Diversity Analysis Based on Morphological Traits of Different Mango Accessions Collected from Selected Areas in the Philippines

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ABSTRACT---- ***Morphological variation and diversity of different mango accessions across seven mango growing areas in the Philippines was assessed and analyzed using Shannon-Weaver Diversity Index (SWDI). The fruits from 208 mango collections were characterized using International Plant Genetic Resources Institute (IPGRI) Descriptors for mango and evaluated for diversity using SWDI on the basis of 21 morphological traits, eight of which were qualitative and 13 were quantitative traits. Most mango varieties and accessions had elliptic fruit shape, good to average fruit attractiveness, yellow skin, yellow orange pulp, intermediate texture, juicy, mild aroma, and very good eating quality.Fourteen percentwere observed to have a red skin color in different shades which varies from greenish yellow with red blush to reddish purple.Based on the result of descriptive statistics, significant variation was observed in 13 quantitative traits from among 208 mango accessions evaluated. The mean SWDI for qualitative traits was H' = 0.63 with pulp aroma being the most diverse (H'=0.84)and skin color of ripe fruit being the least diverse (H=0.37). Significant diversity (H'=>0.70)was also observed in all quantitative traits except for fruit thickness having H'=0.61 diversity index. The mean SWDI for both qualitative and quantitative traits was H'= 0.70 indicating a high level of diversity. This level of diversity among mango accessions studied indicated that these accessions could be very useful in enriching the mango germplasm and utilizing these valuable accessions for varietal improvement mango breeding program.***

Keywords---- accessions, diversity,IPGRI Descriptors for Mango, *Mangiferaindica*L., Shannon-Weaver Diversity Index

1. INTRODUCTION

In the Philippines, mango industry is one of the backbone industries of the country's agricultural sector. The total mango production in the Philippines is 816,199 tons planted in 187,838 has of land (BAS, 2013). It is estimated that 75% of production is consumed as fresh fruit while 25% of production is processed into various products such as mango puree, juice, candy bar, essence, dried, concentrates, frozen, glaze and preserves. Philippine mango products are exported to 48 countries with Japan, Singapore, and Hong Kongas major importers of the shipments. The major destinations of exported mango as fresh fruits are in Japan, Hong Kong, China, and South Korea, while processed mango goods such as mango chunks and dried mangoes are shipped to Canada, Germany, and France.

*Mangiferaindica*L. var. 'Carabao' mango, the country's export variety, is one of the best varieties in the world. The distinct taste and nutritional value of this variety put it above any other mango varieties in the world. It is known all over the world as 'Manila Super' mango. Other *M. indica*popular varieties are 'Pico' and 'Katchamitha' or the 'Indian' mango. On-site selection strategy and identification of other fruit crops varieties available in the country (Coronel et al., 1986) could give us bright opportunities to offer and import wide range of varieties. This will allow production of other varieties which can suit different consumer preferences especially during off-season or lean months of 'Carabao' mango production. Despite high production and the good climatic conditions to produce mango fruits all-year round, the export potential of 'Carabao' is hampered due to short shelf life and general susceptibility to major insect pests and diseases. Constraint posed by these problems could be solved by varietal improvement to produce improved mango variety. The genetic improvement of mango has always been dependent on the utilization of available genetic variability; therefore conservation of different species of *Mangifera*is essential. Due to economic advancement in recent years of Southeast Asia, vast wooded areas have been completely or partially deforested due to the expanding agriculture, urbanization, or removal of tropical hardwoods for export. This has caused great genetic erosion within species and genera. Because of the loss of natural habitat, the establishment of *in situ* and *ex situ*germplasm of different mango species is vital.

Hence, this study was conducted to collect, characterize or evaluate different mango accessions; and to assess the mango diversity across locations in the Philippines.

2. MATERIALS AND METHODS

2.1. Source of mango collections/accessions

At least five to tenrepresentative fruit samples were randomly collected per mango tree from seven different locations in the Philippines including theInstitute of Plant Breeding, University of the Philippines Los Baños (IPB, UPLB) in Laguna; Tiaong,Quezon; Ramon Magsaysay Technological University (RMTU) in Zambales; Don Mariano Marcos Memorial State University (DMMMSU) in La Union; and Central Luzon State University (CLSU) in Nueva Ecija. Other mango growing areas in Davao City,Sultan Kudarat, Rizal, Pampanga, Tarlac, Bulacan, Cebu, and SouthCotabato were surveyed.

