OPEN ACCESS Freely available online

Agrotechnology

ISSN: 2168-9881

Research Article

Physico-chemical and Sensory Characterization of Pineapple (*Ananas comosus (L.) Merr*) Varieties in Southwest Ethiopia

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ABSTRACT

Pineapple makes a significant contribution to food security and medicinal importance in developing countries. In Ethiopia, there is insufficient scientific study on physico-chemical composition and sensory characterization of pineapple. To fill these knowledge gaps, this study was conducted to assess the physico-chemical and sensory characterization of pineapple varieties in Ethiopia. Flour from fruit of five varieties collected and the samples run in duplicates. Data on five biochemical traits were collected and subjected to various data analysis. Results of the mean performance indicated significant variation ($p \leq 0.01$) among the traits on all tested varieties considered. The mean fruit moisture contents ranged from 83.5 to 87.1% with a mean of 85.57%. The ranges of dry matter (12.90 to 18.34%), titratable acidity (0.16 to 1.13%), pH (3.15 to 3.84) and total soluble solids (12.20 to 14.40%), The principal component analysis grouped the variables into five components based on five traits among which the first two are significant (Eigen value >1) and explained 74.46% of the total variability. From all traits, titratable acidity, moisture contents and total soluble solids contributed maximally to the PCs. This variation is attributed to environmental and genetic factors. Further, investigation of the existed pineapple varieties based on molecular marker analysis is vital for better assessment of genetic diversity of pineapple in Ethiopia.

Keywords: Characterization; Food security; Pineapple; Physico-chemical

INTRODUCTION

Pineapple (*Ananas comosus (L.) Merr*) is a perennial herb in the botanical family Bromeliaceae.It is native to South America where the original seed species (wild) are still grown [1]. It is the second most important fruit crop after bananas and contributing over 20 % of the world tropical fruits production [2] and 51% of world global fruit market [3]. It is a major tropical fruit with an estimated about 24.78 million metric tons of global pineapple production in 2012 [4]. Of total fruit production, 70% of the pineapple is consumed as fresh fruit and the remaining 30% used as chunks, slices, juices, syrups, jams, crushed, diced pineapple in major producing countries. Further, wastes from processed of pineapple fruit are now further processed into sugar, wines, vinegar, animal feed during the dry season. The leaves of pineapple have high quality fiber for manufacture of luxury cloth, making rope, fishing nets and pulp in the paper industry. The fruit of pineapple have rich in digestible carbohydrates, fat, vitamins A, C and essential minerals. Besides, pineapple fruit stimulates digestion and the proper performance of the small intestine and kidneys; it helps in detoxification, normalizes colonic flora, helps in hemorrhoid alleviation, and prevents constipation (due to the fiber content of the pulp). It has been used to heal colds, mouth, throat and bronchial infections. The suitability of pineapple as food stores on ships and medical ingredients greatly facilitated their distribution throughout the world. Currently, *Annanas* is a pan tropical genus and different species have been independently domesticated across continents.

In Ethiopia pineapple is first introduced in the 1940's by a religion church at Sidama and Gedeo zones of southern region. Currently the crop cultivated by small scale farming mainly in South and South-Western parts of the country and the average yield of the crop is below 50 tons/ha as compared to global average fruit yield of 63 t/ha [5]. The crop is mainly grown in Ethiopia to ensure food and nutrition security. According to Central Statistical Authority [6], about 104,421.81 hectares of land covered by fruit crops and 7,774,306.92 quintals yield produced. Of these, pineapple contributed 0.18 %, and 0.58% distribution. Different factors that contributed directly and indirectly for low yield: lack of improved pineapple technologies adapted to diverse environmental conditions, lack of information on the biochemical composition of pineapple genotypes/varieties poor marketing system, and lack of improved post-harvest handling technologies are few to mention [7]. These factors can also influence the quality of harvested fruit and ultimately the final products made from pineapple. To increase the

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Received: August 10, 2021; **Accepted:** August 24, 2021; **Published:** August 31, 2021

Citation: Mulualem T, Semman N, Etana G (2021) Physico-chemical and sensory characterization of pineapple (*Ananas comosus (L.) Merr*) varieties in Southwest Ethiopia. Agrotechnology 10: 219.

productivity of the crop, better understanding on the economic, food security and nutritional importance of pineapple through analysis physico chemical and sensory characteristics are needed to boost pineapple production, which minimize poverty and improve the livelihood security of rural households in the country.

