

Alternative Potential of Various Processed Potato Varieties in the Highland

Meksy Dianawati*, and Atin Yulyatin

Assessment Institute of Agricultural Technology, West Java, Jl. Kayuambon 80, Lembang, Bandung Barat, West Java, Indonesia

Abstract. The low production of Atlantic as processed variety has prompted efforts to introduce varieties as well as the creation of new varieties. The purpose of this study was to examine various alternatives of processed potato varieties that have the potential in the highlands of Garut, West Java. The research was conducted in Cikajang, Garut, West Java, from December 2017 to March 2018. The research used a randomized block design with eight varieties and four replications. The varieties tested were Blis, Atlantic M., Medians, Granola L, AR8, AR7, Amabile, and Atlantic. The observed variables were height plant at 2, 4, 6, and 8 WAP, number of tuber by size, and tuber weight. The data was tested with the F test and if it was significantly different, it was continued with the orthogonal contrast test at the 5% level. Heatmap analysis was performed using the R Studio program. The result showed that Granola was not significantly different from all processed varieties. There were three groups of processed varieties, namely the first group, Amabile. The second was AR 7, Medians, and Blis. The third was Atlantic M, Atlantic, and AR 8. Amabile variety had the highest production and number of large tubers.

1 Introduction

Indonesia is still importing processed potatoes, i.e. 51,849 tons at 2017 year with a value of 275 billion rupiah [1]. The high import of processed potatoes is in line with population growth and changes in people's lifestyles who like fast food. There are 3-4 large processed potato industries and hundreds of household-scale processed industries in Indonesia [1]. However, processed potatoes are still rarely cultivated by farmers independently due to limited seeds and the uncertainty of the home industry market. Meanwhile, the large-scale potato processing industry is carried out in partnership by providing imported varieties of seeds. The variety is the Atlantic whose seeds are imported from Canada, Australia, Scotland, and the United States [2], with the amount reaching 2,500 tons per year.

The Atlantic variety is highly favoured by the potato processing industry because of its delicious taste, high yield, and satisfactory fried results, but it is less favoured by farmers because it is susceptible to late blight, bacterial wilt, and nematodes, and low production with a small number of tubers. This low Atlantic production has prompted various efforts to introduce varieties as well as the creation of new varieties with the elder Atlantic varieties.

* Corresponding author: meksyd@yahoo.com

Blis is an example of a processed potato variety introduced by the national chip industry and is widely grown in Garut [1]. However, until now there has not been a variety that can match the quality of the Atlantic [2]. Various processed varieties with elders from the Atlantic in Indonesia have been produced such as Medians, Amabile, AR 7, and AR 8. Medians is a potential variety that has long been developed in Garut highland since 2013 with higher production than Atlantic and Granola and the level of preference higher than Atlantic and Granola [1]. Amabile production in Garut was higher than the Atlantic and the specific gravity was not significantly different from the Atlantic [2]. The specific gravity and reducing sugars of AR 7 and AR 8 were not significantly different from those of the Atlantic, so they had organoleptic responses that were not much different from those of the Atlantic.

The production of Atlantic-derived varieties was inconsistent [2]. This inconsistency can be caused by differences in seasons and planting locations. The production of Amabile was higher than that of the Atlantic in Garut, but the advantage of Amabile in Lembang was not significantly different from that of the Atlantic. Meanwhile, the production of Medians in Lembang was higher than in Garut. Whereas farmers need varieties that have high stable production yields in various environments and seasons [3]. Thus, the choice of variety becomes important for farmers who intend to adjust processed potato market demand [4]. The purpose of this study was to examine various alternatives of processed potato varieties that have the potential in the highlands of Garut, West Java.

2 Methodology

The research was conducted in Cikandang Village, Cikajang District, Garut Regency, West Java, Indonesia, with an altitude of 1,277 m above sea level from November 2016 to march 2017 at the coordinate point 70 22'14.33" LS, 1070 48'49.86" BT. The research soil had a dusty clay texture with soil pH rather acid, high nitrogen content (0.54%), very high P (238.6 ppm), very high K (249.5 ppm), and low CN ratio (8). Garut Regency has a humid tropical climate with an average annual rainfall of 2,589 mm with a wet month of 9 months. Monthly temperature range between 18°C – 27°C.

The research used a randomized block design with eight varieties and four replications. The varieties tested were Blis, Atlantic M., Medians, Granola L, AR8, AR7, Amabile, and Atlantic (Table 1). Granola L was a vegetable potato variety, while the others were processed potato varieties. The seeds of AR7, AR8, Amabile, Atlantic, and Atlantic M varieties were obtained from Indonesia Vegetative Research Institute, while Medians, Blis, and Granola L were obtained from Garut breeders. The seed class used was G3 with an average tuber age of 3 months.

