PAT December, 2020; 16 (2): 104-116 ISSN: 0794-5213
Online copy available at www.patnsukjournal.net/currentissue
Publication of Nasarawa State University, Keffi

Comparative Analysis of Some Selected Physical Properties of three Varieties of Cucumber (Cucumis Sativus L.) In Nigeria

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Abstract

Cucumber has become a very important vegetable in many countries and Nigeria is no exception. However, when designing, grading, sorting and processing operations are to be carried out relevant Information about the physical properties of cucumber is necessary. In this research, some selected physical properties such as diameter, length, height, and weight of three varieties of cucumber (Tokyo F1, Murano F1, and Darina F1) were measured. The results showed that there was no significant difference (P<0.01) in the density values of the researched varieties, but relating to other physical properties studied there were a significant difference (P<0.01) among them. The average density for Tokyo F1, Murano F1 and Darina F1 were 0.98, 0.95 and 0.94 g/cm3, respectively. Tokyo F1 cucumber had the highest diameter, volume, weight, flesh diameter, geometric mean diameter and sphericity. Murano F1 and Darina F1 varieties with 15.49 cm length and 4.61 length to diameter ratio had the highest length and length to diameter ratio, respectively. Smallest skin thickness (1.48 cm) was for Darina F1. Surface area of Tokyo F1, Murano F1 and Darina F1 were 192.29, 192.4 and 131.2 cm2. As well as there was a high and positive correlation between weight and volume in the studied varieties. The study further revealed that there was a non-significant and low correlation (0.56) between diameter and length in Darina F1 and also a high and positive correlation between diameter and geometric mean diameter in all the varieties.

***Key words**: Cucumber, physical properties, Tokyo F1, Darina F1, Murano F1.*

Introduction

Cucumber (Cucumis sativus L.) is one of the popular vegetables in many countries. It belongs to the family of cucurbitaceous which has 118 genera and 825 species. Cucumbers are cultivated gourds scientifically known as Cucumis Sativus. Varieties of cucumber include pickling, slicing and seedless. Cucumber as vegetable can be eaten fresh or prepared as part of food. Fresh Cucumber contains about 90% water and rich in vitamins, Carbohydrates and minerals. Cucumber plants grow under tropical conditions. Cucumbers can be grown under protected cultivation (Tokyo houses, polytunnels or net houses) and in open fields.

The fruit of this plant is Tokyo in color and depending on the variety; it can be small or large. Water is the main component (96%) of the crop and there are a lot of vitamins, minerals and organic acids in this produce which makes it a nutritious product. Regarding different properties of cucumber such as diameter, length, color, skin thickness, etc., it can be used as a fresh produce by the consumers or can be processed further to manufacture different products, for example, pickled cucumber or in salads. According to Shahedy (2007) revealed that due to high failures in harvesting techniques and poor quality of post-harvest technologies, about 30% of world cucumber production is wasted.

Wrzodak and Korzeniow (2012) discovered that Cucumber fruit intended for processing should have small seed chamber, appropriate chemical composition, sugar content above 2%, resistance to the forming and presence of voids, high yield in the production at industrial scale, and high resistance to pests. Besides, it is important that cucumber fruit is of uniform shape and appropriate, regular and equal Colour. To reduce the waste figures, it is necessary to have good designed equipment for harvesting, grading, sorting, and processing of cucumber. (Aydin, Ogut and Konak, 2002). According to (Sirismoboon, Pornchaloempong, and Romphophak, 2007), Knowledge of cucumber physical properties plays an important role in the design and optimization of its machinery. As a result, the sale price of this produce will be decreased and its quality will be improved which helps to reduce the wastage. In a study conducted by (Shetty and Wehner, 2002), on different cucumber classified based on their shape and color into obliged group with a Tokyo and white color, elongated and average size group, and cone-shaped cucumbers with dark Tokyo color. Unfortunately, there is very limited information and published data about the physical and engineering properties of cucumber and our study is one addition to few studies of its kind. However, our main objective was to determine different physical properties of these produce and to comparatively develop some correlations between their properties. The results can be thoroughly used in the design and fabrication of the cucumber seed sheller.

