

Physico-optical Characterization of North Eastern Himalayan Cherry Pepper in Relation to Maturity

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ABSTRACT

This study was undertaken with the objective to study physical and optical properties of cherry pepper at two maturity stages viz., raw green and mature red. The physico-optical properties studied include moisture content, size, sphericity, surface area, unit mass, bulk density, true density, porosity, and colour. The average moisture content of raw green cherry pepper was 89.22 ± 2.19 % wet basis which was higher than the moisture content of mature red cherry pepper (78.59 ± 1.15 % wet basis). The average geometric mean diameter, sphericity, surface area, unit mass were 16.68 ± 1.9 mm, 1.14 ± 0.15 , 8.74 ± 1.59 cm², 2.08 ± 0.11 g respectively for raw green cherry pepper, and 15.84 ± 1.84 mm, 1.01 ± 0.17 , 8.55 ± 1.10 cm², 1.61 ± 0.23 g respectively for mature red cherry pepper. The average bulk density, true density and porosity were measured to be 501.7 ± 29.7 kg.m⁻³, 809.1 ± 21.2 kg.m⁻³ and 35.87 ± 3.26 % respectively for raw green cherry peppers and 380.6 ± 54.6 kg.m⁻³, 782.3 ± 18.1 kg.m⁻³ and 51.4 ± 3.81 % respectively for mature red cherry pepper. The mature cherry peppers showed more darkening and high intensity of red colour compared to the green samples.

Key words: Cherry pepper; Maturity; Physical properties; Colour

INTRODUCTION

Cherry pepper (*Capsicum annum*) is a very beautiful pod type pepper resembling the shape of round fleshy cherry. When fully ripe, it becomes luscious bright red, delightfully round, aromatic and about the size of a cherry tomato. It is mostly cultivated in north eastern states of India. The prominent varieties of cherry pepper cultivated in India are Pusa Jawala, Durga (Hyb), Pant C-1 and Dallay (Local). The local variety of cherry pepper

known as ‘Dallay khorsani’ is extremely popular in NE India especially in Sikkim. It is an excellent source of vitamin A, vitamin C, vitamin B and significant amounts of iron, thiamine, niacin, magnesium and riboflavin. It is cholesterol-free, saturated fat-free, low in calories, low in sodium and high in fiber. Cherry pepper is of ideal size for pickling or brining, and they also make for an excellent garnish on a dish. It is popular in both raw green and mature red stages.

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Raw green cherry pepper is mostly consumed as fresh and the mature red pepper as brined or pickled product. The shelf life of Dally is limited to few days at atmospheric conditions due to desiccation. This reduces the quality of the fresh peppers and very high prices during off season. The absence of adequate facilities and technical know-how for further processing and storage of cherry pepper limits the uses of such excellent pepper to fresh consumption and pickling.

Fruits, vegetables and spices are biomaterials that have several unique characteristics that set them apart from engineering materials. The most important quality attributes in chillies are the colour⁹. These properties determine the quality of the food and identification of correlations between changes in these properties which make quality control easier. Proper design of machinery for post harvest processing, transport and storage of agricultural products necessitates an understanding of their physical properties studied either in bulk or individually.

Shape, size, volume, mass and colour, are important in the analysis of product behaviour during handling, sorting, grading and in the evaluation of consumer preference¹³. Surface area is important during modeling of drying, aeration, heating, and cooling processes. Such information is useful in sizing motor requirements for transportation and handling¹⁰. Bulk, and true density of agricultural products play an important role in drying and storage, design of silos and storage bins, separation from undesirable materials, and grading¹². The porosity is often needed in air flow and heat studies as well as other applications.

Various valuable studies have been published on physical and optical properties of fruits, such as apricot^{1, 6}, cherry¹³, aonla⁷, strawberry¹⁴, pear¹⁵, kiwifruit¹¹ and kumquat fruit⁹.

Despite such extensive study on physical, and optical properties of various fruits and vegetables, no published literature is available regarding properties of cherry pepper

till date. This may be one the major reasons of absence of any scientific study related to processing and storage of cherry pepper. In the absence of technical know-how and research on post harvest processing, and storage of cherry pepper the uses of such excellent pepper has been limited to fresh consumption and pickling. Hence, detail study of various properties of raw green and mature cherry pepper is essential to develop an important database which can be referred in future for further processing and value addition. In light of these facts, the present study has been taken up to investigate various physical, and optical properties of cherry pepper.

MATERIAL AND METHODS

Cherry pepper of local variety 'Dally' was selected for present study. Freshly harvested cherry pepper at two maturity stages viz., raw green and mature red were procured from local market (Ranipool, India). The samples were washed with water, sponged with tissue paper and kept in sealed polyethylene packets in the refrigerator till further analysis. The samples were brought to room temperature for measurement.

