Minitab Statistical Software (Minitab Inc., USA).

3. Results and discussion

3.1. Physicochemical properties of corn and potato flours

The amylose content of potato flours ranged from 9.1 to 10.8% while corn flour had an amylose content of 9.3%. Among the potato flours, Kufri Jyoti flour had the highest amylose content whereas Pukhraj flour had the lowest (Table 1). Corn flour showed lower amylose content among all potato cultivars. The differences in the amylose content between corn and potato flours may be attributed to the botanical origin. The amylose content may have also been affected by climatic conditions and soil type during growth (Cottrell, Duffus, Paterson, & George, 1995). WAI and WSI of all the corn and potato flours differed significantly (Table 1). Potato flours showed higher WAI and WSI than corn flour. Among the potato flours, Kufri Jyoti flour showed highest WAI (6.56) while it was lowest for Pukhraj flour (5.6). The high WAI and solubility of potato flours might be due to higher viscosity patterns and weak internal organization, resulting from negatively charged phosphate ester groups within the starch granules (Kim, Wiesenborn, Lorenzen, & Berglund, 1996). The presence of lipids in the corn flour may have a reducing effect on the swelling of its starch granules (Galliard & Bowler, 1987). Since corn flour contains lipids, contrary to potato flour, this may have been responsible for the difference in WAI between corn and potato flours. The potato flours with higher amylose contents showed higher WAI and solubility (Table 1). The WAI and solubility of the potato tubers has been reported to be mainly due to the swelling and solubility of the starch granules, which in turn depends on the amylose content (Kaur, Singh, & Sodhi, in press). Ash content (%) of the corn and potato flours also differed significantly (Table 1). Potato flours showed higher ash contents than corn flour.

Among the potato flours, Kufri Jyoti flour had the highest ash content (0.33%) while it was 0.313 and 0.303% for Kufri Badshah and Pukhraj potato flours, respectively. The higher ash contents of potato flours may be due to the presence of higher phosphorus contents in their starches (Jane, Kasemsuwan, Chen, &

Table 1
Amylose content, Water absorption index (WAI), Water solubility index (WSI) of corn and potato flours

Flour source	Amylose content (%)	WAI	WSI (%)	Ash (%)
Potato (Kufri Badshah)	10.2b	5.82b	11.28c	0.313b
Potato (Kufri Jyoti)	10.8b	6.56c	11.40c	0.330c
Potato (Pukhraj)	9.1a	5.60b	10.18b	0.303b
Corn	9.3a	3.85a	7.9a	0.215a

Values with similar letters in column do not differ significantly ($P<0.05$).

Juliano, 1996). The differences in ash contents of potato flours may also be attributed to genetic variation and botanical origin. The differences in WAI and solubility for three-potato cultivar flours and corn flour may also be due to the difference in morphological structure of starch granules of the flours (Singh & Singh, 2002).

3.2. Colour characteristics of corn and potato flours

The colour characteristics, such as L^*, a^* and b^* values, for the corn flour and potato flours differed significantly (Table 2). Potato flours from all the cultivars showed higher L^* and lower a^* and b^* values than corn flour. Potato flours from three cultivars also showed variation in colour characteristics. Among the potato flours, Kufri Jyoti potato flour showed the highest L^* (76.85) and lowest a^* (−1.58) and b^* (18.22) values (Table 2). The difference in the colour characteristics may be attributed to the differences in coloured pigment in the corn and potato flours, which in turn depends on the biological origin of the plant. The differences in the colour values of the potatoes may also be attributed to the biological origin, soil type, temperature during growing season and soil moisture (Heisler, Siciliano, & Treadway, 1962; Smith & Nash, 1941).