In regarding to the quality, to the best of our knowledge, there are no efforts so far done in the physico-chemical properties of pineapple in Ethiopia and information on the proximate and mineral composition of the existed varieties are scarce. Furthermore, the sensory attributes of the existing pineapple varieties have never been assessed and the nutritional importance of pineapple at country level hardly unknown; which hinders the wider utilization and researchers to access the mineral and proximate composition of pineapple in the country. Thus, exhaustive imagery of pineapple varieties based on biochemical composition and sensory characterization have tremendous impact to make genetic enhancement and sustainable use of pineapple genetic resource in Ethiopia. Consequently, the present study was designed to assess the physico-chemical and sensory characterization of pineapple from Southwest Ethiopia for breeding and further utilization.

MATERIALS AND METHODS

Study area

The study was conducted at Jimma Agricultural Research Center (JARC). The center located at latitude 7° 40.00' N and longitude 36° 47'.00' E with an altitude of 1753 m.a.s.l. The area received mean annual rainfall of 1432 mm with the maximum and the minimum temperature of 26.5 °C and 12.00 °C, respectively. The soil of the study area is Eutric Nitosol (reddish brown) with pH of 5.63. This environmental condition makes conducive for pineapple production.

Soil sampling and analysis

Fifteen core soil samples randomly collected from 0-30cm top soil and bulk to form a composite sample. The collected samples were air dried, crushed and allowed to pass through a 2 mm sieve. Particle size distribution was carried out by the hydrometer method, while soil pH in soil solution ratio 1:2 in 0.01M C_aCl_2. Soil organic carbon was determined by the Walkey and Black method and total N by the micro-Kjeldahl digestion method [8]. Available P was determined by Bremmer and Mulraney, extraction method. Exchangeable bases were extracted with neutral 1M NH_4OAC at soil solution ratio of 1:10 and measured by flame photometry. Exchangeable acidity was determined by titration of 1M KCL extract against 0.05M NaOH to a pink end point using phenolphthalein as indicated by [9]. The soil sample analysis was conducted at JARC soil and plant tissue laboratory.

Experimental materials, design and management

For this study, five pineapple varieties namely: Smooth cayanne, Red-spanish, Queens, MD-2 and Sugarloaf which are grown in Southwest Ethiopia was used for the study. Slips of the same size from each variety planted in a RCBD with three replications with double row planting pattern of 30 × 60 ×90 cm between plants, paired rows and between rows, respectively. The gross plot size for each treatment was $9m^2$ (3 m × 3 m). One month after planting, seedlings were earthed up, followed by frequent weeding. All other agronomic practices were followed according to the recommendation.

Samples collection and preparation

Samples collected from five plants from each pineapple variety. Pineapple fruits were weighed, peeled, cut into small pieces and dried at 65°C for 72 hours until constant weight was obtained (10%). The dried chips were then milled using an electric grinder to obtain fine powder pineapple flour. The flour was sieved through 1 mm sieve, measured and packed into airtight plastic bag and stored in the refrigerator until used for analysis. The quality analysis was conducted at Jimma University College of Agriculture and Veterinary Medicine (JUCAVM) post-harvest and nutrition laboratory.

