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Selection of 30 Potato (*Solanum tuberosum* L.) Clones Potential For Chips and French Fries Industry

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Abstract.

The existence of local varieties of potatoes for the processed industry in Indonesia is very necessary, most of the raw materials for the potato chip industry are still imported. Even for French fries, one hundred percent of its material is still imported. Selection of 30 potato clones was conducted at the Margahayu Experimental Field (1250 m asl), in Lembang from January to May 2016. It used a completely randomized block design with 3 (three) replications which every plot consisted of 10 plants. The evaluated characters included plant vigor, plant height (cm), stem diameter (mm), tuber weight (g), percentage of consumption tuber (%), yield (ton/ha), specific gravity (Sg), tuber shape, tuber skin color, tuber flesh color and appearance of tuber skin. Analysis of variance showed that all quantitative characters were very significantly different ($P < 0.01$). Clone 15.33 showed the highest tuber yield per plant (831 grams/plant) which was significantly different from the comparable variety of Atlantic (166 grams/plant). The highest percentage of consumption tubers was obtained from clones 15.26 (75.3%) which were significantly higher than comparable varieties (Amabile, Granola, Medians and Atlantic). The result suggested that 2 (two) clones e.g. 15.33 and 15.23 with specific gravity (Sg) higher than 1.067 are potential to be used for industrial potato chips.

Keywords: potatoes, industrial raw materials, chips, french fries

1. Introduction

Potato is the world's leading for non-grain food commodity, the fourth most important food crop after wheat, maize, and rice (Devaux *et al*., 2014). There are 4 types of potato varieties based on their purpose e.g. table potato, food processing, starch production and other purposes including colorful potatoes (Mori *et al.*, 2015). As world lifestyle changes with fast food become a trend, there is an increasing demand for french fry and chip potato production. Nowadays, more than 50% of potato yield (e.g. in the USA and Europe) is driven to food industries (Tesfaye *et al.*, 2010; Melito *et al*. 2017). On the other hand, there is still scarceness of suitable raw materials available for processing industry (Ghulam *et al.* 2012). Most of developing country is still importing raw materials for potato crisp and french fries from USA,

Germany, Canada and Australia (Wustman *et al.*, 2010), even in Indonesia 100% raw materials for french fries are still imported.

Indonesia Agency for Agricultural Research and Development (IAARD) has released about 30 potato varieties. However, not every potato varieties suitable for processing e.g. French fries or fried chips because several tuber quality characters must be met with industrial standards (Amjad *et al.* 2016; Gautam *et al.* 2016). Therefore, tuber characters such as specific gravity, tuber shape, and color which are important for and related with processing quality potato (Abong *et al.* 2010; Zaman *et al.* 2016) have been included into potato breeding programs recently. Considering market (consumer) and industrial demand, potato breeders, thus, are expected to *first*, produce not only high yielding but also high quality and nutritious varieties (Arslan, 2007; Sands *et al.* 2009), *second*, target both the external quality and internal quality of tuber (Kumari *et al*. 2018; Khalid *et al*. 2019).

The external quality of tuber includes skin color, tuber size, and shape, eye depth (Jansky, 2009) whereas characters such as specific sugar quality, dry matter content are part of internal quality (Storey, 2007). Considering processing standard and market demands, long-oval tuber potatoes are suitable for French fries, meanwhile chipping industries prefer round (spherical) tubers (Kabira and Lemaga, 2006; Abong *et al*. 2010; Ekin 2011).

Selection on given variable genotypes/clones is one of the fundamental steps of plant breeding programs (Carputo *et al.* 2005). This research was aimed to select 30 potato clones collected from our previous breeding programs considering the value of specific gravity and tuber shape for industrial processing potatoes.

2. Methods

The selection was conducted at Margahayu KP, Lembang, West Java, Indonesia. The testing period was from January to May 2016. It used a Complete Randomized Block Design with 3 replications and the number of clones tested was 30 clones. The plant population per plot consists of 10 plants. Manure were used as much as 15 tons of chicken manure/ha, for artificial fertilizers the dose used 1000 kg of NPK Mutiara 16:16:16 was given twice, at the time of planting and when the plants were 3 weeks old. Fertilizer application is done at the age of 3 weeks and 6 weeks after planting.

Plant vigor is measured using a score (1=very bad; 9=very vigor), which is done at the age of 60 and 70 days after planting. Vigor plant is a plant architecture that includes plant height, leaf canopy width, leaf blade size and stem size.