3.3. Rheological properties of corn and potato flours

The rheological parameters, i.e. G', G'', tan δ, and η' showed significant variation among corn and potato flours when subjected to frequency testing ranging from 0.1 to 20 Hz at different temperatures (Fig. 1a–d). The storage dynamic modulus (G') is a measure of the energy stored in the material and recovered from it per cycle and represents elastic nature, while the loss modulus (G'') is a measure of the energy dissipated or lost per cycle of sinusoidal deformation and represents the viscous nature of the material (Ferry, 1980). The ratio of the energy lost to the energy stored for each cycle can be defined by tan δ which is another parameter indicating the physical behaviour of a system. The G', G'', increased while η' decreased with the increase in frequency. Corn flour showed lower G', G'' and η' values than potato flours (Table 3). This may be attributed to the presence of lipids in corn flour and the more rigid nature of corn starch granules (Singh, Singh, & Saxena, 2002). Among the potato flours, Kufri Badshah flour showed the highest G', G'' and η' while these were lowest for Pukhraj flour. These differences may be due to the differences in granular size and shape of their native starches. Kufri Badshah potato starch has been reported to contain large irregular and cuboidal granules and very few or negligible small granules (Singh & Singh, 2001, 2002; Kaur et al., in press). The presence of large starch granules in potato flours may likely to be responsible for higher G' and G'' values than corn flour. The starches isolated from cultivars Kufri Badshah and Kufri Jyoti also had the lowest transition temperatures (T_o, T_p, T_c) and higher enthalpy of gelatinization (ΔH_{gel}) values while these were lower for Pukhraj potato starch (Kaur et al., in press). High transition temperatures in starches have been reported to result from a high degree of crystallinity, which provided structural stability and made the granule more resistant to gelatinization (Barichello, Yada, Coffin, & Stanley, 1990). This may possibly have affected the swelling of starch granules that caused the variation in rheological properties of potato flours.

Pukhraj flour contained a large number of small granules that may be responsible for its low G' and G'' and η' (Kaur et al., in press). Tan δ of corn and potato flours decreased with increase in frequency. Corn flour exhibited highest tan δ value of 0.2751. Kufri Badshah and Kufri Jyoti potato flours showed lower tan δ values of 0.0766 and 0.081, respectively; tan δ was highest (0.091) for Pukhraj flour (Table 3). Higher G', G'', η' and lower tan δ values for Kufri Badshah and Kufri Jyoti potato flours suggested that these starches formed a more rigid paste structure than pastes from Pukhraj flour. The rheological properties of potato starches have been reported to depend on granular structure, amylose to amylopectin ratio and presence of phosphate esters (Singh & Singh, 2001; Wiesenborn et al., 1994) that may have affected the rheological properties of the potato flours.

Table 2
Colour characteristics of corn and potato flours

Flour source	L^*	a^*	b^*
Potato (Kufri Badshah)	72.18c	−1.92d	20.11b
Potato (Kufri Jyoti)	76.85d	−1.69c	18.22a
Potato (Pukhraj)	69.80b	−1.58b	23.81c
Corn	59.21a	−1.44a	28.04d

Values with similar letters in column do not differ significantly ($P<0.05$).

3.4. Retrogradation properties of corn and potato flours

The retrogradations of pastes prepared from corn and potato flours were measured by determining syneresis (%) during storage at 4 °C. The syneresis (%) value of cooked pastes from the corn and potato flours differed significantly (Table 4). Corn flour showed less syneresis than all three potato flours. This may be attributed to the rigid starch granular structure and presence of lipids in corn flour (Singh et al., 2002). The differences in amylose content of corn and potato flours may also have affected the retrogradation properties. Starch with high amylopectin content has been reported to retrograde slowly (Chang & Liu, 1991; Teo & Seow, 1992). Kufri Jyoti and Kufri Badshah potato flour pastes

