Grain Quality of Wheat Genotype Dewata Grown Under Wet Tropical Climate of Indonesia

Muhammad Ikhsan Sulaiman [*,1], Irman Syahroni [1], Rita Andini [2], and Lukman Hakim [3]

[1]Department of Agricultural Products Technology, Syiah Kuala University, Jl. T. Hasan Krueng Kalee, Kopelma Darussalam, Banda Aceh, Indonesia

[2]Department of Forestry, Syiah Kuala University

[3]Department of Plant Protection, Syiah Kuala University

Email: ikhsan.sulaiman@unsyiah.ac.id[*]

Abstract

Along with prosperity improvement of countries in the tropic, the consumption of wheat-based products such as breads, cakes, noodles and cookies has increasing tendency in the recent years. Wheat that is grown usually in the sub-tropic has been investigated intensively for trial cultivation in tropical region. Successful cultivation of wheat in the tropic has been reported but the information on its quality was still very few. This paper reported the quality of wheat grown in the field experiment at 5 different provinces of Indonesia at an altitude ranged from 1000 up to 1650 meter above sea level. Two samples of wheat from each location were taken and analyzed the physical, chemical, pasting and dough properties. The quality of wheat genotype Dewata was varied depending on the planting location. Out of five planting locations, only Jawa Tengah could produce good quality of wheat. Meanwhile, the wheat from other locations were characterized by weak in pasting and dough properties. Wheat with weak pasting and dough properties could not be used for bread and noodles' production. However, they were still suitable to produce cookies and cake.

Keywords: *Dewata genotype, dough, paste, quality, wet tropic, wheat*

1. INTRODUCTION

Wheat, rice and maize are three largest staple foods in the world. Wheat is traditionally cultivated in the temperate cool region, while rice and maize in the warm humid climate in the tropic (Saunders 1987). Introduction of wheat to the tropical area could not be separated from the influence of people migration, trading and colonialism. Cakes and breads was brought from Europe, noodles from China, chapatti from India, pasta from Latin America and Africa, and tortilla from Mexico (Fellers 1979). Thenceforth, the consumption of wheat based food has been becoming popular cuisine. Along with prosperity improvement of countries in the tropic, the consumption of wheat-based products such as breads, cakes, noodles and cookies has been increasing rapidly. Indonesia has become the second largest wheat importer in the world (USDA 2018) through the popularity of instant noodle consumption.

In order to increase world production of wheat, researchers initiated by the International Maize and Wheat Improvement Center (CIMMYT) are investigating to expand the cultivation of wheat to the cool highland area in the tropic with a potential area of about 3 – 4 million hectares (Mann, 1984). In association with that, the research on wheat cultivation became more intensive. Ten high yield genotypes of wheat have been released by the Indonesian Government since 1993 (Talanca & Andayani 2015). The challenge came from the high temperature and humidity in relation with the combination of stress, pests and diseases. Heat stress has been reported on the wheat cultivated in Indonesia (Altuhaish et al. 2014). Widyawati, (2013) reported that the population densities dan media composition had affected the agronomic characteristics of Dewata variety of wheat growth in polybags in greenhouse.

Only few publications reported the grain quality of Indonesian wheat. Although the grain quality of three Indonesian wheats including Dewata has been reported (Murtini, Susanto, & Kusumawardani, 2000), there is still no report of the grain quality from large field experiment. This study reported the quality of grain wheat from field experiment in five provinces of Indonesia.

2. MATERIAL AND METHOD

2.1 Materials

Wheat genotype Dewata used in this experiment was originated from Indian's DWR 162 cultivar which was introduced in Indonesia for the first time in 2004. The wheat was grown in an area of at least 1 hectare in five different locations in Indonesia (

Table 1) at an altitude ranged from 1000 up to 1650 meter above sea level. Five kilograms of wheat from each location was sampled, husked and grounded pass the 100-mesh sieve before laboratory analysis.