Materials and Methods

The study was carried out in Faculty of Agricultural sciences, National open University of Nigeria (NOUN) greenhouse research farm (2019) 4km off Kaduna- Zaria expressway, Rigachikun, Kaduna State Northwest of Nigeria (altitude: 722m above sea level, latitude 10.6321° N, and longitude 7.4706° E, from February to June 2019.

Three most common varieties of cucumber, namely Tokyo F1, Murano F1 and Darina F1 (Fig. 1), were cultivated and harvested to produce of hybrid cucumber seeds in are Murano F1, Tokyo F1 and Darina F1. These seeds are high yielding and able to resist pest and diseases than open pollinated varieties. 50 samples were selected from each variety randomly depending on cucumber harvesting criteria (length diameter) for the experiments. Then, measurements of their physical properties including length, diameter, height, weight, volume, density, skin surface area, flesh thickness, skin thickness, geometric mean diameter and number of internal seeds were conducted

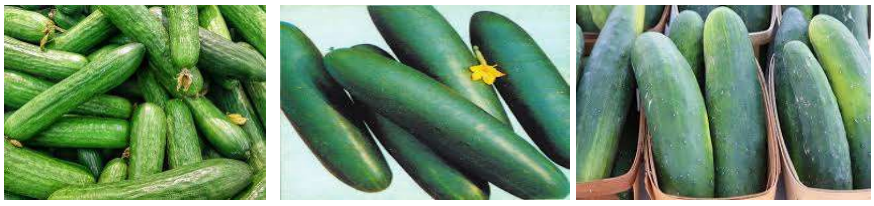

Fig. 1: Picture of Murano F1, Tokyo F1 and Darina F1 Varieties of Cucumber Respectively

Measurement of Dimension and Weight

Depending on cucumber harvesting criteria (length diameter), the selected samples from each were measured to determined their dimensions by a digital micrometer (GUANGLU, Germany). The largest dimension was chosen as length and the smallest one as diameter. Then, the height was considered as perpendicular to diameter. The weight of the samples was measured by an

electronic scale (Sartorious, Germany, TE313S). Finally, the dry matter content of samples was analyzed using the dry basis moisture content determination method, by placing them in an oven (Memmert, Gmbh+Catky, Germany) at 85 °C for 48 hours. This method was conducted individually for the skin and flesh of the samples.

Measurement of Surface Area, Flesh Thickness and Skin Thickness

Fig 2: Pictorial view of the cross-sectional Area of the Cucumber

For the determination of surface area, millimeter paper was used for the measurement. The samples were carefully peeled and then, the separated skin was placed on the millimeter paper to obtain their surface area. The flesh thickness and skin thickness were also analyzed by a digital micrometer. (Fig 2)

Determination of Density

The density of the samples was measured and calculated by the following formula by Sirismoboon, (2007) as;

$$density\left({}^{g}/_{cm^3}\right) = \frac{sample\ weight\ in\ air\ (g)}{sample\ volume\ (cm^3)} \quad ------(1)$$

$$Sample\ Volume\ (cm^3) = \frac{sample\ weight\ in\ water\ (g)}{Water\ density\ \left({}^{g}/_{cm^3}\right)} ----(2)$$

Determination of Geometric Mean Diameter, Sphericity and Length to Diameter Ratio

Determination of geometric mean diameter, sphericity and length to diameter ratio was calculated according to the following method [10]:

Geometric mean diameter = (length X diameter X height) ---------- (3)

$$sphericity = \frac{Geometric\ mean\ diametre}{lenght}\ X\ 100 ------(4)$$

$$Lenght\ to\ diametre\ ratio = \frac{lenght}{diametre} ---------- (5)$$

Statistical Analysis

The samples were selected randomly and the measurements were done on 50 replications. For the comparison between results, least significant difference (LSD) analysis ($P<0.05$) was used and all analyzes performed by SAS software.

Results

Determination of Physical Properties

By carrying out an ANOVA (Table 1) on different physical properties among three cucumber varieties (Tokyo F1, Murano F1, Darina F1), the results showed that there is no significant difference ($P<0.01$) in the physical properties selected.

Table 1: ANOVA of physical properties of Tokyo F1, Murano F1 and Darina F1 cucumber cultivars.