Potato seeds were planted on dry land that used to be a cabbage plantation. Seeds were planted individually with a depth of 2-3 cm and a spacing of 50 cm x 40 cm. The land was given chicken manure as much as 15 tons/ha. ZA inorganic fertilizer as much as 500 kg/ha and NPK (16:16:16) as much as 1 ton/ha were given twice, namely dose at planting and dose at 30 days after planting. Planting using silver black plastic mulch. Pest and disease control in accordance with IPM.

The variables observed were plant height at 2, 4, 6, and 8 weeks after planting (WAP), the number of large, medium and small tubers as well as the total number of tubers, weight of tuber per plant, and weight per tuber. Plant height was measured from the highest growing point to the base of the stem. Tubers were divided into three groups, where large tubers were more than 60 g, medium tubers were 30-60g, and small tubers were less than 30 g. The total numbers of tubers were the number of large, medium, and small tubers. Weight per tuber was obtained by dividing the weight of tubers per plant by the total

number of tuber per plant. The data was tested with the F test and if it was significantly different, it was continued with the orthogonal contrast test at the 5% level. The heatmap analysis was performed using the R Studio program [5].

Table 1. Breeding materials used in this research

Varieties	Parentage
Blis	
Atlantik M	Introduction from Wisconsin USA
Medians	Atlantic x 393284.39
Granola L	Introduction from West Germany
AR 8	Atlantic x Repita
AR 7	Atlantic x Repita
Amabile	Atlantic x 393280.64
Atlantik	Introduction from Wisconsin USA

3 Results and Discussion

3.1. Comparison of vegetable potatoes and processed potatoes

Granola L. as a vegetable potato had higher plant height growth than all processed potato varieties at 2, 6, and 8 WAP (Table 2). However, the high growth in height of the Granola L could not significantly increase the number of tubers and tuber weight per plant compared to processed potatoes. This showed that Granola L was more focused on vegetative growth, so tuber initiation was slower and tuber weight was low. Granola L had a higher habitus, resulting in a smaller tuber diameter than other shorter varieties. Varieties with high plants had low tuber weight per plant because the plants continued to produce new shoots with high endogenous gibberellin content, resulting in late tuber initiation. Late tuber initiation in a variety caused the time of translocation of photosynthetic from shoot to tuber to be limited, resulting in low tuber weight [6]. Gibberellins could inhibit tuber formation [7]. According to [8], plants under non-induced conditions such as those in the tropics have high endogenous gibberellin content, which can inhibit tuberization of potato.

Granola L and all processed varieties were not significantly different on the tuberization variables (Table 2). Thus, the change in the use of varieties from the vegetable potato Granola L which was dominantly grown by farmers in Indonesia to processed potatoes should not be an obstacle to farmers' adoption because there was no significant decrease in production. This was because the most important choice for the adoption of a potato variety by farmers was the high production of tubers. Thus, to encourage the development of processed potato varieties Indonesia, it was necessary to pay attention to the suggestions of [1] to carry out massive promotion of alternative varieties of non-Atlantic processed potatoes and make it easier for farmers to obtain seeds of these non-Atlantic processed varieties.

Based on the order of tuber weight per plant, the highest processed varieties were Amabile, AR 07, Blis, Medians, Atlantic M, AR 8, and Atlantic (Figure 1). The comparison of individual Granola L with processed varieties was ordered from the highest tuber weight per plant and significantly different, namely only in two varieties, i.e. Amabile and AR 7. Granola L had tuber weight per plant and the number of large tubers was lower than Amabile. This was in line with the results of [2] study which reported that Amabile production in Garut was higher than Granola L. In addition, Granola L had more total

tubers and smaller tubers than AR 7. This indicated that Amabile was larger and AR 7 had fewer small tubers than Granola L.

