Greener Journal of Plant Breeding and Crop Science

ISSN: 2354-2292

Submitted: 23/10/2015
Accepted: 30/10/2015
Published:26/03/2016

Subject Area of Article: Agriculture
DOI: http://doi.org/10.15580/GJPBCS.2016.2.102315148

Evaluation of Processing Attributes of Potato (*Solanumtuberosum* L.) Varieties in Eastern Ethiopia

By

Habtamu G
Wahassu M
Beneberu S

Greener Journal of Plant Breeding and Crop Science **ISSN: 2354-2292** Vol. 4 (2), pp. 037-048, March 2016.

Research Article (DOI: http://doi.org/10.15580/GJPBCS.2016.2.102315148)

Evaluation of Processing Attributes of Potato (*Solanumtuberosum* L.) Varieties in Eastern Ethiopia

Habtamu G[1]*, Wahassu M[2] and Beneberu S[3]

[1]Awada Agricultural Research Sub-Center, P.O.Box 205, Yiregalem, Ethiopia.
[2]Haromaya University P.O.Box 138, Dire Dawa, Ethiopia.

*Corresponding Author's Email: habteline @gmail .com; Mobile: +251 922 490 318

ABSTRACT

In Ethiopia, a number of improved potato varieties have been released by different research centers; with much emphasis on adaptability, productivity and late blight resistance, while it has been given less or no emphasis to processing attributes. Therefore, field and laboratory experimentwas conducted at Haramaya, Hirna and Arberekete; allin Eastern Ethiopia to evaluate processing quality attributes of 16 released varieties (Moti, Belete, Bubu, Ararsa, Gudenie, Bule, Gabissa, Marachare, Harchassa, Gera, Gorrebella, Guassa, Jalenie, Bedassa, Zemen & Chiro) and two local cultivars (Bette & Jarso). The experiment was laid in a Randomized Complete Block Design with three replications. Chips were prepared by frying tubers with sunflower oil, which was evaluated by the consumer panelists. The results revealed the significant variations in most of the traits. The highest peel content (22.147%) were observed for Bedassavariety and total sugar content (1.058%) was observed for Jarso cultivar, reducing sugar (0.0618%) was recorded for Bette cultivar. The maximum rate for sweetness (2.84), saltiness (2.36), soreness (2.32) and bitterness (2.44) were observed for chips made from potato slices of Bubu, Gorrebella, Gorrebella, Ararsage no types respectively. Jarso, Bedassa, Motiand Jarsoscored the maximum rate for color (3.88.) crispness (3.24) and flavor (4.44), texture (3.24) respectively. Zemen (7.40) very much liked, as judged from over all acceptability. This study result reviled that the genotype and growing environment has a great influence on processing quality of potato tubers. Finally it is suggested that the import ance of testing genotypes across location to recommend varieties for specific end uses; potato processer and producer in eastern Ethiopia better to look for Belete, Gorobella and Bubuvarieties; which were found to be superior in processing quality attributes in a decreasing order listed here.

Keywords: Chips, interaction effect, variety, sensory attributes, quality, Consumer panelist.

INTRODUCTION

In Ethiopia, Potato is commonly consumed in the form of boiled and cooked meals in different traditional dishes or 'wot'. Recently, consuming potato chips, crisps, and roastedpotato has become common practices; especially in cities like Addis Ababa, Hawassa, Adama, Mekele, etc. In urban areas, it is also usually consumed mixed with other vegetables as salad (Bezabih and Mengistu, 2011). Large scale potato processing is under the process of establishment in Ethiopia. In large cities like Addis Ababa, it is common to see hotels, restaurants and cafes prepare homemade French fries and Chips from potato. Whenever urban consumers go out for recreation, they often prefer go along French fries and chips for snacks. The street vendors also prepare chips that are supplied to consumers at dusk. Meanwhile, the economic importance of potato manufacturing industries has not yet been attained; and quality potato varieties for processing have not been identified.

There are distinct expectations on the part of consumers for certain types of potatoes to have specific cooking qualities. Therefore, before selecting a variety for processing for instance, Chips, growers should consider the market potential and quality characteristics as well as the ability for producing potatoes with high specific gravity (Kimondo, 2007).

Every factor that is a part of the environment has the potential to cause differential performance which is associated with genotype x environment interaction in potatoes. The entire variable encountered in producing a crop can be collectively called environment and every factor that is a part of the environment has the potential to cause differential performance that is associated with genotype, and genotype to environment interaction in potatoes (Fehr, 1987). In addition, the available evidences indicate that the genetic factors inherent in a variety determine the cooking quality of potato within the range of influence exerted by the climate. Since, the cooking qualities of potatoes needed by the processor for different types of food are so specific, it is essential to improve and select the varieties suitable for different processed product (Irene *et al.,* 1964).

In Ethiopia, a number of improved potato varieties have been released by different research centres and institutions. These varieties are widely grown in different growing environments of the country and used for preparation of traditional food types. In developing the varieties, much emphasis was given for adaptability, productivity per unit area and late blight resistance, while less or no emphasis was given to physicochemical and processing attributes in relation to end uses. This showed that the need to study released varieties whether they meet or not the demand of potato tuber qualities for specific market and processed produce like Chips. This has urged to evaluate chips making quality of the released varieties under Hararghe condition. This helps to identify the varieties for processing quality and generating information that could be utilized as a yardstick in variety development for processing. Therefore, this study was conducted with the following objective:

- To evaluate the processing qualities of released potato varieties

MATERIAL AND METHODS

Description of the study area

The field experiment was conducted under rain fed conditions during the year 2012 main cropping season at Haramaya, Hirna and Arberekete; all in Eastern Ethiopia. The latitude, longitude and altitude of the experimental sites are indicated in Table 1.

Experimental treatment and design

A total number of 18 potato genotypes were used for the experiment (Table 2). The experiment was laid out as a Randomized Complete Block Design (RCBD) with three replications. Each plot was 3.60m x 4.50m = 16.2m^2 wide consisting of six rows, which accommodated 12 plants per row and thus 72 plants per plot. The spacing between plots and adjacent replication was 1m and 1.5m, respectively. At each site, medium sized (39-75g) Lung'aho *et al.*, (2007) and well sprouted tubers were planted at the spacing of 75 cm between ridges and 30cm bet ween tubers.