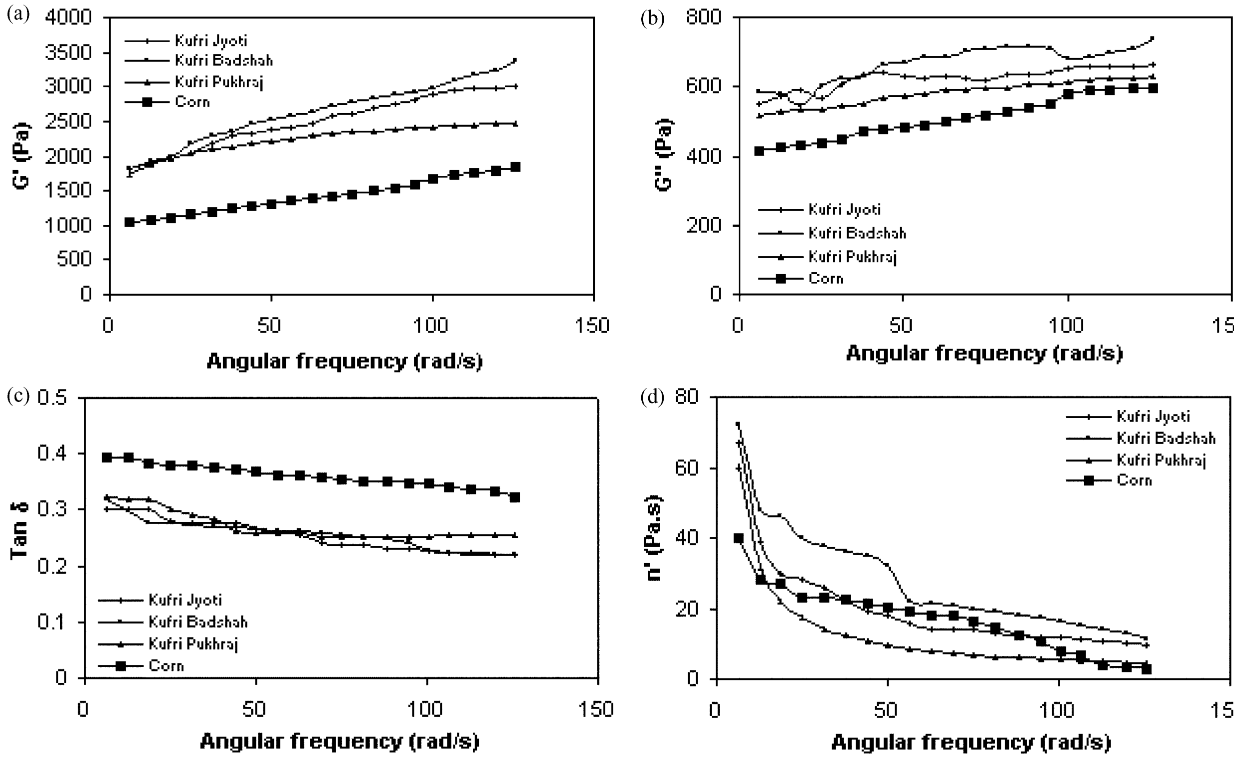

Fig. 1. (a) Storage modulus (G'), (b) loss modulus (G''), (c) loss factor (tan δ) and (d) dynamic viscosity (η') of corn and potato flours at 40 °C.

Table 3
Rheological properties of corn and potato flours at 20 °C (angular frequency of 125.7 rad/s)

Flour source	G' (Pa)	G'' (Pa)	Tan δ	η' (Pa.s)
Potato (Kufri Badshah)	3383d	739c	0.2185a	11.15c
Potato (Kufri Jyoti)	3010c	662b	0.2279ab	9.856b
Potato (Pukhraj)	2467b	628b	0.2540b	4.582a
Corn	1850a	593a	0.3210bc	3.214a

Values with similar letters in column do not differ significantly ($P<0.05$).

