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# Assessment of physicochemical properties of popular brands of corn starch for custard preparation

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**Abstract**
In the present study, corn starch of ‘Brand A’ (carbohydrate 96.8 g/100 g) and ‘Brand B’ (carbohydrate 88.0 g/100 g) were analyzed for their physico-chemical properties to investigate their effect on viscosity of custard prepared using both the brands. The ‘Brand A’ corn starch contained significantly ($P$< 0.05) high moisture, ash, starch, amylose, sediment volume, total blue value, sodium content than ‘Brand B’ corn starch. On the contrary, ‘Brand B’ corn starch showed significantly ($P$< 0.05) high swelling power, solubility, pH, phosphorus, fat, iron and zinc contents than those of ‘Brand A’ corn starch. The mean particle size, protein, calcium, magnesium, potassium and apparent blue value of ‘Brand A’ and ‘Brand B’ did not differ significantly. The turbidity and syneresis of both the corn starch brands increased with storage period. The ‘Brand A’ corn starch showed significantly ($P$< 0.05) low turbidity and syneresis in comparison to ‘Brand B’ corn starch. Pearson correlation analysis showed positive correlation of swelling power with solubility (r = 0.986, $P$<0.01), turbidity (r = 0.933, $P$< 0.01), syneresis (r = 0.869, $P$< 0.01) while negative correlation with sediment volume (r = -.791, $P$< 0.01), total starch (r = -.910, $P$< 0.01), amylose (r = -.922, $P$< 0.01), amylopectin (r = -.825, $P$< 0.01), total blue value (r = -.919, $P$< 0.01), particle size distribution (r = -.714, $P$< 0.05). Both amylose and amylopectin have significantly negative correlation ($P$< 0.01) with swelling power, solubility, turbidity and syneresis.

**Keywords:** Corn starch, Physico-chemical properties, ‘Brand A’, ‘Brand B’, Custard

**AOAC:** Association of the Official Analytical Chemists **CP:** centi-poise **DWB:** dry weight basis **G:** Gram **HCl:** hydrochloric acid **Kcal:** kilo calorie **ML:** Millilitres **NM:** nano meter **NaOH:** Sodium hydroxide **P:** Statistical significance **RPM:** rotation per minute **Wt:** Weight **µm:** Micrometer **%:** Percentage **DC:** degree centigrade

## Introduction

Starch being the chief carbohydrate of corn, constitutes up to 72-73% of kernel (Watson & Ramstad, 1991) [43]. Based on amylose and amylopectin ratio, corn starch is generally categorized as high amylose, normal and waxy starch. Normal corn starch has 75% branched amylopectin; the remaining 25% is linear amylose whereas waxy corn starch contains 100% amylopectin and high amylose corn starch consists of amylose content from 40 to 70%. Corn starch is very important for the food industry as it is used as a thickener, bulking agent, water retention agent and gelling agent (Singh *et al*. 2003) [39]. One reason for the increased use of corn flour in the food industry is its versatility. In addition to having an acceptable flavor, corn flour is economical and possesses a pleasing color. In India, demand for corn starch is rising with the establishment of food processing units engaged in corn processing. Corn fulfills over 80% of the world starch demand of market (LMC International, 2002) [18], followed by cassava, potato and wheat. Globally, corn (*Zea mays*) is recognized as queen of cereals due to its highest genetic potential. It is grown on almost 150 million hectare area in around 160 countries with wide diversity of soil, biodiversity, climate and management practices contributing 36% (782 million tonnes) to the total global grain production. In India, corn (maize) is being cultivated in 8.17 million hectares with production of 19.33 million tonnes and average productivity of 2414 kg/ha. Corn has proved to be India's third most important food grain after wheat and rice and is one of the most adaptable cereal crops with greater enforcement under various agro-climatic conditions.

In India, corn starches of various brands are used for preparation of soups, custard and puddings and other creamy desserts. They are using corn starch as major ingredient for the manufacturing of custard powder along with artificial colors and flavors. As several physicochemical properties and starch composition play vital role in custard product viscosity and gel strength yet the information on these parameters in respect of popular commercial brands of corn starch available in India is very It meagre. In view of above, it is required that corn starch from different brands needs to be analysed for various physico-chemical properties for custard preparation. The present research was undertaken to study the influence of various corn starch physicochemical properties on viscosity of prepared custard.

