Thermal, structural and textural properties of amaranth and buckwheat starches

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Abstract Starches isolated from amaranth and buckwheat were analysed for thermal characteristics, crystallinity, gel textural properties and light transmittance. Buckwheat starch gels were harder with higher chewiness and springiness than amaranth starch gels. Starch from common buckwheat produced the hardest gel and amaranth starch from VL-44 cultivar produced the softest gel. Gelatinisation temperatures of amaranth and buckwheat starches differed significantly and tartary buckwheat starch showed the highest values for T_p and T_c . Buckwheat starches showed lower enthalpy change values than amaranth starches of both the cultivars. X-ray diffractometry confirmed ‘A’ type crystalline pattern for all tested starch samples and higher relative crystallinity was noticed in amaranth starches than buckwheat starches. Tartary buckwheat exhibited the lowest value of relative crystallinity and amaranth starch of Durga cultivars showed the highest value of relative crystallinity. FTIR spectrums showed band at similar wavenumbers (cm^{-1}) with varying intensities. A declining order of paste clarity during storage at refrigeration temperature was observed for all starches.

Keywords Starch · Amaranth · Buckwheat · Thermal properties · Crystallinity

Introduction

Starch is the polysaccharide reserve of plants and has applications range from giving texture and uniformity to foods and papers to adhesives and biodegradable packaging. Starch is widely used functional ingredient for its thickening, stabilizing and gelling ability in food industry. The utilization of starch in food industries is mainly governed by its characteristics including functional, pasting, gelatinization, and structural properties. An elementary characteristic of starches of different origins is that their granular and molecular structures have an effect on their physicochemical and functional properties. During the heating of starch in presence of surplus water a transition phase takes place in starch known as gelatinization, and there is a distinctive temperature range for gelatinization related to starch of each origin. Gelatinization takes place when water disperse into the starch granule and cause swelling due to hydration of the amorphous phase resulting in loss of crystallinity and molecular order. The gelling ability of starch is significant in food manufacturing and textural characteristics of starch gels are used to assess the behaviour of starch in food systems (Li et al. 2014). Transparency and strength of gel are vital parameters for enhancing the applicability of starch in food products. Analysis of thermal properties of starch through differential scanning calorimetry (DSC) presents the significant information about gelatinisation behaviour of starch which supports the easy processing and better exploitation of starch. These properties of starches depend on the biological source from which they are extracted. The major botanical and commercial sources of starch are some cereals, legumes and roots and tubers. Increasing utilization of starch has twisted the interest of researchers in searching the new starch sources. Pseudocereals including

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Table 1 Gel textural properties of amaranth and buckwheat starches

Variety	Hardness (g)	Adhesiveness (g/s)	Springiness	Gumminess (g)	Chewiness (g)	Cohesiveness
Amaranth						
Durga	1.10 ± 0.05 ^a	– 1.90 ± 0.07 ^a	0.94 ± 0.00 ^a	0.63 ± 0.02 ^a	0.56 ± 0.03 ^a	0.57 ± 0.00 ^a
VL-44	0.90 ± 0.09 ^a	– 1.70 ± 0.18 ^a	0.94 ± 0.01 ^a	0.51 ± 0.04 ^a	0.48 ± 0.04 ^a	0.57 ± 0.0 ^a
Buckwheat						
Shimla B-1	9.26 ± 0.04 ^b	– 1.71 ± 0.28 ^a	1.35 ± 0.01 ^b	3.80 ± 0.27 ^b	5.13 ± 0.30 ^b	0.41 ± 0.03 ^b
VL-7	9.63 ± 1.03 ^b	– 2.01 ± 0.5 ^b	1.59 ± 0.01 ^c	4.76 ± 0.69 ^c	7.62 ± 1.18 ^c	0.49 ± 0.01 ^c