S.O. V	Df	Volume (cm^3)	Weight (g)	Height (cm)	Diameter (cm)	Length (cm)	Flesh diameter (mm)	Surface area (cm^2)
Treatment	2	**33996.02	**34354.01	**41.28	**40.66	**194.62	**118.12	**14924.1
Error	147	855.37	795.5	0.15	0.17	0.64	0.47	589.44

S.O. V	Df	Density (g/cm3)	Sphericity (%)	Geometric mean diameter (mm)	Length to diameter ratio	Skin diameter (mm)	No. of Seeds	Skin dry matter (%)	Flesh dry matter (%)
Treatment	2	ns 0.005	**11226.8	**12.58	**40.99	**1.47	**338.05	**5.63	**3.88
Error	147	0.004	6.21	0.248	0.145	0.021	3701.4	0.23	0.42

** Significant at 1% level, ns: Not significant.

Results revealed also, that Tokyo F1 had the highest values in diameter, volume, weight, flesh thickness, geometric mean diameter and sphericity (as shown in Table 2). Murano F1 variety had the highest length which was 15.49 cm. In Darina F1, the highest length to diameter ratio was 4.61.

Table 2: Comparison of physical properties of Tokyo F1, Murano F1 and Darina F1 cucumber cultivars.

S.O. V	Tokyo F1	Murano F1	Darina F1	LSD 5%
Volume (cm3)	180.21a	151.62b	77.11c	24.29
Weight (g)	177.7a	144.97b	73.15c	23.42
Height (cm)	6.55a	3.88b	2.99c	0.32
Diameter (cm)	6.48a	3.92b	2.91c	0.34
Length (cm)	7.66c	15.49a	13.21b	0.66
Flesh diameter (mm)	13.52a	9.56b	7.33c	0.57
Surface area (cm2)	192.29a	192.4a	131.2b	20.16
Density (g/cm3)	0.98a	0.95a	0.94a	0.05
Sphericity (%)	91.16a	39.87b	36.72c	2.07
Geometric mean diameter (mm)	6.87a	6.17b	4.85c	0.41
Ratio of length to diameter	1.14c	3.99b	4.61a	0.316
Skin diameter (mm)	2.06a	2.11a	1.48b	0.12
Seed number	209.3b	474.2a	163.2b	50.53
Skin dry matter (%)	8.3a	8.44a	7.19b	0.40
Flesh dry matter (%)	5.63b	6.24a	5.1b	0.54

Means followed by the same letter are not significantly different at 5% by LSD.

Also, there was no significant difference ($P<0.01$) between Tokyo F1 and Murano F1 in terms of fruit surface area, skin thickness and dry matter content. As shown in Table 2, smallest skin thickness was for Darina F1 (1.48 cm). Therefore, the results agree with the findings of (Shahedy, 2007) and suggested that this variety can be susceptible to physical impacts during harvesting and transportation and it is necessary to reduce these damages because they can bring about discoloration of fruit and reduce the quality of the produce.

Determination of Density

The results from the ANOVA in table 2, showed that there was no significant difference among the densities of the three varieties. The average density for Tokyo F1, Murano F1 and Darina F1 were 0.98, 0.95 and 0.94 g/cm3, respectively. Since the density of these varieties is less than 1.00, therefore cucumber can be sorted by floating in brine solutions. Also, it is possible to remove the "farm heat" from cucumbers by floating them in cool water which is more efficient than cooling by air blast coolers. (Delgado *et al.,* 2001). This is an important step in post-harvest processing of fruits and vegetable, because delay in cooling or not appropriate cooling of harvested produce leads to an increase in their respiration activity and production of more heat in the stored crops.

Cucumbers are mechanically sorted in grades by diameter at the receiving section. The economic value of fruits increases on wet basis, as size decreases. Washing is done only to remove adhered dirt on the cucumber peel. Thibbotuwawa, *et al*., (2020)