Plant height is measured by measuring the stem of the plant from the base of the stem to the highest plant part. Observations were made when the plants were 70 days after planting. The number and weight of tuber yields per plant are observed from 10 random sample plants. Potential yields per hectare was predicted by using following calculation = (tuber weight per plot / plot area) x 100%

The yield of consumption tubers is calculated by separating the tubers by size (> 60 g). Tubers measuring> 60 g per total tuber yield multiplied by 100%. Specific gravity (Sg) is calculated by weighing the tubers of the harvest in water and air :

Sg = tuber weight in the air/(tuber weight in the air - tuber weight in the water).

Data were computed using PKBTSTAT software program and followed Tukey's LSD with 5% significance level.

3. Results

Some of previous studies showed that plant height along with tuber/plant, main stem/plant had positive effect and high direct on tuber weight/plant and tuber yield (Yildrim *et al*. 1997; Islam *et al*. 2002; Arslan 2007). Thus, selection for processing qualified potato clones must also include their basic agronomic characters such as plant height, vigor, stem diameter, etc. There were 5 (five) IAARD released varieties e.g. Amabile, Atlantic, Granola, Medians and Tenggo used as comparison varieties in our selection for processing potatoes.

Table 1. Vegetative data of 30 evaluated potato clones

No.	Clone	Plant Height (cm)	Stem Diameter (cm)	Plant Vigor	No.	Clone	Plant Height (cm)	Stem Diameter (cm)	Plant Vigor
1	18.10	99.00^{bcde}	1.16^{ab}	7.6^{abc}	16	18.21	108.25^{abc}	1.12^{ab}	9.0^{a}
2	16.10	109.08^{abc}	0.80^{c}	4.6^{de}	17	20.20	99.25^{bcde}	1.00^{abc}	5.7^{cde}
3	19.11	88.92^{bcde}	1.03^{abc}	6.3^{de}	18	18.19	96.08^{bcde}	1.19^{ab}	7.7^{abc}
4	15.22	82.17^{cde}	1.13^{ab}	7.0^{abcd}	19	20.70	97.83^{bcde}	1.13^{ab}	9.0^{a}
5	19.8	91.17^{bcde}	0.93^{bc}	7.7^{abc}	20	18.A	106.83^{bcd}	1.16^{ab}	5.7^{cde}
6	15.29	106.00^{bcd}	1.01^{abc}	5.0^{de}	21	Amabile	108.33^{abc}	1.11^{ab}	9.0^{a}
7	18.3	91.67^{bcde}	1.12^{ab}	7.0^{abcd}	22	Atlantic	78.83^{de}	1.07^{abc}	5.7^{cde}
8	18.7A	99.92^{bcde}	1.21^{a}	9.0^{a}	23	Granola	95.92^{bcde}	1.08^{ab}	9.0^{a}
9	14.3	76.92^{e}	1.07^{abc}	7.0^{abcd}	24	Medians	111.58^{ab}	1.19^{ab}	9.0^{a}
10	18.7B	105.50^{bcd}	1.11^{ab}	9.0^{a}	25	Tenggo	136.42^{a}	1.23^{a}	8.3^{ab}
11	16.11	99.00^{bcde}	0.97^{abc}	7.7^{ac}	26	15.2	90.83^{bcde}	1.08^{ab}	7.0^{abcd}
12	18.4	88.75^{bcde}	1.14^{ab}	8.3^{ab}	27	15.23	98.25^{bcde}	1.04^{abc}	7.0^{abcd}
13	13.9	98.67^{bcde}	1.06^{abc}	7.7^{abc}	28	13.6	91.92^{bcde}	1.05^{abc}	4.3^{e}
14	15.33	114.08^{ab}	1.07^{abc}	7.7^{abc}	29	16.7	107.83^{bc}	0.98^{abc}	6.3^{bc}
15	18.9	75.50^{e}	0.97^{abc}	5.0^{de}	30	15.26	86.67^{bcde}	1.18^{ab}	7.0^{abcd}

The result showed that Tenggo was recorded as the tallest clone (136.42 cm) followed by clone 15.33 (114.08 cm) and Medians (111.58 cm). Clone 18.7A featured the biggest stem diameter (1.21 cm) among other clones, similar to Tenggo (1.23 cm). Another important agronomic trait, plant vigor, was also observed in this selection. Table 1 showed that Amabile, Granola, Medians, clone 18.21, clone 18.7A, 18.7B featured the most vigorous plants (score 9). All of them, except clone 18.21, also produced high yield. Previous researches found positive correlations between plant vigor with yield components assuming that more vigorous plant performed longer period of photosynthesis, thus produced higher yield (Silva *et al.* 2007; Silva *et al.* 2012; Pereira *et al*. 2017). In our study, comparing Table 1 and Table 2, there was a tendency for the relationship between plant height and yield. Tenggo which was the tallest variety and performed sufficient vigor (score=8.3) also showed the highest yield, meanwhile Atlantic performed short plants with the lowest yield. This result

also agreed with previous finding (Arslan, 2007) that plant height had a direct effect on yield.