## Materials and Methods

### Materials

Corn flour of two brands named as 'Brand A' and 'Brand B' were procured from market. 'Brand A' corn flour is used for smoother, thicker soups and puddings having energy (389 kcal), carbohydrates (96.83 g/100 g), protein (0.40 g/100 g), free from fat, saturated fat, trans-fat and sugar. Whereas, 'Brand B' corn flour has energy (355 kcal), carbohydrate (88 g/100 g), protein (0.4), fat (0.1 g/100 g) and the corn flour is generally used for puddings and other creamy desserts, cream style soups, smooth sauces and gravies, golden brown fried foods, light and tender cakes and other baked goods.

### Physicochemical properties of starch

Swelling power and solubility

Solubility and swelling power were estimated by protocol of Wang *et al*. (1993) [42]. Starch (250 mg, dwb) was added to 10 ml distilled water, mixed and heated for 30 minutes at 70°C. The weight was adjusted to 12.5 g by adding distilled water and supernatant was centrifuged at 3000 rpm for 15 minutes. Further, it was collected into a pre-weighed dish and dried overnight at 60°C to a constant weight.

### Turbidity

Turbidity of starch pastes was determined using protocol of Perera & Hoover (1999) [25]. A 1% aqueous solution of starch was first heated for one hr with constant stirring in water bath at 90°C and then cooled for one hr at 30°C. These cooled samples were kept at 4°C for 5 days. The turbidity of the samples was calculated by recording the absorbance at 640 nm against water blank every 24 hrs.

### Particle size distribution

Particle size distribution of starch was determined by method of Foehse & Hoseney (1988) [9]. Particle size distribution of corn flour was determined using an alphine sieve system. A 25 g corn flour sample was sieved using a no. 60 sieve, a no. 100 sieve, a no. 120 sieve, a no. 325 sieve. The per cent of corn flour that passed through each sieve was then calculated.

### Blue value

Blue value of starch sample was measured by procedure of Gilbert & Spragg (1964) [10]. Twenty mg of starch was added to one ml of ethanol and 10 ml of 1.0 N NaOH and mixture was kept overnight. The final volume was increased to 50 ml and further diluted five times. One ml of the diluted aliquot was transferred to 25 ml volumetric flask and 2 drops of 0.1% phenolphthalein indicator were added and titrated against 0.1 N HCl and then two third of volume was made by adding distilled water. One ml of diluted iodine solution was added and final volume made as 25 ml. The absorbance was recorded at 680 nm for blue value and at 590 nm for total blue value.

### Syneresis

Syneresis was estimated using procedure of Jacobson *et al*. (1997) [11]. Starch suspension (2% w/w, db) was heated in a water bath with constant stirring for 30 minutes at 90°C and stored at 4°C. Synersis was calculated in form of water percentage released after centrifugation for 10 minutes at 3000 g.

### pH

The pH of starch sample was estimated using protocol of Sosulski *et al*. (1976) [40]. It was measured on 10% dispersion (w/v) of the starch in distilled water with digital pH meter after calibrating with standard buffer.

Sediment volume

Sediment volume of starch was measured by procedure of Singh *et al*. (2006) [38]. One g of starch was mixed with 95 ml distilled water and pH was adjusted to 7.0 by using 5% NaOH/HCl followed by boiling in water bath for 15 minutes. It was adjusted to 100 g by distilled water and transferred to graduated cylinder of 100 ml capacity and sealed. Further, it was kept for 24 hrs at room temperature and sediment volume was determined.

### Starch Composition

Total Starch

For starch estimation, the method of Malick & Singh (1980) [19] was employed.

### Amylose content

It was measured by following protocol described by Williams *et al*. (1970) [44].

### Amylopectin content

The amylopectin content was calculated by the difference between starch and amylose content.

### Proximate composition

Estimation of moisture, protein, fat and ash contents was done as per standard methods of AOAC (2012) [4].

### Mineral analysis

Estimation of calcium, magnesium, iron, potassium, zinc, sodium, calcium, iron, potassium and zinc in acid digested samples was done by atomic absorption spectrophotometer as suggested by Lindsey & Norwell (1969) [17]. Phosphorus was estimated colorimetrically using protocol given by Chen *et al*. (1956) [5].