Fertilizer was applied as the recommendation made by Haramaya University, which Phosphorus and Nitrogen fertilizer was applied at the rate of 92kg P_2O_5 ha^{-1} and 75kg ha^{-1}respectively. Potato plants were treated with Mancozeb 80% WP at the rate of 1.5 kg ha^{-1} diluted at the rate of 40 g per 20 litre water once a week to control late blight disease. All other cultural practices were applied according to the regional (Haramaya University) recommendation.For data estimation, tubers were harvested from middle rows, leaving the plants growing in the two border rows as well as those growing at both ends of each row to avoid edge effect.

Table 1: Descriptions of the experimental sites

Site	Latitude	Longitude	Altitude (m)
Haramaya	09°26' N	043°03'E	1980
Hirna	09°12' N	041°02'E	1870
Arberekete	09°14'N	041°46'E	2280

Table 2: Description of potato genotypes

No	Variety	Released year	Breeder/Maintainer center	Recommended Altitude (m.a.s.l.)
1	Moti	2011	Sinnana	2400-3350
2	Belete	2010	Holeta/East Africa	1600-2800
3	Bubu	2010	HaramayaUinversity	1700-2000
4	Ararsa	2006	Sinnana	2400-3350
5	Gudenie	2006	Holeta	1600-2800
6	Bule	2005	Awassa	1700-2700
7	Gabisa	2005	HaramayaUinversity	1700-2000
8	Marachere	2005	Awassa	1700-2700
9	Harchasa	2004	HaramayaUinversity	1700-2000
10	Gera	2003	Sheno	2700-3200
11	Gorrebella	2002	Sheno	2700-3200
12	Guassa	2002	Adet	2000-2800
13	Jalenie	2002	Holeta	1600-2800
14	Bedasa	2001	HaramayaUinversity	1700-2400
15	Zemen	2001	HaramayaUinversity	1700-2400
16	Chiro	1998	HaramayaUinversity	1700-2400
17	Bette	-	Local cultivar	-
18	Jarso	-	Local cultivar	-

Data Collection

Peel content (%): Ten fresh tubers were randomly selected from each plot, weighted and peeled. The peel of the tubers was weighted. The mean weight of single tuber and peel content was calculated and the percentage peel was computed as follows:

Peel content (%) = $\frac{\text{Peel content}}{\text{Weight of tuber}}$ x 100

Total soluble solids (^{0}Brix): The Brix of the raw potato samples was determined, using a method as described by Pardo *et al.,* (2000)that is hand refractometer. The Brix was measured in the juice obtained after washing, crushing and extracting juice of the tuber samples.

Reducing: Reducing sugars was estimated by using the colorimetric methods of Somogyi *et al.* (1945) as presented by (Tilahun, 2002). The potato juice was extracted from the sample by using juice extractor. 10 mlJuice was added to 15 ml of 80% ethanol; mixed and heated in boiling water bath for 40 minutes. After extraction, 1 ml saturated Pb $(CH_3COO)_2\ 3H_2O$ and 1 ml Na_2HPO_4 was added and the content mixed by gentle shaking and filtered. The filtered extract was made up of 50 ml with distilled water. An aliquot was diluted to 25 ml with 1 ml copper reagent in a test tube and heated for 20 minutes in a boiling water bath. The heated content was cooled under running tap water without shaking. Arsenomolybdate color reagent (1 ml) was added to the cooled content and the volume made up of 10 ml with distilled water and left for about 10 minutes to allow colour development; after which, the absorbance was determined by a UV-VIS spectrophotometer (Model: 6505, SN: 2019, U.K) at 540 nm.A blank was prepared using distilled water.

$$\mathrm{Re}\,ducing\ \ sugar = \frac{1}{slope} \times \frac{absorbancy}{weight\ of\ sample} \times \frac{volum\,made\,up}{aliquat\,taken} \times \frac{1}{1000}$$

Total sugar: Total sugars were estimated by using the colorimetric methods of Somogyi *et al.* (1945) as presented by (Tilahun, 2002). The juiceprepared for reducing sugar analysis was used for total sugar analysis. Juice (10ml) was added to 15 ml of 80% ethanol; mixed and heated in boiling water bath for 30 minutes. After extraction, 1 ml lead acetate and 1.5ml distilled water added and the solution was filtered. The filtered extract was made up of 50 ml with distilled water; and then 1 ml 1 normal HCl mixed and heated in boiling water bath for 30 minutes. After cooling the extract, drop of phenophtalin, drop of 1 normal NaOH and drop of 0.1 normal of HCl added to the solution and the content mixed by gentle shaking and filtered. An aliquot was diluted to 25 ml with 1 ml copper reagent in a test tube and heated for 20 minutes in a boiling water bath. The heated content was cooled under running tap water without shaking. Arsenomolybdate color reagent (1ml) was added to the cooled content made up of 10 ml with distilled water and left for about 10 minutes to allow colour development, after which the absorbance was determined by a UV-VIS spectrophotometer (Model: 6505, SN: 2019, U.K) at 540 nm.A blank was prepared using distilled water.

$$Total\ \ sugar = \frac{1}{slope} \times \frac{absorbancy}{weight\ of\ \ sample} \times \frac{volum\ made\ up}{aliquat\ taken} \times \frac{1}{1000}$$

Frying processes:

Potato slices of 1.2 to 1.5 mm thick were prepared as per procedures described by Lisinka *et al.* (2007). Before frying, the frying oil was heated for about 15 minutes at the required temperature of180 ± 5℃ which was measured using thermometer. The slices were fried using a fryer for about five minutes until the bubbling ceases and all experiments were carried out in three replications.

Organoleptic evaluation of fried potato chips:

Sensory evaluation was performed on potato chips. They were fried which were fried using sunflower oil. Organoleptic evaluation of chips was carried out for each variety at each location. A 50 member panelists consisting of students and faculty staff members of the University, were voluntarily selected to rate the quality attributes. Prior to the sensory tests, the panelists were given orientation for a short period of time which was supposed to help them in evaluating the attributes of the chips.