Table 2. Comparison of Granola L with processed potato varieties

Variables	Granola L vs processed varieties	Granola L vs Amabil	Granola L vs AR 7
PH2	17.8 vs 11.9*	17.2 vs 7.5*	17.2 vs 12.6*
PH4	33.5 vs 33.7	33.5 vs 31.7	33.5 vs 37.0
PH6	78.7 vs 69.4*	78.7 vs 63.7*	78.7 vs 64.8*
PH8	90.5 vs 85.2*	90.5 vs 79.7*	90.5 vs 75.7*
NL	1.8 vs 2.5	1.8 vs 5.0*	1.8 vs 3.3
NM	2.5 vs 2.1	2.5 vs 3.3	2.5 vs 1.3
NS	10.0 vs 6.9	10.0 vs 9.5	10.0 vs 3.5*
NT	14.3 vs 11.5	14.3 vs 17.8	14.3 vs 8.0*
TW	859 vs 732	532 vs 1523*	532 vs 773
TWP	64 vs 70	89 vs 87	89 vs 103

* , ^{NS} indicate significant at $p < 0,05$ or no significant effect, respectively

PH2 = Plant height at 2 WAP, PH4 = Plant height at 4 WAP, PH6 = Plant height at 6 WAP, PH8 = Plant height at 8 WAP, NL = number of large tuber, NM = number of medium tuber, NT = number of small tuber, NT = number of total tuber, TW = tuber weight per plant, TWP = weight per tuber

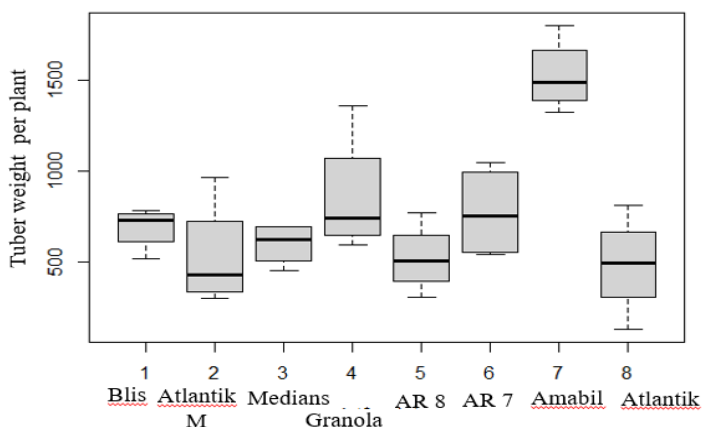


Fig 1. Boxplot of tuber weight per plant of various varieties

3.2. Comparison between processed potato varieties

To see the potential between processed potato varieties, a heatmap analysis was carried out. There were three groups of processed varieties based on the varieties tested (Figure 2). The first group was variety with high tuber character, namely Amabile. The second group was AR 7, Medians, and Blis with medium tuber weight per plant. However, AR 7 had a high weight per tuber criterion, while Medians and Blis had a low weight per tuber. The third group was Atlantic M, Atlantic, and AR 8 which had low tuber character. This grouping was in line with several previous studies. A test based on qualitative characters which

showed that Atlantic was a different group from Blis. Based on the SSR and STS band patterns using 12 markers that the Atlantic was different from the Medians and Amabile groups. Medians and Amabile were varieties formed from crossing the Atlantic with female parents with introduced clones of CIP which have late blight resistance and high productivity. What was interesting about this study, AR 7 and AR 8 as descendants of the Atlantic and Repita (Table 1), but not in the same group.

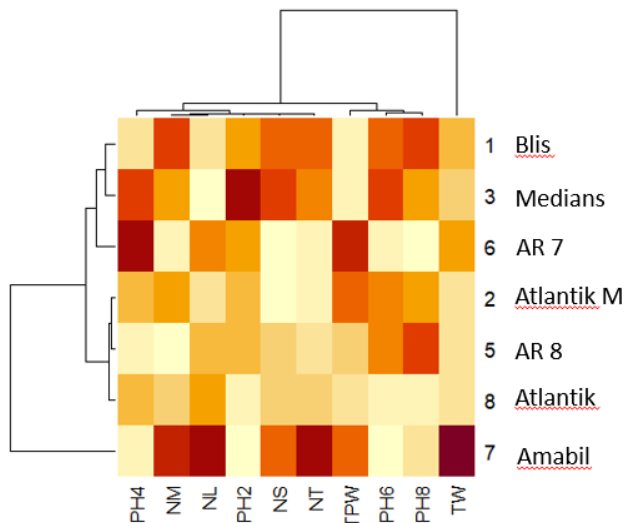


Fig 2. Heatmap among processed potato varieties with each variables
 PH2 = Plant height at 2 WAP, PH4 = Plant height at 4 WAP, PH6 = Plant height at 6 WAP, PH8 = Plant height at 8 WAP, NL = number of large tuber, NM = number of medium tuber, NT = number of small tuber, NT = number of total tuber, TW = tuber weight per plant, TWP = weight per tuber