Determination of Number of Seeds

The results showed that Murano F1 variety contained highest number of seeds (474 seeds) in each cucumber. As well as there is a positive and high correlation ($P<0.01$) between the number of seeds and weight of fruit in Murano F1 and Tokyo F1 (Tables 3 and 4), which can highlight the influence of seeds on the fruit development and growth. This is in agreement with previous finding, which reported there is a positive correlation between weight and number of seeds in melon. (Koohpaiegani, *et al*., 2003). Also, in another research reported by (Mousavizadeh, *et al*., 2010), it is concluded that internal seeds of cucumber are rich in auxin and there is a strong and positive relationship between seeds and weight increase. Interestingly, there was not such a correlation in Darina F1 variety which can be due to parthenocarpy property in this variety as we observed. It should be noted that this correlation between seeds and fruit weight is not common in all types of fruits; for instance, in pomegranate there is not this correlation (Mousavizadeh, *et al*., 2010). Again, reported that some researchers have reported a relationship between the number of internal seeds and skin thickness, for example in pomegranate, there was no such relationship discovered in cucumber.

Correlation Analysis of Physical Properties

From the results of Correlation analysis (Tables 3 and 4) revealed that in Murano F1 and Darina F1 varieties, there were a positive and significant correlation between diameter and skin thickness and weight of fruit. In Murano F1 variety, there was only a positive correlation between skin thickness and weight, which is similar to the results obtained by (Sirismoboon, Pornchaloempong, and Romphophak, 2007) that skin thickness of pea is an important parameter affecting its other properties because there is a high correlation between skin and weight in pea. But this correlation could not be found in pomegranate (correlation=-0.59). There was a strong and positive correlation between fruit length and its weight in all the studied varieties. This trend could be seen in Tokyo house cucumbers too, because when they are being harvested, they have the maximum length and so, the highest weight (Fonseca, *et al*., 2003). Furthermore, the results revealed that surface area of Tokyo F1 (192.29 cm2) and Murano F1 (192.4 cm2) were significantly higher than Darina F1 (131.2 cm2). On the base of this research, Tokyo F1 variety had the highest weight (177.79 g) and volume (180.21 cm3). Also, there was a very strong and positive correlation ($P<0.01$) between weight and volume in all the varieties. Fruit expansion in cucumber includes an exponential growth which follows by a gradual decrease and increase in

wet weight of cucumber is totally correlated with growth in its volume (Mousavizadeh, *et al*., 2010). This trend is in agreement with our data on length and diameter.

However, other correlation results showed that in different varieties of cucumbers, the correlations in their physical properties are not the same (Tables 3 and 4). In Tokyo F1, there was no correlation between fruit diameter and other properties such as volumes surface area, number of seeds, skin thickness, sphericity and weight.

Table 3: Correlation among some physical properties of Tokyo F1, Murano F1 and Darina F1 cucumber cultivars.

Physical property	Cultivar	Length	Diameter	Volume	Weight	Surface Area	Flesh diameter	No. of seeds	Skin diameter	Geometric Mean diameter	Sphericity
Length	Tokyo F1	1									
	Murano F1	1									
	Darina F1	1									
Diameter	Tokyo F1	0.65∗	1								
	Murano F1	**0.81	1								
	Darina F1	0.56	1								
Volume	Tokyo F1	**0.76	0.25	1							
	Murano F1	**0.87	**0.96	1							
	Darina F1	**0.83	**0.89	1							
Weight	Tokyo F1	**0.79	0.22	**0.99	1						
	Murano F1	**0.85	**0.96	**0.99	1						
	Darina F1	*0.63	**0.89	**0.92	1						
Surface area	Tokyo F1	**0.89	0.3	**0.95	**0.98	1					
	Murano F1	**0.90	**0.94	**0.94	**0.94	1					
	Darina F1	*0.58	**0.74	*0.66	0.51	1					
Flesh diameter	Tokyo F1	**0.80	0.13	**0.91	**0.95	**0.97	1				
	Murano F1	-0.09	0.34	0.22	0.23	0.24	1				
	Darina F1	0.26	0.22	0.27	0.22	0.26	1				

