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Comparative study on chemical, functional and pasting properties of chickpea (non cereal) and wheat (cereal) starches

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Abstract

Starch is the most abundant carbohydrate in chickpea as well as wheat and it is considered to be competitive in the food industry. The objective of the present study was to find out the chemical, functional and pasting properties of both chickpea and wheat starches. Starch was isolated and its chemical, functional and pasting properties were analysed by the standard procedures. The results revealed that the yield of chick pea starch was 29.00% and wheat starch was 48.33%. Chickpea starch consisted more moisture (10.93±0.62%) and amylose (30.43±0.35%) than wheat starch however lower dry matter (89.12±0.63%), protein (0.56±0.09%), fat (0.30±0.18%), ash (0.44±0.19%), and pH (5.20±0.12) was observed for chickpea starch than wheat starch. Chickpea starch had higher water binding capacity (93.59±3.12%) and less oil absorption capacity (0.73±0.02g/g). Swelling power of chickpea (1.75-9.54g/g) and wheat starch (1.63-7.11g/g) increased as temperature raised from 50 to 90°C. Solubility of both chickpea and wheat starches was increased with increasing temperatures (70°C) then declined until the temperature raised up to 90°C. Peak, trough, breakdown, final and setback viscosities of chickpea starch were significantly ($P<0.05$) higher than wheat starch. Hence chickpea starch would provide good viscosity to food stuff and is encouraging its use in the preparation of noodles.

Introduction

Chickpea (*Cicer arietinum* L.) is the largest produced food legume in South Asia and the third largest produced food legume globally. Chickpea is grown in more than 50 countries. Asia accounts 89.7% of the area in chickpea production, followed by 4.3% in Africa, 2.6% in Oceania, 2.9% in America and 0.4% in Europe (Gaur, 2010). India ranked first in terms of chickpea production and consumption in the world. About 65% of global area with 68% of global production of chickpea is contributed by India (Reddy and Mishra, 2010). Chickpea is the world's third largest pulse crop based on cultivated area (Hasan *et al.,* 2008), has an average composition of 16-21% protein, 3% ash, 3-7% lipids, 5-13% crude fibre and 59-67% carbohydrates, and of the total grain carbohydrates, about 40-50% is starch (Singh *et al*., 2004; Costa *et al*., 2006).

Composition and properties of chickpea seed and starch vary among cultivars and are influenced by environmental factors and agronomic practices (Hoover and Ratnayake, 2002). Starch is the most abundant carbohydrate in chickpea seed and is considered to be competitive in the food industry (Botham *et al.,* 1995; Goñi and Valentín-Gamazo, 2003). Identifying chickpea varieties that have starches with valuable properties for the food industry will give the potential to use the crop as an alternative to current starch sources and make this a valuable by product following protein extraction (Hira and Chopra, 1995; Liu and Hunga,b,1998; Clemente *et al.,* 1999). A necessary prerequisite to starch characterization research is the isolation of starch granules from plant tissue without inadvertent modification. Equally important are the subsequent steps of drying and grinding the starch before physical and chemical analysis. Starch is the most important carbohydrate in the human diet, and is of considerable commercial importance because of its numerous desirable functional properties (Kaur *et al*., 2010). Amylose component is essentially linear and amylopectin is highly branched. The relative proportion of amylose and amylopectin greatly influences the properties of starch and its technological properties (Leloup *et al*., 1991; Kang *et al*., 2003; Vignaux *et al*., 2005; Soh *et al.,* 2006). In addition, compared with other sources such as cereals, legume starches have reduced digestibility as they are characterized by high resistant starch contents (Hoover and Zhou, 2003). Starch is used in a variety of food products as a raw material or food additive and has an important role as a thickener, bulking agent, gelling agent, water absorbent and is used in foods

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with varying moisture contents such as puddings, cookies and drinks. Some of the starch derivatives are being increasingly used as fat substitutes (Cousidine, 1982; Tharanathan and Mahadevamma, 2003). The variation in swelling and pasting properties among starches should be attributed to difference in AP unit-chain length distribution. Other factors that affect the swelling power and solubility of starch granules are presence of lipids and differences in morphological structures (Singh *et al.,* 2003). Application of starch in various products and manufacturing processes is primarily determined by its functional properties such as gelatinization, pasting, retro gradation, viscosity, swelling and solubility which vary considerably from crop to crop and with ecological and agronomic influences (Yuan *et al.,* 2007). Isolation of pure starches from legumes is very difficult because it contains high protein content. Purity of starch is assessed on the basis of chemical composition and it forms the basis of functional properties for the end use of starches. Wheat starches are mostly used in both food and starch processing industries; therefore the objective of study was to compare the chemical, functional and pasting properties of chickpea (Non cereal) and wheat (Cereal) starches.