Table 1. Location of field experiment

Village	Sub-District	District	Province	Altitude (m)
Sumber Brantas	Bumi Aji	Batu	Jawa Timur	1650
Sibebek	Wonoyoso	Banjar negara	Jawa Tengah	1616
Sindang laya	Cipanas	Cianjur	Jawa Barat	1170
Talang Lahat	Sindang Kelingi	Rejang Lebong	Bengku lu	1100
Ujung Bulu	Rumbia	Janepon to	Sulawesi Selatan	1000

2.2 Analytical Parameters

Physical, chemical, pasting and dough properties of wheat were investigated namely thousand grain weight (TGW), grain length and diameter, crude protein, crude fat, starch, wet gluten and ash content. Pasting properties of wheat was analysed using Brabender Micro-Visco Amylograph and it was presented as pasting temperature, maximum viscosity, peak temperature, breakdown and setback. Brabender Farinograph was employed to investigate dough quality consisted of water absorption (WA), dough development time (DDT), dough stability (DS), mixing tolerance index (MTI) and farinograph quality number (FQN). All parameters were analysed according to the standard method of the International Association for Cereal Science and Technology (ICC) with two replication each sample with an exception of analysis using Brabender Farinograph that was done without replication.

2.3 Statistical Analysis

Data was presented as average of the two-analysis replication. All data with an exception of farinograph test was analysed using generalized linear model procedure of virtual application of SAS University Edition in accordance to the completely randomize design with location as a single factor. Least square different post-hoc test was used to see the different when the effect of location was statistically significant.

3. RESULTS AND DISCUSSION

3.1 Physical Properties

Table 2 shows the physical properties of the wheat genotype Dewata grown in five provinces of Indonesia. The higher the altitude was the bigger the grain as indicated by the TGW. The effect of location was significant on grain size particularly the grain diameter and TGW. The biggest grain size was from the wheat grown in Jawa Timur, while the smallest was from Sulawesi Selatan. Large variation of grain size from various locations was found. The variations came mostly from the diameter and not from the length of the grain. The grain size is important in the milling process because it determines the milling yield (Marshall, Ellison, & Mares 1984).

The grain size from this experiment was slightly smaller compared to the grain of Dewata from Balitkabi (Indonesian Research Institute for legume and tuber plants) (Murtini, Susanto, & Kusumawardani 2005). The variation of grain size could be originated from different management practice by the growers (Gegas *et al.* 2010) and environmental factors (Lukow *et al.* 2013).

Table 2. Physical seed performance of Dewata grown in different provinces of Indonesia

Province	Diameter (mm)	Length (mm)	TGW (g)
Jawa Timur	3.77 [a]	6.62	41.0 [a]
Jawa Tengah	3.37 [b]	6.40	35.2 [c]
Jawa Barat	3.51 [ab]	6.48	38.6 [b]
Bengkulu	2.88 [c]	6.36	28.0 [d]
Sulawesi Selatan	3.55 [ab]	6.39	13.7 [d]
Variations (%)	9.7	1.6	35.1

Different alphabet in a column indicated a significant different at P < 0.01 or at P < 0.05.

3.2 Chemical Properties

Chemical properties of Dewata from different locations of Indonesia are presented in Table 3. Effect of location was significant in the chemical characteristic of wheat. The biggest variation was found in the gluten content followed by fat, starch, protein and ash.

Wheat grown in Bengkulu contained the highest protein and gluten but the lowest in fat, starch and ash content. In contrast, wheat from Jawa Tengah that was low in protein and gluten but they contained high fat, starch and ash. This result was supported by (Hucl & Chibbar 1995).

Protein is key quality parameter of wheat flour (Dowell et al. 1999). Protein has been used in the classification of wheat. Protein content of Dewata was classified as hard wheat because of its high protein content of above 10 g/100g. Protein content is related to many processing properties such as water absorption and gluten strength and attribute of wheat based product such as texture and appearance. Application of nitrogen during plant growth might improve protein content in wheat.

Protein is related to gluten content because gluten is the main protein in the wheat grain. Gluten is responsible for the elasticity and extensibility characteristics of flour dough. Wet gluten content of the wheat from this experiment ranged from 21.30 to 39.94 g/100g with a variation of 23.28%.

Ash content has been used in the classification of wheat flour in Germany. It indicates the milling grad. Ash represents minerals content that is concentrated more in the aleurone or outer layer of wheat grain. The higher ash content is the darker the flour colour.