All values are mean of triplicate determinations ± standard deviation mean. Values within same column with different letters are significantly different ($p \leq 0.05$)

amaranth, buckwheat and quinoa are known for their nutritional value and usually consumed in the form of flour. Amaranthus is communally known as amaranth and belongs to the family *Amaranthaceae*. Amaranth is a cosmopolitan genus of annual or short-lived perennial plants, consisting of around 60 species, which based on the utilization for human consumption are categorised into grain and vegetable amaranth. Only three species of amaranth namely *Amaranthus hypochondriacus*, *Amaranthus cruentus* and *Amaranthus caudatus* are cultivated as grain species. Buckwheat belongs to the *Polygonaceae* family and it is an annual dicotyledonous crop. Mainly two species of buckwheat i.e. common buckwheat (*Fagopyrum esculentum*) and tartary buckwheat (*Fagopyrum tataricum*) are cultivated and consumed worldwide. Starch is the main constituent of flours of amaranth and buckwheat that governs the properties of food products made up of composite flours of these pseudocereals. High content of starch in pseudocereal grains makes them as the promising new starch source that produces starches with different functional, morphological, gel-textural and gelatinisation properties which give them a wide range of potential industrial applications. Although studies on starch systems from different sources have been conducted, research on pseudocereals starches is still lesser. Therefore, the present study was aimed at isolation and analysis of thermal and structural properties of starches from amaranth and buckwheat grown in India.

Materials and methods

Raw materials

Grains of amaranth (*Amaranthus hypochondriacus*) of two cultivars namely Durga and VL -44; common buckwheat (*Fagopyrum esculentum* Moench) of one cultivar namely VL-7 and tartary buckwheat (*Fagopyrum Tataricum*) of one cultivar namely Shimla B-1 grown and harvested in the

farms of National Bureau of Plant Genetic Resources Regional Station, Shimla (India) were procured from the same institute. The grains were cleaned and dried in hot air oven at 40 °C for 6–7 h prior to storage in sealed containers.

Starch isolation

Alkaline steeping method of Choi et al. (2000) was followed for isolation of starch from amaranth and buckwheat. Grains were steeped at room temperature in 0.25% aqueous NaOH solution in ratio of 1:6 (100 g grains in 600 ml solution of NaOH) and stirred 3–4 times during the steeping period of 18 h. The washing of steeped grains was done using distilled water and ground in a kitchen blender. The slurry produced was sieved through 100 mesh (150 µm) and 270 mesh (53 µm) sieves. The filtrate was centrifuged at 8000 rpm for 20 min and supernatant was discarded. From the sediment yellowish coloured top layer of protein was separated using spatula. The starch layer was re-suspended in distilled water, shaken and centrifuged as described above. This step was repeated 4–5 times to achieve white starch sediment. Starch suspension was washed with ethanol once in repeating washing steps to remove lipids from starch. Isolated starch was dried in hot air oven at below 40 °C for 10–12 h, conditioned for 2 h in desiccator at room temperature and stored in well labelled and plastic bags till further analysis. Yield of starch in percentage was calculated as starch (g) produced per 100 g of grains.

Starch characterization

Gel textural properties

For the preparation of starch gel, slurry was prepared by mixing 3 g starch (14% moisture basis) with calculated amount of water to make 28 g total mixture. The slurry was heated to 50 °C and kept at this temperature for 1 min. The

temperature of slurry was raised to 95 °C in time period of 3.30 min and held at this temperature for 3 min before cooling to 50 °C in 3.30 min followed by holding at 50 °C for 2 min. Constant mixing was done during heating and cooling cycle to avoid lump formation. The gel formed from each starch sample in canister was sealed with parafilm to avoid moisture loss and stored at refrigeration temperature for 24 h. The textural properties were analysed by texture profile analysis (TPA) programme using texture analyzer (TA-XT 2i Stable Micro Systems, UK) equipped with Texture Expert software. Gel in each canister was compressed (0.5 mm/s to a distance of 10 mm) with a cylindrical plunger (P/25). The force was applied twice to produce a force–time curve which was used to calculate the hardness, gumminess, adhesiveness and chewiness of gel.

Thermal properties

Thermal characteristics of starches isolated from different cultivars of amaranth and buckwheat were studied using Differential Scanning Calorimeter (DSC 25, TA Instruments) equipped with analysis software named Trios. Starch suspension containing 70% water was prepared in aluminium pan by adding calculated amount of distilled water using micro-syringe in 3–4 mg of starch sample. Pans were hermetically sealed and kept at room temperature for 24 h to ensure equilibration of the starch sample and water. Calibration of instrument (DSC) was done using indium and an empty aluminium pan was used as reference. The samples were scanned from 30 to 130 °C at a rate of 10 °C/min. Gelatinisation temperatures and enthalpy of gelatinisation were determined from thermograms produced.