Materials and Methods

Sample preparation

Chickpea was obtained from Tamil Nadu Agricultural University, Coimbatore, manually cleaned and devoid of contaminants such as stones, soil and bad seeds. Soil particles adhering to plant material were also removed, steeped and ground with water to obtain starch milk. Steeping time ranges from 4 to 16 hr depending on the hardness of the plant material. Wheat (*Triticum aestivum* L.) was purchased from the local market of Salem, Tamil Nadu, these grains had been thoroughly cleaned to remove dirt, dust, insect excreta/ feathers and admixture of other food grains before the grains were ground into fine flour at local mill. The flour samples were kept in an airtight container for further process.

Isolation of starch from chickpea

Starch was isolated from chickpea by the method of Vasanthan (2001). Chickpea was steeped 4-16 hours and the starch milk was obtained by wet grinding. The starch milk was filtered through a series of polypropylene screens (250, 175, 125, and 75 µm) followed by centrifugation and purification. Purified starch was dried and it should be hand ground into powder using a mortar and pestle, sieved (250 µm) and stored in a tightly closed container under dry condition.

Isolation of starch from wheat

Starch was isolated from wheat (*Triticum aestivum* L.) using the method of Vasanthan (2001). Dough washing or the martin process was a popular method for wheat starch isolation. The process involved dry grinding the wheat to produce flour, adding water to make dough (flour/water ratio is 2:1, w/v), and washing the dough with excess water while kneading on double-layered cheesecloth in order to wash out starch granules from the gluten protein network. Washing should be carried out until the milkiness of the filtrate disappeared. The starch in the filtrate was then be filtered through a series of polypropylene screens (250, 175, 125, and 75 µm) followed by centrifugation and purification. Purified starch was dried and hand ground into powder using a mortar and pestle, sieved (250 µm) and stored in a tightly closed container under dry condition.

Chemical properties of chickpea and wheat starches

Moisture content and dry matter were estimated by the method of Adebayo *et al*. (2010). Protein, fat and ash, were estimated by AOAC Methods (1990). Amylose content was determined by the method of Williams *et al*. (1958). pH was estimated according to Benesi (2005).

Functional Properties of chickpea and wheat starches

Water binding capacity and oil absorption capacity of the samples were determined by the method of Yamazaki (1954) and Lin *et al.* (1974) method respectively. The bulk density was determined according to the method of Okaka and Potter (1977). Swelling power and solubility of the starches were determined by the method of Gani *et al.* (2010).

Pasting properties of chickpea and wheat starches

Pasting properties of chickpea and wheat starches were evaluated with a Rapid Visco Analyzer (RVA) (RVA Tech Master, Perten Instruments, Japan) according to the method described by Noda *et al.*(2004).

Statistical analysis

Quantitative data analysis was carried out using MS-Excel 2007. Mean and standard deviation were calculated. Studies on chemical, functional and pasting properties of wheat and chickpea starches were analysed using two sample t-test assuming unequal variance.

Results and Discussion

Starch yield

Starch yield of chickpea and wheat was 29.00% and 48.33% respectively. Miao *et al.* (2009) reported that the starch yield of chickpea was

29.65%-37.94%. Hoover and Ratnayake (2002) reported that the starch yield from different chickpea cultivars was ranged between 20.1% and 37.4%. This result is similar with Lan *et al.* (2008) who stated that the average yield of starch from different wheat varieties was in the range of 38.5% - 48.0%.

Chemical properties

Chemical properties of the isolated starches are presented in the Table-1.