No. of seeds	Tokyo F1	**0.76	0.02	**0.82	**0.88	**0.92	**0.96	1			
	Murano F1	**0.79	**0.83	**0.83	**0.82	**0.86	0.21	1			
	Darina F1	0.22	*-0.57	-0.23	-0.39	-0.28	0.002	1			
Skin diameter	Tokyo F1	0.01	0.57	-0.20	-0.28	-0.25	-0.44	-0.49	1		
	Murano F1	0.48	**0.71	*0.61	*0.60	**0.71	0.22	0.53	1		
	Darina F1	0.50	*0.58	0.55	0.34	*0.70	0.29	-0.32	1		
Geometric mean diameter	Tokyo F1	**0.86	**0.94	0.51	0.50	*0.59	0.44	0.35	0.36	1	
	Murano F1	**0.80	**0.99	**0.96	**0.96	**0.95	0.36	**0.83	**0.71	1	
	Darina F1	*0.69	**0.98	**0.95	**0.91	**0.75	0.25	-0.48	*0.61	1	
Sphericity	Tokyo F1	**-0.84	-0.51	0.48	-0.52	**-0.65	*-0.58	*-0.63	-0.23	*-0.69	1
	Murano F1	0.30	**0.80	*0.69	**0.70	*0.63	*0.66	0.53	*0.68	**0.81	1
	Darina F1	0.01	**0.83	0.52	*0.64	0.52	0.12	**0.86	0.39	**0.73	1

*and ** significant at 5% and 1%, respectively.

Table 4: Correlation Equation of Physical Properties for Tokyo F1, Murano F1 And Darina F1 Cucumber Cultivars.

Trait	Cultivar	Correlation equation coefficients	Diameter	Volume	Weight	Surface Area	Flesh diameter	Seeds number	Skin diameter	Geometric mean diameter	Sphericity
Length	Tokyo F1	A	2.708	-48.41	45.332	-167.7	3.041	121.78	2.06	1.978	131.33
		B	0.492	29.82	29.106	46.96	1.367	11.429	0.0005	0.638	-5.239
	Murano	A	-2.865	-438.2	-403.2	-270.8	11.006	-	0.796	-1.906	27.438

	F1							446.17			
		B	0.438	38.06	35.38	29.90	-0.093	59.404	0.0849	0.521	0.797
	Darina F1	A	-0.42	-165.5	-125.9	-18.76	5.74	-77.427	0.0967	-0.234	35.97
		B	0.252	18.354	15.058	11.35	0.12	18.207	0.1048	0.385	0.057
Diameter	Tokyo F1	A		93.318	107.44	51.09	11.58	206.64	1.928	0.886	119.01
		B		13.401	10.846	21.78	0.3002	0.423	-0.02	0.923	-4.294
	Murano F1	A		-154.0	-143.6	-34.11	7.199	24.308	1.203	1.48	24.676
		B		77.79	73.43	57.65	0.601	114.51	0.231	1.194	3.845
	Darina F1	A	-50.71		-63.97	37.249	6.666	472.11	0.693	1.287	20.034
		B	43.925		47.122	32.309	0.2289	106.14	0.271	1.226	5.736
Volume	Tokyo F1	A			9.981	-44.19	6.318	152.56	2.09	5.117	105.08
		B			0.931	1.312	0.04	0.315	-0.0001	-0.0097	-0.077
	Murano F1	A			2.756	83.55	8.806	257.53	1.74	3.99	33.55
		B			0.938	0.718	0.005	1.429	0.0025	0.014	0.041
	Darina F1	A			-4.17	86.05	6.892	230.39	1.075	2.984	31.011
		B			1.002	0.586	0.0057	-0.87	0.0053	0.024	0.074
Weight	Tokyo F1	A				-62.11	5.61	144.95	2.101	5.072	107.17
		B				1.431	0.044	0.362	-0.0002	0.01	-0.09
	Murano F1	A				82.31	8.767	259.04	1.739	3.96	33.319
		B				0.759	0.0055	1.484	0.0026	0.015	0.0446
	Darina F1	A				100.59	7.014	263.88	1.257	3.279	30.53
		B				0.419	0.0043	-1.375	0.0031	0.021	0.0847
Surface area	Tokyo F1	A					7.559	159.62	2.089	5.295	105.88
		B					0.031	0.258	-0.0001	0.0082	-0.076
	Murano	A					8.196	102.1	1.385	2.591	30.216

