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An Overview of Composition and Physical Characteristics of Millet Starches

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ABSTRACT

Millets were described as a diverse group of small-grained cereal grasses belonging to the family Poaceae and were classified into major and minor categories based on grain size. Millets were commonly referred to as coarse grains and were believed to be among the earliest crops domesticated by humans. Recently, the incorporation of millets into food products has gained attention. However, for incorporation of millets in food products, it is vital to understand the starches of millets, their characteristics and how they influence the product quality. Based upon these starch characteristics, one can choose the right millet starch for a particular application. These aspect of millet starches are discussed in this article.

INTRODUCTION:

Millets are small grain cereals that are drought tolerant and require few chemical inputs such as fertilizers and pesticides to thrive. The unanimous adoption of a resolution by the United Nations General Assembly (UNGA) declaring 2023 as the International Year of Millet (ICRISAT, 2022) a proposal sponsored by India and supported by more than 70 countries, underscoring the community's support, recognized the importance and benefits of these grains to the global food system. Millets have been widely used as an ingredient in several food products over the last decade. However, there is an alternative approach to enhance the widespread utilization of millets is by exploiting the millet starches. The use of millet starches on commercial scale will provide an opportunity to meet the demand of starch and starch derivatives in food, textile and paper industry. Cereal grains, such as corn, wheat, sorghum, and tubers, and root crops including potato, tapioca, cassava, arrowroot etc., serves as commercial sources of starches for numerous applications. Starch (55-60%) is also the major component of the millet grains and being low cost and easily available, they could be used as a substitute for corn starch, as nowadays corn is in great demand for animal feed and biofuel production. Thus, this article presents an overview about the composition and characteristics of millets.

Composition of millet starches

The composition of millet starches usually depends upon the purity of starch. If the starch isolation method leads to a very pure starch then there would be only traces of minerals, lipids and protein. Other than purity, the most important components responsible for the starch properties are amylose and amylopectin content. They also differ on the basis of amylose content. The composition, in turn determines the techno-functional properties such as oil and water absorption capacity, pasting properties etc. This section deals with the composition of starch from different millets as studied by various researchers along with their techno-functional properties. Among all the millets produced in India, the largest share is occupied by pearl millet. Starch is the major component of the pearl millet grains, with its content varying from 53-64% and in some cultivars values as high as 70% are also reported by various researchers for Indian and foreign cultivars (Abdalla *et. al*., 2009; Singh & Popli, 1973; Jambunathan & Subramanian, 1988; Hoover *et. al*., 1996). The free, bound and total starch lipids ranged from 0.04 to 0.08%, 0.40 to 0.47% and 0.44 to 0.55%, respectively, while in some Indian cultivars, the fat content of isolated pearl millet starch was 0.19 to 0.23% (Beleia *et. al*., 1980; Bhupender *et. al*., 2013). Hoover *et. al*., (1996) with 0.12- 0.15% nitrogen and 0.02-0.03% ash. Not much variation has been reported for the ash content of starch from some Indian and African pearl millet cultivars with 0.11 to 0.12% and 0.10 to 0.13% ash content, respectively (Beleia *et. al*., 1980; Bhupender *et. al*., 2013).

Other millets include finger millet (*Eleusine coracana*), foxtail (*Setaria italica*), proso (*Panicum miliaceum*), little (*Panicum miliare)*, kodo (*Paspalum scrobiculatum)* and barnyard millet (*Echinochloa frumentacea)* which are consumed especially in the southern and northern hilly states of India, due to their abundance and low cost. However, there is difference in starch content. According to Wankhede *et al*. (1979), the starch content varied from starch 56.0 to 61.0% for Indian grown finger millet and foxtail millet grains. The starch yield of 63.4, 69.1, 70.4 and 93.7 % was obtained for finger, foxtail, pearl, and proso millet starches, respectively. In case of Canadian-grown species (Annor *et al*., 2014), They also reported 0.12% ash and 1.35% protein content in foxtail millet starch. Further, for starch isolated from three varieties of finger millet, ash and protein content were reported to be 0.08 -0.14% and 1.1 - 1.24%, respectively. The foxtail and finger millet starch had 0.78 to 1.32% total lipids (Wankhede *et al*., 1979).

Amylose content is an important constituent of starch determining various techno-functional properties such as paste viscosity, gelatinization temperature etc. So, as the content of amylose varies in a particular starch, its intended applications vary. In this context, it is vital to note that the amylose content of some Indian and foreign pearl millet varieties range from 18.3 to 24.6 % (Singh & Popli, 1973), 22 to 24% (Beleia *et. al*., 1980) and 21.9 to 28.8 % (Jambunathan &

Subramanian, 1988). While, lesser amylose content (17.5% and 15.8-16.2%) was observed for foxtail and finger millet starch when compared to peal millet starch. The similar pattern was observed for other millets as well with amylose content of 17.21, 18.08, 18.81, 19.61 and 20.02 % for Indian-grown proso, foxtail, little, kodo and barnyard millet starch, respectively (Wankhede *et al*., 1979; Kumari & Thayumanavan, 1998).