Table 1. Chemical properties of wheat and chick pea starches (%)

Chemical properties	Chick pea starch	Wheat starch	t – value
Moisture	10.93±0.62	9.70±1.23	1.54^{NS}
Dry matter	89.12±0.63	90.29±1.23	1.46^{NS}
Protein	0.56±0.09	0.87±0.23	2.11^{NS}
Fat	0.30±0.18	0.90±0.65	1.52^{NS}
Ash	0.44±0.19	0.55±0.19	0.70^{NS}
Amylose	30.43±0.35	23.7±0.17	29.71*
pH	5.20±0.12	6.68±0.48	5.15*

*-Significant at $P<0.05$ level, NS-Not significant

Moisture content of the chickpea and wheat starch was 10.93±0.62% and 9.70±1.23% respectively. This result is confirmed with Huang *et al*. (2007) and Lan *et al.* (2008) who stated that moisture content of chickpea starch was11.9% and wheat starches was 9.11-10.75%. Chickpea starch had higher moisture content than wheat starch. This could be attributable to the fact that it has average grain size which implies that there are larger pore sizes which may trap water and result in high moisture contents (Olayemi *et al*., 2008). Dry matter of chickpea and wheat starches was 89.12±0.63% and 90.29±1.23% respectively. Wheat starch had more dry matter than chickpea starch. This result is in confirmity with Oludare and Macdonald (2010) who stated that the dry matter of cassava starch ranged from 86.71 to 87.57%. Protein content of the chickpea and wheat starch was 0.56±0.09% and 0.87±0.23% respectively. This result is on par with Miao *et al.* (2009) and Sung and Stone (2003) and who stated that protein content of chickpea starches was 0.52 - 0.54% and wheat starches was 0.5 - 0.8%. Wheat starch had higher protein content than chickpea starch. This might be due to high biomolecule (protein and fat) concentrations in cereal starches are difficult to extract and produce highly pure forms (Nuwamanya *et al.*, 2011). Fat content of the chickpea and wheat starches were 0.30±0.18% and 0.90±0.65% respectively. This result is confirmed with

Miao *et al.* (2009) who stated that the fat content of chickpea starches was 0.15-0.26% and wheat starches was 0.81-1.06% (Li *et al*., 1997). The fat content of chickpea starch was about one third of that in wheat starch. This might be due to the lipid contents in chickpea, cowpea and yellow pea starches were low and at the same level as in tuber starches and much lower than in cereal starches (1%) (Eliasson and Wahlgren, 2004). Ash content of the chickpea and wheat starches was 0.44±0.19% and 0.55±0.19% respectively. Wheat starch had more ash content than chickpea starch. This result is confirmed with Sung and Stone (2004) and Nuwamanya *et al.* (2011) who stated that the ash content of chickpea starch was 0.2% and wheat starch was 0.5-0.7%. Total amylose content of chickpea and wheat starches was 30.43±0.35% and 23.7±0.17% respectively. Legume starches had been characterised by high amylose content and the amylose levels of chickpea starches were within the range of 20.7-42.2% (Madhusudhan and Tharanathan, 1996; Hoover and Ratnayake, 2002). Majzoobi *et al.* (2011) stated that amylose content of wheat starch was 24.20%. Chickpea starch had high amylose content than wheat starch. It should be mentioned that amylose content of the starch samples depended on the source of starch, the method used for determination of amylose content, and the chemical composition of starch (Tester *et al.*, 2004; Copeland *et al.*, 2009). Young (1984) reported that starches high in amylose content were used in the food industry as a thickening, stabilizing, gelling and encapsulating agent. pH of the chickpea and wheat starches was 5.20±0.12 and 6.68±0.48 respectively. Wheat starch had significantly higher pH than chickpea starch. This result in confirmty with Shimelis *et al.* (2006) who stated that pH of Improved Bean (*Phaseolus vulgaris* L.) varieties were 5.81-6.06 and wheat starch was 6.8 (Zhu *et al.* ,2009). Ocloo *et al.* (2010) stated that the pH values give a measure of the acidity or alkalinity of the flour and the level of pH is used to estimate the quality of flour.