Starch is the major component in grain cereals. Starch provides the supporting structure of bread. Quality of starch determines the pasting properties of wheat flour (Noda et al. 2003). Starch content of Dewata in this experiment ranged from 56.04 to 71.11 g/100g with a variation of 9.93%. Low content of starch and smaller grain size of Dewata could be caused by environmental stress during grain filling period such as drought and nutrient deficiency.

3.3 Pasting Properties

Pasting properties indicates the starch quality. Maximum viscosity presents the ability of granular of starch to swelling and absorbing water. Swelling granular leads to increase of pasting viscosity. During heating, the paste viscosity will be decreased due to alignment of amylopectin structure followed by the release of amylose. Setback is the occurrence of increasing viscosity after heating because of realignment of amylose and amylopectin structures.

The effect of location was significant on the pasting properties of Dewata (Table 4). It was found that only wheat from Jawa Tengah had good pasting properties. Meanwhile, wheat from other locations presented low value of maximum viscosity and set back. Low maximum viscosity indicated less ability of starch to absorb water. Poor pasting properties associated with high activity of alpha amylose (Noda et al. 2003). High amylose activity could be found in sprouting, starch damage (Every et al. 2002) and Fusarium infected grain (Wang et al. 2008). These results highlighted the importance of pasting properties investigation rather than only the starch content as the quality parameter of wheat grain.

3.4 Dough Properties

Dough properties of Dewata grown in Indonesia are summarized in Table 5. It is presented as farinograph parameters consisted of water absorption, dough development time, dough stability, mixing tolerance index and farinograph quality number. These parameters figure out the quality of gluten in wheat grain. Strong gluten representing good quality of wheat should have high DS, low MTI and high FQN.

WA is defined as the amount of water required by the wheat flour to reach the farinograph curve on the 500-Brabender Unit (BU) line. It figures out the optimal amount of water to make quality dough. The WA value of Dewata was ranged from 62.1 to 72.3 percent. Grain from Jawa Timur and Bengkulu had the highest and the lowest WA, respectively. The WA value related to the content of protein and gluten (Table 3). The relation between protein and gluten with water absorption was also found by Lei et al. (2008).

DDT is the required time for the farinograph curve to reach the 500 BU line while mixing wheat flour with water. It shows the time to reach greatest torque of the dough. The lowest and the highest DDT was found on wheat from Jawa Barat and Jawa Timur, respectively. There was no clear association between DDT with the chemical properties of wheat.

DS is the required time for the farinograph curve staying on the 500 BU line. DS indicates the quality of gluten to keep maximum torque. It associates with the sulphur bound in the structure formation of gluten. High value of DS represents strong gluten and good quality of wheat for producing maximum volume of bread or various wheat-based products. The DS of the wheat varied between 2.0 and 5.3 minutes. The DS of wheat from Jawa Tengah was much higher compared to the wheat from other location. Low DS might be an indication of damage structure of gluten. Protease activity from Fusarium infestations could impair the gluten quality (Wang et al. 2005) that is responsible to the low dough stability in the farinograph test. Furthermore, the quality of gluten was also affected by complex factors in the environment (Uhlen et al. 2015).

MTI indicates the degree of softening during mixing that was measured the difference in BU between the top of curve at peak and after 12 minutes Farinograph testing. Dewata was found to have high MTI value that was varied from 102 – 230 BU. It was much higher than 30 BU, the MTI value for good quality hard wheat flour. High MTI value indicates sticky consistency of dough. It can lead to difficulties in mechanical handling and formation of dough during processing. This result indicated that the wheat from Jawa Tengah had better dough characteristics than the one from other locations.

FQN was the distance from mixing start until the middle of the descending curve crossing this lower line. The higher the FQN is the better the quality of wheat. In respect to the FQN, the best dough quality of Dewata in order from the best to the worst was from Jawa Tengah, Sulawesi Selatan, Jawa Timur, Jawa Barat and Bengkulu.