Measurement of Physical Properties

Moisture content was measured using standard hot air oven method². The weight loss on drying to a final constant weight was recorded as moisture content. Three replications were followed for both types of cherry pepper.

500 numbers of both raw green and mature red cherry peppers were randomly selected for measurement of size, shape and surface area. Size was expressed in terms of geometric mean diameter (D_g). The length (L) and diameter (D) of the selected samples were measured using micrometer (Mitutoyo APB 1B, Japan) with 0.01 mm least count. From the measured values, size of the cherry pepper samples was expressed as geometric mean diameter which was computed using the following expression^{15, 7}.

$$D_g = (L \times D^2)^{1/3} \quad \dots (1)$$

Shape of the samples was expressed in sphericity (Φ). Sphericity was estimated using the following formula^{15,7}.

$$\Phi = D_g/L \dots (2)$$

Surface area (S) of the selected mature and raw cherry peppers was computed using the following expression.

$$S = (\pi D_g^2) \dots (3)$$

Unit mass (M) of fifty samples from each raw and mature cherry pepper was measured using a digital balance (Shimatzu, Japan) with an accuracy of ± 0.01 g.

Bulk density (ρ_b) was determined using mass and volume of cherry peppers by filling into an empty volumetric cylinder¹³. The fruits were left to fall from constant height of 15 cm, striking off top level. The weight of the samples was measured using a digital balance. The bulk density was calculated from the ratio of mass to volume. The samples were not compacted in any way during the experiment.

True density (ρ_t) was measured using toluene displacement method¹³. Toluene (C_7H_8) was used, rather than water, because water is absorbed by the fruits. Also its surface tension is low, so it fills even shallow dips in a fruit and its dissolving power is low¹². Randomly selected cherry peppers were weighed on digital balance with ± 0.01 g accuracy. The fruits were lowered with a metal sponge sinker into a volumetric cylinder containing toluene such that the fruits did not float during immersion in toluene. Volume of toluene displaced by the samples was recorded as true volume (V_t). Three replications were followed for the measurement of bulk and true density. Porosity (ε) was calculated using the following expression⁸.

$$\varepsilon = \left[(\rho_t - \rho_b) / \rho_t \right] \times 100 \dots (4)$$

Measurement of Optical Properties

Colour of mature red and raw green cherry pepper samples were measured using a digital colorimeter (Colorflex 45°/0°, Hunter Lab,

U.S.A.). The colorimeter was standardized with a black and white standard tile prior to analysis. For each sample, at least three measurements were performed at different positions and the mean values were recorded. Three replications were followed for both mature and raw samples. The measurements were displayed in the hunterlab color coordinate system (CIELab scale) L^* = lightness (0 = black, 100 = white), a^* ($-a^*$ = greenness, $+a^*$ = redness) and b^* ($-b^*$ = blueness, $+b^*$ = yellowness) values.

Hue angle (H) and chroma were also determined using the following formula^{15, 11}. These parameters are generally used to effectively express the visual color appearance of sweet cherry³. Chroma indicates intensity of colour whereas hue angle represents the whether the object is red, orange, yellow, green, blue, or violet¹¹.

$$H = \left[\tan^{-1}(b^*/a^*) \right] \dots (5)$$

$$Chroma = (a^{*2} + b^{*2})^{1/2} \dots (6)$$

External colour was expressed in terms of hue angle, considered the most important measure in the perception of any fruit quality, because external fruit colour relates better to perception of colour by the human eye¹⁷. Hue angle ranges between 0° and 360° .

Statistical Analysis

Single factor Analysis of Variance (ANOVA) was carried out using SPSS 16.0 software to analyse the data obtained for both forms of cherry pepper.

RESULTS AND DISCUSSION

Moisture Content

Table 1 summarizes the experimental results of moisture content and measured physical properties of raw green and mature red cherry pepper. From Table 1, it can be observed that the average moisture content of raw green cherry pepper was 89.22 ± 2.19 % wet basis which was higher than the moisture content of mature red cherry pepper i.e. 78.59 ± 1.15 % wet basis. The moisture content of raw green cherry pepper was found to be higher than the mature red pepper. It may be due to loss of moisture from the cherry pepper as it

approached maturity and ripening stage⁵. From the results of ANOVA, this difference was found to be highly significant ($p < 0.001$).

Linear Dimensions, Geometric Mean Diameter, Sphericity, and Surface Area

The length for raw green and mature red peppers varied between 10.95 and 25.65 mm and 10.42 and 24.12 mm respectively, where as the diameter varied in the range of 11.21 to 26.2 mm and 10.73 to 25.73 mm respectively (Table 1). The average geometric mean diameter of 500 samples of raw green and mature red cherry pepper was found to be 16.68 ± 1.90 mm and 15.84 ± 1.84 mm respectively. From the results of ANOVA, the variation in linear dimensions and geometric mean diameter at different maturity stages was found to be non significant.