Characteristics of millet starches

Structure/granule morphology

The starch granules exhibit diverse morphology such as spherical, oval, polygonal, round which varies with the botanical origin. The millet starch granules are slightly smaller than the major cereal crops i.e. rice, wheat and corn. The pearl millet starch granules are round or polygonal with numerous indentations and pores on their surface. They are somewhat lesser in size than corn and sorghum starch granules (Freeman & Bocan, 1973) and the size has been reported by various authors for different varieties ranges from 8 to 12 µm (Badi *et. al*., 1976), 2-22 µm (Hoover *et. al*., 1996), 10-16 µm (Wankhede *et. al*., 1990) and 3–12 µm (Sharma *et al*., 2015). Pearl millet and foxtail millet starch have big size granules with maximum size of about 23 µm and peak size of 7.6 µm (Kumari & Thayumanavan, 1998). Finger millet starch granules have size ranging from 5 to 8 µ with some bigger size granules of about 8 - 15 µ and their shape varies from polygonal to round with absence of spherical granules. Further, Foxtail millet starch granules range from little oval (5-8 µ) to outsized 'polygonal' (8-25 µ). Proso and finger millet starch granules have a peak size of 5.7 µm. In case of kodo, barnyard, little and foxtail millet, the size is about 1.2–9.5, 1.2–10.0, 1.0–9.0 and 0.8–9.6 µm, respectively. Usually all the millets have small spherical starch granules except for kodo and finger millet, which exhibits large polygonal shaped starch granules (Wankhede *et. al*., 1979; Kumari & Thayumanavan, 1998; Annor *et al*. 2014; Kumari & Thayumanavan, 1998).

Swelling behaviour and pasting properties

The starch molecules absorb water due to hydrophilic nature and in turn the granules increase in size which is referred as swelling. When starch is heated in excess of water, the leaching of amylose will take place leading to viscous nature of the starch slurry. When compared to wheat, rice, yellow corn and sorghum; millets tend to form a pastier gruel in water owing to higher swelling factor and amylose leaching as observed for pearl millet starches from 50-95ºC (Hoover *et. al*., 1996; Abd Allah *et. al*., 1987). The gelation capacity of pearl millet starch is also reported to be higher and lesser syneresis (20.4 to 28.8%) from their gels stored at sub-zero temperatures than wheat (51%) and corn (65%) starch gels, which indicates their suitability for utilization in frozen products as they sustain water loss upon thawing.

The efficient applications of modified starches could be determined by studying the viscosity profile of starch-water solutions/dispersions upon application of certain time-temperature conditions using rapid visco analyzers. The pasting properties of pearl millet have been studied by some researchers (Beleia *et. al*., 1980; Wankhede *et. al*., 1990; Freeman & Bocan 1973; Hoover *et. al*. 1996). Badi *et. al*., (1976) observed lower (72ºC) pasting temperature of pearl millet starch. Beleia *et. al*., (1980) reported a pasting temperature of 76.5 ºC, while higher value of 90ºC has been reported by Hoover *et. al*., (1996) for pearl millet. In case of finger and foxtail millet starch nearly identical pasting temperature from 67.5 to 69˚C was observed (Wankhede *et al*., 1979).

According to Hoover *et. al*., (1996) an increase in viscosity was observed during the holding period at 95 ºC, contradicting the decreases in viscosity during the same period has been reported by others (Freeman & Bocan 1973; Beleia *et. al*., 1980; Wankhede *et. al*., 1990). Peak viscosity (PV) of starch samples of different pearl millet cultivars was observed in the range of 1665 to 1998 cP by Bhupender *et. al*., (2013).

According to Kumari & Thayumanavan (1998), barnyard millet had the highest cold paste viscosity (1165 BU) followed by kodo, little, foxtail and proso millets and differed significantly from other small millets. Setback viscosity of barnyard and kodo millets was higher than those of proso, foxtail and little millet. Different finger millet varieties; Purna, Indaf and Hamsa starch exhibited the setback to be 560, 530 and 440 BU, respectively. Further, a setback value of 460 BU was reported for foxtail millet starch.