CONCLUSIONS

Dewata wheat genotype can grow in the high altitude of Indonesian under tropical wet climate of Indonesia. The effect of location on the quality of grain wheat was significant. Out of five planting location, only wheat grown in Jawa Tengah had a good pasting and dough properties. The wheat from other provinces characterized by weak in pasting and dough properties. Wheat with weak pasting and dough properties could not be used for bread and noodle production, however they are still suitable for making cookies and cake.

ACKNOWLEDGEMENT

Acknowledgement is addressed to Indonesian Institute of Science (LIPI) for provision of sample and Prof. E. Pawelzik and staff from the Quality of Plant Products Division of Department of Crop Science, University of Goettingen for sample analysis.

REFERENCES

Altuhaish, A. A. K., Miftahudin, Trikoesoemaningtyas, & Yahya, S. (2014). Field Adaptation of Some Introduced Wheat (Triticum aestivum L .) Genotypes in Two Altitudes of Tropical Agro-Ecosystem Environment of Indonesia. HAYATI Journal of Biosciences, 21(1), 31–38. https://doi.org/10.4308/hjb.21.1.31

Dowell, F. E., Maghirang, E. B., Pierce, R. O., Lookhart, G. L., Bean, S. R., Xie, F., … Chung, O. K. (2008). Relationship of bread quality to kernel, flour, and dough properties. Cereal Chemistry, 85(1), 82–91. https://doi.org/10.1094/CCHEM-85-1-0082

Every, D., Simmons, L., Al-hakkak, J., Hawkins, S., & Ross, M. (2002). Amylase , falling number , polysaccharide , protein and ash relationships in wheat millstreams. 135–142.

Fellers, D. A. (1979). Wheat and Wheat Foods in the Tropics. In G. E. Inglett & G. Charalambous (Eds.), Tropical Foods: Chemistry and Nutrition (pp. 575–597). Honolulu: Academic Press.

Gegas, V. C., Nazari, A., Griffiths, S., Simmonds, J., Fish, L., Orford, S., … Snape, J. W. (2010). A Genetic Framework for Grain Size and Shape Variation in Wheat. The Plant Cell, 22(April), 1046–1056. https://doi.org/10.1105/tpc.110.074153

Hucl, P., & Chibbar, R. N. (1995). Variation for Starch Concentration in Spring Wheat and Its Repeatability Relative to Protein Concentration. Cereal Chemistry, 73(6), 756–758.

Lei, F. U., Ji-chun, T., Cai-ling, S. U. N., & Chun, L. I. (2008). RVA and Farinograph Properties Study on Blends of Resistant Starch and Wheat Flour. Agricultural Sciences in China, 7(7), 812–822.

Lukow, O. M., Adams, K., Suchy, J., Depauw, R. M., & Humphreys, G. (2013). The effect of the environment on the grain colour and quality of commercially grown Canada hard white spring wheat, Triticum aestivum L. "Snowbird." Canadian Journal of Plant Science, (93), 1–11. https://doi.org/10.4141/CJPS2012-102

Mann, C. E. (1984). Selecting and Introducing Wheats for the Environments of the Tropics. In R. L. Villareal & A. R. Klatt (Eds.), Wheats for More Tropical Environments (p. 24). Mexico: CIMMYT.

Marshall, D. R., Ellison, F. W., & Mares, D. J. (1984). Effects of grain shape and size on milling yields in wheat. Theoretical analysis based on simple geometric models. Australian Journal of Agricultural Research, (35), 619–630. https://doi.org/10.1071/AR9840619

Murtini, E. S., Susanto, T., & Kusumawardani, R. (2000). Karakterisasi Sifat Fisik, Kimia dan Fungsional Tepung Gandum Lokal Varietas Selayar, Nias dan Dewata. Jurnal Teknologi Pertanian, 6(1), 57–65.

Murtini, E. S., Susanto, T., & Kusumawardani, R. (2005). Karakterisasi sifat fisik, kimia dan fungsional tepung gandum lokal varietas Selayar, Nias dan Dewata. Jurnal Teknologi Pertanian, 6(1), 57–65.