Among the processed varieties, Amabile was the variety with the highest crop yield (Table 3). This was in accordance with the research of [2] which reported that Amabile was the variety with the highest tuber yield in Garut compared to the Medians and Atlantic. Amabile in this study had the highest total number of tubers, especially the number of large tubers. Whereas the plant height growth of 2, 6, and 8 WAP of Amabile variety was lower than other processed potato varieties (Table 3). This showed that the growth of Amabile varieties was more concentrated on tuber growth after vegetative growth was achieved. Ability of stolons of the Amabile variety to form tubers was higher than that of the Atlantic and Medians. This was because the ability of stolons to produce many tubers was strongly influenced by its variety [6]. This was indicated by the large number of total tubers, but did not reduce tuber weight per plant, so Amabile was assumed to have a sufficient number of photosynthetic yields for tuber growth. The phenomenon in the Amabile variety agreed with the research results of [9] that the number of tubers was associated with the yield of tubers, thus forming a large number of tubers was an important matter that must be considered.

The second group of processed varieties were Blis, Medians, and AR 7. These three varieties had a higher total number of tubers than the other three cultivated varieties (Atlantic M, Atlantic, and AR 8). [10] stated that varieties with high total numbers could increase potato tuber production. Meanwhile, Blis, Medians, and AR 7 had higher initial plant height growth of 2 WAP than Atlantic M, Atlantic, and AR 8, although later they were not significantly different at 4, 6, and 8 WAP (Table 3). This showed that the three varieties, Blis, Medians, and AR 7 had fast vigor with high initial plant height growth (2

WAP), but then after sufficient vegetative growth, immediately change to tuber growth. [3] stated that tuber growth begun when leaf vegetative growth decreased and plants trans located food products from shoots to tubers to the tuber maturation phase.

Table 3. Comparison of varieties among processed potato varieties on various variables

Variables	G vs others	A,C,F vs B,E,H	F vs A,C	A vs C	B vs E,H	B vs EH
PH2	7.5 vs 12.6*	14.3 vs 10.9*	12.6 vs 15.2*	12.8 vs 17.7*	11.8 vs 10.4	11.6 vs 9.3*
PH4	31.7 vs 34.0	35.0 vs 33.0	37.0 vs 34.0	32.3 vs 35.8	33.7 vs 32.7	31.8 vs 33.6
PH6	63.7 vs 70.4*	71.1 vs 69.7	64.8 vs 74.2*	74.0 vs 74.4	72.5 vs 68.3*	72.6 vs 64.1*
PH8	79.7 vs 86.14*	86.1 vs 86.2	75.7 vs 91.3*	94.6 vs 88.1*	87.7 vs 85.4	92.7 vs 78.2*
NL	5.0 vs 2.1*	1.9 vs 2.3	3.3 vs 1.3*	1.8 vs 0.8	1.8 vs 2.5	2.3 vs 2.8
NM	3.3 vs 1.9	2.2 vs 1.7	1.3 vs 2.6	3.0 vs 2.3	2.3 vs 1.4	1.0 vs 1.8
NS	9.5 vs 6.5	7.9 vs 5.0	3.5 vs 10.1*	9.8 vs 10.5	3.5 vs 5.8	5.5 vs 6.0
NT	17.8 vs 10.5*	12.0 vs 8.9*	8.0 vs 14.0*	14.5 vs 13.5	7.5 vs 9.6	8.8 vs 10.5
TW	1523 vs 600*	687 vs 513	773 vs 644	690 vs 599	532 vs 504	523 vs 485
TWP	55 vs 67	66 vs 68	103 vs 47*	49 vs 45	89 vs 57	58 vs 55

* , ^{NS} indicate significant at $p < 0,05$ or no significant effect, respectively

PH2 = Plant height at 2 WAP, PH4 = Plant height at 4 WAP, PH6 = Plant height at 6 WAP, PH8 = Plant height at 8 WAP, NL = number of large tuber, NM = number of medium tuber, NT = number of small tuber, NT = number of total tuber, TW = tuber weight per plant, TWP = weight per tuber
 A = Blis, B = Atlantik M, C = Medians, E = AR 8, F = AR 7, G = Amabil, H = Atlantik

Of the processed varieties of the medium group, AR 7 had a lower total number of tubers, especially the number of small tuber, but the number of large sizes was higher, so the weight per tuber was higher than Medians and Blis (Table 3). This indicated that AR 7 was dominated by large tubers. Meanwhile, Medians and Blis had the same tuber characteristics, namely the total number of tubers and a number of small tubers, so that the weight per tuber was small. The phenomenon of Medians and Blis, as stated by [9] that low tuber weight was positively correlated with a number of small tubers. Taking into account the growth of plant height, AR 7 had the same pattern of plant height growth as Amabile where the height of AR 7 plants aged 2, 6, and 8 WAP was lower than Medians and Blis. This showed that AR 7 also had growth characteristics that concentrate more on tuber growth, such as Amabile.