Quality analysis

The analyses were carried out using Juice form the fruit of pineapple. The samples were run in duplicates and the mean value was used. The fruit moisture content, dry matter, titratable acidity, pH, and total soluble solids (TSS) were determined in accordance with the standard methods of the AOAC [10]. The fruit flour moisture content was determined by the standard analytical method AOAC [11]. Duplicate fruit samples (100 g) were weighed in aluminum dishes and oven dried at 65°C for three days. The dried samples were cooled in a desiccator's room temperature and weighed. The fruit moisture content was determined by loss of weight due to drying was converted to percent flour moisture content as follows: Fruit moisture %=(weight of moisture evaporated/weight of fruit sample) ×100. The fruit dry matter content of pineapple was calculated by taking a representative duplicate sample of about 100 g (W1) prepared by thoroughly mixing sliced pieces from fruit was oven dried at 65°C for 72 hours and weighed (W2) and the value was expressed in percentage [12]. The percentage dry matter content was calculated as: % Dry matter= (W2/W1) × 100. Or % Dry matter=100 - % moisture content. Titratable acidity was assessed as outlined by AOAC 962.12 method. The pineapple peel extract contains a number of organic acids, which are readily neutralized by strong bases and can be titrated against standard bases such as sodium hydroxide. A 10ml sample of pineapple peel extract was weighed. Then, the sample was transferred in to a 500 ml Erlenmeyer flask. The sample was diluted to 250 ml with deionized water. Using a standard solution of 0.1 N sodium hydroxide, the sample was titrated to the end point. The end point was determined using a phenolphthalein indicator. One ml of phenolphthalein indicator was added to the sample and titrated until faint pink end point was observed. The volume of 0.1 N sodium hydroxide used was recorded. The total acidity can be calculated using equation and expressed as concentration of citric acid (g/l). The measurement was repeated at least three times. The percentage of citric acid was calculated according to the following expression: % Acid (as anhydrous citric acid) = Volume of 0.1 N NaOH (ml) × 0.64 / 10. The pH of the pineapple peel extract was determined using a pH meter (pH 211 Microprocessor pH meter Hanna) at room temperature. Total soluble solids were determined using a refractometer (Digital ABBE Refractometer, Kruss Optronic) [13]. A drop of the solution was squinted on the prism of refractometer. The percentage of TSS was obtained from direct reading of the instrument.

Data analysis

The collected data were subjected to analysis of variances and treatment means separated by Least Significant Difference (LSD) by using Statistical Analysis System (SAS) package [14].

RESULTS AND DISCUSSION

Soil physico-chemical property

The result of the soil physico-chemical properties of the study area was presented in the result revealed, the soil of study area is sandy clay with low N and available P, its characterization indicated soil p^H 5.65 in water, 0.539 g kg^1 N, 3.27 g kg^1 organic C. 0.691 ppm available P, 1.969 meq/100g K, 5.636 % organic matter, 0.120 meq/100g exchangeable acidity and 22.76 meq/100g CEC. Particle size distributions were 52% sand, 36% clay and 12% silt (Table 1).

Analysis of variance

The analysis of variance (ANOVA) was performed to determine the physicochemical and sensory quality attributes of the pineapple varieties at Jimma as presented in the result on the analysis of variance indicated, mean squares due to variety were non-significant ($p \geq 0.05$) difference for all tested physico-chemical traits considered in this study (Table 2).

Mean performance quality traits

The mean performance of quality attributes and pineapple varieties indicated significant variation ($p \leq 0.01$) among all traits considered. TSS is an important quality factor for many fruits during ripening. The soluble solids content is also used as an indication of fruit maturity and quality. Senescence is enhanced by increasing sugar content in fruits. Soluble solids are also known to impact sweetness index than does the total sugars [15]. For total soluble solids, variety MD-2 and Smooth cayenne were best performed varieties due to highest value of total soluble solids with its value of 14.4 and 14.2%, respectively. Variety queens recorded lowest (12.20%) total soluble solids value. The variability among pineapple varieties in respect to TSS also revealed wide chance of developing pineapple varieties possessing desirable quality traits. The other varieties sugar loaf and red Spanish produced the moderate TSS value. The result obtained from this study was similar with the report Nadya *et al.*, [16].

