Pasting Properties of Selected Rice Varieties from Several Provinces in Indonesia

S D Ardhiyanti1 and S D Indrasari2

1Indonesian Centre for Rice Research
2Assessment Institutes for Agricultural Technology of Yogyakarta

Email corresponding author: shinta.090886@gmail.com

Abstract. Pasting properties play an important role in determining the quality of cooked rice, or other related food products. These attributes of several rice varieties from North Sumatera, West Sumatera, South Sumatera, Banten, West Java, Central Java, Yogyakarta, East Java, and South Sulawesi were measured, using Brookfield viscometer DV-II+Pro. Popular brands are believed to leverage the potentials, in order to possibly predict customer’s preference. Pasting temperature, peak viscosity, viscosity after 10 minutes at 93.5°C, break down intensity, viscosity at 50°C, and degree of setback, were subsequently evaluated. The extent of breakdown and setback situations were instrumental in characterizing paste stability as well as the retrograde tendency, after cooling. Furthermore, Anak Daro (West Sumatera) demonstrated optimal paste stability, with very minimal breakdown value (231cP). This estimate was significantly lower, compared to most samples, with exception to Ceredek, IR 42 (West Sumatera), Jago Pelung, Pandan Wangi (West Java), Pandan Wangi (East Java), and Memberamo (South Sulawesi). Conversely, Berlian (East Java) showed the greatest retrograde tendency, with maximum setback value (3865 cP). However, the evaluation was more extensively, than other varieties, excluding Ramos Kembang, Ramos Walet (Banten), and C4 (Central Java).

Keywords: rice brands, pasting properties, Indonesia, provinces

1. Introduction
Rice is one of the predominantly consumed staple food among several Asian countries, including Indonesia. Majority of the samples in the country’s markets occur as the “Indica type”, although, other brands exist, but are barely visible, as most are often mixed and labelled differently. Indonesian Centre for Rice Research (ICRR) recently released hundreds of newly improved varieties, with separate characteristics and superiorities, focused on increasing productivity, strengthening plant resistance to pests and diseases, in addition to grain quality enhancement. As a primary objective, the new products are expected to demonstrate sufficient adaptability and widespread acceptance by farmers and consumers.

Pasting properties are important features to consider during the assessment of starch applications in food industry. These attributes are equally predominant parameters in describing cooked rice quality [1], including pasting temperature, peak viscosity, breakdown value, final viscosity, and setback estimate. Higher breakdown rate was perceived as valuable eating quality in Japanese rice market [2]. Several Indonesia’s provinces exhibit varying consumer characteristics and preference. Therefore, the
need to ascertain eating quality appears as an alternative in accessing customer’s choice. Furthermore, identifying pasting properties of popular high-value rice varieties are probably employed for adaptation trials, in an attempt to breed superior products [3].

Food preference is significantly influenced by social and environmental factors, often referred as primary food choice motivators [4]. The purpose of this research, therefore, is to determine pasting properties of several rice brands from North Sumatera, West Sumatera, South Sumatera, Banten, West Java, Central Java, Yogyakarta, East Java, and South Sulawesi. Subsequent analytical data are expected to describe cooking and eating quality of rice, in order to predict consumer preference. This information finds useful application in further developing the newly improved varieties, particularly relevant to consumer choices.

2. Materials and Methods

2.1 Materials
Several rice brands from North Sumatera (Kuku Balam, Ramos, Si Udang Manis, Lucky Flower), West Sumatera (Anak Daro, Cisokan, Ceredek, IR 42), South Sumatera (Cap Dewi, Ikan Belido, Topi Koki, Selancar), Banten (Bedug Banten, Menara Banten, Ramos Kembang, Ramos Walet), West Java (IR, Jago Pelung, Jembar, Pandan Wangi), Central Java (Memberamo, C4, IR, Mentik Wangi), Yogyakarta (C4, Ikan Mas, Rojolele, Mentik Wangi), East Java (Pandan Wangi, Mentari, IR 64, Berlian), South Sulawesi (Ayam Jago, Bogor, Cisantana, Membramo), and Ciherang, which is the most adopted and newly improved variety, (VUB) used as control, were involved in this study. The species were obtained from local markets in separate provinces, in the form of milled rice. In addition, the control was acquired from ICRR’s Sukamandi experimental field.