Table 2. Tuber quantitative data of 30 evaluated potato clones

No	Clone	Tuber Weight /plant (g)	Number of Tuber/plant	Percentage of consumption tuber (%)	Yield (ton/ha)	Specific Gravity (Sg)	No.	Clone	Tuber Weight /plant (g)	Number of Tuber/plant	Percentage of consumption tuber (%)	Yield (ton/ha)	Specific Gravity (Sg)
1	18.10	477^{abcd}	12.5^{bc}	56.3^{abcd}	26.53^{abcd}	1.060	16	18.21	679^{abcd}	13.9^{abc}	55^{bcde}	13.9^{bcde}	1.060
2	16.10	684^{abcd}	12.7^{bc}	60.3^{abcd}	22.32^{bcde}	1.058	17	20.20	621^{abcd}	8.7^{efgh}	57^{abcd}	8.7^{efgh}	1.063
3	19.11	480^{abcd}	9.3^{dgh}	51^{def}	17.93^{defg}	1.060	18	18.19	613^{abcd}	13^{bc}	57^{abcd}	24.9^{abcd}	1.060
4	15.22	444^{abcd}	7.1^{gh}	58^{abcd}	12.37^{gi}	1.052	19	20.70	782^{ab}	5.2^{h}	71.3^{ab}	15.07^{fgh}	1.058
5	19.8	675^{abcd}	13.7^{ad}	60^{abcd}	26.3^{ad}	1.051	20	18.A	583^{abcde}	13.7^{abcd}	60.3^{abcd}	21.73^{bcde}	1.047
6	15.29	404^{cdef}	7.9^{fgh}	63.7^{abcd}	12.3^{gi}	1.064	21	Amabile	761^{ab}	14.7^{abc}	52.7^{cde}	29.17^{ab}	1.068
7	18.3	505^{abcd}	14.9^{ab}	33.7^{f}	18.43^{dh}	1.057	22	Atlantic	166^{f}	4.8^{h}	59.3^{cde}	5.7^{i}	1.073
8	18.7 A	657^{abcd}	12.2^{bf}	54^{bcde}	27.4^{abc}	1.062	23	Granola	741^{ab}	17.7^{a}	46.7^{def}	29.9^{ab}	1.055
9	14.3	470^{abcd}	7.4^{gh}	62^{abcd}	14.43^{fgh}	1.060	24	Medians	714^{abc}	11.9^{bcde}	51.7^{cdef}	26.73^{abc}	1.078
10	18.7 B	558^{abcd}	13.2^{bcd}	50.3^{def}	22.47^{bcde}	1.050	25	Tenggo	809^{ab}	14.5^{abc}	61.3^{abcd}	32.6^{a}	1.060
11	16.11	574^{abcd}	7.9^{fgh}	73.3^{ab}	20.03^{cdef}	1.065	26	15.2	447^{bcde}	5.7^{h}	59.7^{abcd}	10.67^{hi}	1.055
12	18.4	568^{abcd}	10.7^{bcdf}	52.3^{cde}	10.7^{cdef}	1.050	27	15.23	429^{cdef}	6.5^{gh}	61^{abcd}	12.9^{ghi}	1.069
13	13.9	687^{abcd}	10.3^{cdef}	63.7^{abcd}	10.3^{cdef}	1.054	28	13.6	570^{abcd}	6.5^{gh}	64.7^{abcd}	10.4^{hi}	1.044
14	15.33	831^{a}	13.2^{bcd}	55^{bcd}	13.2^{bcdf}	1.067	29	16.7	326^{cdef}	7.2^{gh}	64.3^{abcd}	10.1^{hi}	1.065
15	18.9	350^{def}	8.7^{efgh}	42^{cdef}	8.7^{efgh}	1.054	30	15.26	419^{cdef}	7.4^{gh}	75.3^{a}	12.77^{gi}	1.056

Although processing industry demands certain characters of tuber qualities, growers, yet, still call for high yielding varieties considering their profitable income. In this selection, clone 15.33 produced tuber weight/plant higher (831 g) than all comparative varieties. However, its predicted yield was still lower than Tenggo (32.6 ton/ha) which was the highest among all evaluated clones. This probably because yield is defined by some related factors such number of tuber per plant, tuber weight per plant and percentage of consumption tuber.