2.2. Morphological characterization

2.2.1. Qualitative Traits

The International Plant Genetic Resources Institute(IPGRI, 2006)Descriptors List for mango (*Mangiferaindica* L.) was used to characterize21fruit morphological characters with eight qualitative traits consisting of fruit shape and attractiveness;skin color of ripe fruit; pulp color; texture; juiciness; aroma; and eating quality. Sensory evaluation was also conducted to assess the fruit attractiveness and overall eating quality.

2.2.2. Quantitative Traits

The quantitative characters considered include four fruit, three flesh, one skin, four stone, and one seed traits (IPGRI, 2006). Weight, dimension, and pulp Total Soluble Solids (TSS; ^{0}Brix) per sample were determined using digital pocket scale (SWAN brand) 0.1 g precision, electronic digital caliper 150 mm (6") precision, and hand refractometer model N-1α (Atago brand), respectively.The 13 quantitative traits were deviation, sample variance, and coefficient of variation.

2.3. Diversity Analysis

The phenotypic diversity for each trait was determined by calculating the Shannon-Weaver Diversity Index (H') using the formula (Jain *et. al*. 1975):

$$H' = -\sum_{i=1}^{n} p_i(log_2 p_i)$$

where $p_i$is the proportion of the total number of entries belonging to the i^{th} class or phenotype (I = 1, 2, …, n).Frequency distribution per trait was also determined.

3. RESULTS AND DISCUSSION

3.1. Source of mango accessions

A total of 208 mango accessions were collected from sevenfield gene banks and mango production areas in the Philippines including 87 from Institute of Plant Breeding, University of the Philippines Los Baños (IPB, UPLB), Laguna and vicinities; 29 from Tiaong, Quezon; 30 from Ramon Magsaysay Technological University (RMTU), Zambales and vicinities; 18 from Don Mariano Marcos Memorial State University (DMMMSU), La Union; 6 from Central Luzon State University (CLSU),Nueva Ecija; 10 from Toril and 11 from Hagonoy, Davao City; and 5 from Tacurong, Sultan Kudarat. Twelve entries were collected from other mango growing areas including Rizal, Pampanga, Tarlac, Bulacan, Cebu, and South Cotabato.

3.2. Morphological Characterization

Morphological traits are measured or scored visually; therefore it is subjective and error-prone due to environmental factors affecting the expression of the trait. However, in the absence of molecular markers or other tools to aid the selection of breeders prior to hybridization, morphological characterization can be employed as an initial step for varietal improvement.

3.2.1. Qualitative Traits

The proportions of accessions (percentage out of 208 accessions) showing the morphological charactersbased on eight qualitative traits observed are presented in Table 1.

3.2.1.1. Fruit Characters

The fruit shape was 77% elliptic for most of the collections. Others had fruit shape varying from oblong to obovoid (Figure 1). This is in concordance with the findings of Ribeiro et al. (2013) in his study of *M. indica* accessions located in Brazil where most entries had an elliptic fruit shape. However, Ahmed and Mohamed (2015) found that most grafted cultivars in Shendi, Sudan had oblong fruit shape (62%) followed by round (25%) and elliptic (12.5%).

Table 1.Proportion of mango collections showing different morphological traits.

Trait/Descriptor State	Collections showing the trait	
	No.	%
Fruit Shape		
Oblong	10	5
Narrowly oblong	2	1
Elliptic	161	77
Narrowly elliptic	12	6
Spheroid/round	16	8
Ovoid	4	2
Obovoid	3	1
Fruit Attractiveness		
Poor	9	4
Average	67	32
Good	100	48
Excellent	32	16
Skin Color of Ripe Fruit		
Green	2	1
Light green	3	1
Greenish yellow	2	1
Greenish yellow with red blush	3	1
Yellow	167	80
Yellow orange	6	3
Yellow with red blush	12	6
Red	1	1
Red with yellow	11	5
Reddish purple	1	1
Pulp Color		
Light yellow	4	2
Golden yellow	65	31
Yellow orange	106	51
Orange	8	4
Yellow	19	9
Light orange	4	2
Dark orange	2	1
Pulp Texture		
Soft	8	4
Intermediate	155	75
Firm	45	21
Pulp Juiciness		
Slightly juicy	17	8
Juicy	161	77
Very Juicy	30	15
Pulp Aroma		
Mild	137	66
Intermediate	57	27
Strong	14	7
Eating Quality		
Poor	13	6
Good	82	39
Very good	86	42
Excellent	27	13