Table 4
Retrogradation (syneresis %) properties of corn and potato flours

Flour source	Fourth day	Sixth day	Eighth day
Potato (Kufri Badshah)	9.14c	12.20c	16.23c
Potato (Kufri Jyoti)	10.01d	13.90c	18.45d
Potato (Pukhraj)	8.25b	9.56b	12.85b
Corn	4.31a	7.8a	8.6a

Values with similar letters in column do not differ significantly ($P<0.05$).

showed more syneresis. The syneresis of cooked pastes from the corn and potato flours increased progressively during storage. Potato flours containing large-sized starch granules showed higher syneresis (%) values while those having small-sized starch granules showed lower syneresis (%). The retrogradation properties of the flours may be indirectly influenced by the structural arrangements of starch chains within the amorphous and crystalline regions of the ungelatinized granule which in turn, influence the extent of granule breakdown during gelatinization and the interactions that occur between starch chains during gel storage (Perera & Hoover, 1999).

3.5. Cookie properties

The effects of addition of corn flour and potato flours at different levels (2, 4, 6%) in wheat flour on spread factor and colour characteristics (L*, a*, b* values) of cookies prepared by the addition of 2, 4 and 6% corn and potato flours are shown in Table 5. The cookie spread factor increased with the addition of corn and potato flours. This effect may be attributed to the increased extension of the dough (Chanderashekhra & Shurpalekar, 1984). Glabau (1958) and Willard and Hix (1987) also reported increase in cookie diameter with the addition of potato flour in the range 1–4%. The spread factor of cookies containing corn flour was lower than those having potato flours and ranged from 6.2 to 6.9 for different levels of addition. The cookies with potato flour showed spread factors ranging from 7 to 8.5. This may be attributed to the higher swelling power of starch granules present in the potato flour. Corn starch granules exhibit lower swelling power than potato starch granules, because of the small granule size, higher lipid content and gelatinization temperature (Singh et al., 2002). The addition of corn and potato

Table 5
Spread factor, fracture force and colour characteristics of cookies made by the addition of corn and potato flours

Flour source	Flour (%)	Spread factor	Fracture force (g)	L*	a*	b*
Control	0	6	965	67.72	2.92	38.61
Potato (Kufri Badshah)	2	7.6	712	62.29	3.65	41.22
Potato (Kufri Jyoti)	2	7.8	625	65.32	3.15	39.95
Potato (Pukhraj)	2	7.0	765	61.04	4.02	45.84
Corn	2	6.2	895	59.52	4.15	45.95
Potato (Kufri Badshah)	4	8.2	502	60.12	4.55	42.25
Potato (Kufri Jyoti)	4	8.5	465	61.90	4.18	42.15
Potato (Pukhraj)	4	7.3	555	62.85	4.05	43.82
Corn	4	6.8	775	59.10	4.22	46.94
Potato (Kufri Badshah)	6	8.1	495	59.8	4.61	46.20
Potato (Kufri Jyoti)	6	8.2	460	60.95	4.35	43.85
Potato (Pukhraj)	6	7.5	540	61.12	4.11	43.12
Corn	6	6.9	715	58.2	4.45	47.20