A 5-point hedonic test was used to measure taste (sourness, bitterness, saltiness and sweetness), color, texture and crispness (Kita, 2002). A 9-point hedonic test was employed to assess flavour and overall acceptability of chips according to Yost *et al.* (2006).

The potato chips from each variety was coded with three-digit cods, placed randomly in coded plates (plastic trays) and served to each panelist at 2 pm. Water was provided to the panelists to rinse their mouth before and between testing samples as suggested by Watts *et al.* (1989), and the evaluation were repeated 3 times for each sample. Supervisors were placed in different places to avoid communication among panelists during the evaluation and to give them short and precise description how to score chips for taste, texture, appearance, color, flavor and overall acceptability whenever they need.

Data analysis

The data were subjected to analysis of variance (ANOVA) using the general linear model (GLM) of the statistical analysis system (SAS) statistical package. As suggested by Watts *et al.*, (1989), in analyzing the sensory data, the 5-point hedonic scale and the 9- point hedonic scales were used and the numerical values for each sample were tabulated and analyzed by ANOVA to determine whether significance differences in mean degree of scoring points exist among the samples or not.

RESULT AND DISCUSSION

Peel content, reducing sugar and total sugar content of potato

The growing environment, genotype and their interaction significantly ($P < 0.01$) influenced the peel content, total sugar & reducing sugar of tubers (Appendix Table 1).

Significant maximum tuber peel content was recorded for Bedassa (22.147%) grown at Arberekete; whereas significant minimum tuber peel content was registered for Guasa (14.39%) variety grown at Haramaya (Table 3).

Potatoes are usually peeled during processing, which may be accomplished either by steam, abrasive, or lye peeling, depending on the product to be produced. The by-products can be divided in cull potatoes; those are whole potatoes which are not meant for human consumption, and potato processing waste, derived from the manufacturing of potato based products. On one side, the peels, which are the major portion of processing waste, represent a severe disposal problem to the potato industry, especially since the wet peels are prone to rapid microbial spoilage (Charmley E. *et al.*, 2006).

The peeling condition is dependent on surface characteristics of potatoes such as eye depth, cortex thickness and surface injuries (Lisinska, 1989). The control of the peeling operation is essential as insufficient peeling may result in poor appearance of the chip (Bennett, 2001).Deep eye depths lead to heavy losses during peeling and trimming and overall lowered yields of cull (Smith, 1987; Kabira and Lemaga, 2006).

Total and reducing sugar content

The significant highest total sugar content was recorded for Jarso (1.058%) at Hirna whereas significantly lowest total sugar content was registered for Moti (0.114%) grown at Arberkete. The significant maximum reducing sugar content was recorded for Jarso (0.0618%) at Arberekete; whereas a, a significant minimum reducing sugar content was registered for Bubu (0.0081%) at Haramaya.

Factors, such as environmental (e.g. temperature), or cultural practices (e.g. mineral nutrition, harvesting and storage conditions), genetic component have a strong influence on reducing sugar levels in a mature tuber as well as in the rate of conversion during storage (Kumar *et al.*, 2004).

Reducing sugars react with amino acids in non-enzymic browning during frying of crisps to give them a golden brown colour. The levels of reducing sugars and amino acids present in the potato therefore determine the extent of the brown colour formation. Very high levels of reducing sugars would result in undesirable dark brown crisps as opposed to the required golden brown colour (Abong*et al.*, 2009). Potatoes intended for chip production should have a reducing sugar level below 0.35 mg/g (or 0.035%) of fresh tuber weight. Accordingly, Jarso (0.0619%) and Bette (0.040%) grown at Arberkete; Bette (0.0428%), Jalenie (0.0369%) and Jarso (0.0358%) grown at Haramaya; and Jarso (0.0473%), Marachare (0.0402%), Bette (0.0396%), Jalenie (0.0384%) and Moti (0.0366%) grown at Hirna are not suitable for chips production. However, according to combined analysis, except Jarso (0.0447%) and Bette (0.0366%) of the two farmers' local cultivars, all other verities in these studies can be intended for chips production.

Sweetness, saltiness, sourness and bitterness of potato chips

Sweetness: The location, the genotype and the interaction significantly ($P<0.01$) influenced the sweetness, saltiness, sourness and bitterness of potato chips (Appendix table 1).The significantly maximum rate for sweetness was recorded for Bubu (2.84) grown at Arberekete while minimum rate for sweetness was registered for Gabissa (1.76) grown at Haramaya (Table 4). In vegetables, sweetness is a stimulant for consumption (Dinehart *et al.*, 2006).

Saltines: A significant maximum rate for saltiness was recorded for Gorobella (2.36) at Arberekete whereas significant minimum rate for saltiness was registered for Chiro (1.44) at Haramaya (Table 4). Salt enhances the positive sensory attributes of foods, even in some otherwise unpalatable foods; it makes them "taste" better. This study was in agreement with (Gillette, 1985), who reported that in relation to potato chips, salt was found to improve the perception of the product thickness, enhance sweetness, mask metallic or chemical off-notes, and round out overall flavor while improving flavor intensity.

Sourness: A significant maximum rate for sourness was recorded for Gorobella (2.32) at Arberekete, whereas significant minimum rate for sourness was registered (1.31) for Jalenie, Bedassa, and zemen all grown at Haramaya (Table 4). This finding contradicts with the findings of (Elfinesh, 2008) who reported that the growing environment, varieties and their interaction did not significantly influence the sourness of the chips.

Bitterness: A significant maximum rate for bitterness was recorded for Ararsa (2.44) at Hirna, whereas significant minimum rate for bitterness (1.04) were registered for Bedassaat Haramaya and Gudenie grown at Arberkete (Table 4). The result of the current study was supported by previous work of (Elfinesh, 2008) who reported that interaction of growing environment and varieties significantly influence the bitterness of chips. In vegetables, bitterness is considered a deterrent for consumption (Dinehart *et al.* 2006). Unlike fruits, potato tubers have evolved mechanisms to deter consumption. Toxic glycoalkaloids in wild potato tubers produce a strong bitter taste, providing protection against pests and disease (Valkonen *et al.*, 1996). Domestication has been selected for the low levels of bitterness in potato tubers (Johns and Alonso 1990), but they still contain glycoalkaloids. The major glycoalkaloids in commercial potato cultivars are oc-solanine and oc-chaconine (Bushway and Ponnampalam 1981). The upper limit allowed for a new cultivar release is 20mg/100g fresh weight, bitterness can be tested in tubers with glycoalkaloid levels higher than 14mg/100g (Sinden *et al.*, 1976).