	F1	B				0.0071	1.934	0.0038	0.0186	0.0497
	Darina	A				6.517	322.01	0.497	2.01	25.78
	F1	B				0.0062	-1.209	0.0075	0.0217	0.0834
	Tokyo	A					94.775	2.161	14.27	120.08
	F1	B					8.47	-0.0072	0.192	-2.137
	Murano	A					313.11	1.707	3.785	22.33
	F1	B					16.85	0.042	0.249	1.825
Flesh	Darina	A					159.37	0.513	2.568	30.303
diameter	F1	B					0.528	0.132	0.3119	0.876
	Tokyo	A						2.254	3.237	146.69
	F1	B						-0.0009	0.017	-0.265
	Murano	A						1.515	2.742	30.968
	F1	B						0.0013	0.0072	0.0186
	Darina	A						1.614	5.388	42.043
Seeds	F1	B						-0.0008	-0.0033	-0.032
number	Tokyo	A							-13.547	201.26
	F1	B							9.892	-53.336
	Murano	A							0.541	18.217
	F1	B							2.666	10.215
Skin	Darina	A							2.418	27.94
diameter	F1	B							1.644	5.929
	Tokyo	A								131.61
	F1	B								-5.884
	Murano	A								19.743
	F1	B								3.247
Geometri	Darina									
c mean	F1	A								17.006
diameter										

		B							4.0617

In Murano F1, there is a significant correlation between sphericity and weight. In Tokyo F1, there is a positive and significant correlation (P<0.01) between flesh thickness and the properties of diameter, volume, weight, surface area, and number of seeds. Conversely, there was a negative and significant correlation between sphericity and mentioned properties in Tokyo F1. There was no correlation between flesh thickness and other properties in two other varieties (Murano F1 and Darina F1). It was revealed Table 3, there is a positive and high correlation between diameter and geometric mean diameter in all the varieties (P<0.01). Also, there is a positive and significant correlation between diameter and sphericity in Murano F1 and Darina F1, but this correlation was negative and not significant in Tokyo F1. Similar results have been obtained for hackberry (Celtis australis L.) (Demir, *et al*., 2002). Researchers reported that there is a strong and significant correlation between diameter and length, diameter and weight, diameter and sphericity in wild melder (Mespilus germanica L.) (Haciseferogullari, *et al*., 2005)]. It can be seen that length, weight, surface area, geometric mean diameter, and sphericity are directly correlated with diameter. In spite of this trend, there is non-significant and low correlation (0.56) between diameter and length in Darina F1 which could be due to parthenocarpy in this variety of cucumber. In fact, with increase in length of the fruit, diameter is not increasing significantly in Darina F1. Hence, fruit shapes of different varieties of cucumber are not the same and for harvesting, individual varieties should be studied and considered. For example, researchers found that for all variety of cucumber, optimum dimensions for harvesting are 20.95 cm in length, 3.28 cm in diameter, and 143.53 g in weight. In another work, Beit alpha optimum conditions for harvesting are 16 cm in length and 3.81 cm in diameter (Lamb, Shaw and Cantliffe, 2001). For Dutch varieties of cucumber which are elongated, they are harvested when their length is 27.94 cm and their diameter is 3.17-4.44 cm. In the Tokyo F1, there is no correlation between diameter and weight, and diameter and surface area. While, there is a negative correlation (-0.51) between diameter and sphericity which could be due to fruit shape of this variety and high number of internal seeds. According to Table 1, Darina F1 variety had the highest length to diameter ratio (4.61), but Tokyo F1 and round fruits in general had the lowest ratio (1.14).

Discussion

Generally, there was no significant difference (P<0.01) in some of the physical properties. Also, there was no significant difference (P<0.01) between Tokyo F1 and Murano F1 in terms of fruit surface area, skin thickness and dry matter content. Therefore, these agree with the findings of Shahedy, 2007 and suggested that this variety can be susceptible to physical impacts during harvesting and transportation and it is necessary to reduce these damages because they can bring about discoloration of fruit and reduce the quality of the produce.

There was no significant difference among the densities determined. This is because the rate of moisture loss from a fresh produce is mainly controlled by moisture difference between the intercellular spaces of plant material and the surrounding air. This difference could be the major factor that contributed to the high densities observed during the measurement. The average

density for Tokyo F1, Murano F1 and Darina F1 were 0.98, 0.95 and 0.94 g/cm3, respectively. Since the density of these varieties is less than 1.00, therefore cucumber can be sorted by floating in brine solutions. This is justified the findings of Thibbotuwawa, et.al.2020 that Cucumbers are mechanically sorted in grades by diameter at the receiving section. The economic value of fruits increases on wet basis, as size decreases. Washing is done only to remove adhered dirt on the cucumber peel.

