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Pasting properties of starches from amaranth and buckwheat

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Abstract
Starch is the major reserve polysaccharide in plants and is a valuable functional ingredient in the food industry. The physicochemical and functional characteristics that are imparted by starch to the aqueous system in various food applications vary with the biological origin (Sindhu and Khatkar, 2016) [26]. The present study was carried out to evaluate the pasting properties of amaranth and buckwheat starch. Peak viscosity, trough viscosity, breakdown viscosity, final viscosity and setback viscosity of amaranth and buckwheat starch were reported as 1229-3024cP, 943-1285cP, 419-1682cP, 1144-3882cP and 205.3-2369cP, respectively. Pasting viscosities of amaranth starch were found significantly lower than pasting viscosities of buckwheat starch.

Keywords: Amaranth, buckwheat, reserve polysaccharide

Introduction
Starch is the major dietary component in all human populations. Amylose fraction of starch contributes the characteristic of gelling. Therefore, starches of varying amylose content impart differing texture to foods. Amylopectin is the non-gelling portion of the starch and generally contributes a pituitous or stringy consistency to food products because of its solubility (Zondag, 2003) [36]. In the food industry, starch is utilized to produce various functionalities such as thickening, stabilizing, texturizing, gelling, bulking, water retention encapsulation and shelf-life extension (Ayucitra, 2012) [3]. Not only, amount of the starch is the important for various functionalities in food products, but also the type of starch is critical (Biliaderis, 1991) [7] as the physicochemical properties of starches depend on the botanical source from which they are isolated (Sandhu *et al.*, 2004) [24].
Thus to accomplish the aim, this study was undertaken to determine the pasting behaviour of starch extracted from amaranth and buckwheat.

Material and methods
The experiment was conducted at Choudhary Charan Singh Haryana Agricultural University, Hisar during 2015-2016**.** Amaranth seeds were procured from the Department of Plant Breeding, CCSHAU, Hisar. Buckwheat seeds were procured from Regional Research Centre, Sangla, Himachal Pradesh Krishi Visavavidyalaya, Palampur, Himachal Pradesh. Starch was extracted from amaranth grains using alkali (0.25% NaOH) whereas, starch was extracted from buckwheat grains using simple wet method.
Samples of amaranth and buckwheat flour were analyzed for starch content and its components i.e. amylose and amylopectin.

Starch content
Starch was extracted by the method of Cerning and Guilbot (1973) [9].

Amylose content
Amylose content was determined by the method described by Williams *et al.*, (1970) [33].

Amylopectin
Amylopectin was calculated using following formula:
Amylopectin = 100 – amylose content

Pasting properties of starch extracting from amaranth and buckwheat

Starch extracted from amaranth and buckwheat was assessed for various pasting characteristics viz. Peak Viscosity, Peak time, Break down, Final viscosity, Set back and Pasting temperature using Rapid-Visco Analyzer, Newport Scientific Australia.

Twenty five ml of distilled water was weighed into a canister. 3.5 g sample was weighed and transferred in canister. Paddle was placed into the canister and jogged to disperse the sample. Paddle and canister was inserted into Rapid-Visco Analyzer (RVA) and wait for the command for pressing down the tower from the thermocline windows till the temperature of RVA reached50ºC. Pressed down the tower and wait till the test was run for 13 min. Canister was removed on completion of test. From Thermocline windows following observations were recorded:

Peak Viscosity: Maximum viscosity developed during or soon after the heating portion of the test.

Trough viscosity: Maximum viscosity after the peak, normally occurring around the commencement of sample cooling.

Peak time: Time taken at which peak viscosity occurred.

Pasting temperature: Temperature where viscosity first increases by at least 25 cP over a 20sec. period using the standard-1 profile.

Break down viscosities: Peak viscosity minus trough viscosity.

Final viscosity: Viscosity at the end of the test.

Set back: Final viscosity minus trough viscosity.