Table 3: The interaction effect of environment and genotype on sourness and bitterness of potato chips

	Tuber peel content (%)			Total sugar (%)			Reducing sugar (%)		
Variety	Haromaya	Arberkete	Hirna	Haramaya	Arberkete	Hirna	Haramaya	Arberkete	Hirna
Moti	14.44^{ef}	16.08^{cb}	12.79^{ef}	0.254^{bcd}	0.114^{h}	0.535^{bcd}	0.0341^{bcd}	0.0131^{hi}	0.0366^{abc}
Belete	17.94^{ab}	16.87^{cb}	19.01^{ab}	0.228^{bcd}	0.124^{h}	0.221^{ef}	0.0159^{ij}	0.0153^{ghi}	0.0248^{bcde}
Bubu	15.25^{def}	16.20^{cb}	14.30^{cdef}	0.120^{e}	0.105^{h}	0.264^{def}	0.0081^{k}	0.0106^{i}	0.0294^{abcd}
Ararsa	15.76^{cdef}	16.49^{cb}	15.03^{cdef}	0.234^{bcd}	0.219^{ef}	0.152^{f}	0.0273^{efg}	0.0204^{efgh}	0.0176^{cde}
Gudenie	14.91^{def}	14.17^{c}	15.65^{cde}	0.193^{cde}	0.270^{cde}	0.204^{f}	0.0132^{ijk}	0.0251^{d}	0.0224^{bcde}
Bule	17.71^{abc}	18.20^{b}	17.21^{abc}	0.231^{bcd}	0.298^{c}	0.150^{f}	0.0176^{hi}	0.0343^{bc}	0.0141^{de}
Gabisa	15.25^{def}	17.69^{b}	12.44^{f}	0.234^{bcd}	0.288^{cd}	0.131^{f}	0.0218^{gh}	0.0311^{cd}	0.0131^{de}
Marachere	16.83^{abcd}	18.65^{b}	15.01^{cdef}	0.254^{bcd}	0.147^{gh}	0.596^{b}	0.0328^{bcde}	0.0160^{fghi}	0.0402^{ab}
Harchasa	16.46^{bcde}	18.02^{b}	14.90^{cdef}	0.284^{bc}	0.287^{cd}	0.278^{cdef}	0.0251^{fg}	0.0260^{cde}	0.0361^{abc}
Gera	18.58^{a}	17.43^{cb}	19.73^{a}	0.229^{bcd}	0.220^{ef}	0.571^{b}	0.0164^{hij}	0.0212^{efgh}	0.0267^{cde}
Gorrebella	14.91^{def}	15.99^{cb}	13.83^{def}	0.174^{de}	0.192^{fg}	0.126^{f}	0.0090^{k}	0.0178^{efghi}	0.0094^{e}
Guassa	14.39^{f}	15.88^{cb}	12.91^{ef}	0.248^{bcd}	0.225^{ef}	0.174^{f}	0.0302^{cdef}	0.0234^{defg}	0.0179^{cde}
Jalenie	17.36^{abc}	17.92^{b}	16.79^{bcd}	0.324^{b}	0.224^{ef}	0.557^{bc}	0.0369^{b}	0.0217^{efgh}	0.0384^{ab}
Bedasa	17.88^{ab}	22.42^{a}	13.35^{ef}	0.188^{cde}	0.200^{f}	0.209^{ef}	0.0106^{jk}	0.0197^{efghi}	0.0226^{bcde}
Zemen	16.59^{abcd}	19.01^{b}	14.18^{cdef}	0.187^{cde}	0.313^{cb}	0.501^{bcde}	0.0094^{k}	0.0346^{bc}	0.0364^{abc}
Chiro	14.52^{ef}	17.07^{cb}	11.97^{f}	0.243^{bcd}	0.245^{def}	0.278^{cdef}	0.0288^{def}	0.0247^{def}	0.0324^{abcd}
Bette	16.25^{bcdefg}	18.09^{b}	14.41^{cdef}	0.329^{b}	0.348^{b}	0.228^{ef}	0.0428^{a}	0.0400^{b}	0.0396^{ab}
Jarso	15.33^{def}	16.58^{cb}	14.07^{cdef}	0.441^{a}	0.418^{a}	1.058^{a}	0.0359^{bc}	0.0618^{a}	0.0473^{a}
Significance	**	**	**	**	**	**	**	**	**
CV (%)	6.49	9.85	10.96	21.54	11.85	34.86	14.29	19.59	26.2

*, & ** = Significant at P<0.05 and P<0.01, respectively.
CV (%) = Coefficient variation in percent.

Means followed by the same letter with in a column are not significantly different

Table 4: The interaction effect of environment and genotype on sourness and bitterness of potato chips