**Descriptions/illustrations of various traits are found in Descriptors for Mango (IPGRI, 2006)*

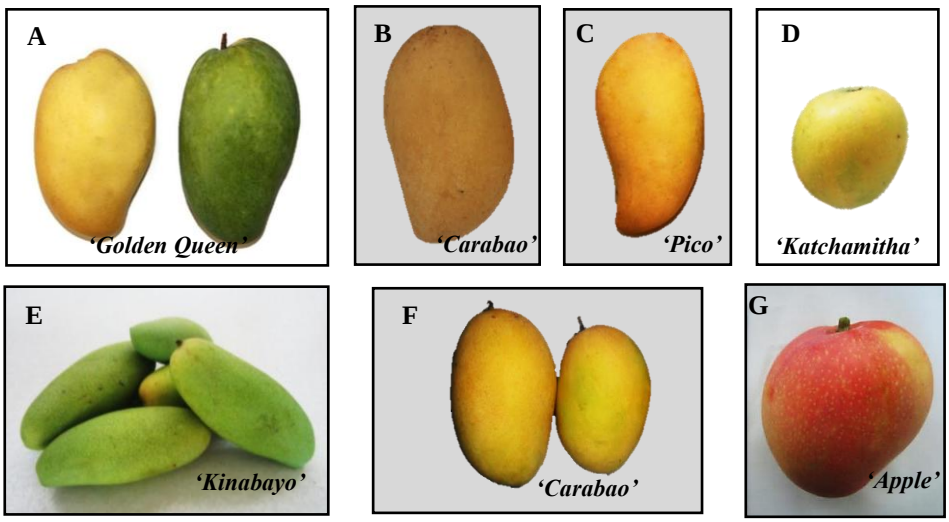

Figure 1: Variations in fruit shape: a) elliptic, b) oblong, c) narrowly elliptic, d) obovoid, e) narrowly elliptic, f) ovoid, and g) round/spheroid.

Most entries had average to good fruit attractiveness while 15% of the total accessions had an excellent attractiveness. The predominant skin color of ripe fruit for all mango collections was 80% yellow (Table 1) while only 2% of the total accessions had peel color varying from light green to greenish yellow. Fourteen percent of 208 accessions evaluated were observed to have a red skin color in different shades varying from greenish yellow with red blush to reddish purple. Five 'Carabao' mango collections; three from IPB, UPLB and two from La Union; had a slight red blush skin color on the skin. 'King', 'Pahutan', and 'Tommy atkins' were also observed to have a yellow with red skin color (Figure 2). On the other hand, 'Piget' and 'Apple' collections had red with yellow skin color.Greenish yellow with red peel color was observed among 'Kensington and 'Florida' collections while yellow orange was observed among 'Pico', 'Julie', and 'Millenium' collections (Figures 1 &2). These results coincide with the findings of Ahmed et al. (2015) and Abdelrahman(2009) that there was a great variation among skin color especially in South African cultivars.

Developed countries such as in Europe and America are the main exporters of mango and they seem to prefer mango fruits with red color of the peel or skin (Saave, 2011; Morton, 1987). In addition, European consumers, in general, prioritize this color of mango fruits since for them; it is the attribute that best translates ripeness for them. The Centre for the Promotion of Imports from Developing Countries (2009) reported that 28% of mangoes traded in the European Union were red color varieties, whereas the green color varieties were preferred species in India and Pakistan. Araujo and Garcia (2012) reported that in the fastest growing market in the European Union in the last seven years, the preference is for the red skin varieties.