The third variety group, Atlantic M, Atlantic, and AR 8 were not significantly different towards tuber characters (Table 3). Atlantic M had higher plant heights at 2 and 6 WAP than the two varieties of the third group, namely Atlantic and AR 8. AR 8 was higher at 2, 6, and 8 WAP than Atlantic (Table 3). AR 8 was a processed quality variety that has the potential to replace Atlantic because it had resistance to late blight and bacterial wilt from its parent Repita. However, in this study, the production of AR 8 was not significantly different from that of the Atlantic.

3.3 Comparison between groups of processed potato varieties

Comparing groups of Atlantic and non-Atlantic varieties, the Atlantic group had lower tuber weights per plant and total number of tubers than non-Atlantic (Table 4). This was in accordance with the research of [2] which reported the number of Atlantic tubers was less than Medians and Amabile. The low production of Atlantic tubers was due to sensitivity to late blight, bacterial wilt, and root nematodes.

The AR variety group had a lower total number of tubers, especially the number of small and medium-sized tuber, but the number of large-sized tuber was more than non-AR (Table 4). This showed that the AR variety group has a large tuber size.

Table 4. Comparison of varieties among processed potato variety groups

Variables	Atlantic vs non Atlantic	AR vs Non AR
PH2	10.5 vs 12.4*	12.1 vs 11.8
PH4	33.6 vs 33.7	34.4 vs 33.4
PH6	68.3 vs 69.9*	68.7 vs 69.7
PH8	82.9 vs 86.1*	84.2 vs 85.6
NL	2.3 vs 2.6	2.8 vs 2.4*
NM	2.0 vs 2.2	1.1 vs 2.5*
NS	4.8 vs 7.8	4.5 vs 7.9*
NT	9.0 vs 12.5*	8.4 vs 12.8*
TW	508 vs 822*	648 vs 765
TWP	72 vs 69	81 vs 65

*, ^{NS} indicate significant at $p < 0,05$ or no significant effect, respectively

PH2 = Plant height at 2 WAP, PH4 = Plant height at 4 WAP, PH6 = Plant height at 6 WAP, PH8 = Plant height at 8 WAP, NL = number of large tuber, NM = number of medium tuber, NT = number of small tuber, NT = number of total tuber, TW = tuber weight per plant, TWP = weight per tuber

4 Conclusions

The result showed that Granola L was not significantly different from all processed varieties. There were three groups of processed varieties, namely the first group Amabile. The second group was AR 7, Medians, and Blis. The third group was Atlantic M, Atlantic, and AR 8. The production of the Atlantic variety group was lower than that of the non-Atlantic group. The group of AR varieties was larger than non-AR. Amabile variety had the highest production and number of large tubers.

References

1. W. Adiyoga, D. Musaddad, A. Sembiring. *J. Hort.* **30**, 2 (2020)
2. Y. Kusandriani. *J. Hort.* **24**, 4 (2014)
3. S. Das, S. B. Mitra, S.K. Luthra, A. Saha, M.M. Hassan, A. Hossain. *Agronomy* **11**, 335 (2021)
4. J. Mohammadi, Khasmakhi-sabet, S.A. Olfati, J.A. Dadashpour, A., Lamei, J. Salehi, B. Biosci. Biotech. Res. Asia **7** (2010)
5. A. Kassambara. *Practical guide to cluster analysis in R.* (STHDA. 2017)
6. E. Mihovilovich, Carli, C., De Mendiburu, F., Hualla, V., Bonierbale, M. *Tuber Bulking Maturity Assessment of Elite and Advanced Potato Clones Protocol.* (International Potato Center: Lima, Peru, 2014)
7. C.M. Menzel. *Annals of Bot.* **55** (1985)
8. T. Tekalign, P.S. Hammes. *Pl Growth Regul.* **45** (2015)
9. M. Khayatnezhad, R. Shahriari, R. Gholamin, S.J. Somarin, R.Z. Mahmoodabad. *Middle-East J. Scie. Res.* **7**, 1 (2011)
10. S. K. Bhawneshwariverma, Narayan K., Paikra M.S. *Asian J. Hort.* **8** (2013)