X-ray diffractometry

The X-ray diffraction patterns of starch samples were observed using MiniFlexII X-ray diffractometer (Rigaku Denki Co., Tokyo, Japan). Starch samples were scanned at 5–50° (2 θ) with a rate of 5°/min, at target voltage of 40 kV and a current of 30 mA. A theoretical diffractogram with peak description was used for determination of XRD pattern (Zobel 1988).

Fourier Transform Infrared (FTIR) Spectroscopy

The FTIR spectra of the starch samples were recorded using FTIR spectrometer (Spectrum BX, Perkin Elmer, USA). The starch samples were mixed with KBr at a ratio of 1:100 (starch: KBr), ground and pressed to form a pellet. FTIR spectra were collected in the 400–4000 cm^{−1} region.

Paste clarity

Paste clarity of starches was measured as light transmittance by using the method described by Perera and Hoover (1999). Starch suspension (1%) prepared in test tube was mixed thoroughly and kept in water bath at 90 °C for 1 h with continuous stirring. Samples were cooled to room temperature and stored for a period of 5 days at refrigeration temperature. Transmittance of starch suspensions was measured at 640 nm taking distilled water as blank using UV–VIS Spectrophotometer (GENESYS 10S, Thermo Fisher Scientific, USA) at an interval of 24 h.

Results and discussion

Starch yield of amaranth grains of Durga and VL-44 cultivars was 39.4 and 31.3%, respectively. Grains of common buckwheat and tartary buckwheat exhibited 27.9 and 25.8% starch yield correspondingly. Comparatively higher starch yield noticed for amaranth grains of both the cultivars than common and tartary buckwheat grains that might be attributed to higher portion of seed coat in buckwheat seeds. Starches from these cultivars of amaranth and buckwheat isolated using the same method had very low level of protein (0.84–0.97% on dry basis), crude fat (0.64–0.8% on dry basis), crude fibre (0.04–0.5% on dry basis) and ash content (0.07–0.3% on dry basis) as reported in our earlier studies (Sindhu and Khatkar 2016a, b, c, d). It was also observed that amylose content (on dry basis) of amaranth starches of Durga and VL-44 was 6.93 and 7.27% respectively while buckwheat starches of Shimla B-1 and VL-7 cultivars exhibited higher values (32.12 and 35.66%, respectively).

Gel textural properties

The textural properties including hardness, adhesiveness, springiness, gumminess and chewiness of starch gels of different cultivars of amaranth and buckwheat are given in Table 1. A huge difference was noticed in these parameters of amaranth and buckwheat starch gels. Hardness is the measure of textural property that corresponds to the force applied to cause deformation of the sample. Compared to amaranth starches, buckwheat starches showed more hardness and the maximum hardness value (9.63 g) was noticed for the gel of VL-7 cultivar of buckwheat while the minimum hardness (1.10 g) was recorded for amaranth starch of VL-44 cultivar. Retrogradation of gelatinized starch due to reassociation of amylose and recrystallization of side chains of amylopectin to form a network during storage is chiefly responsible for gel firmness. The development of starch gels chiefly depends on the quantity of

Table 2 Thermal properties of amaranth and buckwheat starches

Variety	T _O (°C)	T _P (°C)	T _C (°C)	ΔH (J/g)
Amaranth				
Durga	67.06 ± 0.00 ^a	71.42 ± 0.04 ^a	80.67 ± 0.04 ^a	3.59 ± 0.32 ^a
VL-44	66.77 ± 0.06 ^b	72.12 ± 0.10 ^b	82.51 ± 0.27 ^b	3.57 ± 0.05 ^a
Buckwheat				
Shimla B-1	66.94 ± 0.12 ^a	72.18 ± 0.15 ^b	85.15 ± 0.13 ^c	2.70 ± 0.06 ^b
VL-7	64.92 ± 0.03 ^c	69.65 ± 0.04 ^c	77.90 ± 1.70 ^d	2.97 ± 0.02 ^b

TO: onset temperature; TP: peak temperature; TC: conclusion temperature; ΔH: gelatinisation enthalpy