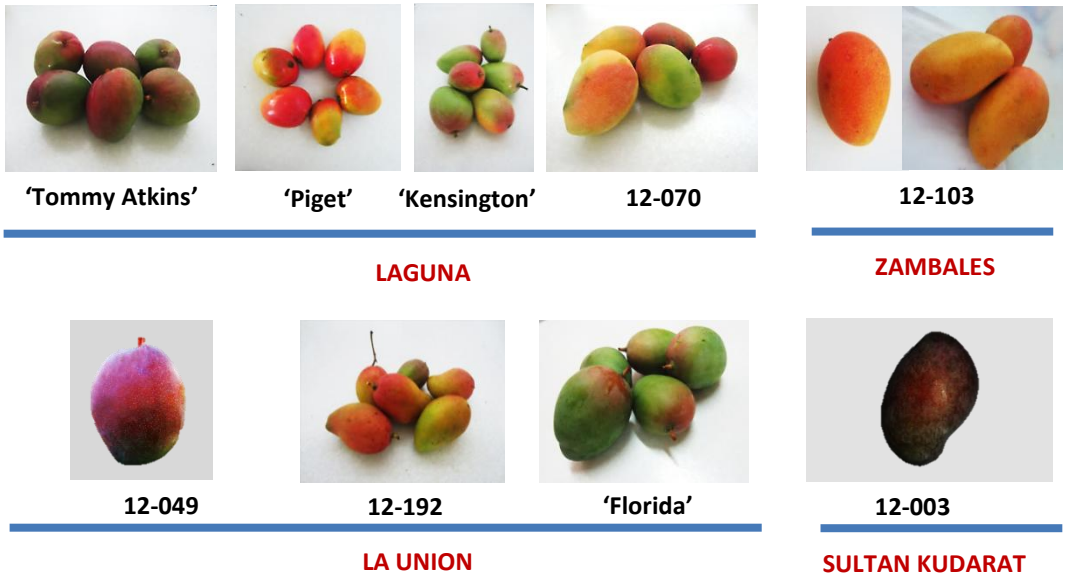

Figure 2: Mango collections from different locations exhibiting various shades of red blush on the fruit skin.

3.2.1.2. Pulp Characters

Fifty-one percent of the collections had yellow orange pulp color followed by golden yellow with 31% (Table 1). Iyer (1991) found out that the yellow color dominates the orange, while Ribeiro et al. (2013) found out that in the characterization of mango using Brazilian adapted descriptors, the flesh colors which stood out were yellow and orange.

The predominant character for pulp texture was 75% intermediate while other accessions were soft (4%) and firm (21%).Elgozuli (2011) reported in his study that the color of mango pulp is normally yellow to yellow orange with soft and intermediate pulp texture.

Most accessions were 77% juicy and had66% mild pulp aroma. Thirteen percentof the total mango collection had an excellent eating quality while 42% had very good eating quality. Thirty-nine percent mango selections were identified to have a good quality while 6% had a poor eating quality based on the sensory/taste test.

3.2.2. Quantitative traits

The calculated descriptive statistics of 13 quantitative traits is shown in Table 2. From the results of mean, standard deviation, sample variance, and coefficient of variation, significant variation was observed in 13 quantitative traits among 208 mango accessions evaluated.

3.2.2.1. Fruit character

The average fruit weight of 208 mango selections ranged from 48.65–1,031.80g (Table 2).The biggest fruit based on weight was ‘Florida’ from Sultan Kudarat, followed by ‘Golden Queen’ from Zambales, 12-193 (red variety) from La Union, and ‘Millenium’ from Zambales, with an average weight of 1,031.80, 983.38, 672.75, and 667.00g, respectively (Figure 3). For ‘Carabao’ mango collections, ‘Carabao’ from Sta. Cruz, Zambales had the heaviest fruit weight of 384.00g. The smallest fruit was ‘Paho’ (*Mangiferaaltissima*) from IPB field gene bank with an average weight of 48.65g, followed by ‘Pahutan’ (54.83g) and ‘MangaPali’ (76.34g) as shown in Figure 4.

Figure 3: Big-fruited mango based on weight: a) unripe ‘Florida’, b) unripe ‘Golden Queen’ c) 12-193 red variety and ‘Millenium’.