2.2 Methods
The samples and control were finely grounded into powder, using laboratory electrical mill. Rice flour pasting properties were determined with the aid of Brookfield Viscometer DV-II+Pro, and the aqueous suspension (1 g of rice flour and 10 ml of water) was subsequently introduced into the Brookfield vessel. The content was then heated from 50 to 93°C, at a rate of 3°C/minute, followed by a pause at 93°C for 10 minutes, to allow for further cooling to 50°C. Also, the viscosities during heating and cooling were recorded in centipoise (cP). Pasting temperature, peak viscosity, viscosity after 10 minutes at 93.5°C, breakdown intensity, viscosity at 50°C, and the degree of setback were known parameters measured in a single attempt. However, the difference between sample properties were determined, using standard deviation.

3. Result and Discussion
Table 1 and Figure 1 illustrates the sample’s pasting properties from individual province. The pasting temperature is commonly related to starch gelatinization temperature, but was unable to reflect the real value [1]. This indicated the minimum heat required to cook the flour [5]. According to [6], RVA pasting temperature of the starch was significant higher, compared to DSC onset temperature (To), where the crystalline melting occurring usually above viscosity, tends to increase. Furthermore, samples’ pasting temperature ranged between 63°C (Ikan Mas-DIY) - 79°C (Anak Daro-West Sumatera, Si Udang Manis-North Sumatera, C4-Central Java, and Pandan Wangi-East Java). Higher amylose starch demonstrated substantial value [6][7], although, Anak Daro, classified as high amylose content rice, exhibited the ultimate pasting temperature. Meanwhile, other superior amylose variety from West Sumatera, occurred between 72-77°C.

The size of starch granules was observed within 3 - 8 μm, in form of polygonal, irregular, and angular-shaped. However, certain types existed individually, while others were fused compound materials [8][9]. Furthermore, variation in cultivar significantly influenced pasting properties of rice starch, although, higher amylopectin varieties showed extensive swelling power (SP) [8].

Peak viscosity revealed the water binding capacity of starch granules [9], known to vary from 2464 cP (IR-West Java) – 4422 cP (Mentik Wangi-Yogyakarta). Similar range was reported for Nigerian rice flour, occurring between 2376.0 - 3988.5 cP [10]. Majority of the samples ranged from 3000 – 4000 cP.
in peak viscosity, with exception to barely two varieties from Yogyakarta, obtained above 4000 cP and seven (3 West Java, 1 South Sulawesi, 1 East Java, 1 West Sumatera, and 1 Yogyakarta) existed below 3000 cP. In contrast to the research of [11][12][13], where higher peak viscosity values in lower amylose and vice versa were observed, this research did not record any correlation between amylose and peak viscosity (coefficient of correlation -0.0128). However, the deficient outcome was also reported by [6].

