Physicochemical and Pasting Properties of Pearl Millet Cultivars

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Abstract- *Physicochemical and pasting properties of four pearl millet cultivars varying in amylose content were studied. Following Pearl millet cultivars P 443, P 612, L 74 and ICTP 8203 were taken for study. Amylose content varied from 12.15 to 24.42 %. Pasting properties studied by Rapid visco analyzer viz, The peak viscosity of the pearl millet varieties ranged from 587 to 1011 mPa.s, setback from peak 427 to1120 mPa.s, break down viscosity 115 to 537 mPa.s, holding strength 169 to 709 mPa.s And final viscosity 854 to 1560 mPa.s.*

Keywords- Pearl millet starch, Amylose and Pasting properties.

I. INTRODUCTION

India is also the single largest producer of the pearl millet (*Pennisetumglaucum*) but most of itsproduction is diverted to non-food use. In recent years, these minor millets have gained importance becauseof raising awarenessof their nutritional strength in terms of dietary and functional requirement, and also due to reportedly significant lower glycemic index. Since they are underutilized there is a potential demand for food processing at nascent stage, presents encouraging prospects for value addition.The functionality of starch in millets is comparable to other cereals.Starch contributes greatly to the textural properties of various foods and has many industrial applications as a thickener, colloidal, stabilizer, gelling agent, bulking agent, water retention agent and adhesive. With increasing industrial demand for starches, there is a need to explore new and alternative sources of starch.

Gelatinization behavior and the pasting profiles of flour water and starch–water mixtures are commonly monitored using a Rapid ViscoAnalyser (RVA), which is a heating and cooling viscometer that measures the resistance of a sample to controlled shear. The RVA is considered to simulate food processing and is used to relate functionality to structural properties (Crosbie 1991). The viscosity increase to a maximum, followed by a decrease to a minimum value as the granules rupture (referred to as the breakdown). As the temperature is decreased, the viscosity again increases from the minimum to a final value, which is referred to as the setback. The peak time and peak viscosity are indicative of the water binding capacity of the starch and the ease with which the starch granules are disintegrated, whereas higher setback values are usually correlated with the amylose content of the starch. The RVA provides a convenient way of studying the effects of additives on rheology of starch systems (Tang & Copeland, 2007). The RVA parameters have been correlated with texture and product quality. For example, larger breakdown value is considered to be an indicator of better palatability of cooked rice. Viscometric analyses can detect differences in functional properties between starches and flours from different varieties or growth environments that may not be evident from conventional chemical analyses (Dang & Copeland, 2004)**.** During the holding period of the viscosity test, the material slurries are subjected to high temperature and mechanical shear stress which further disrupt starch granules in the grains, resulting in amylose leaching out and alignment. This period is commonly associated with a breakdown in viscosity. The ability of starches to withstand heating at high temperature and shear stress is an important factor in many processes. High values of Break down are associated with high peak viscosities which in turn, are related to the degree of swelling of the starch granules during heating. With a high swelling capacity result in a higher peak viscosity. The peak viscosity often correlates with quality of end product and also provides an indication of the viscous load likely to be encountered by a mixing cooker. During cooling, re-association between starch molecules, especially amylose, will result in the formation of a gel structure and, therefore, viscosity will increase to a final viscosity. This phase is commonly described as the setback region and is related to retrogradation and reordering of starch molecules. The low setback values indicate low rate of starch retrogradation and syneresis. Starches displayed pasting properties that featured decreasing peak, breakdown and final viscosities with increasing total amylose content. Swelling power of flour was found to be a useful predictive tool of amylose content and pasting characteristics of the starches.

Keeping in the view of applications of millets in food industry the present study was undertaken to study the functional and pasting properties of starch of various pearl millet cultivars varying in amylose content.

II. MATERIALS AND METHODS

Proximate composition: Pearl millet varieties (P 443, P 612), L 74 and ICTP 8203 were procured from IARI and National Seeds Corporation, respectively.Moisture content of flours was determined through gravimetric method in hot air oven at 100 ± 10°C for 24 h. (AOAC, 2000). Fat content was determined by employing solvent extraction using soxtec extraction unit (J.P. Selecta, Barcelona, España) using petroleum ether (60-80°C) at 120°C for 90 min boiling phase, followed by 60 min. rinsing phase and 10 min solvent recovery stage. Ash content was determined in muffle furnace at 550°C for 8 hours and cooling in dessicator until constant weight was attained. Protein content was determined through nitrogen estimation by using micro kjeldhal method (UKD, Welp, Italy). Nitrogen conversion factor was 5.6 for converting nitrogen to protein. Anthrone method of starch estimation was used to determine the total starch content in pearl millet varieties (Hodge and Hofreiter, 1962).