### Preparation of custard

Various types of custard were prepared using different quantities of custard powder (15, 20, 25 and 30 g) of both the products i.e. 'Brand A' and 'Brand B'. For preparation of custard, out of 500 ml milk, 50 ml milk was taken and each quantity of custard powder mentioned above was dissolved separately and a smooth paste was made. The remaining milk (450 ml) was boiled with 50 g sugar and the custard paste was added slowly to the boiling milk and stirred continuously to avoid burning for 2-3 minutes and brought to a boil. The custard was allowed to cool and stored in the container to record the viscosity.

### Viscosity of custard product
Viscosity of various types of custard prepared was measured by Brookfield viscometer using spindle no. 4 at 20 rpm.

### Sensory evaluation
All the custard samples were subjected to trained panel of 10 members for sensory evaluation with respect to colour, appearance, aroma, texture, taste and overall acceptability by using 9 point hedonic rating scale.

### Statistical analysis
The data depicted under this study is an average of five independent observations and was statistically analyzed using SPSS software version 16 according to the standard method. Pearson correlation coefficient (r) for relationship between various properties was calculated using SPSS software version 16.

## Results and Discussion
### Physicochemical properties of starch
### Swelling Power and Solubility
'Brand B' corn starch exhibited significantly ($P< 0.05$) high value of solubility and swelling power as compared to 'Brand A' corn starch (Table 1). Swelling performance of cereal starches depends largely on property of their amylopectin content, and amylose functions as swelling inhibitor, particularly in the presence of lipids (Morrison *et al*. 1993 [23]; Tester & Morrison, 1990) [41]. The variations in swelling power and solubility is due to differences in amylose content, viscosity patterns and weak internal organization as a result of presence of negatively charged phosphate groups in granules of starch (Jane *et al*. 1999) [13]. As the 'Brand B' corn starch exhibited low amylose content than 'Brand A' corn starch (Table 3), that enabled free entry of water which leads to high swelling power and solubility. Similarly, Rani & Bhattacharaya (1989) [30] reported that starch granules having low amylose content can swell freely upon heating and they were found to be less rigid. On the other hand, starch granules having high amylose content were reported to be more rigid and hence swell less freely. Solubility index depicts the interactions among starch chains in crystalline and amorphous regions and water molecules. Solubility reflects the hydrophilicity and amylose content causing extra dissociation of inter and intra molecular hydrogen bonds, leading to higher amylose leaching exerting increased solubility (Lawal, 2009) [16]. The semi-crystalline structure of starch granule and hydrogen bonds present between starch molecules may be the reason of their low solubility (Eliasson & Gudmundsson, 1996) [7].

**Table 1:** Physicochemical properties of corn starch

| Physicochemical properties | Brand | |
|---|---|---|
| Brand A | Brand B | |
| Swelling power (g/g) | 7.98$^a$ | 9.94$^b$ |
| Solubility (%) | 9.92$^a$ | 16.23$^b$ |
| Mean particle size (µm) | 157.16$^a$ | 156.07$^a$ |
| Sediment volume (mL) | 1.66$^b$ | 1.30$^a$ |
| pH | 6.12$^a$ | 6.44$^b$ |
| Apparent Blue value (680 nm) | 0.57$^a$ | 0.55$^a$ |
| Total blue value (590 nm) | 0.68$^b$ | 0.55$^a$ |

Values are mean of five independent determinations
Mean given in column with superscripts are significant ($P<0.05$)

### Particle Size Distribution
The average particle size of 'Brand B' corn starch was slightly lower than 'Brand A' (Table 1). This might be due to the weak associative forces binding the endosperm together thereby resulting in increased smaller sized particles during milling. Akingbala *et al*. (1987) [1] and Nche *et al*. (1996) [24] observed that during flour production stimulation of enzyme activity occurs thereby causing partial dextrinization of amylose and amylopectin molecules which in turn can lead to the weakening of associative forces within the starch granules (Moorthy *et al*. 1996) [22].

### Sediment Volume
Sediment volume is the ratio of sediment gel to dry weight of starch. The sediment volume of 'Brand A' was reported to be significantly ($P< 0.05$) high than 'Brand B' (Table 1). The lower value of sediment volume in 'Brand B' may be due to smaller size of polyhedral shape of starch granules. Similar results were reported by Jan *et al*. (2015) [12].