Functional properties

Functional properties of chickpea and wheat starches are shown in the Table 2. Water binding capacity of chickpea and wheat starches was 93.59±3.12% and 82.82±4.86% respectively and significant difference was found between chickpea and wheat starches. This result is confirmed with Miao *et al*. (2009) and Grant (1998) who stated

Table 2. Functional properties of wheat and chick pea starches

Functional properties	Chick pea starch	Wheat Starch	t – value
WBC (%)	93.59±3.12	82.82±4.86	3.22*
OAC (g/g)	0.73±0.02	0.90±0.05	4.64*
BD (g/ml)	0.94±0.09	0.90±0.04	0.64 NS

*-Significant at P<0.05 level, NS-Not significant, WBC-Water Binding, Capacity, OAC-Oil Absorption Capacity, BD-Bulk Density.

that water binding capacity of chickpea starch was 88.72% - 92.25% and wheat starch was 80.2% - 85.1% respectively. Chickpea starch had significantly higher water binding capacity than Wheat starch. This might be attributed to the involvement of a larger proportion of hydroxyl groups in forming hydrogen bonds between starch chains than with water (Miao *et al*., 2009). Imbibition of water is an important functional trait in foods such as sausages, custards and doughs. Moreover, oil absorption capacity is useful in structure interaction of food especially for flavor retention, improvement of palatability and extension of shelf life particularly in bakery or meat products (Adebowal and Lawal, 2004). Oil absorption capacity of wheat starch (0.90±0.05g/g) was significantly higher than chickpea starch (0.73±0.02g/g).This result is confirmed with Adebowale *et al*. (2006) who reported that Oil absorption capacity of Sword bean *(Canavalia gladiata)* starches was 2.9 - 3.6g/g. Hydrophobicity of proteins also play a major role in oil absorption (Voutsinas and Nakai, 1983). Bulk density of chickpea and wheat starches was 0.94±0.09g/ml and 0.90±0.04g/ml respectively. This result is on par with Agunbiade and Longe (1999) who reported that bulk density of legume starches ranged from1.01-1.08g/ml. Swelling power of wheat and chickpea starches for different temperatures ranging from 50 to 90°C is shown in the Figure 1.

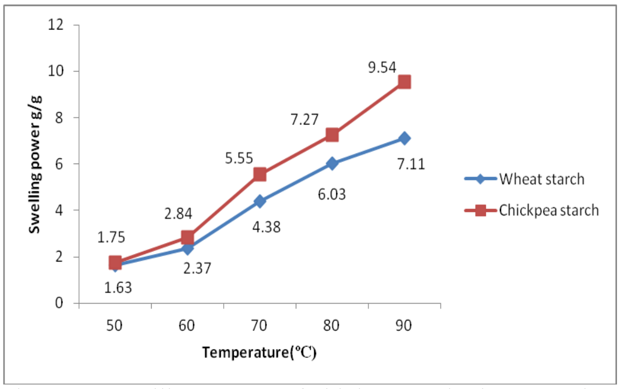

Figure 1. Swelling power of chickpea and wheat starches submitted to heat from 50 to 90°C

The swelling power of chickpea and wheat starches increased gradually when the temperature was raised to 90°C. Swelling power of chickpea and wheat starches was significantly varied from 50 to 90ºC except at 70ºC. This result is confirmed with Sung and Stone (2004) who reported that swelling power of chickpea starch from 60-90°C was in the range of 2.9-9.8g/g respectively. Similarly Nuwamanya *et al.* (2011) who reported that swelling power of wheat starch from 60-90°C was in the range of 0.48-10.87g/g respectively. The low swelling power of starches might be attributed to the presence of a large number of crystallites formed by the association between long amylopectin chains. Crystallite formation increases granular stability, thereby reducing the extent of granular swelling (Miao *et al*., 2009). Swelling volume of starch was affected by amylose content and the structure of amylopectin (Sasaki and Matsuki, 1998). The level of amylose lipid complexation total leached amylose in addition to the phosphate content had a significant effect on the swelling power. Amylose lipid complexes reduce swelling power, while existence of phosphate groups in starch increases the water binding capacity of starch, hence, the swelling power increased (Zuluag*a et al*., 2007). High amylose starches had high swelling powers, it was observed that at high temperatures these patterns change where some starches with high amylose had lower swelling powers at higher temperatures (Van Hung *et al*., 2007). Starch solubility of chickpea starch (2.33-7%) and wheat starch (2-5%) increased slightly from 50°C to 70°C then decreased gradually to 2.33 and 3.33% in chickpea and wheat starch respectively. A possible reason for the decrease in solubility with increasing temperature in mung bean and chick pea starch samples is that gelatinized starch can prevent leaching of soluble material into water (Sung and Stone, 2004).