Gelatinization temperature of starch

Starch absorbs water at room temperature, however, when the starch slurry is heated, it undergoes structural change by losing the crystalline structure resulting in an amorphous structure at gelatinization temperature. The swelling of granules caused at the gelatinization temperature is irreversible. This temperature varies with the source of starch and in turn influences their applications in food industry. Different millets also exhibit different gelatinization temperature and between cultivar differences are also observed in the millet starches. The gelatinization temperature of three cultivars (ICTP 8203, ICMH 356, and ICMS 7703) of pearl millet starch was in the range of 61.9-70.5 ºC, 60.9-67.5ºC and 64.5-78.0ºC, whereas in contrary to this, the gelatinization temperature of as high as 90.8ºC has also been reported (Abd Allah *et. al*., 1987; Hoover *et. al*., 1996). Considering gelatinization as a process with different phases owing to varied swelling and disruption of individual starch granules, the initiation/onset, mid and conclusion gelatinization temperatures for five cultivars of pearl millet have been reported as 60.8- 64.8, 67.1- 69.9 and 74.1- 78.0ºC, respectively (Bhupender *et. al*. 2013). In case of finger millet starches, the gelatinization began at 62 to 66°C while it continued till the final temperatures of 66.5 to 70˚C. The process of gelatinization begins a little earlier in case of foxtail millet starch with initial, interim and conclusion gelatinization temperatures of 55, 57.5 and 62º C, respectively (Wankhede *et al*., 1979). The gelatinization temperature increases with increasing the branch chain lengths of the amylopectin portion. Thus, from the lower gelatinization temperature values, it could be predicted that foxtail millet starch has lesser number of branched chain amylopectin fraction thereby fastening the process of gelatinization. Further, the higher conclusion temperature for pearl millet starch could be attributed to higher amount of amylose as similar effect has been found in certain rice cultivars (Juliano, 1979). There are literature reports on gelatinization temperature for barnyard, kodo, little, foxtail and proso millet to be 84.9, 82.8, 79.3, 78.8, and 75.8˚C, respectively. This variation in gelatinization temperature could be explained by its positive correlation with the amylose content in the respective millets as the highest amylose content is present in barnyard millet and it takes highest temperature to gelatinize. The higher amount of amylose is associated with more ordered structure which takes more severe treatment to disrupt the structure in order to facilitate water absorption and swelling of starch granules.

Glycemic index of millet starches

Usually, waxy starches such as waxy corn and tapioca are the preferred substrates for starch modification. However, the millet starches also contain a lesser amount of amylose and moreover, their starch is slowly digestible; making them suitable for utilization as a low glycemic ingredient or as resistant starch for diabetics and obese people and as a potential ingredient of low-calorie foods (Tharanathan, 2005).

CONCLUSION

Millet starches offer a wide range of possibilities for application in various food products owing to distinct characteristics. Each millet starch offers unique rheological properties, nutritional and structural attributes. Thus, their judicious use may help modify the processed products characteristics to a large extent.

REFERENCES

Abdalla AA, Ahmed UM, Ahmed AR, El Tinay AH, Ibrahim KA (2009) Physicochemical characterization of traditionally extracted pearl millet starch (Jir). J Appl Sci Res 5: 2016–2027

Annor GA, Marcone M, Bertoft E, Seetharaman K (2014) Physical and molecular characterization of millet starches. Cereal Chemistry 91: 286-292

Badi SM, Hoseney RC, Finney PL (1976) Pearl millet. II. Partial characterization of starch and use of millet flour in breadmaking. Cereal Chemistry 53: 718-722

Beleia A, Varriano-Marston E, Hoseney RC (1980) Characterization of starch from pearl millets. Cereal Chemistry 54 (12): 1096–1107

Bhupender SK, Rajneesh B, Baljeet SY (2013) Physicochemical, functional, thermal and pasting properties of starches isolated from pearl millet cultivars. International Food Research Journal 20 : 1555-1561

Freeman JE, Bocan BJ (1973) Pearl millet: A potential crop for wet milling. Cereal Science Today 18: 69

Hoover R, Swamidas G, Kok LS, Vasanthan T (1996) Composition and physicochemical properties of starch from pearl millet grains. Food Chemistry 56(4): 355- 367

ICRISAT (2022). International crops research institute for the semi-arid tropics. https://www.icrisat.org/mighty-millets-super-grains-of-power. Accessed on 20 March 2022.

Jambunathan R, Subramanian V (1988) Grain quality and utilization of sorghum and pearl millet. In Biotechnology in tropical crop improvement. Proceedings of the International Biotechnology Workshop, Patancheru, Inde, 12-15 Jan 1987. pp. 133-139. Patancheru, ICRISAT

Juliano, B (1979) The Chemical Basis of Rice Grain Quality. Proceedings of the Workshop on Chemical Aspects of Rice Grain Quality (International Rice Research Institute). 69-90.

Kumari SK, Thayumanavan B (1998) Characterization of starches of proso, foxtail, barnyard, kodo, and little millets. Plant Food for Human Nutrition 53: 47-56

Sharma M, Yadav DN, Singh AK and Tomar SK (2015) Rheological and functional properties of heat moisture treated pearl millet starch. Journal of Food Science and Technology 52: 6502–6510.

Singh R, Popli S (1973) Amylose content and amylolytic studies on high-yielding varieties of bajra (Pennisetum typhoides). Journal of Food Science and Technology 10: 31-33

Tharanathan RN (2005) Starch — Value Addition by Modification, Critical Reviews in Food Science and Nutrition 45 (5): 371-384

Wankhede DB, Shehnaz A, and Raghvendra MR (1979) Preparation and physiochemical properties of starches and their functions from finger millet (Eleusine coracana) and foxtail millet (Steria italica). Starch/Starke 31 (5): 153-159

Wankhede DB, Rathi SS, Gunjal BB, Patil HB, Waide SG, Rodge AB, Sawate AR (1990) Studies on isolation and characterization of starch from pearl millet (Pennisetum americanurn (L) Leeke) grains. Carbohydrate Polymers 13: 17-28.