Table 1. Pasting properties of rice samples*

| Provinces | Varieties     | Amylose (%)* | Pasting Temp. (°C) | Peak Viscosity (cP) | Trough Viscosity (cP) | Final Viscosity (cP) | Break Down (cP)** | Setback (cP)*** |
|-----------|---------------|--------------|-------------------|---------------------|----------------------|---------------------|------------------|----------------|
| North Sumatera | Control      | 21.3         | 78b               | 3008b               | 1408b               | 4045b               | 1600b            | 2637b          |
|            | Kuku Balam   | 19.8         | 78b               | 3096b               | 1421b               | 4346b               | 1677b            | 2925b          |
|            | Ramos        | 22.9         | 74b               | 3014b               | 1613b               | 4294b               | 1401b            | 2681b          |
|            | Si Udang Manis | 18.3         | 79b               | 3206b               | 1421b               | 4307b               | 1785b            | 2886b          |
|            | Lucky Flower | 20.4         | 75b               | 3699b               | 1830b               | 5101b               | 1869b            | 3271b          |
| West Sumatera | Anak Daro    | 26.1         | 79b               | 3149b               | 2918b               | 6042b               | 231b             | 3124b          |
|            | Cisokan      | 26.3         | 77b               | 2893b               | 1619b               | 3872b               | 1274b            | 2253b          |
|            | Ceredek      | 26.7         | 77b               | 3149b               | 2189b               | 5376b               | 960a             | 3187b          |
|            | IR 42        | 26.9         | 72b               | 3667b               | 2938b               | 5901c               | 729a             | 2963b          |
| South Sumatera | Cap Dewi    | 20.2         | 77b               | 3744b               | 1798b               | 4998b               | 1946b            | 3200b          |
|            | Ikan Belido  | 23.5         | 77b               | 3469b               | 1882b               | 4877b               | 1587b            | 2995b          |
|            | Topi Koki    | 19.4         | 77b               | 3360b               | 1574b               | 4474b               | 1786b            | 2900b          |
|            | Selancar     | 20.0         | 78b               | 3590b               | 1990b               | 5286b               | 1600b            | 3296b          |
| Banten     | Bedug Banten | 19.3         | 70a               | 3699b               | 1562b               | 4570b               | 2137b            | 3008b          |
|            | Menara Banten| 20.0         | 69b               | 3213b               | 1267b               | 3558b               | 1946b            | 2921b          |
|            | Ramos Kembang| 19.5         | 77b               | 3661b               | 1952b               | 5555c               | 1709b            | 3635b          |
|            | Ramos Walet  | 17.6         | 75b               | 3680b               | 1888b               | 5523c               | 1792b            | 3635b          |
| West Java | IR           | 18.3         | 74b               | 2464c               | 1050b               | 3104c               | 1414b            | 2054b          |
|            | Jago Pelung  | 20.1         | 77b               | 2522a               | 1395b               | 4038b               | 1127a            | 2643b          |
|            | Jembrar      | 20.3         | 75b               | 3264b               | 1677b               | 5056b               | 1587b            | 3379b          |
|            | Pandan Wangi | 18.4         | 73b               | 2669a               | 1715b               | 4499b               | 95a              | 2784b          |
| Central Java | Memberamo   | 18.2         | 76b               | 3571b               | 1267b               | 3898b               | 2304c            | 2631b          |
|            | C4           | 22.3         | 79b               | 3443b               | 1517b               | 5088b               | 1926b            | 3571b          |
|            | IR           | 21.9         | 75b               | 3424b               | 1139b               | 3885b               | 228b             | 2746b          |
|            | Mentang kawi | 22.6         | 76b               | 3603b               | 1581b               | 4346b               | 2022b            | 2765b          |
| Yogyakarta | C4           | 22.4         | 68b               | 3616b               | 1011b               | 3136a               | 2605c            | 2125b          |
|            | Ikan Mas     | 21.5         | 63b               | 4301c               | 1152b               | 2976c               | 3149c            | 1824b          |
|            | Rojolele     | 19.6         | 67a               | 2970c               | 973c                | 2816c               | 1997b            | 1843a          |
|            | Mentang Wangi| 18.2         | 71b               | 4422c               | 2042b               | 5357b               | 2380c            | 3315b          |
| East Java | Pandan Wangi | 18.4         | 79b               | 2880a               | 1715b               | 4915b               | 1165a            | 3200b          |
|            | Mentari      | 20.2         | 74b               | 3776b               | 1978b               | 5344b               | 1798b            | 3366b          |
|            | IR 64        | 20.9         | 75b               | 3462b               | 1555b               | 4870b               | 1907b            | 3315b          |
|            | Berlian      | 20.7         | 78b               | 3885c               | 2010b               | 5875c               | 1875b            | 3865b          |
| South Sulawesi | Ayam Jago  | 22.4         | 74b               | 3725b               | 1382b               | 4544b               | 2343c            | 3162b          |
|            | Bogor        | 20.2         | 75b               | 3610b               | 1402b               | 4467b               | 2208b            | 3065b          |
|            | Cisantana    | 20.2         | 77b               | 3168b               | 1146b               | 3674a               | 2022b            | 2528b          |
|            | Membrano     | 20.7         | 76b               | 2810a               | 1651b               | 4742b               | 1159a            | 1511a          |