Results and Discussion

Starch, amylose and amylopectin content of starch of amaranth and buckwheat

Table 1: Starch, amylose and amylopectin content of starch of amaranth and buckwheat

Sample	Starch (%)	Amylose (% of starch)	Amylopectin (% of starch)
Pseudo-cereals			
Amaranth	64.26±0.02	8.17±0.02	91.34±0.26
Buckwheat	62.23±0.02	22.98±0.15	77.01±0.14

In the food industry, starch is utilized to produce various functionalities such as thickening, stabilizing, texturing, gelling, encapsulation and self-life extension. It plays an important role in determining the quality and texture of many food; controlling the acceptability and palpability of most food products.

Amaranth contained 64.26% starch (Table 1) which was lower than the values (67.3 and 69.1 g/100g) reported by Souci *et al.*, (2000) [29] and Menegassi *et al.*, (2011) [17], respectively and higher than the values (62.0 and 61.4%) observed by Paredes-Lopez *et al.*, (1989) [19] and Alvarez-Jubete *et al.*, (2009) [2]. in amaranth. Buckwheat contained 62.33% starch content which was comparable to the starch content (61.7%) observed by Vojtiskova *et al.*, (2014) [31]. Bonafaccia *et al.*, (2003) [8], Alvarez-Jubete *et al.*, (2009) [2]; Hung *et al.*, (2009) [13] and Beitane*et al.*, (2015) [5] observed lower (55.8, 58.9, 54.5-57.4 and 52.6%, respectively) starch content whereas, Souci *et al.*, (2000); Demin *et al.*, (2012) [10] and Deng *et al.*, (2015) [11] observed higher starch content (67.2, 68.94 and 69.77%, respectively) than the value of starch observed in present study for different varieties of buckwheat.

The differences in starch content of amaranth and buckwheat flour could be explained by different cultivars, determination methods and growth conditions (Beitane *et al.*, 2015) [5].

Amaranth starch contained 8.17% amylose content (Table 1) which was in the range (0.1-11.1%) of amylose content of amaranth starch observed by Stone *et al.* (1984) [30]. Hoover *et al.*, (1998) [12], Menegassi *et al.* (2011) [17] and Sindhu and Khatkar (2016) [26] observed lower amylose content in amaranth starch than the value found in present study. Buckwheat starch contained 22.98% amylose (Table 1) which was in the range of values (21.5-25.7, 22.0-28.5 and 21.1-46.6%) reported by Li *et al.*,(1997) [16]; Acquistucci and Fornal (1997) [1] and Hung *et al.*,2009 [13], respectively. Sindhu and Khatkar (2016) [25, 27] observed higher amylose content of buckwheat starch than the present study.

This variation in amylose and amylopectin content is related to different factors such as genotype, environmental conditions, and agronomic practices (Beta and Corke, 2001[6] and Singh *et al.*, 2006[28]) and activity of the enzymes involved in starch synthesis.

Pasting properties of amaranth and buckwheat starch

Table 2: Pasting properties of amaranth and buckwheat starch

Sample	Peak Viscosity (cP)	Trough Viscosity (cP)	Breakdown Viscosity (cP)	Final Viscosity (cP)	Setback Viscosity (cP)	Peak time (min.)	Past. temp. (ºC)	Gelatinization temp. (ºC)
Pseudo-cereals starch								
Amaranth starch	1229±3.05	943±4.72	419.3±4.8	1144±6.80	205.3±2.96	4.22±0.09	75.16±0.03	95.14±0
Buckwheat Starch	3024±3.44	1285±5.21	1682±3.60	3882±4.35	2369±11.32	4.21±0.03	75.17±0.02	95.05±0

The pasting curve represents changes in behaviour of paste viscosity of starch with change in temperature and mainly varies with composition and characteristics of starch. Increase in viscosity during heating may be attributed to the swelling of granules, as a result of loss of crystalline order and absorption of water (Bao and Bergman, 2004) [4].

Peak viscosity of amaranth and buckwheat starch was 1229 and 3024 cP, respectively (Table 2) which was similar to the value of peak viscosity of amaranth (1212 cP) and buckwheat (3106 cP) starch reported by Sindhu and Khatkar (2016) [26, 27]. Jindal and Saxena (2015) reported higher value of peak viscosity (6062 cP) of buckwheat starch than the peak viscosity of buckwheat starch observed in present study.

