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Varietal Effect on Physical and Textural Properties of Chayote from Sikkim

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ABSTRACT

Chayote or Squash, locally called "Iskush" is cultivated extensively and in different varieties in Sikkim. In absence of scientific study on different NE varieties of chayote has led to limited use and less return. In this regard, proper study of physical and textual characteristics of chayote varieties may facilitate development of different processing machineries and value-added products which will enhance farmers' income. In the present investigation, six varieties of chayote found in Sikkim were analyzed for physical properties viz., size, shape, surface area and textural characteristics viz., firmness, puncture force, toughness and cutting force using TA-HD Plus Texture Analyzer. The equivalent diameter of the selected chayote varieties varied between 53.82±4.67 mm and 88.61±4.01 mm. From the sphericity and other dimensions of the fruits, the shape of the chayote samples can be designated as oblong for LGS variety, conic for LS variety and regular for YS, GS, DGS and YLS variety. The surface area of the six chayote varieties varied in the range of 9099.68 mm^2 to 24669.67 mm^2. The firmness of chayote varieties varied between 42.83 ± 1.72N and 84.63±8.1 N. Puncture force varied between 36.5±2.19N and 41.29±3.42N. The toughness values ranged between 101.49 N-mm to 134.27 N-mm cutting force varied between 77.7±7.11N and 100.29±9.13N. From the results of Analysis of variance, the effect of variety on firmness and cutting force was found to be significant ($p < 0.05$) whereas varietal effect was non-significant ($p > 0.05$) on puncture force and toughness.

Key words: *Chayote; Variety; Size; Firmness; Texture analyzer*

INTRODUCTION

Chayote (*Sechium edule*) also known as cho-cho, pear squash, vegetable pear, choko (New Zealand), Iskush (Sikkim) is an edible plant belonging to the gourd family Cucurbitaceae, along with melons, cucumbers and squash species etc. Chayote is a rough pear-shaped fruit which squashes in the end. This fruit also have coarse wrinkles, ranging from 4-20 cm in length[9]. This fruit appears identical to a green pear that has a shrill green skin merged with the green to white flesh and a single, large and compressed pit. Some variety of chayote is thorny in nature. Chayote is originally native to Mesoamerica. The main growing regions are Brazil, Costa Rica, Veracruz Mexico and Abkhazia, Georgia.

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In India, chow-chow is widely grown in Madurai and Nilgiri district of Tamil Nadu, Karnataka, West Bengal, Mandi district of Himachal Pradesh and entire north-eastern hills region. Mizoram is the leading state with an estimated area of 845ha and 10,985 metric tonnes production. Though, it is a native of Mexico but considerable diversity is found in NEH region particularly, Meghalaya, Mizoram and Sikkim.

Sanwal *et. Al*[8], reported that the chayote fruit are rich source of carbohydrates, fats, proteins, minerals and vitamin A and vitamin C. Chayote is used mainly for human consumption. As it is soft in nature as compared to other fruits, it has been used for children's food, juices, sauces and pasta dishes. It gives positive results while preparing jams and other sweet products. In India, fruit and roots are not only consumed as human food but also used as fodder.

Food quality is the quality characteristics of food that is acceptable to consumers. This includes external factors as appearance (i.e. size, shape, colour, gloss and consistency), flavour and texture (firmness and crispiness) which are the most important traits that are directly related to the product's commercial values. Shape, size, and surface are important criteria in the analysis of product behaviour during handling, sorting, grading, drying, cooling and in the evaluation of consumer preference[5,3]. Textural parameters of fruits and vegetables are perceived with the sense of touch, either when the product is picked by with the sense of touch, either when the product is picked by hand or placed in the mouth and chewed (Sensory evaluation). In contrast to flavour attributes, these characteristics can be easily measured using instrumental methods.

Texture represents the principal factor defining the fruit quality. Firmness is a mechanical principal characteristic for consumers while eating different solid foods. In addition to firmness, puncturing force, toughness and cutting force allow us to quantify texture traits related to the degree of crispness, maturity more accurately and as a replacement for subjective sensory evaluation.

All physical and textural properties of food materials vary widely with variety. In light of the importance of these properties, many researchers have investigated the effect of varietal difference on these properties for better understanding of the fruits and vegetables[1]. However, systematic studies related to physical and textural traits of chayote varieties of North Eastern India is very scanty in literature[2]. Hence, in view of the above the present study was undertaken to analyze the differentiation in the physical and textural attributes among different varieties of chayote available in Sikkim.

