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Evaluation of improved potato (*Solanum tuberosum* L.) varieties for some quality attributes at Shebench Woreda of Bench-Maji Zone, Southwestern Ethiopia

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In Ethiopia, potato sub-sector is expanding, with more value added products, such as potato chips, mainly due to increasing demands associated with growth of population and urbanization. Processing industry is very dependent on the quality parameters of tuber to satisfy the increasing demand of customers. Thus, this experiment was conducted with the objective to evaluate the quality of some improved potato varieties at Shebench district of Bench-Maji Zone. The study comprised of nine improved potato varieties laid out in randomized complete block design (RCBD) with three replications. The tuber size distribution and proximate quality data were collected and analyzed by using SAS Version 9.2 statistical software. The results of the study revealed that all of the variables considered were significantly (P<0.01) affected by varieties except pH. Accordingly, considering tuber size distribution, the highest percentage of medium tuber was observed for Gudanie (77.4) followed by Belete (72.18). Whereas the highest percentage of large tuber was observed for variety Belete (17.35) followed by Shenkola (14.03). On the other hand, the least percentage of small tuber size was observed for variety Belete (10.47) followed by Gudanie (13.59). With regard to physicochemical qualities, the highest value of dry mater content (21.67%), specific gravity (1.08) and starch content (14.69%) were observed for Gudanie variety whereas Degemegn (3.28%) and Gudanie (3.27%) varieties showed the highest protein contents. Therefore, considering majority of the tested marketable and processing quality attributes, variety Gudanie can be considered as superior and recommended for the study area. In addition to this, growers in the study area can also use variety Belete for its good marketable tubers and varieties Gera, Gorebela and Chala for their acceptable processing quality.

Key words: Potato, variety, quality, gudanie.

INTRODUCTION

Potato, *Solanum tuberosum*, is the most cultivated not cereal crop in the world, ranking fourth after rice, wheat and corn (FAO Statistics, 2012). It represents an important component of human diet, because tubers are able to supply several nutrients, such as essential amino acids, vitamins (as vitamin C) and minerals (Melito et al.,

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2017). Between 1991 and 2007, the potato production in the world increased by almost 21%, interestingly, a massive increase of harvested tubers was shown by developing countries with approximately 94% (FAO, 2008). In Ethiopia, its production was estimated to be 0.92 million tons from an area of 0.07 million hectares by 1.2 million smallholder farmers (CSA, 2016/2017).

Nowadays, one of the most important aspects of potato production is tuber quality, that includes biological traits (e.g. proteins, carbohydrates, and minerals), sensorial traits (e.g. flavour, texture), and industrial traits (e.g. tuber shape, cold sweetening, starch quality) (Carputo et al., 2005). According to Rytel et al. (2013), the quality of potato tuber and their chemical composition are influenced by genetic factors, soil fertility, weather conditions and chemical treatments that are applied.

These days, the utilization of potatoes is shifting away from table consumption to processed products such as French fries, mashed and canned potatoes. Although the direct consumption of potato represents an important part of the market, more than 50% of tuber yield is used by processing firms (Carputo et al., 2005). Mainly in developed countries, approximately 60% of potatoes are consumed in a processed form; it is caused by the changing of consumers' lifestyle that prefer for greater convenience (Kirkman, 2007; Storey, 2007). In Ethiopia, majority of potatoes produced are used for preparation of different kinds of traditional foods. Recently, however, small-scale potato processors are flourishing in cities and big towns. These require a supply of raw materials with specific internal attributes and regular tuber size (e.g. for the production of French fries and chips, tubers must have a high specific gravity). So far many improved potato cultivars have been developed and widely used for commercial purpose all over the country. In developing these varieties, much emphasis was given to productivity per unit area and late blight reaction while less emphasis was given to quality. Moreover, information on the performance of varieties in relation to their tuber quality at Shebench woreda of Bench-Maji zone was not known due to lack of research in the area. For quality potato tuber production in the area, it is essential to evaluate the fitness of the released cultivars in terms of quality under the agro-ecological condition of the area and to incorporate quality as a yardstick in variety selection procedure for growers in the area. Hence, this study was initiated to evaluate quality of some released potato varieties in Shebench wereda of Bench-Maji zone.

MATERIAL AND METHODS

Description of the study area

The experiment was conducted at Ziagin Farmers Training Center (FTC) of She-Bench district, during 2015/2016-2016/2017 main cropping season. Geographically, the study area is located at 60° 52"N – 70`N, 35° 21``E with an altitude of 1950 m.a.s.l. The site has a bimodal rainfall distribution and receives mean annual rainfall ranging from 1801 to 2000 mm with mean minimum and maximum temperatures of 15.1 to 25°C, respectively. The area is considerably characterized by mid and high land and with high length of growing period (Masresha and Solomon, 2015).