flours may also have affected the formula water content that increased the dough extensibility that resulted in cookies with higher spread factors. Chanderashekhra and Shurpalekar (1984) reported higher extensibility of dough made by the addition of potato flours from different Indian potato cultivars. The differences in spread factors of cookies containing flours of different potato cultivars may be attributed to the differences in swelling patterns and rheological properties. The spread factor increased with the increase in potato flours; however, the increase was more pronounced with the addition of Kufri Jyoti potato flour (Table 5). The results clearly reveal that potato flour having the higher peak G' and WAI resulted in cookies with a higher spread factor and vice-versa. The addition of corn and potato flours in the formulation significantly affected the colour characteristics of the cookies. The L^* values decreased with the addition of both corn and potato flours in the cookies. Cookies containing potato flour showed higher L^* value (59.8–65.32) than those having corn flour (58.2–59.5). The addition of both the flours increased the starch and the pigment contents that may have resulted cookies with lower L^* values after baking. The a^* and b^* values increased with the addition of both the flours and were comparatively higher for cookies with the addition of corn flour at all levels of addition (4.15–47.20). The increase in a^* and b^* stimulus may be due to increase in redness and yellowness during baking. The variation in the colour characteristics among all the cookies made with the addition of corn and potato flours may be attributed to the differences in the pigment content of their flours (Table 5). The difference in the physicochemical, rheological and thermal properties, such as swelling behaviour and melting of starch crystallites in corn and potato flours, may also have affected the colour characteristics of the cookies. Kufri Jyoti and Kufri Badshah cookies showed higher L^* values at 2% level than Pukhraj cookies. This variation may be attributed to the difference in the transition temperatures of starches present in the three flours (Kaur et al., in press). The crystallites present in the starches from Kufri Jyoti and Kufri Badshah cultivars, with lower transition temperatures, may have melted at lower temperatures; this resulted in cookies with higher L^* values at 4 and 6% levels. The effects of the addition of corn and potato flours on fracture force of cookies are shown in Table 5. Addition of both corn and potato flours to wheat flour reduced the fracture force of cookies (Table 5). Cookies without the addition of flours required a force of 965 g to fracture while cookies containing 6% corn flour showed a fracture force of 715 g. The cookies containing 6% potato flour showed a fracture force ranging from 460 to 540 g. Cookies containing flours of different potato cultivars also exhibited varied fracture force. Cookies containing Pukhraj flour showed higher fracture forces than those containing Kufri Badshah and Kufri Jyoti flour. The difference in cookie properties may be attributed to the differences in the physicochemical and starch granular properties of corn and potato flours. The differences in the swelling behaviour of the individual starch granules of different cultivars, may have led to the formation of air zones of different volumes that resulted in cookies with varied hardness.

4. Conclusion

Physicochemical, rheological and cookie-making properties of corn and potato flours were significantly affected by the properties of their starches. Potato flours with large-sized starch granules exhibited higher amylose content, water absorption index and rheological parameters, such as G' and G'', which subsequently resulted in cookies with lower hardness and spread factor. The cookie colour characteristics, such as L^*, a^* and b^* values, varied significantly with the addition of corn flour and potato flours from different cultivars and can be critically controlled by the addition of corn and potato flours in the control formulation at different levels.

References

American Association of Cereal Chemists. (1995). *Approved methods of the AACC* (9th ed.). St. Paul, MN: The Association.

Anderson, R. A., Conway, H. F. M., Pfeiffer, V. F., & Griffin, E. J. (1969). Gelatinization of corn grits by roll- and extrusion cooking. *Cereal Science Today*, *14*, 4–12.

Barichello, V., Yada, R. Y., Coffin, R. H., & Stanley, D. W. (1990). Low temperature sweetening in susceptible and resistant potatoes:

starch structure and composition. *Journal of Food Science*, *54*, 1054–1059.

Bielawny, J. (1980). The influence of mineral content on the viscosity of potato starch emulsions. *Lebensm. Ind*, *27*, 169–170 (German).

Chandrashekara, S., & Shurpalekar, S. R. (1984). On the use of potato and cassava flours in soft dough biscuits. *Journal of Food Science and Technology*, *21*, 239–241.

Chang, S. M., & Liu, L. C. (1991). Retrogradation of rice starches studied by different scanning colorimetry and influence of sugars, NaCl and lipids. *Journal of Food Science*, *56*, 564–570.

Cottrell, J. E., Duffus, C. M., Paterson, L., & George, R. M. (1995). Properties of potato starch: effects of genotype and growing conditions. *Phytochemistry*, *40*, 1057–1064.

Galliard, T., & Bowler, P. (1987). Morphology and composition of starch. In T. Galliard (Ed.), *Starch properties and potential* (pp. 57–78). Chichester: Wiley.

Glabau, C. A. (1958). Cookie production with potato flour as an ingredient. *Bakers Weekly*, *178*, 40–42.

Heisler, E. G., Siciliano, J., & Treadway, R. H. (1962). After-cooking discoloration of potatoes. I. Potassium content of juice in relation to blackening tendency of tissue. *Food Technology*, *16*, 120–124.