Table 2: Descriptive statistics of 13 quantitative traitsused in the characterization of mango varieties.

Descriptive Statistics	Mean	Lowest	Highest	Standard Error	Standard Deviation	Sample Variance	CV (%)
Fruit Weight (g)	244.45	48.65	1031.80	8.14	117.33	13765.27	48.00
Fruit Length (mm)	110.56	62.28	200.50	1.25	17.97	322.86	16.25
Fruit Width (mm)	67.30	40.55	129.61	0.74	10.65	113.34	15.82
Fruit Thickness (mm)	57.71	32.98	278.40	1.25	18.03	325.18	31.25
Flesh Thickness (mm)	20.38	2.18	40.80	0.30	4.28	18.29	20.98
TSS(^{o}B)	15.24	8.00	21.33	0.18	2.53	6.39	16.58
%EP	75.21	42.81	90.95	0.56	8.07	65.17	10.73
Skin Thickness (mm)	0.90	0.18	2.40	0.02	0.36	0.13	39.79
Stone Weight (g)	28.78	35.03	155.60	0.78	11.29	127.57	39.25
Stone Length (mm)	89.25	15.70	59.35	1.04	14.99	224.74	16.80
Stone Width (mm)	37.08	11.41	26.19	0.40	5.76	33.16	15.53
Stone Thickness (mm)	16.26	12.79	82.75	0.22	3.20	10.24	19.68
Seed Weight (g)	13.26	5.44	30.00	0.31	4.45	19.83	33.59

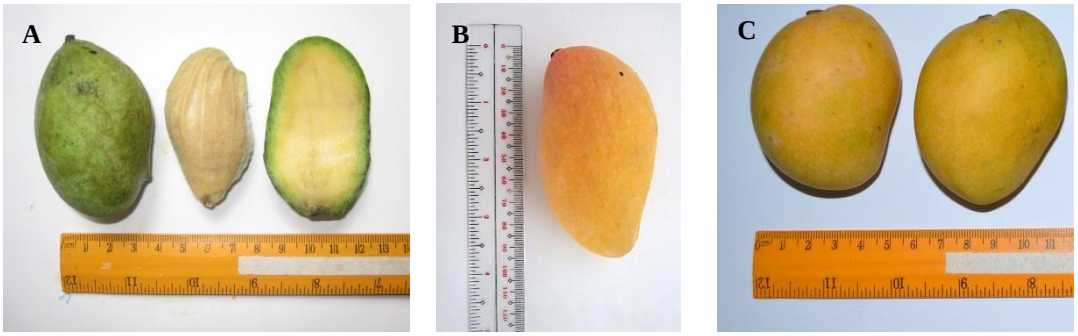

Figure 4: Small-fruited mango collections based on weight: a) 'Paho', b) 'Pahutan', and c) 'ManggaPali'.

3.2.2.2. Pulp Characters

The pulp TSS of the 208 mango selections evaluated ranged from 8.00–21.33^{0}B with 'Katchamitha'–262 from IPB field genebank being the sweetest (Table 2). This was followed by 'Carabao'-Tree R2T6 from IPB, Laguna, 'Carabao'-Tree 4 from Zambales, and 'Carabao' from Manicla, Nueva Ecija having 21.14, 20.6, and 20.4^{o}B, respectively. Sixty percent (60%) of the total accessions had medium TSS value (14.1-18.0^{o}B) while 11% had high TSS value (18.1-22^{o}B). This is in concordance with the study of Ribeiro et al.(2013) wherein most of the mango accessions evaluated had greater than 14^{o}B. The % Edible Portion (EP) of the fruits ranged from 42.81-90.95% with a mean of 75.27%. One hundred six (106) mango accessions had high % EP of greater than 78%, with 'Carabao'–R1T11 had the highest EP of 90.95% from Laguna.Ahmed and Mohamed (2015) found that the %EP of the grafted mango fruits in Sudan were 72.2 to 85.3%.