Experimental materials and design

For this study, 9 potato varieties released by different research centers for different agro-ecologies of Ethiopia were used. Descriptions of the varieties are shown in Table 1. The experiment was laid out in a randomized complete block design with three replications. Each plot was 3 m × 3 m = 9 m^2 wide consisting of four rows, which accommodated 10 plants per row and thus 40 plants per plot. The spacing between plots and block were 0.5 and 1 m, respectively. Well-sprouted potato seed tubers of each variety were planted by hand in furrows at a depth of about 15 cm and at a spacing of 75 cm between rows and 30 cm between plants. According to EARO (2004) recommendation, 110 kg N ha^{-1} fertilizer in the form of Urea (in split: half at planting and the rest during flowering) and 90 kg of P2O5 ha^{-1} fertilizer in the form of side dressing at the time of planting (DAP) was applied. Management practices such as weeding; cultivation and ridging was practiced as per the recommendation (Gebremedihin et al., 2008). Harvest was under taken by hand when the leaves of 50% of the plants in the plot turned yellowish.

Data collection and analysis

Data on tuber size distribution and physiochemical quality analysis were recorded for individual response variables from the two harvestable middle rows of each plot.

Tuber size categories

Tubers from two central rows were graded into three groups considering size of tubers: <35 mm (small), 35 - 55 mm (medium) and >55 mm (large) (Hassanpanah et al., 2009; Abbas et al., 2012).

Tuber dry matter content (%)

Tubers from randomly chosen five plants per plot was washed, chopped and mixed. 200 g of sample was taken and pre-dried at a temperature of 60°C for 15 h and further dried for 3 h at 105°C in a drying oven (Zelalem et al., 2009). Finally, dry matter content was calculated as:

Dry matter content (%) = (Dry weight /Fresh weight) × 100

Specific gravity and starch contents (%)

They were computed from the recorded dry matter content. Consequently, the equation from Kleinkopf et al. (1987) of dry matter (%) = -214.9206 + 218.1852 × (specific gravity) and the equation from Von Schéele et al. (1937) of starch (%) = 17.565 + 199.07 × (Specific gravity – 1.0988) were used to convert the dry matter value of varieties in this study to specific gravity and starch content, respectively.

Tuber pH

Five potato tubers were peeled and homogenized in a juice extractor (Model 31JE 35 New Hartford Connecticut 06057 USA). The pH then directly measured using HI 9025 microcomputer pH

Table 1. Descriptions of potato varieties used for the study.

S/N	Variety	Released year	Breeder/Maintainer	Recommended altitude (m.a.s.l.)
1	Belete	2010	Holeta Research Centre	1600-2800
2	Gudenie	2006	Holeta Research Centre	1600-2800
3	Marachere	2005	Awassa Research Centre	1700-2700
4	Gera	2003	Sheno Research Centre	2700-3200
5	Gorrebella	2002	Sheno Research Centre	2700-3200
6	Jalenie	2002	Holeta Research Centre	1600-2800
7	Chala	2004	Haramaya University	1700-2000
8	Shenkola	2005	AwARC/SARI	-
9	Degemegn	2002	HARC/EIAR	-

meter and the test was performed in three replications according to Pardo et al. (2000).

Crude protein content

Potato tubers were sorted, washed, peeled, sliced and dried using an oven drying method. Dried samples were finely ground using a mortar and pestle to prepare the flour and then crude protein content was determined by micro-Kjeldahl method (digester F30100184, SN 111051, VELP Scientifica; distiller F30200191, SN 111526, Europe) of nitrogen analysis (% protein = %N × 6.25) by taking about 1.0 g potato flour (AOAC, 1994) using urea as a control in the analysis.

Data analysis

The raw data were subjected to analysis of variance (ANOVA) following the standard procedure given by Montgomery (2013). After fitting ANOVA model for those significant response variables, a mean separation was carried out using LSD method at 5% level of significance. All the statistical analyses were carried out using SAS-9.2 statistical soft ware package (SAS institute Inc, 2008).

RESULTS AND DISCUSSION

Results of ANOVA of eight quality characters for 9 improved Irish potato varieties are shown in Table 2. Accordingly, all the quality characters considered showed significant ($P<0.01$) difference among the tested varieties except pH which showed non-significant ($p > 0.05$).