Hopkins, S., & Gormley, R. (2000). Rheological properties of pastes and gels made from starch separated from different potato cultivars. *Lebensmittel-Wissenchaft und -Technologie*, *33*, 388–396.

Jane, J., Kasemsuwan, T., Chen, J. F., & Juliano, B. O. (1996). Phosphorus in rice and other starches. *Cereal Foods World*, *41*, 827–832.

Kaur, L., Singh, N., & Sodhi, N. S. Some properties of potatoes and their starches II. Morphological, thermal and rheological properties of starches. *Food Chemistry*, *79*, 183–192.

Kim, S. Y., Wiesenborn, D. P., Orr, P. H., & Grant, L. A. (1995). Screening potato starch for novel properties using differential scanning calorimetry. *Journal of Food Science*, *60*, 1060–1065.

Kim, Y. S., Wiesenborn, D. P., Lorenzen, J. H., & Berglund, P. (1996). Suitability of edible bean and potato starch noodles. *Cereal Chemistry*, *73*, 302–308.

Krueger, B. R., Knutson, C. A., Inglett, G. E., & Walker, C. E. (1987). A differential scanning calorimetry study on the effect of annealing on gelatinization behaviour of corn starch. *Journal of Food Science*, *52*, 715–718.

Pant, S., & Kulshresthra, K. (1995). Physical characteristics of potato flour made from six varieties. *Journal of Food Science and Technology*, *32*, 71–73.

Perera, C., & Hoover, R. (1999). Influence of hydroxypropylation on retrogradation properties of native, defatted and heat–moisture treated potato starches. *Food Chemistry*, *64*, 361–375.

Roy Choudhuri, R. N., Joseph, A. A., Joseph, K., Narayana Rao, M., Swaminathan, M., Sreenivasan, A., & Subramanyan, V. (1963). Preparation and chemical composition of potato flour from some varieties of potato. *Food Science (Mysore)*, *12*, 251–253.

Singh, J., & Singh, N. (2001). Studies on the morphological, thermal and rheological properties of starch from some Indian potato cultivars. *Food Chemistry*, *75*, 67–77.

Singh, J., & Singh, N. (2002). Studies on the morphological and rheological properties of granular cold water soluble corn and potato starches. *Food Hydrocolloids*, *17*, 63–72.

Singh, J., Singh, N., & Saxena, S. K. (2002). Effect of fatty acids on the rheological properties of corn and potato starch. *Journal of Food Engineering*, *52*, 9–16.

Smith, O., & Nash, L. B. (1941). Potato quality. III. Relation of soil reaction, irrigation and mineral nutrition to cooking quality. *Proc. Am. Soc. Hort. Sci.*, *38*, 507–512.

Srivastava, S. N. S., Singh, M., & Verma, S. C. (1973). Sundry your surplus potatoes. *Indian Farming*, *17*, 16–17.

Teo, S. H., & Seow, C. C. (1992). A pulsed NMR method for the study of starch retrogradation. *Starch*, *44*, 288–292.

Treadway, R. H., Willits, C. O., Heisler, E. G., Ross, L. R., & Osborne, M. F. (1950). *Composition of flour from the 1948 potato crop*. US Dept. Agr. AIC-277.

Wiesenborn, D. P., Orr, P. H., Casper, H. H., & Tacke, B. K. (1994). Potato starch paste behaviour as related to some physical/chemical properties. *Journal of Food Science*, *59*, 644–648.

Willard, M. J., & Englar, W. J. (1959). *Factors influencing the absorption of potato flour*. Paper presented at the Institute of Food Technology, Philadelphia.

Willard, M. J., & Hix, V. M. (1987). Potato flour. In W. F. Talburt, & O. Smith (Eds.), *Potato processing* (4th ed.) (pp. 665–681). New York: Van Nostrand Reinhold Co.

Williams, P. C., Kuzina, F. D., & Hlynka, I. (1970). A rapid colorimetric procedure for estimating the amylose content of starches and flours. *Cereal Chemistry*, *47*, 411–420.