In the analysis of Determination of Number of Seeds, Murano F1 variety contained highest number of seeds (474 seeds) in each cucumber. Obtained was a positive and high correlation ($P<0.01$) between the number of seeds and weight of fruit in Murano F1 and Tokyo F1 (Tables 3 and 4), which can highlight the influence of seeds on the fruit development and growth. This is in agreement with previous finding, which reported there is a positive correlation between weight and number of seeds in melon. (Koohpaiegani, *et al*., 2003). Also, in another research reported by Mousavizadeh, *et al*., 2010), it is concluded that internal seeds of cucumber are rich in auxin and there is a strong and positive relationship between seeds and weight increase. Curiously, there was not such a correlation in Darina F1 variety which can be due to parthenocarpy property in this variety as we observed. It is pertinent to be noted that this correlation between seeds and fruit weight is not common in all types of fruits, for instance, in pomegranate there is not this correlation. (Mousavizadeh, *et al*., 2010.) again reported that some researchers have reported a relationship between the number of internal seeds and skin thickness, for example in pomegranate, there was no such relationship discovered in cucumber. The Correlation Analysis of the selected Physical Properties revealed that in Murano F1 and Darina F1 varieties, there were a positive and significant correlation between diameter and skin thickness and weight of fruit. In Murano F1 variety, there was only a positive correlation between skin thickness and weight, which is similar to the results obtained by (Sirismoboon, Pornchaloempong, and Romphophak, 2007) that skin thickness of pea is an important parameter affecting its other properties because there is a high correlation between skin and weight in pea. But this correlation could not be found in pomegranate (correlation=-0.59). There was a strong and positive correlation between fruit length and its weight in all the studied varieties. This trend could be seen in Tokyo house cucumbers too, because when they are being harvested, they have the maximum length and so, the highest weight (Fonseca, *et al*., 2003). Furthermore, the relationship between the surface area of Tokyo F1 (192.29 cm2) and Murano F1 (192.4 cm2) were significantly higher than Darina F1 (131.2 cm2). On the base of this research, Tokyo F1 variety had the highest weight (177.79 g) and volume (180.21 cm3). Also, there was a very strong and positive correlation ($P<0.01$) between weight and volume in all the varieties. Fruit expansion in cucumber includes an exponential growth which follows by a gradual decrease and increase in wet weight of cucumber is totally correlated with growth in its volume (Mousavizadeh, *et al*., 2010). This trend is in agreement with our data on length and diameter.

However, In Tokyo F1, there was no correlation between fruit diameter and other properties such as volumes surface area, number of seeds, skin thickness, sphericity and weight. In Murano F1, there is a significant correlation between sphericity and weight. In Tokyo F1, there is a positive and significant correlation ($P<0.01$) between flesh thickness and the properties of diameter, volume, weight, surface area, and number of seeds. Conversely, there was a negative and significant correlation between sphericity and mentioned properties in Tokyo F1. There was no correlation between flesh thickness and other properties in two other varieties (Murano F1 and Darina F1). The analysis further revealed a positive and high correlation between diameter and

geometric mean diameter in all the varieties (P<0.01) and there was a positive and significant correlation between diameter and sphericity in Murano F1 and Darina F1, but this correlation was negative and not significant in Tokyo F1. Similar results have been obtained for hackberry (Celtis australis L.) (Demir, *et al*., 2002). Researchers reported that there is a strong and significant correlation between diameter and length, diameter and weight, diameter and sphericity in wild melder (Mespilus germanica L.) (Haciseferogullari, *et al*., 2005)]. It can be seen that length, weight, surface area, geometric mean diameter, and sphericity are directly correlated with diameter. In spite of this trend, there was a non-significant and low correlation (0.56) between diameter and length in Darina F1 which could be due to parthenocarpy in this variety of cucumber. In fact, with increase in length of the fruit, diameter is not increasing significantly in Darina F1. Hence, fruit shapes of different varieties of cucumber are not the same and for harvesting, individual varieties should be studied and considered. It is worthy to note, that researchers found that for all variety of cucumber, optimum dimensions for harvesting are 20.95 cm in length, 3.28 cm in diameter, and 143.53 g in weight. In another work, Beit alpha optimum conditions for harvesting are 16 cm in length and 3.81 cm in diameter (Lamb, Shaw and Cantliffe, 2001). For Dutch varieties of cucumber which are elongated, they are harvested when their length is 27.94 cm and their diameter is 3.17-4.44 cm. In the Tokyo F1, there was no correlation between diameter and weight, and diameter and surface area. While, there is a negative correlation (-0.51) between diameter and sphericity which could be due to fruit shape of this variety and high number of internal seeds. Accordingly, Darina F1 variety had the highest length to diameter ratio (4.61), but Tokyo F1 and round fruits in general had the lowest ratio (1.14).