### pH
'Brand A' corn starch had significantly ($P< 0.05$) low pH (6.12) than 'Brand B' (6.44) (Table 1). Mishra & Rai (2006) [21] also observed the pH of corn starch as 6.24.

Apparent Blue Value and Total Blue Value

The total blue value of 'Brand A' was recorded to be significantly ($P<0.05$) high than'Brand B' (Table 1). The apparent blue value of 'Brand A' and 'Brand B' did not differ significantly. As blue value is an indication of starch disintegration (Kalim, 2005) [14], the significantly higher blue value of 'Brand A' indicating the better quality of starch due to its less disintegration as compared to 'Brand B' corn starch.

### Turbidity
The turbidity of both the corn starch samples increased progressively with the increase in period of storage (Table 2). Similarly increase in turbidity with duration of storage has been reported by Sandhu *et al*. (2004) [28]; Sandhu & Singh (2007) [27]. Interaction of various factors like granule remnants, granule swelling, chain length of amylase and amylopectin as well as their leached quantity, inter or intra-bonding, lipid and cross-linking substitution is mainly responsible for turbidity development in native starches during storage (Jacobson *et al*. 1997) [11]. Such interactions among leached amylose and amylopectin chains can result into formation of function zones, which in turn scatter a large amount of light (Perera & Hoover, 1999) [25]. Turbidity of 'Brand B' corn starch was reported to be significantly ($P<0.05$) high in comparison to 'Brand A' from day 1 to day 5 (Table 2). Lower turbidity of 'Brand A' could be attributed to the larger particles of starch as compared to starch of 'Brand B'. Singh & Singh (2001) [34] also reported that starches with larger size granules had lower turbidity whereas starches containing smaller size granules exhibited higher turbidity values.

**Table 2:** Effect of storage duration on the turbidity and syneresis (%) of corn starch

| Days | Turbidity (absorbance) | | Syneresis (%) | |
|---|---|---|---|---|
| | Brand A | Brand B | Brand A | Brand B |
| Day 1 | 1.25$^a$ | 1.54$^b$ | 4.39$^a$ | 5.22$^b$ |
| Day 2 | 1.45$^a$ | 1.67$^b$ | 4.62$^a$ | 5.44$^b$ |
| Day 3 | 1.55$^a$ | 1.75$^b$ | 4.86$^a$ | 5.79$^b$ |
| Day 4 | 1.69$^a$ | 1.87$^b$ | 5.12$^a$ | 6.20$^b$ |
| Day 5 | 1.81$^a$ | 1.95$^b$ | 5.44$^a$ | 6.58$^b$ |

Values are mean of five independent determinations
Mean in column with different superscript are significant ($P< 0.05$)

### Syneresis

The data given in Table 2 revealed that during the storage period syneresis of both the corn starches increased progressively from day 1 to day 5. Singh *et al.* (2004) [37]; Sandhu *et al*. (2004) [28] and Ali *et al*. (2016) [2] observed that syneresis of corn starch enhanced in a progressive manner with increase in storage duration owing to interaction among leached amylose and amylopectin chains resulting in formation of functional zones (Perera & Hoover, 1999) [25]. Amylose crystallization and aggregation gets accomplished during initial few hours of storage, whereas, amylopectin crystallization and aggregation takes place in later stages (Miles *et al*. 1985) [20]. The syneresis of 'Brand B' corn starch was reported to be significantly high ($P< 0.05$) than 'Brand A' from day 1 to day 5. As syneresis was positively correlated with turbidity and swelling power (Perera & Hoover, 1999) [25], the higher values of these parameters in 'Brand B' corn starch resulted in higher syneresis. It is an undesired property in food as well as non food applications which depicts retrogradation of starch at low temperatures. 'Brand B' corn starch showed more syneresis (%) than 'Brand A' corn starch due to rigid granular structure and presence of lipids in it (Singh *et al*. 2002) [36].

### Starch Composition

The data presented in Table 3 depicted that the total starch and amylose contents of corn starches differed significantly ($P< 0.05$), whereas amylopectin content did not differ significantly. The 'Brand A' corn starch was found to have significantly higher ($P< 0.05$) contents of total starch and amylose in comparison to 'Brand B'. Similarly, Alonso *et al.* (1999) [3] reported 86.2% starch content in corn flour. The amylose content in the range of 15.3-25.6% was reported by Seetharaman *et al*. (2001) [33], Singh & Singh (2003) [35], Singh *et al*. (2004) [37], Sandhu *et al*. (2004) [28], Mishra & Rai (2006) [21] and Sandhu *et al*. (2007) [29]. The difference in amylose content of starch could be owing to botanical source of starch in addition to climatic and soil conditions during grain development and enzyme activity involved in starch biosynthesis (Yano *et al*. 1985; Krossmann & Lloyd, 2000) [45, 15].