	Sweetness			Saltiness			Sourness			Bitterness		
Variety	Haramaya	Arberkete	Hirna	Haramaya	Arberkete	Hirna	Haramaya	Arberkete	Hirna	Haramaya	Arberkete	Hirna
Moti	2.48^{abc}	2.60^{abc}	2.00^{f}	1.60^{def}	2.16^{ab}	2.04^{abcde}	1.60^{abc}	1.96^{bcd}	1.76^{abc}	1.44^{abc}	1.80^{abc}	1.96^{bc}
Belete	2.15^{efg}	2.36^{bcde}	2.08^{ef}	1.59^{def}	2.04^{bcd}	2.00^{bcde}	1.59^{abc}	1.84^{bcde}	2.00^{a}	1.63^{a}	1.68^{abcd}	1.72^{cdefgh}
Bubu	2.00^{fgh}	2.84^{a}	2.24^{cdef}	2.00^{b}	2.12^{ab}	1.92^{cde}	1.68^{ab}	1.88^{bcd}	1.72^{abc}	1.36^{abcd}	1.52^{bdc}	2.08^{b}
Ararsa	1.88^{gh}	2.52^{bcd}	2.24^{cdef}	1.84^{abcde}	2.08^{abc}	1.96^{bcde}	1.56^{abc}	2.00^{bc}	1.48^{c}	1.44^{abc}	1.80^{abc}	2.44^{a}
Gudenie	2.28^{bcdef}	2.40^{bcde}	2.12^{ef}	1.88^{abcd}	1.84^{cde}	2.20^{ab}	1.76^{a}	1.84^{bcde}	1.92^{ab}	1.44^{abc}	1.40^{d}	2.00^{bc}
Bule	2.04^{fg}	2.12^{e}	$2.20d^{ef}$	1.60^{def}	1.80^{def}	1.92^{cde}	1.64^{abc}	1.72^{def}	1.48^{c}	1.36^{abcd}	1.92^{a}	1.88^{bcd}
Gabisa	1.76^{h}	2.68^{ab}	2.16^{def}	1.96^{ab}	2.12^{ab}	2.16^{abc}	1.44^{abc}	2.00^{bc}	1.84^{ab}	1.32^{abcd}	1.60^{abcd}	1.84^{bcde}
Marachere	2.36^{bcde}	2.36^{bcde}	2.00^{f}	1.68^{abcde}	2.20^{ab}	2.08^{abcd}	1.64^{abc}	1.88^{bcd}	1.92^{ab}	1.32^{abcd}	1.80^{abc}	1.64^{defghi}
Harchasa	2.20^{def}	2.32^{cde}	2.12^{ef}	1.84^{abcde}	1.76^{f}	1.88^{de}	1.68^{ab}	1.60^{ef}	1.64^{bc}	1.28^{bcd}	1.48^{dc}	2.00^{bc}
Gera	2.54^{ab}	2.32^{cde}	2.68^{ab}	1.92^{abc}	2.32^{ab}	1.96^{bcde}	1.42^{bc}	1.84^{bcde}	1.64^{bc}	1.42^{abc}	1.72^{abcd}	1.44^{hij}
Gorrebella	2.04^{fg}	2.08^{e}	2.68^{ab}	1.88^{abcd}	2.36^{a}	1.56^{f}	1.52^{abc}	2.32^{a}	1.60^{bc}	1.32^{abcd}	1.80^{abc}	1.20^{j}
Guassa	2.17^{def}	2.24^{ed}	2.00^{f}	1.83^{abcde}	1.80^{def}	1.92^{cde}	1.38^{bc}	1.56^{f}	1.72^{abc}	1.17^{cd}	1.68^{abcd}	1.56^{efghi}
Jalenie	2.12^{efg}	2.52^{bcd}	2.40^{cd}	1.76^{abcde}	1.56^{f}	2.00^{bcde}	1.32^{c}	1.76^{cdef}	1.80^{abc}	1.28^{bcd}	1.52^{bdc}	1.52^{fghi}
Bedasa	2.00^{fgh}	2.36^{bcde}	2.76^{a}	1.64^{cdef}	2.16^{ab}	1.96^{bcde}	1.32^{c}	1.92^{bcd}	1.72^{abc}	1.04^{d}	1.84^{ab}	1.40^{ij}
Zemen	2.68^{a}	2.48^{bcd}	2.28^{cde}	1.56^{ef}	2.20^{ab}	1.96^{bcde}	1.32^{c}	2.04^{b}	1.60^{bc}	1.40^{abc}	1.56^{bdc}	1.48^{ghi}
Chiro	2.26^{cdef}	2.52^{bcd}	2.12^{ef}	1.44^{f}	2.20^{ab}	2.24^{a}	1.41^{bc}	1.88^{bcd}	1.84^{ab}	1.44^{abc}	1.68^{abcd}	1.64^{defghi}
Bette	$2.43a^{bcd}$	2.64^{abc}	2.48^{bc}	1.74^{abcde}	2.04^{bcd}	1.88^{de}	1.57^{abc}	2.00^{bc}	1.80^{abc}	1.39^{abc}	1.48^{dc}	1.76^{bcdef}
Jarso	2.64^{a}	2.40^{bcde}	2.48^{bc}	1.88^{abcd}	2.20^{ab}	1.80^{e}	1.52^{abc}	1.96^{bcd}	1.60^{bc}	1.56^{ab}	1.68^{abcd}	1.80^{bcdef}
Significance	**	**	**	**	**	**	**	**	**	**	**	**
CV (%)	19.78	20.06	17.55	25.16	21.09	18.53	32.31	21.30	28.15	36.04	31.56	25.44

Table 5: The interaction effect of growing environment and genotype on color and texture of potato chips