MATERIAL AND METHODS

Six major varieties of chayote (Fig. 1) were collected from local market (Gangtok, India). These samples exhibit light green, yellow, deep green in colour as shown in the figure 1. Some varieties were smooth and some had spines on the surface. Due to these variations, the six selected varieties were designated as Yellow smooth (YS), Long smooth (LS), Green Smooth (GS), Long green spine (LGS), Yellow long spine (YLS) and Deep green spine (DGS) in the present study. The samples were washed, wiped dry and packed in polyethylene pouches and stored under refrigeration till further use.

Fig. 1. Selected Varieties of Chayote

2.1 Measurement of Physical Properties of Chayote

To differentiate between the chayote varieties, the samples were analyzed for moisture content, size and sphericity. Initial moisture content of the fresh chayote samples was determined using Infrared Moisture meter (Model - MA35, Sartorius, Germany). The average value of moisture content of samples obtained from three replications was expressed as per cent wet basis. The dimensions of the vegetable samples were determined by Digital Vernier calliper (Mitutoyo, Japan) having least count of 0.01 mm. The physical dimensions such as length (L), width (W), and thickness (T) of the individual fruit were measured separately. The equivalent diameter (D) of the chayote samples were expressed in terms of geometric mean diameter using Eq. (1). The sphericity (Φ) of the samples were calculated using Eq. (2). The surface area (S) of the samples was calculated using the dimensions from Eq. (3). All measurements were done in triplicate.

$$D = (LWT)^{1/3} \quad ...(1)$$

$$\phi = \frac{(LWT)^{1/3}}{L} \quad ...(2)$$

$$S = \pi D^2 \quad ...(3)$$

2.2 Textural Evaluation of Chayote

The clean stored chayote samples were brought to room temperature prior to experiment. The samples were then subjected to compression test, cutting test and puncture tests in a Texture Analyser (TA-HD Plus, Stable Micro Systems, UK). Under each variety, five samples of chayote were selected for measurement.

2.2.1 Compression Test

For compression test, all the four variety chayote samples were cut into cylindrical shape of 6 mm diameter and 9 mm height. The compression test was carried out with Texture Analyser (TA-HD plus, Stable Micro Systems, UK). These tests were performed to evaluate the compressive force and deformation of the material. The probe used was 25mm cylinder (p/25) with load cell of 35kg. The pre-test speed was 2 mm/s and post-test speed was 10mm/s. For each test, the sample was placed on the working platform and compressed up to a penetration depth of 5 mm. Force-deformation curves for each experimental trials were taken from Exponent lite software inbuilt with the system. The firmness values corresponding to the peak force were estimated from the force-deformation curves. These values were noted for each experimental runs and the test was replicated for all varieties.

2.2.2 Toughness and Puncture Test

For puncture test, all the six variety chayote samples were cut into cube shape of 9 mm diameter and 9 mm height. Fig. 3.6 shows the samples prepared for puncturing test. The puncture test was carried out with TA-HD Plus Texture Analyser. This test was performed to evaluate the force required to penetrate into the chayote sample. The probe used was 5mm cylindrical stainless steel (p/5). The pre-test speed was 2 mm/s and post-test speed were 10 mm/s. For each test, the sample was subjected to a penetration of 5 mm from the platform. The puncture force (F) is the peak force for each puncture test which was recorded from the force-deformation curves of samples. Toughness (T_f) of samples during puncturing test was also calculated as the product of maximum puncture force and corresponding deformation (δ) (Eq. 4).

$$T_f = F \times \delta \quad ...(4)$$

2.2.3 Cutting Test

The cutting test was also carried out with TA-HD Plus Texture Analyser to evaluate the force and energy required for cutting the sample. The probe used was shear rig with a stainless-steel cutter (HDP / BS; Blade) with a load cell of 30kg. The pre-test speed was 2 mm/s and post-test speed were 10 mm/s. A separate cube shape sample was placed on the working platform and cut up to a depth of 5 mm. The force deformation curves were used to evaluate maximum cutting force. The test was replicated for all varieties.

2.3. Statistical Analysis

The textural characteristics viz., firmness, puncturing force, toughness and cutting force of selected chayote samples were measured. The data collected for all six varieties of chayote were analyzed through ANOVA and Duncan Multiple Range Test (*DMRT*) using SPSS 16.0 software.

RESULTS AND DISCUSSION

3.1 Physical Properties of Selected Chayote Varieties

Table 1 shows the measured values of moisture content and physical properties of the six selected chayote varieties. The moisture content varied between 86.52 ± 0.72 % and 95.19 ± 0.65 % wet basis. This moisture content value was similar to the value of 95% wet basis for chayote samples as reported by Mancini *et. Al*[4].