Table 1: Physico-chemical properties of top soil (0-30cm) of experimental fields of Jimma.

No	Physico-chemical composition	
1	% Sand	52
2	% Silt	12
3	% Clay	36
4	Textural class	Sandy clay
5	p^H (H_2O)(1:2:5)	5.65
6	Organic carbon	3.269
7	Available P (ppm)	0.691
8	Total N (g/kg)	0.539
9	Available K (meq/100g)	1.969
10	%Organic matter	5.636
11	Exchangeable acidity (meq/100g)	0.12
12	CEC (meq/100g)	22.76
13	Exchangeable AL^{+++} (meq/100g)	Trace

Table 2: Analysis of variance of different quality traits of pineapple from Southwest Ethiopia.

Quality traits	Mean square		CV	R2
	Variety	Error		
MC (%)	288.41	196.3	17.6	0.57
DM (%)	1.51	0.76	6.1	0.6
TA(%)	0.004	0.0008	19.3	0.56
pH	0.98	0.34	13.5	0.73
TSS (%)	12.20	0.34	4.16	0.83
	NS			

MC= Moisture content, DN= Dry matter, TA= Titratable acidity, TSS= Total soluble solids

The pH of pineapple fruit extract with different varieties is presented in (Table 3). There was significant difference among pH values for all tested varieties. The mean pH value ranged from 3.15 (Red Spanish to 3.84 Sugar loaf. This result was consistent with the report of Nadzirah *et al.*, who reported the pH value of pineapple Variety N36 ranged from 3.0 to 6.5. The low pH value on variety Red Spanish may attribute to high weak acids like citric acid and malic acid and sodium, potassium and calcium salts concentration in the fruit. Variety Sugarloaf had the maximum pH value 3.84. This variability mainly depends on the maturity stages and the concentration hydrogen ion of the fruit. As the fruit matured, the pH was increased and contributed less acidity to the pineapple fruit. While, when concentration increased, the acidity increased due to the increase in hydrogen ions present in the solution. Hydrogen ions determined the degree of acidity. As the concentration of hydrogen ions were reduced, so it was expected pH value to increase. Fruit pH increases at the high rate of respiration by accelerated acid metabolism and accumulated cations [17]. Further, the pH values obtained also reflected a significant extent to the microbial stability of the various varieties.

Based on TA contents, significant difference among pineapple varieties observed. Red Spanish contained the maximum (1.13%) total TA while the minimum value observed from Sugarloaf (0.16%). TA was evaluated to determine the citric acid in pineapple fruit extract. TA reflecting fruit quality and good indicator of the sourness. In pineapple, TA is reported as citric acid, not malic acid. It varies primarily with fruit developmental stages but does not relatively respond to short term environmental changes, while the malic acid varies with environmental changes especially the light [18]. It has been suggested that during storage, fruits utilize organic acids for metabolic activities and this results in a decrease in the TA content during the storage periods. The report further explained the decrease in acidity coincided with an increase in sugar concentration in the pomegranate fruits (Table 3).

Further, Joomwong et al., [19] suggested that a slow decrease in acidity, concomitant with increased TSS and total sugar content, is an intrinsic process during ripening of fruits to impart the flavor [20].

During ripening, organic acids are respired or converted to sugars and acid levels decline. The TSS and acid content are the factors influencing consumption quality. From all varieties considered, MD2 and Queens had high moisture contents with value of 87.10 and 86.83%, respectively. However, Red Spanish and sugar loaf had lowest moisture content.

Principal component analysis

The patterns of variation and the relative importance of each quality trait in explaining the observed variability was assessed through principal component analysis (PCA). The result of PCA

Table 3: The mean quality traits of pineapple varieties grown at Jimma.