Pasting properties

The pasting properties of the starches were evaluated using starch pasting cell (C-ETD160/ST) on dynamic rheometer (MCR 52, Anton paar, Austria). Viscosity profile of starches from different finger millet and pearl millet varieties were recorded using starch suspension. A programmed heating and cooling cycle was used, where samples were to held at 50˚C for 1 min, heated to 95˚C at 0.1˚C/s, held at 95˚C for 5 min, before cooling from 95 to 50˚C (7.5 min.) and holding at 50˚C for 5 min. Constant stirring at 160 s^{-1} was done throughout the experiment. Parameters were calculated through Rheoplus software version 3.61 and included peak viscosity (mPa.s.), peak time (min.), peak temperature (°C), break down viscosity (mPa.s.), holding strength (mPa.s.), final viscosity (mPa.s.), set back from peak (mPa.s.) and set back from trough (mPa.s.).

III. RESULTS AND DISCUSSION

The proximate composition of the four pearl millet varieties investigated is presented in Table 1. The moisture contents of the pearl millet varieties ranged from 8.6-10.06%. Crude fat content in pearl millet varied from 1.11 to 3.505% while protein content was found to be within the range of 8.96-10.36%. The nutritive value of pearlmillet has been found to be superior to sorghum and maize based on their use in diets of rats (Deyoe& Robinson, 1979)**.** Pearl millet gave greatest weight gain in rats and had highest protein efficiency ratio compared to other millets. On protein quality scores, finger millet was ranked higher followed by pearlmillet, sorghum and maize (Deyoe& Robinson, 1979). Pearl millet is also significantly rich in resistant starch, soluble and insoluble dietary fibers, minerals, and antioxidants (Ragaee*et al.*, 2006). The major component of pearlmillet is starch which comprises 63.2% of total composition (Ali *et al.*,2003).

Table 1: Proximate Composition of Pearl millet Cultivars

Variety → Component ↓	P 612	L 74	P 443	ICTP 8203
Moisture (%)	8.61	9.32	10.06	9.95
Total Starch (%)	67.07	69.09	63.48	67.14
Crude fat	4.05	3.505	3.11	3.70
Protein	10.36	8.96	9.43	10.36
Ash (%)	2.46	2.54	2.12	2.08

The cooking behaviour of the pearlmillet flours is most efficiently determined by the rapid-viscoamylograph assay. This assay was simulated in the starch pasting cell of the rheometer (Anton paar, MCR 52). Fig. 1 presents the pasting behaviour parameters of the pearl millet flours. The different phases of the pasting profile correspond to the starch granules initially absorbing water and swelling, followed by a disruption of the granule structure under the shear force and leaching of the starch molecules (Tang & Copeland, 2007).These pasting parameters have been correlated with texture and product quality (Bason and Booth, 1994; Copeland *et al.*, 2009). The peak viscosity of the pearl millet varieties ranged from 587 to 1011 mPa.s, while the setback from peak ranged from -1336 to -808 Pa.s(Table 3). Wide variation could be seen from the temperature-viscosity curves for the four selected varieties.