3.2.2.3.Skin Characters

The skin thickness of the mangoes evaluated ranged from 0.18-2.06mm (Table 2). 'Golden Queen' from Rosa farms, Zambales had the thickest skin measuring an average of 2.06mm (Figure3). This was followed by 'Millenium', 12-049 (red variety), 'Florida', and 12-193 (red variety) with an average skin thickness of 1.80, 1.65, and 1.63mm, respectively (Figure3). Based on evaluation for 'Carabao' mango fruits, 'Carabao'–Tree 6 from RMTU, Zambales had the thickest skin with an average measurement of 1.16mm.A similar study conducted by Ahmed and Mohamed (2015) found that great variation in skin thickness was also observed among mango cultivars in Sudan measuring 0.5-2.5mm.Peel thickness is also an important trait of mango because thicker peel renders the mango fruit more resistant to insect pest and disease development and longer shelf life.

3.2.2.4.Stone and Seed Characters

The stone weight ranged from 12.79-82.75g with a mean of 28.78g (Table 2). The heaviest stone (82.75g) and longest width (59.35mm) was obtained by 'Florida' while the longest fruit and stone (155.60mm) was 'Kinabayo'.Although 'Florida' and 'Kinabayo' had heavy stones, their computed % EP was still high (>78%). Both accessions were from Sultan Kudarat. The smallest stone in terms of weight was 'Carabao'-Tree 106 from Tiaong, Quezon but in terms of stone length and width, 'Carabao'-Tree R1T5 from IPB, Laguna was the smallest. As to the seed characters,'Carabao'-Tree 156 from Tiaong, Quezon had the smallest seed weighing 5.44g while an 'Apple' mango collection from Zambales had the heaviest seed weighing 30g.Abdelrahman (2009) reported that seed length is proportional to fruit length, but the width and thickness of the seeds have no definite pattern.

3.3. Diversity Analysis

Presented in Table 3 are the computed diversity indices for qualitative traits. Variability and diversity among *Mangifera spp.* were observed in this study. The highest diversity was observed in eating quality with H'=0.84 diversity index, followed by fruit attractiveness (H'=0.82) and pulp aroma (H'=0.74), indicating that the mango collections were well distributed in each of the descriptor states per trait. The skin color of ripe fruit was the least diverse (H'=0.37), followed by fruit shape (H'=0.46) which are both not good indicators of variability.Most collections had yellow skin fruit color with elliptic shape. On the average, the qualitative traits had medium variability with a value of 0.63 diversity index.

For quantitative traits, the mean diversity index was high (H'=0.78). High diversity indices were calculated with pulp TSS (H'=0.90) being the most diverse, followed by pulp thickness (H'=0.84) and stone length (H'=.83) as shown in Table 3. Normal frequency distribution curves were also observed for these traits indicating a wide variation among accessions (Figure 5A-C). All traits had high diversity indices (H'=>0.70) except for fruit thickness having H'=0.61. The distribution for seed and stone weight were skewed to the left (Figure 5D-E). One hundred forty mango collections had stone weight ranging from 11.84-28.77g while 159 collections had seed weight ranging from 8.80-15.47g. On the other hand, the distribution for % EP was right-skewed indicating that most of their accessions had higher % EP with 90.95% as its highest (Figure 5F).

Table 3: Computed diversity indices of 21 morphological traits.

Quantitative Traits			**Qualitative Traits**		
	Trait	**H'**		**Trait**	**H'**
Fruit	Weight	0.75	**Fruit**	Shape	0.46
	Length	0.78		Attractiveness	0.82
	Width	0.79	**Skin**	Color of ripe fruit	0.37
	Thickness	0.61	**Pulp**	Color	0.60
Pulp	Thickness	0.84		Texture	0.62
	TSS	0.90		Juiciness	0.62
	% EP	0.77		Aroma	0.74
Stone	Weight	0.75		Eating Quality	0.84
	Length	0.83			
	Width	0.77		**Mean**	**0.63**
	Thickness	0.73			
Seed	Weight	0.77			
Skin	Thickness	0.80			
	Mean	**0.78**			
General Mean: H' = 0.70					