Tuber size categories

Percentage of small sized tuber (%)

There was highly significant ($P< 0.01$) variation among the tested varieties with respect to small size tuber number in percentage (Table 2). The result revealed that significantly, the highest percentage of small tubers (34.35) was obtained from variety Maracharre, whereas the lowest and statistically similar values were recorded from Belete (10.47) and Gudanie (13.59) varieties (Table 3). These results are in confirmation with the findings of Bilate and Mululalem (2016) who reported that the highest and significantly different small sized tuber number per hill was recorded from Marrachare variety. The highest percentage of small size tubers observed in this experiment may be due to higher vigor of plants coupled with delayed maturity as reported by Sharma and Singh (2009).

Percentage of medium sized tuber (%)

Percentage of medium sized tuber was highly and significantly ($P< 0.01$) influenced by the tested varieties (Table 2). The highest percentage of medium sized potato tuber (77.44) was recorded from Gudanie variety followed by Belete (72.8) but the lowest percentage (60.68) was obtained from Maracharre variety (Table 3). This result is in agreement with the findings of Bilate and Mululalem (2016) and Habtamu et al. (2016) who observed highly significant variation among potato varieties with regard to percentage of medium sized potato tuber. Higher value observed for this variable might be due to rapid plant emergence and better plant growth as described by Kumar and Ezekiel (2006) and Patel et al. (2008).

Percentage of large sized tuber (%)

Percentage of large sized tuber was found to be highly and significantly ($P<0.01$) influenced by varieties (Table 2). Belete (17.35) produced significantly highest percentage of large sized tuber, while Jalenie (1.68) produced significantly the lowest percentage of large sized tuber (Table 3). This variation observed for percentage of large sized tuber could be genetically controlled. This result is similar to the finding of Habtamu et al. (2016) who confirmed that significantly highest number of large size tubers in percentage was calculated for Belete variety grown in eastern Ethiopia. Bilate and Mululalem (2016) also reported that large sized tuber

Table 2. Mean square values on some quality response variables of Potato (*Solanum tuberosum* L.).

Source of variation	DF	Tuber size categories (%)			Dry matter content (%)	Specific gravity (g/cm^3)	pH	Protein content (%)	Starch content (%)
		Small tuber (%)	Medium tuber (%)	Large tuber (%)					
Variety	8	213.02**	70.44**	83.44**	11.98**	0.00025**	0.026^{ns}	1.39**	9.97**
Block	2	3.27	6.13	2.24	0.78	0.000018	0.036	0.05	0.65
Error	16	0.73	1.57	1.99	0.45	0.0000099	0.03	0.06	0.38
Total	26	-	-	-	-	-	-	-	-
CV (%)	-	3.61	1.84	16.99	3.62	0. 29	1.77	9.12	5.17

In the column mean square values showed that **=highly significant at 5% level of probability, ns=non-significant at 5% level of probability, CV= coefficient of variation, DF=degree of freedom.

Table 3. Mean values of small, medium and large tuber percentage of improved potato varieties.

Variety	Tuber size category		
	Small tuber (%)	Medium tuber (%)	Large tuber (%)
Jalenie	30.06^{C}	68.26^{CD}	1.68^{E}
Belete	10.47^{E}	72.18^{B}	17.35^{A}
Degemegn	20.80^{D}	67.85 ^{CD}	11.35^{C}
Chala	29.95^{C}	66.39^{DE}	3.66^{DE}
Shenkola	20.42^{D}	65.54^{EF}	14.043^{B}
Gorebela	32.19^{B}	64.09 ^{F}	3.72^{DE}
Gera	21.11^{D}	69.91^{C}	8.99^{C}
Gudanie	13.59^{E}	77.443^{A}	8.97^{C}
Maracharre	34.35^{A}	60.68^{G}	4.97^{D}
$LSD_{0.05}$	1.48	2.17	2.44
CV (%)	3.61	1.84	17

Means followed by different letters in the same column are significantly different at 5% level of probability.

number per hill was significantly influenced by varieties. In general, the observed significant variations among the varieties for tuber size distribution may be attributed to inherent potential of the varieties.

Tuber dry matter content and specific gravity

Dry matter content and specific gravity of the potato tubers were very highly and significantly ($P < 0.01$) influenced by varieties (Table 2). Variety Gudanie produced the highest percentage of dry matter (21.67%), closely followed by Chala, Gera and Gorebela, which showed the same dry matter content (20%). Whereas the lowest value was recorded from Maracharre and Jalanie with 15.83% dry matter content. Similarly, the highest specific gravity was obtained for Gudanie (1.084) variety, followed by Gera, Gorebela and Chala, which showed the same value (1.080), and the lowest value (1.06) was observed for Jalanie and Maracharre varieties (Table 4). This variation in tuber dry matter content and specific gravity may be attributed to inherent genetic differences among the potato varieties in the production of dry matter (total solids) contents of tubers. This result is in confirmation with the report of Tekalign and Hammes (2005) who observed significant variation among cultivars with respect to total dry matter production.