### Proximate Composition

A significant difference was observed in proximate composition of corn starches of 'Brand A' and 'Brand B' (Table 3). The moisture and ash contents were significantly ($P< 0.05$) high in 'Brand A' than 'Brand B'. Similar result for moisture content of corn starch was reported by Mishra & Rai (2006) [21]. The fat content was significantly ($P< 0.05$) higher in 'Brand B' as compared to 'Brand A'. The difference was observed to be not significant for protein content of 'Brand B' and 'Brand A' corn starches. The higher lipid content is adverse as it can lead to off flavours, high pasting temperature, high turbidity and low starch viscosity (Roller, 1996) [26]. In addition, protein can also have detrimental effect as it may lead to mealy flavour and has foaming tendency (Roller, 1996) [26]. Starch moisture content in these samples was similar as used for dry products to get desirable shelf life and the variation might be due to the genetic makeup.

**Table 3:** Starch and proximate composition of corn starch

| Composition | Brand | |
|---|---|---|
| **Brand A** | **Brand B** | |
| **Starch composition** | | |
| Total starch (%) | $89.09^{b}$ | $81.63^{a}$ |
| Amylose (wt %) | $24.23^{b}$ | $19.69^{a}$ |
| Amylopectin (wt %) | $64.86^{a}$ | $61.94^{a}$ |
| Amylose/Amylopectin ratio | 0.373 | 0.317 |
| **Proximate composition** | | |
| Moisture (%) | $7.07^{b}$ | $5.58^{a}$ |
| Protein (%) | $0.38^{a}$ | $0.40^{a}$ |
| Fat **(%)** | $0.01^{a}$ | $0.10^{b}$ |
| Ash (%) | $0.19^{b}$ | $0.16^{a}$ |

Values are mean of five independent determinations
Mean in column with different superscript are significant ($P< 0.05$)

### Mineral analysis (P, Ca, Mg, K, Na, Fe, Zn)

The mineral contents of corn starch from both the brands presented in Table 4 showed a significant ($P< 0.05$) difference for phosphorus, iron, zinc and sodium contents, whereas calcium, potassium and magnesium contents of corn starches did not differ **s**ignificantly.

The phosphorus, iron and zinc contents were higher in 'Brand B' corn starch as compared to those of 'Brand A' corn starch. Sodium content was high in 'Brand A' corn starch than 'Brand B' corn starch. Similar findings were reported by Chinnaswamy & Hanna (1987) [6] for phosphorus content (14 mg/100 g), while, results of Enyisi *et al*. (2014) [8] were at variance with the present values for phosphorus (23.00%), magnesium (29.33%), potassium (10.67%) and sodium (1.50%), whereas, other mineral content such as calcium, zinc, iron were in low percentages.

In cereal starches phosphorus is present in the form of phospholipids which are responsible for opaque starch pastes and a decrease in viscosity (Schoch, 1942 a, b) [31, 32].

**Table 4:** Mineral composition of corn starch (mg/100 g)

| Mineral composition | Brand | |
|---|---|---|
| **Brand A** | **Brand B** | |
| Calcium (mg/100 g) | $1.19^{a}$ | $1.24^{a}$ |
| Phosphorus | $11.71^{a}$ | $16.61^{b}$ |
| Iron | $0.46^{a}$ | $0.55^{b}$ |
| Zinc | $0.06^{a}$ | $0.09^{b}$ |
| Sodium | $5.61^{b}$ | $3.56^{a}$ |
| Potassium | $10.13^{a}$ | $10.13^{a}$ |
| Magnesium | $21.51^{a}$ | $21.32^{a}$ |

Values represent mean of five independent determinations
Mean in column with different superscript are significant ($P< 0.05$)

### Viscosity of custard product

Data presented in Table 5 indicated that viscosity of 'Brand A' custard was reported to be significantly ($P< 0.05$) high as compared to 'Brand B' and it increased significantly ($P< 0.05$) as quantity of custard powders increased from 15 to 30 g.