Variety	MC	DM	TA	pH	TSS
Smooth cayanne	85.86[b]	14.20[b]	0.26[b]	3.51[d]	14.20[b]
MD-2	87.10[a]	12.90[d]	0.19[c]	3.77[b]	14.40[a]
Queens	86.83[a]	13.06[d]	0.18[d]	3.75[c]	12.20[e]
Sugarloaf	84.60[c]	15.13[b]	0.16[e]	3.84[a]	13.30[c]
Red spanish	83.50[c]	18.34[a]	1.13[a]	3.15[e]	13.64[d]
Mean± Se	85.57±3.74	14.73±0.93	0.38±0.09	3.60±0.76	13.55±0.76
CV (%)	0.49	0.62	4.55	0.1	0.11
LSD (5%)	0.85	0.32	0.22	0.01	0.012

MC= Moisture content (%), DN= Dry matter (%), TA= Titratable acidity, TSS= Total soluble solids (%)

Table 4: Eigen values, proportion, cumulative variance and component scores of the first five principal components for quality traits in five varieties of pineapple.

Variables	PC-1	PC-2	PC-3	PC-4	PC-5
Eigen value	2.113	1.639	0.806	0.263	0.207
Proportion	42.27	32.19	16.13	5.27	4.14
Cumulative	0.422	0.744	0.905	0.958	1
Moisture contents (%)	-0.074	0.669	0.482	0.494	-0.261
Dry matter (%)	0.408	-0.51	0.391	0.55	0.34
TA	0.635	-0.125	-0.053	-0.081	-0.755
pH	0.395	0.375	-0.695	0.376	0.278
TSS (%)	0.517	0.366	0.357	-0.55	0.408

grouped the variables into five components based on five quality traits, among which the first two are significant (Eigen value>1) and explained 74.46% of the total variability (Table 4).

The first principal component (PC-1) accounted 42.27% of the total variation and was correlated positively with dry matter (0.408), titratable acidity (0.635), pH (0.395) and total soluble solids (0.517), while only moisture contents (-0.074) contributed negatively. The second principal component (PC-2) accounted 32.19% of the total variability and mainly correlated with moisture contents (0.669), pH (0.597), and total soluble solids (0.366) and negatively with the titratable acidity (-0.125) and dry matter (-0.510). The third principal component (PC-3) had 16.13% of the total variation. The total moisture content contributed (0.482), dry matter (0.391) and total soluble solids (0.357), while PC-4 accounted 5.27% of the variation and correlated positively with moisture content (0.494), dry matter (0.550) and pH (0.376). Finally, PC-5 had 4.14% of the variation and negatively correlated with moisture content (-0.261) and titratable acidity (-0.755).

CONCLUSION

The mean performance of quality attributes and pineapple varieties indicated significant variation ($p \leq 0.01$) among all traits considered. For total soluble solids, variety MD-2 and Smooth cayenne were best performed varieties due to highest value of total soluble solids with its value of 14.4 and 14.2%, respectively. The variability among pineapple varieties in respect to TSS also revealed wide chance of developing pineapple varieties possessing desirable quality traits. The principal component analysis grouped the variables into five components based on five traits among which the first two are significant (Eigen value>1) and explained 74.46% of the total variability. From all traits, titratable acidity, moisture contents and total soluble solids contributed maximally to the PCs. This variation is attributed to environmental and genetic factors.

ACKNOWLEDGMENTS

We are grateful thanks to EIAR and JARC for the financial support of this study. We also thank to Jimma University College of Agriculture and Veterinary Medicine (JUCAVM) post-harvest and nutrition laboratory staffs who gave us all help we needed during laboratory work.