All values are mean of triplicate determinations ± standard deviation mean. Values within same column with different letters are significantly different ($p \leq 0.05$)

leached amylose and swollen granules. Our earlier studies on same cultivars of amaranth and buckwheat revealed that amaranth starches were waxy in nature having lesser amylose than buckwheat starches (Sindhu and Khatkar 2016a, b, c). Therefore, lower content of amylose in amaranth starches could be the reason for more softness or lesser hardness of starch gels than that of buckwheat starches. Textural parameters of amaranth starches of both cultivars showed statistically similar values while buckwheat cultivars showed significantly different values of these parameters. The maximum gumminess (4.76 g), adhesiveness (− 2.01 g/s) and chewiness (7.62 g) were noticed in common buckwheat (VL-7) starch gels while the minimum values of these parameters (0.51 g, − 1.70 g/s and 0.48 g respectively) were shown by starch gels of VL-44 cultivar of amaranth. Higher values of gumminess, adhesiveness and chewiness of gels of buckwheat starches than amaranth starches indicated comparatively weaker starch gels of amaranth. Springiness and cohesiveness of starch gels ranged from 0.94 to 1.59 and 0.41 to 0.57 respectively. Kong et al. (2009) studied starches from fifteen cultivars of amaranth and reported hardness, cohesiveness and adhesiveness of starches in the range from 18 to 129 g, 0.47 to 0.65 and − 26 to − 846 g/s respectively which were comparable to results of amaranth starch gels in present study. Gel textural analysis of starches from different cultivars of rice showed 6.72–79.54 g hardness, 4.18–29.79 g gumminess and 8.07–31.91 g mm chewiness (Sodhi and Singh 2005). Liu et al. (2014) observed harder gels with higher values of hardness (83.6 g), adhesiveness (− 113 gs), gumminess (42.1 g) and chewiness (39.8 g) while lower values of springiness (0.95) for tartary buckwheat starch than that of starch gels of buckwheat in present investigation.

Variations in textural properties of starch gels may be attributed to variation in the rheological properties of amylose matrix, the volume of fraction, the rigidity of the gelatinized starch granules and interactions between dispersed and continuous phase of starch pastes (Biliaderis

1998). Different conditions of gels preparation like concentration of starch, time and temperature of heating–cooling cycle and length of storage period as well as storage temperature could also be the reason for variation in gel textural properties of amaranth and buckwheat starches from previous studies. Characteristics of starch gels of different cultivars of amaranth and buckwheat were noticeably different from starches of wheat, corn, potato, sweet potato, cassava, mung bean and peas as reported by Li et al. (2014). The divergence in properties may be due to different origin, growing conditions, composition and structure of starch as well as testing conditions like storage time and temperature.

Thermal properties

The results of differential scanning calorimetry analysis of starches isolated from different cultivars of amaranth and buckwheat are summarized in Table 2. Transition temperatures T_O (onset), T_P (peak), T_C (conclusion) and gelatinization enthalpies (ΔH) of amaranth starches of both the cultivars differed significantly and similar trend was observed for buckwheat starches differed cultivars. The value of onset temperature symbolize the inner structure of starch granule during its disintegrations and consequently liberation of polysaccharide into the surrounding medium (Singh et al. 2006a, b). Buckwheat starch of Shimla B-1 cultivar exhibited the highest values for T_O (66.94 °C), T_P (72.18 °C) and T_C (85.15 °C) whereas amaranth starch of VL-7 cultivar showed the lowest values (64.92 °C, 69.65 °C and 77.90 °C respectively) for these parameters. The higher transition temperatures for starch may be attributed to the compact nature and higher level of molecular order of starch granules (Krueger et al. 1987). Singh et al. (2014) analysed thermal properties of starches from *A. hypochondriacus* (13 cultivars) and *A. caudatus* (8 cultivars). In that study, the transition temperatures exhibited negative correlation between amylopectin with short chains while positive correlation between amylopectin of medium and long chains. Amylopectin with

Fig. 1 X-ray diffractograms of amaranth and buckwheat starches. **a** Durga; **b**: VL-44; **c**: Shimla B-1; **d**: VL-7. RC: relative crystallinity

longer chains formed more stable double helical structure and required more energy for disruption while shorter chains of amylopectin got disrupted at lower temperature due to absence of strong crystalline network. Authors concluded that the length of chain of starch granule was