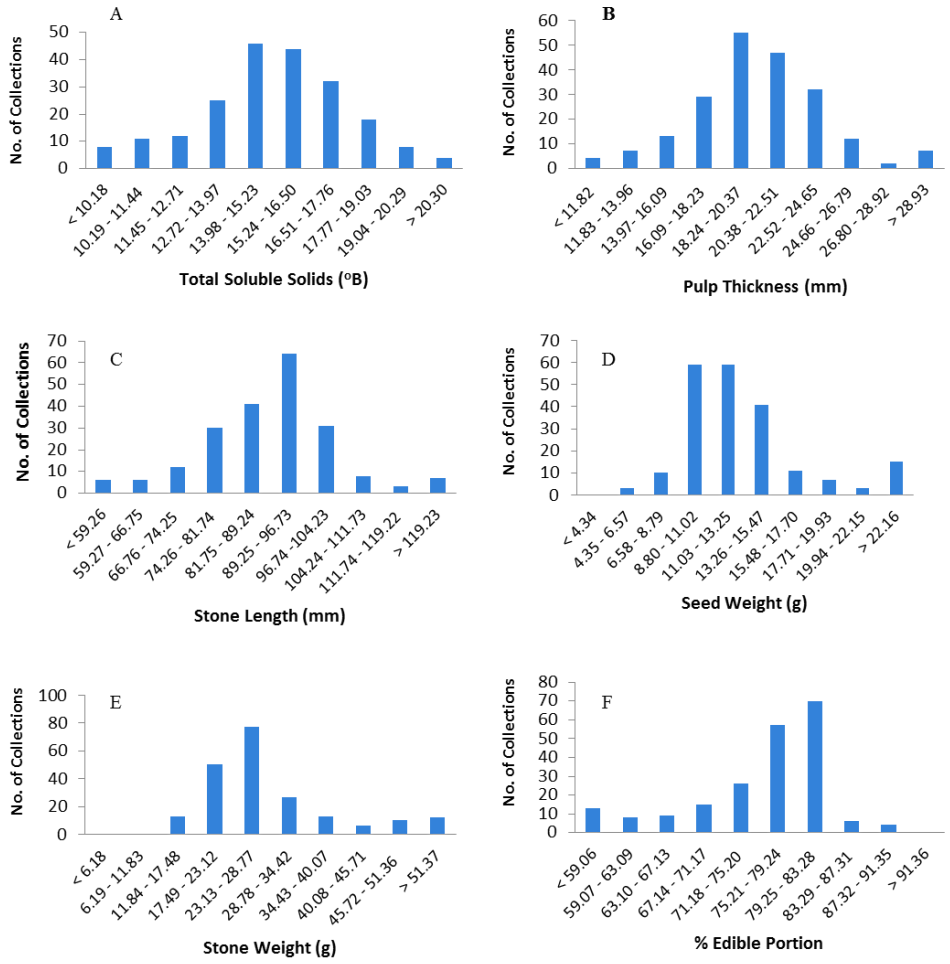

Figure 5: Variation among 208 mango accessions based on frequency distribution of selected quantitative traits: A) Total Soluble Solids, B) Pulp Thickness, C) Stone Length, D) Stone Weight,E) Seed Weight, and F) % Edible Portion.

4. CONCLUSION

Most accessions had elliptic fruit shape, good to average attractiveness, yellow skin, juicy yellow orange pulp, intermediate texture, mild aroma, and very good eating quality based on the qualitative traits derived from IPGRI (2006). Variation was observed in 13 quantitative traits from among 208 mango accessions evaluated. The average fruit weight ranged from 48.65–1,031.80g. The biggest fruit based on weight was 'Florida' from Sultan Kudarat, followed by 'Golden Queen' from Zambales, 12-193 (red variety) from La Union, and 'Millenium' from Zambales with an average weight of 1,031.80, 983.38, 672.75, and 667.00g, respectively. These accessions also obtained the thickest skin. The smallest fruit was 'Paho' (*Mangiferaaltissima*) from IPB field genebank with an average weight of 48.65g. The pulp TSS of the 208 mango selections evaluated ranged from 8.00–21.33^0 Brix (^{o}B) with 'Katchamitha'–262 from IPB Field Genebank being the sweetest. One hundred six mango collections had high % EP (>78%) with 'Carabao'–R1T11 having the highest %EP of 90.95%. The stone weight ranged from 12.79-82.75g with a mean of 28.78g. The heaviest stone (82.75g) and longest width (59.35mm) were obtained by 'Florida' while the longest fruit and stone (155.60mm) were obtained by 'Kinabayo'. Although 'Florida' and 'Kinabayo' (both collections from Sultan Kudarat)had heavy stones, their computed % EP was still high (>78%).