	Color			Texture			Crispness			Flavor		
Variety	Haramaya	Arberkete	Hirna	Haramaya	Arberkete	Hirna	Haramaya	Arberkete	Hirna	Haramaya	Arberkete	Hirna
Moti	2.92^{c}	1.16^{fg}	3.16^{bc}	2.92^{cde}	2.60^{bcde}	2.72^{bcdef}	2.60^{d}	2.28^{def}	2.60^{fg}	4.20^{a}	2.84^{abcd}	4.44^{a}
Belete	2.22^{fghi}	1.36^{fg}	2.64^{ef}	2.60^{f}	2.16^{f}	2.24^{h}	1.75^{i}	1.96^{g}	2.00^{k}	3.04^{defg}	2.68^{cde}	4.16^{b}
Bubu	1.16^{j}	1.12^{g}	2.84^{de}	2.68^{ef}	2.40^{d}	2.44^{efgh}	2.20^{ij}	2.00^{fg}	2.20^{ijk}	3.60^{b}	2.68^{cde}	3.16^{efg}
Ararsa	2.48^{defg}	1.84^{e}	2.32^{g}	3.00^{bcd}	2.64^{bcde}	2.96^{b}	2.63^{d}	2.32^{de}	3.68^{b}	2.96^{defg}	3.04^{abcde}	2.80^{h}
Gudenie	2.20^{ghi}	2.88^{bc}	2.56^{fg}	2.76^{def}	2.56^{bcde}	2.48^{efgh}	2.13^{fgh}	2.24^{defg}	2.20^{ijk}	2.92^{fgh}	3.16^{a}	3.48^{d}
Bule	2.40^{efgh}	3.32^{b}	2.00^{h}	2.80^{def}	2.44^{cdef}	2.80^{bcde}	2.20^{fg}	2.04^{efg}	2.84^{ef}	2.56^{ij}	2.76^{abcd}	3.32^{de}
Gabisa	2.40^{efgh}	3.24^{b}	1.68^{i}	2.92^{cde}	2.72^{bcd}	2.52^{efgh}	2.48^{de}	2.40^{cd}	2.24^{ijk}	3.28^{cd}	2.56^{de}	4.12^{bc}
Marachere	2.72^{cd}	1.40^{fg}	3.88^{a}	2.87^{cdef}	2.76^{bc}	2.92^{bc}	2.36^{def}	2.72^{b}	3.16^{d}	2.60^{ij}	2.84^{abcd}	3.96^{bc}
Harchasa	3.00^{c}	3.16^{bc}	3.00^{cd}	2.89^{cdef}	2.60^{bcde}	2.84^{bc}	2.36^{def}	2.24^{defg}	2.96^{de}	3.24^{cde}	2.64^{cde}	3.88^{c}
Gera	2.24^{fghi}	2.20^{d}	3.28^{b}	2.84^{def}	2.48^{cde}	2.56^{defg}	2.28^{efg}	2.16^{defg}	2.36^{hig}	3.21^{cdef}	2.96^{abc}	2.80^{h}
Gorrebella	1.28^{j}	1.40^{fg}	1.40^{j}	2.76^{def}	2.36^{ef}	2.28^{gh}	2.16^{fgh}	1.96^{g}	2.12^{jk}	3.08^{cdefg}	3.04^{ab}	2.84^{h}
Guassa	2.64^{de}	2.40^{d}	2.48^{fg}	2.76^{def}	2.48^{cde}	2.56^{defg}	2.08^{gh}	2.08^{efg}	2.44^{ghi}	2.38^{j}	2.64^{cde}	3.28^{def}
Jalenie	3.00^{c}	2.32^{d}	3.16^{bc}	2.79^{def}	2.52^{cde}	2.80^{bcde}	2.19^{fgh}	2.20^{defg}	2.64^{fg}	2.96^{defg}	2.44^{e}	3.40^{de}
Bedasa	2.12^{hi}	1.44^{f}	2.56^{fg}	3.17^{abc}	2.72^{bcd}	2.88^{bc}	2.96^{c}	2.60^{bc}	3.12^{d}	3.36^{bc}	2.88^{abcd}	3.40^{de}
Zemen	1.96^{i}	3.36^{b}	3.08^{bcd}	2.68^{ef}	2.60^{bcde}	2.96^{b}	1.92^{hi}	2.32^{de}	3.40^{c}	2.68^{hi}	2.72^{abcd}	3.00^{gh}
Chiro	2.52^{de}	2.44^{d}	2.96^{cd}	2.92^{cde}	2.68^{bcde}	2.64^{cdef}	2.40^{def}	2.32^{de}	2.44^{ghi}	2.89^{gh}	2.68^{cde}	2.88^{h}
Bette	3.83^{b}	4.28^{a}	2.64^{ef}	3.24^{ab}	2.88^{b}	2.96^{b}	3.36^{b}	2.80^{b}	3.80^{ab}	2.96^{defg}	2.92^{abc}	3.32^{de}
Jarso	4.56^{a}	4.40^{a}	3.88a	3.32^{a}	3.24^{a}	3.32^{a}	4.44^{a}	3.20^{a}	4.00^{a}	3.60^{b}	2.48^{e}	3.04^{fgh}
Significance	**	**	**	**	**	**	**	**	**	**	**	**
CV (%)	18.67	20.74	15.46	16.64	19.49	17.68	17.35	19.15	14.68	15.34	18.46	14.34

Color, texture, crispness, flavor and over all acceptability

Colour: Growing environment and varietal interaction influenced significant for colour, texture, crispness and flavour of chips (Table 5). The highest colour score values were recorded for Jarso (3.88) at Hirna, whereas significant minimum rate for colour was registered for Gorobella (1.14) grown at Hirna. This study in line with previous result of (Anon., 2010), who reported that potatoes with high reducing sugar levels make dark fries which is not liked by the consumers. Fried potato colour is the result of Millard, non-enzymatic browning reactions that depend on the superficial reducing sugar content, and the temperature and frying period (Marquez and Anon, 1986). Similarly, Yost *et al.* (2006) reported that color development in potatoes in conjunction with thermal processing methods such as frying or baking is the result of Maillard browning.

Texture: Statistically, maximum rate for texture was recorded for Jarso (3.24) grown at Arberekete whereas significantly, minimum rate for texture was registered for Belete (2.60) at Haramaya (Table 5). Cultivar affects starch concentration and thus texture. Potatoes high in sugar have a poor/soft texture after cooking (Adams, 2004). A mealy potato is dry and granular while a waxy potato is moist gummy. Texture is influenced by starch content (Van Marle *et al*., 1997). Pandey *et al*., (2004), evaluated that the texture of fries were affected by dry matter and reducing sugar content. Potatoes having more dry matter show mealiness when processed types (Mehdi, *et al.,* 2008).

Crispness: Significantly, maximum rate for crispness was recorded for Jarso (3.32) at Arberekete whereas significantly, minimum rate for crispness was registered for Belete (1.96) as well as Gorobella (1.96) both were grown at Arberkete Table 5). Lisinska and Leszynski (1998) has established that crispy texture is associated with the dry matter content of raw potato tubers, chips obtained from potatoes rich in dry matter (above 25%) can exhibit hard textures whereas, crispiness of chips made from potatoes with low dry matter are characterized by greasy and sticky textures. Kita (2002) reported that the percentage of the dry matter in potatoes for crisp production should be 20-25% and that of starch should be more than 15%. For potato chips, a very crispy texture is expected since it is an indicator of freshness and high quality (Moreira *et al*., 1999).