Table 2: Amylose content of Pearlmillet varieties

Variety	Percentage Amylose
P 612	12.15
P 443	24.42
L 74	15.73
ICTP 8203	21.71

Table 3: Pasting properties of pearl millet varieties

Pasting parameters	P443	ICTP 8203	P 612	L 74
Peak viscosity (mPa.s)	587.40^{a}±19.86	1011.4^{d}±100.80	603.27^{a}±24.42	823.37^{c}±94.53
Peak time (min)	7.8717^{a}±0.04	8.0383^{a}±0.12	8.27^{c}±0.12	8.50^{d}±0.00
Peak temperature (°C)	73.5567^{d}±0.19	72.0367^{c}±3.38	71.12^{b}±0.80	70.6767^{a}±0.92
Breakdown viscosity (mPa.s)	165.7^{b}±3.21	301.6^{c}±32.74	115.00^{a}±15.23	537.73^{d}±7.31
Final viscosity (mPa.s)	854.7^{a}±39.50	1560.00^{d}±96.95	1075.67^{b}±25.15	1268.667^{c}±22.19
Set back from peak (mPa.s)	238.03^{c}±32.25	548.93^{a}±95.14	472.43^{b}±23.24	582.7^{a}±38.54
Holding strength (mPa.s)	421.667^{b}±20.67	709.633^{c}±68.50	488.23^{b}±9.60	169.00^{a}±8.70
Set back from trough (mPa.s)	427.175±11.29	850.57±28.94	587.40±19.20	1122.0±20.89

The pasting properties of different pearl millet cultivars measured using RVA are presented in Table 3**.** Starches from different cultivars displayed a significant variation in all their pasting parameters. The starch suspensions showed gradual increase in viscosity with increase in temperature. Amylose content of pearl millet cultivars were presented in Table 2.The increase in viscosity with temperature may be attributed to the removal of water from the exuded amylose by the granules as they swell.The time to attain the peak viscosity and pasting temperature were also significantly correlated to the amylose content. Though peak viscosity is an important parameter for study of the pasting properties, it was not found to be significantly affected by the amylose content. This is also in agreement to studies by Hermansson*et al.*, (1996)who stated that at lower amylose content, the structure of starch gel is easily disrupted by heating.Amylose suppresses swelling and maintains the integrity of swollen starch granules. Since starch swelling is mainly a property of amylopectin (Tester and Morrison 1990)**,** waxy starch swells rapidly and swollen granules degrade at lower temperature, indicating that waxy starch rapidly develops viscosity but cannot maintain the stability of paste viscosity. However Sasaki *et al.*,. (2000) reported a negative relationship between the amylose content of starch, the gelatinization temperature and peak viscosity. The peak time and peak viscosity are indicative of the water-binding capacity of the starch and the ease with which the starch granules are disintegrated. Dithal*et al.*, (2011) also suggested that peak viscosity might be affected more by the lipid content than by the apparent amylose content. The higher the lipid content associated with the amylose–lipid complexes (and the higher the amount of surface-associated lipid and protein) might reduce granule swelling and lower the peak viscosity to greater extents in smaller granules compared to larger granules (Dithal*et al.*, 2011)**.** Negative and statistically significant ($p< 0.05$) correlations were found between amylose and final viscosity (−0.45), peak viscosity (−0.32), trough height (−0.36) and setback (−0.32) as established by Cozzolino*et al.*, (2013) for barley cultivars.

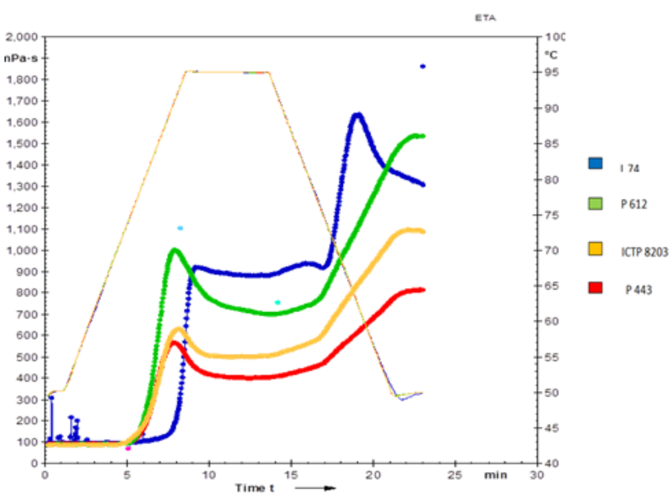

Fig. 1: Pasting profile of Pearlmillet varieties

IV. CONCLUSION

Study revealed variation in amylose content in pearl millet cultivars and little or non-significant variation in proximate composition. Pasting properties studied by Rapid visco analyzer viz**,** The peak viscosity of the pearl millet varieties ranged from 587 to 1011 mPa.s, setback from peak 427 to1120 mPa.s, break down viscosity 115 to 537 mPa.s, holding strength 169 to 709 mPa.sAnd final viscosity 854 to 1560 mPa.s. This information will help in production of novel food production in food industry.

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