significantly responsible for change in structure from liquid-like to solid-like. Enthalpy change (ΔH) is represented by the area under the endothermic peak during differential scanning calorimetry analysis reflects the transformed part of starch. Cooke and Gidley (1992) reported that the gelatinisation enthalpy reflects the loss of double helical rather than crystalline order. The high value of ΔH of starch implies that interactions between double helices (which are packed in cluster) in the crystalline regions are perhaps more widespread owing to longer chains in amylopectin (Zhou et al. 2004). The gelatinization enthalpies of starches varied from 2.70 to 3.69 J/g with the highest value for Durga cultivar of amaranth while the lowest value for Shimla B-1 cultivar of buckwheat. Amaranth starches showed significantly higher ΔH values than buckwheat starches which could be attributed to the higher amylopectin content in amaranth starches as crystallinity increases with increase in amylopectin content (Chandla et al. 2016). The trend of enthalpy values was in close conformity with results of relative crystallinity of starches with higher values of amaranth than buckwheat starches in present investigation. Singh et al. (2007) investigated starches from different rice cultivar and reported higher enthalpy values for higher crystalline starches than that of

Fig. 2 FTIR spectra of starches of amaranth and buckwheat. **a** Durga; **b**: VL-44; **c**: Shimla B-1; **d**: VL-7

starches with lower relative crystallinity. Gelatinisation temperatures of amaranth starches were found to be comparable with the finding of Chandla et al. (2016) analysed starches from different cultivars of amaranth while ΔH values were reported considerably higher than that observed in present study.

The values of gelatinisation temperatures of buckwheat starches were comparable with that recorded in literature (Li et al. 2014; Liu et al. 2015); however, gelatinisation enthalpies were lower than that reported in earlier studies. Zhu (2016) evaluated results of thermal properties analysis of buckwheat starches from various investigations and observed diversity in enthalpy change and peak temperature of buckwheat starches isolated from twenty seven cultivars and found the values varying from 9.4 to 13.9 J/g and 57.2 to 66.7 °C, respectively. The variation could be attributed to the different varieties and/or cultivars as well as growing location of the analysed buckwheat. The deviation in gelatinization temperatures might be due to the divergence in amylose content, morphological characteristics and allocation of starch granules as well as packing arrangement of starch fractions within the granule. It has been proposed by Noda et al. (1998) that thermal properties of starches are affected by the allocation of amylopectin short chains and not by relative amount of crystalline area.

X-ray diffractometry

The X-ray diffraction patterns of the amaranth and buckwheat starches are presented in Fig. 1. Starches had similar diffractograms with strong peaks at 15.05°, 16.90°, 17.50° and 23° at 2θ with the highest intensity of all peaks were shown by amaranth starch of Durga cultivar. Peaks on diffractograms clearly demonstrated 'A' type crystal pattern, characteristics of cereals starches as reported for rice, barley and maize starches (Chávez-Murillo et al. 2008; Halal et al. 2015). Relative crystallinity ranged from 13.97 to 16.16% with the highest value observed for Durga cultivar of amaranth and the lowest value was noticed for tartary buckwheat starch. Singh et al. (2006a, b) studied X-ray diffraction pattern of starches isolated from different cultivars of maize and noticed greater peak intensities and higher relative crystallinity of lower amylose containing starches as compared to starches having higher amylose content. Similarly, higher relative crystallinity of amaranth starches of both the cultivars than tartary and common buckwheat could be attributed to more amylopectin content in amaranth starches as degree of crystallinity of starch increase with increase in amylopectin content. Relative crystallinity was reported in the range of 20.55–30.08% for the starches of *A. hypochondriacus* while lower range (19.09–24.65%) was recorded *A. caudatus* by Singh et al. (2014). Chandla et al. (2016) observed "A" type crystalline

pattern and 22.6–33.88% relative crystallinity of amaranth starches of different cultivars. Buckwheat starches were noticed with relative crystallinity of 38.02% and 28.2% by Li et al. (2014) and Liu et al. (2015) respectively. Variations in crystallinity of starches might be due to different origins, growing conditions of source, composition and amylopectin content of starch granules.