From Table 1, the length, width, thickness, and equivalent diameter of the studied varieties varied in the range 63.97-152.76 mm, 52.91 – 69.20 mm, 45.69 – 62.36 mm, and 53.82±4.67 – 88.61±4.01 mm respectively. These results are similar to the values reported for different Chayote varieties of NE India as reported by Kapoor *et. Al*[2]. From the results of ANOVA, effect of variety on the dimensions viz., length, width and thickness and equivalent diameter of chayote samples were found to be significant ($p<0.05$). From Table 1, it can be observed that YS variety was found to be of lowest size and LGS variety was of highest size. The sphericity of all the selected chayote varieties were in the range of 0.58±0.01 for LGS variety to 0.87±0.04 for DGS variety.

Table 1. Physical properties of selected chayote varieties

Properties	YS	LS	GS	LGS	DGS	YLS
Moisture content (% wb)	93.07	95.19	92.83	91.92	91.31	86.52
Length, mm	63.97^{a}	97.37^{b}	89.80^{b}	152.76^{c}	70.71^{d}	90.21^{b}
Width, mm	53.33^{a}	52.91^{a}	66.11^{b}	74.18^{c}	60.59^{b}	69.20^{c}
Thickness, mm	45.69^{a}	45.97^{a}	57.93^{bc}	61.433^{cd}	53.595^{b}	62.36^{d}
Equivalent diameter, mm	53.82^{a} (4.67)	61.87^{b} (1.33)	70.06^{c} (1.05)	88.61^{d} (4.01)	61.23^{b} (4.38)	73.02^{c} (4.82)
Sphericity	0.84^{a} (0.03)	0.63^{b} (0.04)	0.79^{a} (0.05)	0.58^{b} (0.01)	0.87^{a} (0.04)	0.81^{a} (0.03)
Surface Area, mm²	9099.58^{a}	12025.3^{b}	15421.31^{cd}	24669.67^{e}	11779.84^{bc}	16750.26^{d}
Shape	Regular	Conic	Regular	Oblong	Regular	Regular

*The values in parentheses denote standard deviation values. Values followed by different superscripts in a row are statistically significant (*p*<0.05)

The surface area of the six chayote varieties varied in the range of 9099.68 mm^2 to 24669.67 mm^2 as observed from Table 1. LGS variety was found to have largest surface area whereas YS variety had the least surface area. From the results of ANOVA, varietal effect on the sphericity and surface area of chayote samples were found to be significant ($p<0.05$). From DMRT analysis of equivalent diameter, LS and DGS variety; GS and YLS variety were found to be of similar size. From the DMRT analysis of sphericity, it was observed that YS, GS, DGS and YLS varieties showed sphericity in the similar range and were close to spherical in shape where as LS and LGS are similar in terms of sphericity. From the sphericity and other dimensions of the samples, the shape of the chayote samples can be designated as oblong for LGS variety, conic for LS variety and regular for YS, GS, DGS and YLS variety. On comparison of the surface characteristics, YS, LS and GS varieties were found to be smooth whereas LGS, DGS and YLS varieties had spikes on their surface.

3.2. Textural Characteristics of Chayote

The textural properties viz., firmness, cutting force, toughness and puncturing force were estimated from the force deformation data collected during textural analysis of different varieties of chayote samples selected in the present study. The estimated values of textural properties of selected varieties of chayote samples are presented in Table 2.

Table 2. Firmness, puncturing force, cutting force and toughness of selected chayote varieties

Textural parameters	**Varieties of chayote**					
	YS	**LS**	**GS**	**LGS**	**DGS**	**YLS**
Firmness, N	42.83^{a} (1.72)	58.07^{bc} (10.92)	50.91^{ab} (11.8)	65.38^{c} (9.58)	65.11^{c} (2.51)	84.64^{d} (8.1)
Puncture Force, N	41.29^{a} (3.42)	38.25^{ab} (9.76)	36.52^{ab} (2.19)	37.46^{ab} (2.05)	34.35^{b} (2.35)	42.07^{a} (1.36)
Cutting force, N	82.94^{a} (5.89)	82.08^{a} (5.07)	77.77^{a} (7.12)	78.56^{a} (8.06)	95.37^{b} (6.64)	100.29^{b} (9.13)
Toughness, N-mm	134.27	121.85	110.97	104.04	101.49	111.19

*The values in parentheses denote standard deviation values. Values followed by different superscripts in a row are statistically significant ($p<0.05$)

3.2.1 Effect of chayote variety on firmness

The firmness values were calculated from the peak value of force-deformation curves collected during compression test. From Table 2, the firmness values varied in the range of 42.83 N±1.72 (YS) to 84.64±8.1 N (YLS) for the selected six varieties of chayote. Fig. 1 shows the variation in firmness values of all six chayote varieties. From the Fig. 1, the lowest firmness value was observed for YS variety whereas the highest value was noted for YLS variety. This may be due to the fact that the lowest moisture content of YLS variety might have contributed to the increased firmness. From single factor ANOVA results, the effect of chayote varieties on firmness was found to be significant ($p < 0.05$). Bianchi et al. (2016) reported similar findings for different cultivars of melons. From DMRT results, YS and GS variety; LGS and DGS varieties were similar in terms of their firmness.