Specific gravity (Sg) is the key character for french fries potato varieties since it is higly correlated to dry matter content, high value of Sg indicate that the raw potatoes will produce high chip volume (Elfnesh et al, 2011). The result showed that clone 15.23 possessed fairly high Sg (1.069), although still lower than comparative varieties, Medians and Atlantic and standard value for french fries and chipping potatoes (>1.070). Table 2 showed that clones with higher Sg value did not always perform higher yield. Pereira *et al*. (2017) evaluated that tuber yield component e.g. tuber number, total tuber yield were not highly correlated positively with Sg value (0.275). This clone potency could be improved either through breeding program or agronomical approaches. Although genetic make up plays major role in defining tuber qualities, but there are still environmental conditions, agronomic practice, harvest and postharvest circumstances that contribute to yield and tuber qualites (Carputo *et al.*, 2005; Abong *et al.* 2010).

Appearance of tuber potato is another important note in both industry and consumer's choice. Most of our evaluated clones have yellow tuber skin, cream flesh color and oval tuber shape (Table 3). Tuber skin colors are genetically controlled

through presence and absence of red and blue pigments, making up wide range of variability that range from white cream to blackish (Kumari *et al*. 2018). Previous studies also indicated that genotype gave dominant effect on determining quality characters of potato tubers e.g. tuber skin color, tuber shape and specific gravity since they are heritable (Kabira and Lemaga, 2006; Vreughdenhil *et al.* 2007; Abbas *et al.* 2012). Tuber shape determines its utilization in processing industries. In our selection, clone 15.23 which showed fairly high Sg, also bearing round-oval tubers.

Table 3. Qualitative Data of 30 evaluated potato clones

No.	Clone	Tuber Shape	Tuber Skin Color	Flesh Color	Tuber Skin Appearance	No.	Clone	Tuber Shape	Tuber Skin Color	Flesh Color	Tuber Skin Appearance
1	18.10	oval	yellow	cream	smooth	16	18.21	oval	pink	yellow	smooth
2	16.10	oval	cream	cream	netted	17	20.20	oval	cream	cream	netted
3	19.11	long-oval	yellow	yellow	netted	18	18.19	oval	yellow	cream	smooth
4	15.22	oval	cream	cream	netted	19	20.70	oval	cream	cream	netted
5	19.8	oval	yellow	yellow	netted	20	18.A	oval	pink	white	smooth
6	15.29	oval	cream	white	smooth	21	Amabile	oval	cream	cream	netted
7	18.3	oval	yellow	cream	netted	22	Atlantic	oval	yellow	white	netted
8	18.7A	oval	yellow	yellow	smooth	23	Granola	oval	yellow	cream	smooth
9	14.3	oval	yellow	white	netted	24	Medians	oval	yellow	cream	smooth
10	18.7B	long-oval	pink	cream	netted	25	Tenggo	round	yellow	cream	smooth
11	16.11	oval	yellow	cream	netted	26	15.2	long-oval	yellow	white	smooth
12	18.4	oval	yellow	yellow	smooth	27	15.23	oval	yellow	white	netted
13	13.9	long-oval	cream	yellow	netted	28	13.6	long-oval	yellow	cream	smooth
14	15.33	oval	cream	cream	netted	29	16.7	long-oval	brown	cream	smooth
15	18.9	oval	red	yellow	netted	30	15.26	oval	yellow	cream	smooth

Having appropriate weight and round-oval shape are among the tuber characters needed in industry for processing chips meanwhile french fries industry prefers long-oval shaped tuber (Nacheva and Pevicharova, 2008; Wayumba *et al.* 2019). There were six clones bearing long-oval shaped tubers in this selection, unfortunately none of them produced high yield. These clones could be used in further breeding programs to gain high Sg and high yield long-oval tuber potato varieties. Most of evaluated clones were netted (russet) tuber skin appearance, among them were clones with fairly high Sg value e.g. Amabile (1.068), Atlantic (1.073), clone 15.33 (1.067) and clone 15.23 (1.069). Bali *et al* (2018) evaluated that russet potatoes in United States are preferred for French fries considering their high dry matter content which refers to low oil uptake during frying. Although, the inheritance of tuber skin characters is mostly unknown, it seemed to be strongly controlled by genetic factor (Vreugdenhill, 2007)

4. Conclusion

Although still lower than the comparable varieties, Clone 15.23 with round-oval tuber and specific gravity (Sg) higher than 1.067 is potential to be used for industrial potato chips. Clone 15.33 had tuber weight per plant heavier (891 g) than comparable varieties.

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