Flavour: This study results revealed that the judges assigned a highest score of the chips flavour was recorded for Moti (4.44) at Hirna whereas, the significant minimum rate for flavor was registered for Guassa (2.38) at Haramaya (Table 5). The differences among the genotypes may be due to their differences in genetic makeup for flavour and a growing environmental factor. This result was supported by Pardo*et al*., (2000) and Abong *et al*., (2009), who investigated and reported that values obtained for each of the varietal sensory characteristics of flavor, significantly differed among cultivars due to their genetic make-ups.

Potato flavor involves the combination of taste, aroma, and texture. The flavour precursors synthesized by the plant are present in the raw potatoes and consist mainly of sugars, amino acids, RNA, and lipids. Plant genotype, production environment, and storage environment influence the levels of these compounds and the enzymes that react with them to produce the flavour compounds. During cooking, the flavor precursors react to produce the Maillard reaction compounds and the sugar, lipid and RNA degradation products that contribute to the flavour (Duckham *et al*., 2001).

Over all acceptability: The overall acceptability of the potato chips was significantly ($P< 0.05$) influenced by the growing environment and genotype but not significantly influenced by the interaction (Table 6). The potato chips consumer panelist judges ranged from 6.67 (like moderately) in Moti as long to 7.40 in Zemen (like very much). Next to Zemen, Marachare (7.3) and Bule (7.25) provided the highest score of overall acceptability, while Jarso (6.75) and Bette (6.77) provided the lowest score of overall acceptability. The highest mean score of overall acceptability for genotype was observed for Arberekete (7.3) growing site while lowest mean specific gravity was observed for Haramaya (6.86) (Table 6).

Consumers respond differently regarding preference of sensory attributes of a product (Guinard*et al*., 2001). Therefore expressing preference (overall liking) interims of a mean value will fail to account for inter individual differences (Guinard*et al*., 2001). Thus, it was important to investigate the direction of preference for the consumers (internal preference mapping) and sensory attributes influencing their preference (external preference mapping).

Table 6: Effects of the growing environment and the genotype on the overall quality of potato chips

Treatment	Parameter
Location	Over all acceptability
Arberkete	7.30[a]
Haromaya	7.05[b]
Hirna	6.86[c]
Level of significance	**
Variety	
Moti	6.67[c]
Belete	7.02[abc]
Bubu	7.19[ab]
Ararsa	6.96[abc]
Gudenie	6.98[abc]
Bule	7.25[ab]
Gabisa	7.12[abc]
Marachere	7.302[a]
Harchasa	7.24[ab]
Gera	7.07[abc]
Gorrebella	7.21[ab]
Guassa	7.07[abc]
Jalenie	7.12[abc]
Bedasa	7.02[abc]
Zemen	7.40[a]
Chiro	7.21[ab]
Bette	6.77[bc]
Jarso	6.75[bc]
Level of significance	*
CV	16.05

*, & ** = significant at P<0.05 and P<0.01, respectively. Means followed by the same letter with in a column are not significantly different.

SUMMARY AND RECOMMENDATION

The result of the study revealed that the genotype and the growing environment have a great influence on peel content, total sugar content, reducing sugar content and chips quality of a potato tuber. Since, the peels are the major portion of processing waste and represent disposal problem to the potato industry, as well as prone to rapid microbial spoilage; Potato producer and processor have to look for Gera, Belete, Bedasa at Haramaya; Bedasa, Zemen, Marachere at Arberekete; and Gera Belete and Jalenie at Hirna growing environment. As sugar content increased, the colour of chips became darker and the taste of chips was also poor. According to the consumer sensory evaluation, the texture, colour, crispness, of chips was lower for high reducing sugar and total sugar content genotypes. According to overall acceptability of potato chips, consumer panelist preferred potato chips made from Marachare, Bule, Harchassa, and Gorrebela in decreasing order listed here; potato chips processer have to look those varieties. Since environment has significant influence on processing attributes, the environmental genotype interaction should be taken into consideration in developing varieties suitable for processing.

ACKNOWLEDGMENT

I am profoundly grateful to the Haramaya University potato research program for sponsoring and covering all the financial expenses needed for this study. My special gratitude goesto Haramaya University field assistances' for their unreserved support and substantial contribution to the accomplishment of my job peacefully. I am also grateful to horticulture laboratory workers AbebawuKabite, Tsehay H/mariam, YimenashuKasaye and AberaGirma for their cooperation and assistance during the laboratory work. I am very much indebted to the Department of Food Science and Postharvest Technology, Soil Science and Horticulture of Haramaya University, for the permission granted meto use laboratory facilities for quality analysis and for their technical support during the work.

REFERENCE

Abong G.O., OkothM.W., KaruriE.G., KabiraJ.N. and Mathocko F.M., (2009). Influence of potato cultivar and stage of maturity on oil content of French fries (chips) made from eight Kenian potato cultivars. *Afri. J. Food Agric. Nutrition*, 9(8).

Adams J.,(2004).Raw materials quality and the texture of processed vegetables.*In*: *Texture in Foods, Solid Foods*. (Ed.): D. Kilcast, Woodhead Publ. Ltd.: Cambridge, 2: 342-363.

Bennett R.M., (2001). Managing potato crisp processing.*In*; *Rossell, J. B.* (Ed.) *Frying:Improving Quality. CRC Press*: Florida. 215-235.

Bezabih E. and Mengistu N.,(2011). Potato Value Chain Analysis and Development in Ethiopia Case of Tigray and SNNP Regions.International Potato Center (CIP-Ethiopia).

Bushway R.J, PonnampalamR.,(1981). Alpha-chaconine and alpha-solanine content of potatoproducts and their stability during several modes of cooking.*J.Agric Food Chem*29(4):814-7.

Dinehart M.E., HayesJ.E., BartoshukL.M., LanierS.L., DuffyV.B.,(2006). Bitter taste markers explain variability in vegetable sweetness, bitterness and intake. *PhysiolBehav*87:304-13.

Duckham S.C., Dodson A.T., Bakker J., Ames J.M.,(2001). Volatile flavour components of baked potato flesh: A comparison of eleven potato cultivars. *Food/Nahrung*45:317-23.

Elfinesh F., (2008). Processing quality of improved Potato (*Solanumtuberosum*L.) varieties as influenced by growing environment, genotype and blanching. An M. Sc. Thesis submitted to the school of graduate studies of Haramaya University.