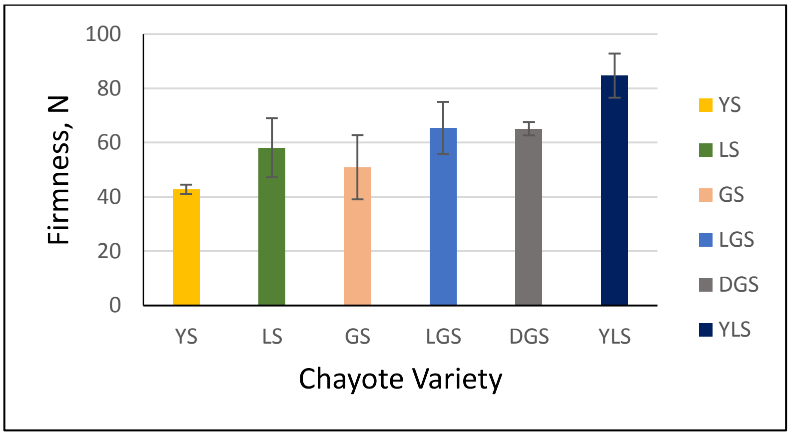

Fig. 1. Variation in firmness of selected chayote varieties

3.2.2 Effect of chayote variety on puncturing force

The puncturing force values as calculated from the force deformation curves for selected varieties of chayote samples. From Table 2, the puncture force varied between 34.35±2.35N (DGS) to 42.07±1.63 N (YLS) for selected six varieties of chayote. In order to test the effect of variety on puncture force, ANOVA was conducted. From the ANOVA results, it was found that the effect of variety on puncture force was non-significant (p>0.05). The same was confirmed from the DMRT results (Table 2).

3.2.3 Effect of chayote variety on toughness

The toughness values as calculated using puncture force and deformation from the force deformation curves for selected varieties of chayote samples are given in Table 2. From Table 2, the toughness values ranged between 101.49 N-mm (DGS) to 134.27 N-mm (YS) as observed. The results of ANOVA revealed that, the variety of chayote samples did not show any significant effect on toughness of chayote samples (p >0.05). Since the toughness was calculated using puncture force, it showed same behaviour as puncture force with variety.

3.2.4 Effect of chayote variety on cutting force

The cutting force values as calculated from the force deformation curves for selected varieties of chayote samples are presented in Table 2. From Table 2, the cutting force varied between 77.77± 7.12 N to 100.29±9.13 N. The lowest cutting force was observed for GS variety whereas the highest value was noted for YLS variety as observed form Table 2. Fig. 2 shows the variation in cutting force values of selected chayote varieties. From the ANOVA results, the effect of variety of chayote on cutting force was found to be significant (p <0.05). Similar behaviour has been reported by Pham and Liou[6] for Fengshui and Shingo pears. From the DMRT results (Table 2), YS, LS, GS, LGS chayote varieties showed similar cutting force range where as DGS and YLS varieties required more force to cut.

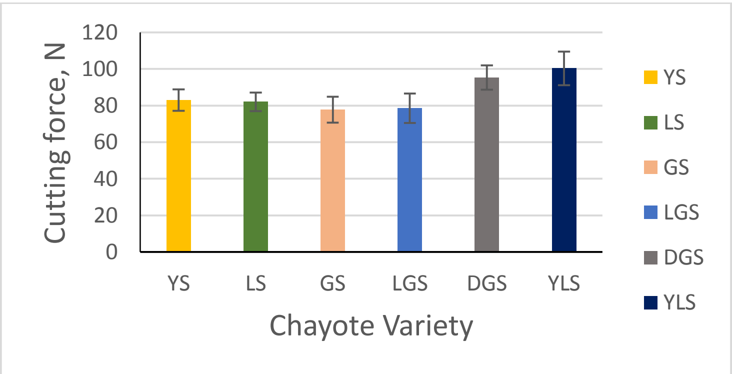

Fig. 2. Variation in cutting force in selected chayote varieties

CONCLUSIONS

Six varieties of chayote samples were studied for their physical and textural properties. From the study, it was revealed that YS variety was found to be of lowest size and LGS variety was of highest size. Majority of the chayote varieties studied were of regular shape. Varietal effect on both shape and size were found to be significant. Firmness and cutting forces showed significant varietal difference between the tested varieties whereas no significant variation was found for puncturing force and toughness among the selected chayote varieties. The findings of the present study would be very useful in the design of suitable primary processing equipment for chayote.

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