Dry matter contents and specific gravity are important parameters of the potato tubers quality. According to Rommens et al. (2010) tubers with high specific gravity and dry matter generally give higher yields of French fries or chips of low oil absorption and better texture and are more economical to process. Processing of potato tuber into different products require tubers with dry matter contents greater or equal to 20% and specific gravity of greater or equal to 1.08 (Lefort et al., 2003; Abebe et al., 2013).

High dry matter has a direct effect on chips and French fries yield as the weight of the processed product depends directly on the amount of dry matter present per quantitative weight of fresh potatoes. Therefore, based on specific gravity and dry matter content selection criteria, from the tested varieties Gudanie, Chala, Gorebela and Gera meet these requirements and observed to be suitable for processing.

Table 4. Mean value of dry weight, specific gravity, starch content and crude protein content as affected by potato varieties.

Variety	Dry matter content (%)	Specific gravity (g/cm^3)	Starch content (%)	Crude protein content (%)
Jalenie	15.83^D	1.06^D	9.36^D	3.17^{AB}
Belete	17.50^C	1.07^C	10.89^C	3.14^{AB}
Degemegn	18.33^C	1.07^C	11.65^C	3.28^A
Chala	20.00^B	1.08^B	13.17^B	1.82^D
Shenkola	18.33^C	1.07^C	11.65^C	2.56^C
Gorebela	20.00^B	1.08^B	13.17^B	1.65^D
Gera	20.00^B	1.08^B	13.17^B	2.77^{BC}
Gudanie	21.67^A	1.084^A	14.69^A	3.27^A
Maracharre	15.83^D	1.06^D	9.36^D	1.82^D
$LSD_{0.05}$	1.1674	0.0055	1.065	0.4119
CV (%)	3.62	0. 29	5.17	9.12

Means followed by different letters in the same column are significantly different at 5% level of probability.

Total starch content (%)

There was highly significant (P<0.01) variation among the tested varieties with respect to total starch content (%) (Table2). Accordingly, Gudanie had significantly the highest total starch content (14.69) than the other varieties. This is followed by Chala, Gera and Gorebela which showed the same value (13.17%) and the lowest total starch content was observed for Maracharre and Jalanie (9.36%) (Table 4). The results are in line with that of Tsegaye (2014) who reported that the total starch contents of potato tubers are significantly influenced by potato genotypes. The significant differences in the tuber total starch contents among the potato varieties in this study could be attributed to varietal differences as suggested by Storey and Davies (1992) who reported that concentration and desired functional properties of starch could be achieved by the selection of potato cultivar. Potato varieties with a starch content of 13% and above are the most preferred for processed products (Kirkman, 2007). Thus, from the tested varieties, Gudanie, Chala, Gera and Gorebela had total starch content of 13% and above indicating that they are fit for processing.

Crude protein contents (%, dry matter basis)

Crude protein contents was significantly (P<0.01) affected by the varieties (Table 2). Variety Degemegn (3.28%) and Gudanie (3.27%) are statistically similar and were found to have the highest total crude protein contents as compared to the rest of the varieties (Table 4). The lowest crude protein contents were observed for the variety Gorebela (1.65%) and Chala (1.82%). This variation in the protein contents of the potato varieties in this study may have occurred due to differences in the varieties. The crude protein (N × 6.25) represents in tubers approximately 2% of a fresh weight that creates approximately 10% of dry matter, however, the crude protein content ranges significantly in dependence on genotype and growing conditions (Bártová, 2009).

Conclusion

The result of the current study revealed that potato varieties significantly affected all the tested quality attributes of potato tuber. According to this study result, with regard to tuber size distribution, Gudanie and Belete varieties were superior in percentage of medium sized tuber in decreasing order, whereas Belete and Shenkola in decreasing order showed high percentage of large sized tuber. On the other hand, the least percentage of small tuber size was observed for variety Belete followed by Gudanie. The highest value of dry mater content (21.67%), specific gravity (1.08) and starch content (14.69%) was observed for Gudanie variety. In addition to this, Gera, Gorebela and Chala varieties have also showed the acceptable range for processed products. In terms of protein content, Degemegn (3.28%) and Gudanie (3.27%) depicted significantly the highest value followed by Jallenie (3.17%) and Belete (3.14%). Therefore, it can be concluded from this study that for the majority of potato tuber quality attributes, variety Gudanie performed best in producing attractive and marketable tubers with superior processing quality. In addition to this, variety Belete can also be selected for its good marketable tubers whereas Gera, Gorebela and Chala varieties can also be grown for their acceptable processing quality.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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