* Values with different superscript varied significantly
** [14][15]

Mean ±SD: 75±4 3375±439 1639±441 456±835 1737±533 2880±54
A swift reduction in viscosity to a minimum value (trough viscosity), due to starch granule disintegration and lesser glucan polymers leaching, e.g. amylose, was observed after peak viscosity was achieved. These occurrences were as a result of high temperature and shear force. Breakdown value, known to describe the susceptibility of gelatinized starch to disintegrate, was the disparity between peak and trough viscosities [9][12][16]. In addition, the value varied from 231 cP (Anak Daro-West Sumatera) – 4422 cP (Ikan Mas-Yogyakarta). Majority of the high amylose rice from West Sumatera acquired lower breakdown value, while extensive estimate was reported for most Yogyakarta rice. However, starch with lower amylose content appeared more susceptible to disintegration, using heat and shear force, compared to higher substitutes, as a result of substantial swelling power [12][13]. Furthermore, both Ikan Mas and Mentik Wangi from Yogyakarta exhibited optimal swelling power and sufficient breakdown, respectively.

Under the condition of decreased paste temperature, the viscosity was also known to gradually increase to form additional rigid gel, until final viscosity was attained at 50°C, within the ranged of 2816 cP (Rojolele-Yogyakarta) – 6042 cP (Anak Daro-West Sumatera). This growing paste viscosity, caused by the re-combination of starch polymer, is known as retrogradation or setback [17], and is possibly evaluated as the difference between final and trough viscosities. In essence, high-amylose starch tends to precipitate more easily, compared to high-amylopectin grade [9], resulting to larger final viscosity [18]. Conversely, superior amylose rice from West Sumatera (Anak Daro) demonstrated maximum final viscosity (6042 cP), while Rojolele from Yogyakarta recorded the most minimal viscosity (2816 cP). Moreover, the setback value ranged from 1511 cP (Membramo-South Sulawesi) - 3865 cP (Berlian-East Java).

Rice grain potentially encounters certain changes in physical and chemical properties during storage, particularly in texture and flavor. This ageing process tends to also decrease the breakdown value and peak viscosity, as stored starch granules were more resistant to swelling and dissociation on applying heat, compared to fresh rice [2]. In contrast, the pasting temperature showed an increase [10][13]. Moreover, the changes were attributed to starch molecule rearrangement during ageing, in a bid to form a more organized structure [2]. In this research, rice was acquired from the local market in separate
provinces, and therefore, no information on harvest date was obtainable. Insignificant correlation coefficient of peak viscosity (-0.0128), breakdown value (-0.0128), final viscosity (-0.3733), and setback estimate (-0.0535) with amylose, were caused by varying storage duration of each rice variety and probably by extensive sample sizes [3]. In addition to amylose content, surface lipids and proteins, endogenous enzyme presence [10][13], and distinct starch interaction, with the associated compound are potential influencing factors of pasting properties [9].

Cooking quality of rice samples was described by pasting temperature, peak viscosity and breakdown value. Yogyakarta variety (Ikan Mas, Rojolele, C4) required less energy to prepare. Moreover, along with Mentik Wangi (Yogyakarta), Ikan Mas also exhibited higher water absorption during cooking, while most of West Java’s rice attracted less water, compared to other samples. Particular rice species with insufficient amylose content than West Sumatera rice, recorded minimal peak viscosity, due to the ageing process.