Noda, T., Ichinose, Y., Takigawa, S., Matsuura-Endo, C., Abe, H., Saito, K., … Yamauchi, H. (2003). The Pasting Properties of Flour and Starch in Wheat Grain Damaged by alpha-Amylase. Food Science and Technology Research, 9(4), 387–391.

Saunders, D. A. (1987). Characterization of Tropical Wheat Environments: Identification of Production Constraints and Progress Achieved, South and Southeast Asia. In A. R. Klatt (Ed.), Wheat Production Constraints in Tropical environments (pp. 12–26). Chiang Mai: CIMMYT.

Talanca, A. H., & Andayani, N. N. (2015). Perkembangan Perakitan Varietas Gandum di Indonesia. Retrieved from Balitkabi website: http://balitsereal.litbang.pertanian.go.id/wp-content/uploads/2017/01/perkembgdm.pdf

Uhlen, A. K., Dieseth, J. A., Koga, S., Boecker, U., Hoel, B., Anderson, J. A., & Moldestad, A. (2015). Variation in gluten quality parameters of spring wheat varieties of different origin grown in contrasting environments. Journal of Cereal Science, 62, 110–116. https://doi.org/10.1016/j.jcs.2015.01.004

USDA. (2018). Grain : World Markets and Trade. Retrieved from https://apps.fas.usda.gov/psdonline/circulars/grain-wheat.pdf

Wang, J., Pawelzik, E., Weinert, J., Zhao, Q., & Wolf, G. A. (2008). Factors influencing falling number in winter wheat. European Food Research and Technology, (226), 1365–1371. https://doi.org/10.1007/s00217-007-0666-0

Wang, J., Wieser, H., Pawelzik, E., Weinert, J., Keutgen, A. J., & Wolf, G. A. (2005). Impact of the fungal protease produced by Fusarium culmorum on the protein quality and breadmaking properties of winter wheat. 552–559. https://doi.org/10.1007/s00217-004-1112-1

Widyawati, N. (2013). Pertumbuhan dan Hasil Tanaman Gandum (Triticum aestivum L.)

varietas Dewata dalam Polybag Pada Berbagai Populasi dan Komposisi Media Tanam. Agric, 1(December), 1–8.

Table 3. Chemical properties of Dewata wheat grown in different locations in Indonesia (g/100g DM)

Location	Protein	Fat	Starch	Gluten	Ash
Jawa Timur	12.74 c	0.055 bc	71.11 a	21.30 e	0.57 b
Jawa Tengah	12.20 d	0.068 a	65.89 b	36.77 c	0.62 a
Jawa Barat	13.30 b	0.064 ab	60.08 c	39.94 b	0.63 a
Bengkulu	15.26 a	0.042 d	56.04 d	42.17 a	0.55 b
Sulawesi Selatan	13.06 b	0.042 cd	63.93 b	35.15 d	0.55 b
Variation (%)	8.75	22.31	9.93	23.28	6.59

Different alphabet in a column indicated a significant different at P < 0.01 or at P < 0.05

Table 4. Pasting properties of Dewata grown in different locations in Indonesia

Location	Pasting Temperature (oC)	Maximum Viscosity (BU)	Peak Temperature (oC)	Breakdown (BU)	Setback (BU)
Jawa Timur	62.4	91 bc	79.9 ab	50 bc	31 c
Jawa Tengah	63.4	520 a	89.6 a	209 a	418 a
Jawa Barat	65.2	83 bc	74.0 b	65 bc	15 cd
Bengkulu	67.6	40 c	71.8 b	26 c	10 d
Sulawesi Selatan	61.3	145 b	77.6 b	84 b	56 b

Different alphabet in a column indicated a significant different at P < 0.01 or at P < 0.05

Table 5. Dough properties of Dewata grown in different locations in Indonesia

Location	Water Absorption (%)	Dough Development Time (min)	Dough Stability (min)	Mixing Tolerance Index (BU)	Farinograph Quality Number (mm)
Jawa Timur	62.1	7.4	3.5	136	88
Jawa Tengah	69.5	7.0	5.3	102	101
Jawa Barat	67.7	5.3	3.7	166	72
Bengkulu	72.3	6.5	2.8	230	72
Sulawesi Selatan	67.8	7.2	2.0	165	89