**Table 5:** Viscosity of custard product

| Quantity (g) of powder | | Viscosity (cP) |
|---|---|---|
| Brand A | | Brand B |
| 15 | 2140 | 1990 |
| 20 | 2690 | 2570 |
| 25 | 3554 | 3478 |
| 30 | 5086 | 4982 |

## Sensory evaluation of custard

The data on organoleptic score in respect of colour, appearance, aroma, texture, taste, and overall acceptability is given in Table 6. In both brands, the custard prepared by 20 g custard powder (Fig. 1) had the highest mean scores of colour, appearance, aroma, texture, taste, and overall acceptability among all samples. Mean scores of all the sensory parameters of 'Brand B' custard were higher than 'Brand A' custard except texture.

**Table 6:** Sensory evaluation of custard product

| Sensory Parameter | Organoleptic Score | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Brand A | | | | Brand B | | | |
| | 15 g | 20 g | 25 g | 30 g | 15 g | 20 g | 25 g | 30 g |
| Colour | 8.0 | 8.1 | 8.0 | 7.5 | 8.0 | 8.2 | 8.1 | 7.7 |
| Appearance | 7.6 | 8.2 | 7.8 | 7.3 | 7.8 | 8.3 | 7.9 | 7.4 |
| Aroma | 8.0 | 8.0 | 7.8 | 7.5 | 8.0 | 8.1 | 7.9 | 7.5 |
| Texture | 7.6 | 8.3 | 7.8 | 6.4 | 7.4 | 8.1 | 7.7 | 6.3 |
| Taste | 7.5 | 8.0 | 7.7 | 6.2 | 7.6 | 8.2 | 7.8 | 6.4 |
| Overall Acceptability | 7.74 | 8.12 | 7.82 | 6.98 | 7.76 | 8.18 | 7.88 | 7.06 |

Values are mean of ten independent determinations

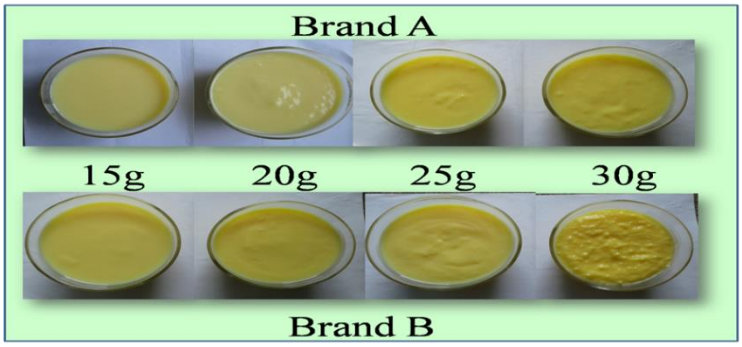


**Fig 1:** Custards prepared with different quantities of powder

The colour of 'Brand A' and 'Brand B' custard were 'desirable' upto 25 g, whereas, custard powder prepared with 30 g was 'moderately desirable'. The mean scores of appearance of 'Brand A' and 'Brand B' custard with 20 g custard powder was 'desirable' whereas, those prepared with 15, 25 and 30 g custard powder were 'moderately desirable'. The aroma of custard prepared with 15 and 20 g custard powder of 'Brand A' and 'Brand B' were 'desirable' and those of 25 and 30 g were 'moderately desirable'. The texture and taste of 'Brand A' and 'Brand B' custard with 20 g custard powder were 'desirable' and that of 15 and 25 g were 'moderately desirable' and 30 g was 'slightly desirable'. The overall acceptability of both 'Brand A' and 'Brand B' custard with 20 g custard powder was 'desirable' and that of 15 and 25 g were 'moderately desirable' and 30 g was 'slightly desirable' by the judges.