The eating quality of rice samples was described by breakdown value, trough and final viscosities, as well as setback estimate. Rice with lesser breakdown value, including most West Sumatera rice, showed superior stability during cooking, and normally produced firmer texture, characterized by higher trough value. Also, greater final viscosity, known to contribute to the prevailing hard texture, was observed. Furthermore, rice with extensive breakdown value, e.g. most Yogyakarta variety, commonly exhibited tender texture. This particular category also reported minimal setback value and final viscosity, indicating the ability to preserve the tenderness. Despite medium amylose content, certain rice brands from other provinces, showed higher retrograde tendency, compared to West Sumatera. However, West Sumatera (Anak Daro and IR 42) demonstrated the hardest texture after cooling.

4. Conclusion
Pasting properties of rice brands from several Indonesia’s province described distinct cooking and eating qualities. Selected West Sumatera varieties were classified as high amylose content rice, with the most minimal breakdown value, but optimal trough and final viscosities. The species from other regions were categorized as low and intermediate amylose rice. However, the extent of storage probably influenced these attributes, in addition to other intrinsic factors. Further studies in chemical composition impactful on cooking and eating qualities, are necessary in supporting the newly advanced variety development program.

References

[1] Jin-song BAO 2008 Rice Sci. 15 69–72
[2] Zhou Z, Robards K, Helliwell S and Blanchard C 2003 Food Res. Int. 36 625–634
[3] Pang Y, Ali J, Wang X, Franje NJ, RevillezEA, Xu J and Li Z 2016 PLoS One 11 1–14
[4] Committee on Examination of the Adequacy of Food Resources and SNAP Alotments; Food and Nutrition Board; Committee on National Statistics; Institute of Medicine; National Research Council,. Individual, Household, and Environmental Factors Affecting Food Choices and Access. 2013.
[5] Kaur H, Gill BS and Karwasra BL 2018 Int. J. Food Prop. 21 70–85
[6] Jang EH, Lee SJ, Hong JY, Chung HJ, Lee YT, Kang BS and Lim ST 2016 LWT - Food Sci. Technol. 66 530–537
[7] Sholehah JM, Restanto DP, Kim KM and Handoyo T 2020 J. Crop Sci. Biotechnol. 23 171–180
[8] Ashogbon AO and Akintayo ET 2012 Int. Food Res. J. 19 665–671
[9] Ashogbon AO and Akintayo ET 2013 Int. J. Biotechnol. Food Sci. 1 72–83
[10] Falade KO and Christopher 2015 AS Food Hydrocoll. 44 478–490.
[11] Li Y, Shoemaker CF, Moon JMKJ and Zhong F 2008 Food Chem. 106 1105–1112
[12] Bhat FM and Riir CS 2019 Food Chem. 297 124984
[13] Li C, Hu Y, Huang T, Gong B and Yu WW 2020 Int. J. Biol. Macromol. 164 2717–2725
[14] Indrasari SD, Kusbiantoro B, Setyono A, Junali, Wibowo P, Mardiah Z, Rakhmi AT, Suhartini, Ardhiyanti SD and Arofah D 2010 Laporan Pemetaan Preferensi Konsumen Beras Berdasarkan Kepulenan dan Komposisi Aroma untuk Menunjang Perakitan Varietas Padi.
Sesuai Selera Konsumen di Empat Provinsi (Subang: BB Padi)  
[15] Indrasari SD, Kusbiantoro B, Jumali, Wibowo P, Mardiah Z, Rakhmi AT, Suhartini, Ardhiyanti SD and Arofah D 2011 Pemetaan Preferensi Konsumen Beras Berdasarkan Kepulenan dan Komposisi Aroma Untuk Menunjang Perakitan Varietas Padi Sesuai Selera Konsumen di Propinsi Sumatera Barat dan Kalimantan Barat (Sukamandi: BB Padi)

[16] Mitchell CR 2009 Rice starch production and properties on Starch Chemistry and Technology 3rd Edition (New York: Academic Press) p 879.

[17] Belitz HD, Grosch W and Schieberle P 2009 Food Chemistry 4th Revised and Extended Edition (Berlin: Springer-Verlag)

[18] Nikitha M and Natarajan V 2020 J. Food Sci. Technol. 57 4065–4075