REFERENCES

1. Tewodros M, Mesfin S, Getachew W, Ashenafi A, Neim S. Effect of inorganic N and P fertilizers on fruit yield and yield components of pineapple (Annanas comosus Merr L. Var. Smooth cayanne) at Jimma, Southwest Ethiopia. Agrotechnology. 2018;7(1):1-6.
2. Hanafi MM, Halimah A. Nutrient supply and dry-matter partitioning of pineapple cv. Josapine on sandy tin tailings. Fruits. 2004;59(5):359-366.
3. Amador JR. Laboratory manual procedures for analysis of citrus products. Florida, USA. JBT FoodTech. 2008.
4. FAO. FAOSTAT database. Food and Agriculture Organization, Roma, Italy. 2013.
5. Spironello A, Quaggio JA, Teixeira LA, Furlani PR, Sigrist JM. Pineapple yield and fruit quality effected by NPK fertilization in a tropical soil. Rev Baraos Jabt. 2004;26:155-159.
6. CSA (Central Statistical Agency). Ethiopian agricultural sample enumeration for Oromia region: Statistical report on population size, density and area coverage of Jimma zone, Addis Ababa, Ethiopia. J. Agric. Appl. Econ. 2019;2(1):1-7.
7. Tewodros M, Tadesse E, Getachew W, Mesfin S, Addisu B. Pineapple production, postharvest utilization and marketing, production manual. Amharic version, EIAR. 2014.
8. Bremmer JM, Mulraney CS. Nutrient Total In: Methods of soil analysis. 1982;l:565-624.

9. Maclean EO. Soil pH and lime requirement. In: methods of soil analysis part 2. Madison, USA. Amer Soc Agro. 1982;10: 199-234.

10. AOAC. Association of Official Agricultural Chemist, Official Methods of Analysis, (17th edn), Horowitz edition intern, Maryland, USA. 2000.

11. AOAC. Official Methods of Analysis. Association of Official Analytical Chemists, (14th edn), Arlington. 1984.

12. Cozzolino D, Labandera M. Determination of dry matter and crude protein contents of undried forages by near-infrared reflectance spectroscopy. J Sci Food Agr. 2002; 82(4):380-384.

13. AOAC. Association of Official Agricultural Chemist, Official Methods of Analysis, (15th edn), Washington DC, U.S.A. 1990.

14. SAS Institute. Statistical Analytical Systems SAS/STAT user's guide version 9 cary NC: SAS Institute inc. 2000.

15. Wardy W, Saalia FK, Steiner-Asiedu M, Budu AS, Sefa-Dedeh S. A Comparison of Some Physical, Chemical and Sensory Attributes of Three Pineapple (*Ananas comosus*) Varieties Grown in Ghana. Afr J Food Sci. 2009;3(1):022-025.

16. Hajar N, Zainal S, Nadzirah KZ, Roha AS, Atikah O, Elida TT. Physicochemical properties analysis of three indexes pineapple (Ananas Comosus) peel extract variety N36. APCBEE Procedia. 2012;4:115-121.

17. Fernando MF, De Silva PH. Post- harvest handling of mauritius pineapple (Ananas Comosus. L. Merr) at ambient temperature. Annals of the Sri Lanka Department of Agriculture. 2000;4:359-366.

18. Chuenboonngarm N, Juntawong N, Engkagul A, Arirob W, Peyachoknakul S. Changing in TSS, TA and sugar contents and sucrose synthase activity in ethephon-treated 'Pattavia'pineapple fruit. Agric Nat Resour. 2007;41(2):205-212.

19. Joomwong AD, Sornsrivichai J. Impact of cropping season in northern Thailand on the quality of smooth cayenne pineapple. II. Influence on physico-chemical attributes. Int J Agri Biol. 2006;8(6):330-336.

20. Tehrani M, Chandran S, Hossain AB, Nasrulhaq-Boyce A. Postharvest physico-chemical and mechanical changes in Jambu Air (Syzygium aqueum Alston) fruits. Aust Crop Sci. 2011;5(1):32-38.