FTIR analysis

The FTIR spectrums of starches of amaranth and buckwheat are represented in Fig. 2. The spectrums of amaranth and buckwheat starches were found to be similar with no noticeable shift. Sharp peak was observed around 1241–1244 cm^{-1} in spectra of each starch sample that could be due to vibration modes offered by amylose and amylopectin. These bands were assigned to the C–O stretch and chiefly attributed to C–O stretch of C–O–H in starch. Cael et al. (1975) reported that band at 1242 cm^{-1} on the spectrum of starch was assigned to the CH_2OH (side chain) and C–O–H deformation mode. All spectra had shown band around 1364 cm^{-1} that could be originated from CH_2 bending modes. The band observed at 1647 cm^{-1} was due to water present in the amorphous fraction of granules. Difference in the crystallinity of starch can influence the intensity of this band (Kizil et al. 2002). The wide band noticed around 3250–3500 cm^{-1} might be attributed to the O–H stretching of alcohols and phenols in free form. The peak observed between 2931 and 2932 cm^{-1} in spectra of starches could be due to asymmetric stretching of C–H bonds. The band at 920 cm^{-1} observed was attributed to vibration C–O–C in α -1,4 glycosidic linkage starch structure and band noticed at 860 cm^{-1} was attributed to C–H bond in CH_2 deformation mode which were in conformity with the reports of Kizil et al. (2002) analysed starches of various sources using FTIR. Spectrums of amaranth and buckwheat starches were similar to the typical spectrums with common bands for native starches reported in earlier studies (Kizil et al. 2002; Chandla et al. 2016; Kumar and Khatkar 2017) indicated that no other functional groups were present in the isolated starched samples of amaranth and buckwheat. Variations in intensity of bands on spectrums of starches could be due to difference in amylose-amylopectin ratio.

Paste clarity

The transparency or opacity of cooked paste of starch is an important quality parameter of starch as an ingredient which affects the appearance and acceptability of final product. In some products like soups, dressings and puddings low transmittance is not a drawback while in jellies and fruit fillings types of products starch pastes with high

Fig. 3 Effect of storage on paste clarity of amaranth and buckwheat starches

clarity are desired. Starches of both the cultivars of amaranth showed more transmittance than buckwheat starches. Clarity of paste depends on various factors such as swollen granules, presence of granule remnants and leaching of granules amylose and amylopectin. Jacobson et al. (1997) observed that network of amylose in the fresh paste of amylose containing starches was responsible for transmittance and during storage turbidity increased due to formation of higher density aggregates of amylose. Phosphorus is found in starches in the form of phosphate monoesters and phospholipids. The phosphate monoesters bound covalently to the amylopectin fraction of the starch and enhance starch paste clarity and viscosity while phospholipids produce opaqueness and reduced viscosity pastes (Craig et al. 1989). Therefore, high phospholipids containing products like wheat and rice starches produce suspensions with low transmittance power than less phospholipid containing products such as potato or corn starch. Amylose content was reported to be one of the factors that affect the clarity of paste (Lim and Seib 1993). As amaranth starch is waxy type starch having lower content of amylose than buckwheat starch resulting in different swelling and solubility behaviour that might be the cause for variation in light transmittance of amaranth and buckwheat starches in present investigation.

With progressive storage at refrigeration temperature transmittance was found to decrease significantly in all starch samples as shown in Fig. 3. Reduction in paste clarity during storage was also observed by Ali et al. (2016) in rice and corn starches. Sarkar (2016) reported increased turbidity during storage of buckwheat starch pastes. Transmittance power of starch suspensions changed during storage and decreasing order was noticed that could be due to increasing association of amylose and/or amylopectin molecules (Waterschoot et al. 2015). Retrogradation of

gelatinised starch during storage develops the turbidity in paste. Bhupender et al. (2013) suggested that amylose and amylopectin with long chain are liable to retrograde rapidly consequently influences the light transmittance of starch paste during storage. The decrease in transmittance value during storage could be attributed to leached amylose and amylopectin chains which caused formation of functional zones that scatter a considerable amount of light.

Conclusion

This study showed that there is a marked difference in the structural and thermal characteristics of starches isolated from different cultivars of amaranth, common buckwheat and tartary buckwheat. Characteristics of these starches were also diverse from major cereal starches. Production of hard gels from buckwheat starches and soft gels from amaranth starches represents their wide applicability in variety of foods. Variations in gelatinisation temperatures indicate the suitability of amaranth and buckwheat starches for food products based on the different cooking temperature and energy requirement for processing. FTIR confirmed the absence of other functional groups in starch isolates. Crystallinity or structure of starch is major factor for behaviour of starch during processing and characteristics of starch based final products. XRD analysis showed ‘A’ type crystallinity pattern and different range of crystallinity for amaranth and buckwheat starches. Decreasing transmittance during storage indicate the rising tendency of opaqueness in starchy cooked foods.

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