**Pearson correlations between various properties of corn starches**

Correlations among various physicochemical parameters of corn starches are given in Table 7. Swelling power was positively correlated to solubility (r = 0.906, $P< 0.01$), turbidity (r = 0.933, $P< 0.01$), syneresis (r = 0.869, $P< 0.01$) and negatively correlated to sediment volume (r = - 0.791, $P< 0.01$), total starch, (r = - 0.910, $P< 0.01$) amylose, (r = - 0.922, $P< 0.01$), amylopectin, (r = - 0.825, $P< 0.01$), total blue value (r = - 0.919, $P< 0.01$), particle size distribution (r = - 0.714, $P< 0.05$). Similarly, solubility was positively correlated to turbidity (r = 0.970, $P< 0.01$) and syneresis (r = 0.975, $P< 0.01$) and negatively correlated to sediment volume (r = - 0.864, $P< 0.01$), total starch (r = - 0.980, $P< 0,01$), amylose (r = - 0.993, $P< 0.01$), amylopectin (r = - 0.894, $P< 0.01$), total blue value (r = - 0.969, $P< 0.01$), particle size distribution (r = - 0.790, $P< 0.01$). PSD was positively correlated to TBV (r = 0.732, $P< 0.01$), TS (r = 0.809, $P< 0.01$), AM (r = 0.755, $P< 0.01$), AP (r = 0.816, $P< 0.01$) and negatively correlated to turbidity (r = - 0.677, $P< 0.01$) and syneresis (r = - 0.786, $P< 0.05$). SV was positively correlated to TS (r = 0.899, $P< 0.01$), AM (r = 0.879, $P< 0.01$), AP (r = 0.809, $P< 0.01$) and negatively correlated to turbidity (r = - 0.879, $P< 0.01$) and syneresis (r = - 0.869, $P< 0.05$). TBV was positively correlated to TS, AM, AP and negatively correlated to turbidity and syneresis. TS, AM and AP were negatively correlated to turbidity and syneresis.

**Table 7:** Pearson correlations coefficient between various properties of corn starches

| | SP[a] | SOL[a] | PSD[a] | SV[a] | TBV[a] | TS[a] | AM[a] | AP[a] | SYN5[a] | TUR5[a] |
|---|---|---|---|---|---|---|---|---|---|---|
| SOL | .906[c] | | | | | | | | | |
| PSD | -.714[b] | -.790[c] | | | | | | | | |
| SV | -.791[c] | -.864[c] | .614 | | | | | | | |
| TBV | -.919[c] | -.969[c] | .732[b] | .888[c] | | | | | | |
| TS | -.910[c] | -.980[c] | .809[c] | .899[c] | .973[c] | | | | | |
| AM | -.922[c] | -.993[c] | .755[b] | .879[c] | .984[c] | .986[c] | | | | |
| AP | -.825[c] | -.894[c] | .816[c] | .809[c] | .834[c] | .921[c] | .892[c] | | | |
| SYN5 | .869[c] | .975[c] | -.786[c] | -.869[c] | -.964[c] | -.969[c] | -.981[c] | -.897[c] | | |
| TUR5 | .933[c] | .970[c] | -.677[b] | -.879[c] | -.983[c] | -.960[c] | -.838[c] | -.941[c] | .966[c] | |
| P | .905[c] | .975[c] | -.753[b] | -.818[c] | -.983[c] | -.950[c] | -.980[c] | -.817[c] | .970[c] | .976[c] |

[a] SP: Swelling Power; SOL: Solubility; PSD: Particle Size Distribution; SV: Sediment Volume; TBV: Total Blue Value; TS: Total Starch; AM: Amylose Content; AP: Amylopectin Content; SYN5: Synersis 5$^{th}$ day; TUR5: Turbidity 5$^{th}$ day; P: Phosphorus.

[b] Significant Correlation ($P< 0.05$)

[c] Significant Correlation ($P< 0.01$)

**Conclusions**

The present study revealed that significant variation exists in several physicochemical properties and composition of corn starches from different brands which played a significant role in improving the viscosity and gel strength of prepared custard. Corn starch with comparatively higher carbohydrate exhibited superior physico chemical properties resulting in high viscosity and better texture of custard prepared as compared to custard prepared from corn starch having comparatively less carbohydrate. However, mean scores of all the sensory attributes of less carbohydrate containing custard were higher except texture. Total starch, amylose and amylopectin were negatively correlated to syneresis and turbidity. Swelling power and solubility were positively correlated to turbidity and syneresis and negatively correlated to total starch, amylose, amylopectin, sediment volume and particle size distribution.

**Ethical Statements**

**Conflict of Interest**

The authors declare that there are no financial/commercial conflicts of interest.

**Ethical Statement**

This study does not involve any human or animal testing

This study was approved by Departmental Research Committee of Department of Food Technology, Guru Jambheshwar University of science and technology, Hisar, Haryana, India.

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