The differences observed in the peak viscosities of the amaranth and buckwheat starch may be attributed to different rates of water absorption and swelling of starch granules during heating (Ragaee and Abdel-Aal, 2006) [22].

Trough viscosity of amaranth starch was 943 cP (Table 2)

which was comparable with the trough viscosity (846 cP) of amaranth starch (Sindhhu and Khatkar, 2016) [26]. Trough viscosity of buckwheat starch was 1285 cP (Table 2). Jindal and Saxena (2015) [14] and Sindhu and Khatkar (2016) [27] reported higher (2970.22 and 1904.33 cP, respectively) trough viscosity of buckwheat starch than the present study.
The degree of viscosity reduction during heating process is termed as breakdown viscosity and can be used as an indicator for pasting stability during heating and stirring (Oke *et al.*, 2012 and Zaidul *et al.*, 2007) [18, 35]. Breakdown viscosity of amaranth starch was 419 cP (Table 2) which was comparable with breakdown viscosity (371.66 cP) of amaranth starch observed by Sindhu and Khatkar (2016) [26]. Qian and Kuhn (1999) [20] observed higher breakdown viscosity (870 cP) of amaranth starch than the present study. Breakdown viscosity of buckwheat starch was 1682 cP (Table 2). Jindal and Saxena (2015) [14] reported higher whereas, Sindhu and Khatkar (2016) [27] reported lower breakdown viscosity of buckwheat starch than the present study.
Final viscosity of amaranth starch was 1144 cP (Table 2) which was comparable with the final viscosity (1032.33 cP) of amaranth starch observed by Sindhu and Khatkar (2016) [26]. Final viscosity of buckwheat starch was 3882 cP (Table 2) which was higher than the final viscosity of buckwheat starch observed by Jindal and Saxena (2015)[14] and Sindhu and Khatkar (2016)[27].The variations in the final viscosity may be due to the simple kinetic effect on cooling on viscosity and the association of starch molecules.
The stability of paste during cooling and storage is indicated by setback viscosity; *i.e.* the differences between final viscosity and trough viscosity. The higher setback viscosity indicates the higher tendency of amylose to retrograde (Zaidul *et al.*, 2007)[35].Setback viscosity of amaranth and buckwheat starch was 205.33 and 2369.33 cP, respectively (Table 2). Value of setback viscosity of buckwheat starch observed in present study was comparable with the setback viscosity (2359 cP) of buckwheat starch observed by Jindal and Saxena (2015) [14]. Lower setback viscosity (186.33 cP) of amaranth (Sindhu and Khatkar, 2016) [26] and (1610 cP) of buckwheat starch (Sindhu and Khatkar, 2016) [27] has been reported.
Buckwheat starches exhibited distinctive pasting profiles with much higher peak, trough, breakdown, final and setback viscosity values compared with starches extracted from amaranth (Table 2). The reason for highest pasting viscosities of buckwheat starch may be attributed to a large proportion of DP (degree of polymerization) 6-12 branch chains of amylopectin (Ratnayake *et al.*, 2001)[23]. Pasting temperature of amaranth and buckwheat starch was 75.16 and 75.17 ^{0}C, respectively (Table 2). Lower pasting temperature (68.5 and 65.5 ^{0}C) of amaranth (Radosavljevic, 2006 and Sindhu and Khatkar, 2016, respectively) [21, 26] and buckwheat (71.33 ^{0}C) starch (Sindhu and Khatkar, 2016) [27] has been found. Pasting temperature is positively correlated to amylose content and protein content (Wani and Kumar, 2015 and Kaur *et al.*, 2016) [32, 15]. High pasting temperature might be due to internal starch granule is tightly packed, swelling slows during heating, which, in turn, increases the pasting temperature (Yoon *et al.*, 2009) [34].

Conclusion
Peak viscosity, trough viscosity, breakdown viscosity, final viscosity and setback viscosity of amaranth and buckwheat starch were reported as 1229-3024cP, 943-1285cP, 419-1682cP, 1144-3882cP and 205.3-2369cP, respectively. Pasting viscosities of amaranth starch were found significantly lower than pasting viscosities of buckwheat starch.

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