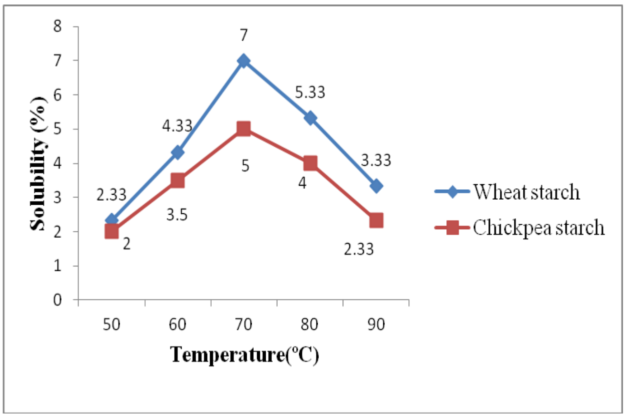

Figure 2. Solubility of chickpea and wheat starches submitted to heat from 50 to 90°C

Pasting properties of chickpea and wheat starches

Pasting properties of starch samples is given in Table 3. Peak, trough, breakdown, final and setback viscosities of chickpea starch (4453±267.27cP,

Table 3. Pasting properties chick pea and wheat starches (%)

Pasting properties	Chick pea starch	Wheat starch	t – value
Peak viscosity (cP)	4453±267.27	3011.33±87.78	8.87*
Trough (cP)	2861±223.54	2129±79.89	5.34*
Breakdown (cP)	1592±243.21	882.33±67.92	4.86*
Final viscosity (cP)	5603±264.17	3582.33±69.11	12.81*
Setback (cP)	2742±112.86	1453.33±49.16	18.13*
Peak time (min)	4.22±0.10	6.11±0.10	22.80*
Pasting temperature (ºC)	72.35±0.47	83.46±0.96	17.85*

*-Significant at P<0.05 level

2861±223.54cP, 1592±243.21cP, 5603±264.17cP and 2742±112.86cP respectively) were significantly (P<0.05) higher than those of wheat starch (3011.33±87.78cP, 2129±79.89cP, 882.33±67.92cP, 3582.33±69.11cP and 1453.33±49.16cP respectively). This result is confirmed with Majzoobi *et al*. (2009) who stated that a peak, trough, breakdown and final viscosities for native wheat starch were 2087cP, 1904cP, 203cP and 4810cP respectively. The strong swelling power makes it easy to reach maximum viscosity, but pastes are likely to break down easily because of their weak intermolecular forces and because they are more sensitive to the shear force as the temperature goes up. Thus, starch granules were easily broken down by the shear force, which increased the swelling power (Kim *et al*., 1999). Chickpea starch (4.22±0.10 min) showed significantly (P<0.05) lower peak time than wheat starch (6.11±0.10min). Majzoobi *et al.* (2009) reported that peak time of 9.73min for native wheat starch. Wheat starch (83.46±0.96ºC) showed higher pasting temperature than chickpea starch (72.35±0.47ºC). Miao *et al*. (2009) reported a pasting temperature of 70.7ºC for desi chickpea starch and Singh *et al.* (2004) reported a pasting temperature of chickpea starches in the range of 75.1–77.1ºC. The high pasting temperature of kabuli type starch indicates that this starch had a higher resistance to swelling and rupture (Miao *et al*. 2009).

Conclusion

The results showed that starch could be isolated with less associated components such as protein, fat and ash from chickpea than wheat. Chickpea starch had been characterized by significantly higher amylose and water binding capacity than wheat starch. Similarly moisture content of Chickpea starch was also high but it was not significant. Swelling power of chickpea and wheat starches was significantly varied from 50 to 90ºC except at 70ºC. Pasting properties of chickpea starch were significantly higher than those of wheat starch. Hence chickpea starch would provide good viscosity to food stuff and is encouraging its use in the preparation of noodles.

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