Variability and diversity among *Mangifera spp.* were observed with eating quality (H'=0.84) being the most diverse and the skin color of ripe fruit being the least diverse (H'=0.37). The skin color of ripe fruit and fruit shape (H'=0.46)were not good indicators of variability as reflected by their calculated diversity indices.For quantitative traits, the mean diversity index was high (H'=0.78). High diversity indices were calculated with pulp TSS (H'=0.90) being the most diverse followed by pulp thickness (H'=0.84) and stone length (H'=.83). All quantitative traits had high diversity indices (H'=>0.70) indicating wide variation except for fruit thickness having H'=0.61. The level of diversity (H'=0.70) among 20*M.indica*accessionsbased on the Shannon-Weaver Diversity Index indicated that these accessions could be very useful in enriching the mango germplasm and utilizing these valuable accessions for varietal improvement under

different mango breeding programs. Although mango is highly heterozygous, there is still a need to conserve and maintain the variability of this crop.The Philippines should explore more on mango researches particularly on mango collections with more phenotypic variations useful for the conservation and utilization of germplasm, and varietal development to produce more varieties that would suit thedifferent types of consumers.

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6.REFERENCES

- Abdelrahman, E. A. (2009). Characterization and evaluation of different mango(*Mangiferaindica*L.) cultivars in Shendi Area.Ph.D. Thesis, Sudan Academy of Sciences.
- Ahmed, THM and ZHA Mohamed.(2015). Diversity of Mango(*Mangiferaindica*L.) Cultivars in Shendi Area: Morphological Fruit Characterization. International Journal of Research in Agricultural Sciences.Vol. 2. Issue No. 4. PP. 141-148.
- Araújo, José Lincoln P. and José Luis L. Garcia.(2012). A Study of the Mango Market in the European Union. In: Technical-Scientific Documents. Vol. 43.No. 2. April-June 2012.
- Bureau of Agricultural Statistics (BAS). 2013. Crop Production statistics of the Philippines, Quezon City.
- Centre for the Promotion of Imports from developing Countries. 2009. CBI market survey: the EU market for fruit juices. Rotterdam.
- Elgozuli, A. A. (2011). Characterization and evaluation of selected mango (*Mangiferaindica*L.) cultivars in Sudan using morphological descriptors and DNA molecular markers.PhD.Thesis, Faculty of Agriculture, University of Khartoum, Sudan.
- Evans, Edward A. (2008). Recent Trends in World and U.S. Mango Production, Trade, and Consumption. Food and Resource Economics Department, Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida, Gainesville, FL. Available in: http://edis.ifas.ufl.edu/pdffiles/fe/fe71800.pdf.
- Food and Agriculture Association Statistics (FAOSTAT).(2012). World Mango Production Statistics.
- International Plant Genetic Resources Institute (IPGRI).(2006). Descriptors for Mango (*Mangiferaindica* L.).International Plant GeneticResources Institute, Rome, Italy.
- Iyer, C.P.A. (1991). Recent advances in varietal improvement in mango, ActaHorticulturae. 291 pp. 109-132.
- Jain SK, Qualset CO, Bhatt GM & Wu KK.(1975). Geographical patterns of phenotypic diversity in a world collection of durum wheats. Crop Science 15:700-704.
- Morton, J. (1987). Mango. p. 221–239. In: Fruits of warm climates. Julia F. Morton, Miami, Florida.
- Ribeiro, ICNS, Santos, CAF, and Neto, FPL. (2013). Morphological characterization of Mango (*Mangiferaindica*L.*)*Accessions based on Brailian Adapted Descriptors. Journal of Agricultural Science and Technology B3. Pp. 798-806.
- Singh, HP. (2008). Consumer Trends and Quality Standards of Mango Export from India. In: Consumer Trends and Export of Tropical and Subtropical Fruits. Bangkok, Thailand.
- Saave, Nanakaan. (2011). Export Factsheet Ecowas: Mangoes. International Trade Centre, Switzerland.