Conclusions

The results of this study revealed that there is no significant difference (P>0.01) in the density values of the studied varieties (Tokyo F1, Murano F1, Darina F1), but regarding other physical properties, there is a significant difference (P<0.01) among the three varieties. There is a high and positive correlation between weight and volume in the studied varieties. There is also a high and positive correlation between diameter and geometric mean diameter in all the varieties. The findings of our study can be used to determine the optimum conditions of cucumber varieties for harvesting. Also, these physical properties can be helpful in breeding programs and design of related equipment.

References

Aydin, C, Ogut, H and Konak, M. 2002. Some physical properties of Turkish Mahaleb, Biosystems Eng. 82 (2002) 231-234.

Delgado, A.E and Sun, D.W. 2001. Heat and mass transfer models for predicting freezing process-a review, Food Eng. 47 (2001) 157-174.

Demir, F, Dogan, H, Ozcan, M and Haciseferogullari, H. 2002. Nutritional and physical properties of Hackberry (Celtis australis L.), Food Eng. 54 (2002) 241-247.

Haciseferogullari, H., Ozcan, M., Sonmete, M.H. and Ozbek, O. 2005. Some physical and chemical parameters of wild melder (Mespilus germanica L.) fruit grown in Turkey, Food Eng. 69 (2005) 1-7.

Koohpaiegani, J.A., Kashi, A., Vezvae, A., Mozafari, J and Aghae, M.J. 2003. Genetic diversity based on fruit characteristics in some Iranian melon landraces, Irania Horticultural Science and Technology 4 (2003) 71-82.

Lamb, E.M, Shaw, N.L and Cantliffe, J.D. 2001. Bief Alpha Cucumber: A new Tokyo house

Crop for Florida Institute of Food & Agriculture Science, 2001, available online at: http://www.edis.ifas.ufl.edu.

Mousavizadeh1, S.J, Mashayekhi1, K and Daraei, A. 2010. Garmakhany2, A. Ehteshamnia1 and S. M. Jafari2, 2010, Journal of Agricultural Science and Technology, Volume 4, No.4 (Serial No.29) ISSN 1939-1250, USA

Shetty, N.V and Wehner, T.C. 2002. Screening the cucumber germ plasm collection for fruit yield and quality, Crop Sci. 42 (2002) 2174-2183.

Shahedy, B.M. 2007. Comparison of postharvest waste of fruits and vegetables between Iran and other Asian countries and way to reduce it, Agri. Natu. Res. Eng. Regu. 4 (2007) 15-24.

Sirismoboon, P., Pornchaloempong, P, and Romphophak, T. 2007. Physical properties of Tokyo soybean, criteria for sorting, Food Eng. 79 (2007) 18-22.

Thibbotuwawa, G., Marapana, U., Rathnayake, H. and Maduwanth. T. [accessed Apr 18 2020]. *CUCUMBER VEGETABLE AS A BRINE FERMENTED PICKLE*. Available from:Https://Www.Researchgate.Net/Publication/331533088_Cucumber_Vegetable_as_a Brine Fermented Pickle

Ogut, H. 1998. Some physical properties of Lupin, Agri. Eng. Res. 69 (1998) 273-277.

Wrzodak A., and Korzeniowski M., 2012: -Jakosc senso-ryczna ogórków kwaszonych zowoców traktowanych fungicydami w uprawie polowej. Nowosci Warzywni-cze. 54-55,5-13