FAOSTAT DATA, (2014).Agricultural data. Provisional 2012 Production Indices Data.Crop Primary. (http://apps.fao.org/default.jsp).

Fehr W.R., (1987). Principles of Cultivar Development.Theory and Technique. Mcgram- hill, New York. 368p.

Gillette M., (1985).Flavor effects of sodium chloride.J. *Food Technology* 1985; 39(6):47–52.

Guinard J.,UotaniB., &Schlichp., (2001). Internal and external mapping of preferences for commercial large beers: Comparison of hedonic ratings by consumers blind versus with knowledge of brand and price. Food quality and preference, 12, 243-255.

Irene, H., StuckeyR., TuckerE., and SheehanJ.E., (1964).Cooking qualities of Rhode Island potatoes.*Am. Potato. J.* 41: 1-13.

Johns T, AlonsoJ.G.,(1990). Glycoalkaloid change during the domestication of the potato, *Solanum*section Petota. *Euphytica*50:203-10.

Kabira J.N. and LemagaB.,(2006). Potato Processing: Quality Evaluation procedures for research and food industries applications in East and Central Africa. Kenya Agricultural Research Publication, Nairobi, Kenya.10 p.

Kimondo N.E., (2007). Sensory quality of deep fat fried potato chips manufactured from potatoes with different physic-chemical characteristics. MSc thesis in food science submitted to university of Pretoria, South Africa.

Kumar D., SinghB.P.& Kumar P., (2004).An overview of the factors affecting sugar content of potatoes. Annals of Applied Biology, 145, 247-250.

Lisinska G., (1989). Manifacture of potato chips and french fries. In: Lisinka, G. & Leszcyns ki, W. (Eds.) *potato Science and Technology*. Elsevier Science Publisher: London, 166-233.

Marqueez G. and Anon M.C., (1986). Influence of reducing sugars and amino acids in the color development of fried potatoes. *J. Food Sci.* 51: 157-160.

Mehdi M., SaleemT., RaiH.K., MirM.S. andRaiG.,(2008).Effect of nitrogen and FYM interaction on yield and yieldtraits of potato genotypes under Ladakh condition.*Potato J.*, 35(3&4): pp. 126-129.

Moreira, R.G., Castell-perez M.E.,&Barrueft M.A., (1999).Deep-Fat frying; Fundamentals and Applications. Aspen Publishers: Gaithersburg, 75-108.

Smith O., (1987). Potato chips. In: Tarbut W.F., Smith O., editors. Potato processing. 4thed. New York: Van Nostrand Reinhold Co., Inc. p 371-490.

Sinden, S.L, DeahlK.L., AulenbachB.B.,(1976). Effect of glycoalkaloids and phenolics on potato flavor. / *Food Sci*41(3):520-3.
Tilahun S., (2002). The improvement of the shelf life of vegetables through pre and post harvest treatment. Ph.D. Thesis Presented to the University of Free State. South Africa. 270p.
Valkonen J.P. Keskitalo T,M., VasaraT., PietilaL.,(1996). Potato glycoalkaloids: A burden or a blessing? *Crit Rev Plant Sci*15(1):1-20.
Van Marle J.T., Smits T.S., DonkersJ., Dijk C.V., Voragen A.G.and RecourtK.,(1997). Chemical and microscopic characterization of potato (*solanumtuberisum* L.) cell walls during cooking. J. Agric. food chem., 45:50-58.
Lisinska G., Tajner-Czopek A., Kalum L., (2007). The effect of enzymes on fat content and texture of French fries. J. Food Chem., 102: 1055-1060.
Pandey S.K., SingS.V., KumarP. and ManivelP.,(2004). Sustaining potato chipping Industry from western and central Uttar Pardesh: Adoption of suitable varieties.*Potato J*., 31(3-4): 119-127.
Pardo J.E., AlvarruizA., PerezJ., GomezR. and VaronR., (2000). Physical- chemical and sensory quality evaluation of potato varieties.J. Food Quality. 23: 149-160.
Charmley E., Nelson D., Zvomuya F., (2006).Nutrient cycling in the vegetable processing industry; utilization of potato by-products.*Canadian J. of soil science***86** 621-629.
Watts B.M., Ylimaki G.L., JefferiL.E. and Elias L.G., (1989). Basic Sensory Methods for Food Evaluation, The International Development Research Center, Ottawa, Canada, 160p
Yost M., Abu-AliJ.M. andBarringerS.A., (2006). Kinetics of potato color and texture development during backing, frying, and microwaving with the addition of liquid smoke. J. Food Sci. 71.

Cite this Article: Habtamu G, Wahassu M and Beneberu S (2016). Evaluation of Processing Attributes of Potato (*Solanumtuberosum* L.) Varieties in Eastern Ethiopia. Greener Journal of Plant Breeding and Crop Science, 4(2): 037-048, http://doi.org/10.15580/GJPBCS.2016.2.102315148

APPENDIX TABLE

Appendix table 1Mean squares for chips sensory attribute parameters of potato genotypes grown at Haramaya, Hirna and Arberkete and their interaction

		Mean square												
S.V	d.f	Peel content	Total Sugar	Reducing Sugar	**Color**	Texture	Crispness	Flavor	Sweetness	Saltiness	Sourness	Bitterness	Over all acceptability
Var	17	16.57**	0.1106**	0.0142**	34.18**	1.623**	7.3525*	4.717**	1.24**	0.559**	0.538**	1.114**	2.2126*
Loc	2	84.95**	0.2051**	0.0083**	12.10**	8.996**	26.32**	44.5**	5.17**	10.59**	15.43**	17.558**	17.35**
Var*Loc	34	5.867**	0.0516**	0.0073**	9.573**	1.270**	7.152**	3.732**	1.42**	0.913**	0.608**	1.0273**	1.7829^{ns}
Error	106	2.239	0.0092	0.0012	0.219	0.237	0.183	0.221	0.197	0.172	0.213	0.239	1.289

** Significant at P < 0.01, * Significant at P < 0.05, ns non-significant at P < 0.05 probability level. S.V: source of variation, d.f: degree of freedom.