The sphericity of raw green cherry peppers varied between 0.75 and 1.61 where as for mature red cherry pepper the range was from 0.81 to 1.57 as observed from Table 1. The average sphericity of raw green and mature red cherry pepper were found to be 1.14 ± 0.15 and 1.01 ± 0.17 respectively. Due to the greater diameter, sphericity of cherry pepper was higher than 1 which means all most all samples were spherical. Similar type

of results with sphericity of more than one have been reported for Aonla fruits (1.08 - 1.11) by Goyal *et al.*⁷ and 1.17 ± 0.01 for strawberry fruits by Ozcan and Aciferogullari¹⁴. The effect of maturity stage on sphericity of pepper samples was found to be non-significant.

The average surface area values for raw green and mature red cherry peppers were found to be 8.74 ± 1.59 cm² and 8.55 ± 1.10 cm² respectively (Table 1). No significant variation in surface area was observed between green and red cherry peppers. This may be due to the fact that surface area has been calculated from the geometric mean diameter which showed non-significant variation with maturity.

Unit Mass

The average unit mass of raw green and mature red cherry peppers were 2.08 ± 0.11 g and 1.61 ± 0.23 g respectively (Table 1). From the comparison of masses, the mature red cherry peppers were found to be lighter than raw green samples. This decrease in mass may be attributed to the loss of moisture from the peppers up on ripening. This effect of maturity on loss of mass was found to be highly significant ($p < 0.001$).

Table 1: Physical properties of raw green and mature red cherry pepper

Property	Raw green			Mature red		
	Max.	Min.	Mean	Max.	Min.	Mean
Length, mm	25.65	10.95	15.16 ± 0.76^a	24.15	10.42	14.87 ± 2.00^a
Diameter, mm	26.2	11.21	17.94 ± 1.55^a	25.65	10.73	16.93 ± 2.02^a
Geometric mean diameter (D_g), mm	22.89	11.01	16.68 ± 1.90^a	21.76	10.52	15.84 ± 1.84^a
Sphericity (Φ)	1.61	0.75	1.14 ± 0.15^a	1.57	0.81	1.01 ± 0.17^a
Surface area (S_p), cm ²	16.46	3.80	8.74 ± 1.59^a	14.87	3.48	8.55 ± 1.10^a
Mass, g	3.02	1.13	2.08 ± 0.11^a	2.81	1.06	1.61 ± 0.23^b
Bulk Density, kg.m ⁻³	529.7	454.3	501.7 ± 29.7^a	461.6	379.1	380.6 ± 54.6^b
True Density, kg.m ⁻³	854.8	652.7	809.1 ± 21.2^a	819.1	757.1	782.3 ± 18.1^b
Porosity, %	39.99	32.25	35.87 ± 3.26^a	57.45	43.24	51.40 ± 3.81^b
Moisture content, % wb	-	-	89.22 ± 2.19^a	-	-	78.59 ± 1.15^b

Values followed by different superscripts in a row are significantly different ($p < 0.001$)

Bulk Density, True Density and Porosity

The values of bulk density, true density and porosity of raw green and mature red cherry peppers have been presented in Table 1. The average bulk density of green and red cherry peppers were 501.7 ± 29.7 kg.m⁻³ and 380.6 ± 54.6 kg.m⁻³ respectively. From Table 1,

higher values of bulk density can be observed for raw green compared to mature red cherry peppers. This may be attributed to higher moisture content of fresh raw green samples.

Similar to bulk density, the average true density decreased from 809.1 ± 21.2 kg.m⁻³ for raw green cherry pepper to 782.3 ± 18.7

kg.m⁻³ for mature red cherry pepper. The average porosity values were 35.87±3.26 % and 51.40±3.81 for green and mature red cherry peppers respectively. It was observed that porosity increased with maturity and decreased with higher moisture content green cherry pepper samples. Similar trends were observed by Demir *et. al.*⁴ for hackberry fruits and Fathollahadeh *et. al.*⁶ for barberry. These effects of maturity on bulk density, true density and porosity of cherry pepper samples were found to be significant ($p < 0.001$).

Optical Properties

Fig. 1 represents the Hunterlab color values viz., L^* , a^* , and b^* of raw green and mature red cherry peppers. From the comparison of L^* values of both cherry peppers, it was observed that lightness decreased with maturity which

indicates darkening of cherry pepper as it matures. The a^* value showed a sharp increase changing from negative (green colour) to positive (red colour) for mature cherry peppers. Similar type of behaviour was observed by Radzevičius *et. al.*¹⁶ for tomato ripening. Chroma values increased as the cherry pepper changed from raw green to mature red stage which suggested that the red colour intensity in mature cherry pepper was higher in comparison to the greenness intensity of raw cherry peppers. External colour was expressed in terms of hue angle. The raw cherry pepper showed a hue angle of 75.85° which indicated green colour whereas the mature samples had a lower value of 34° suggesting red colour.

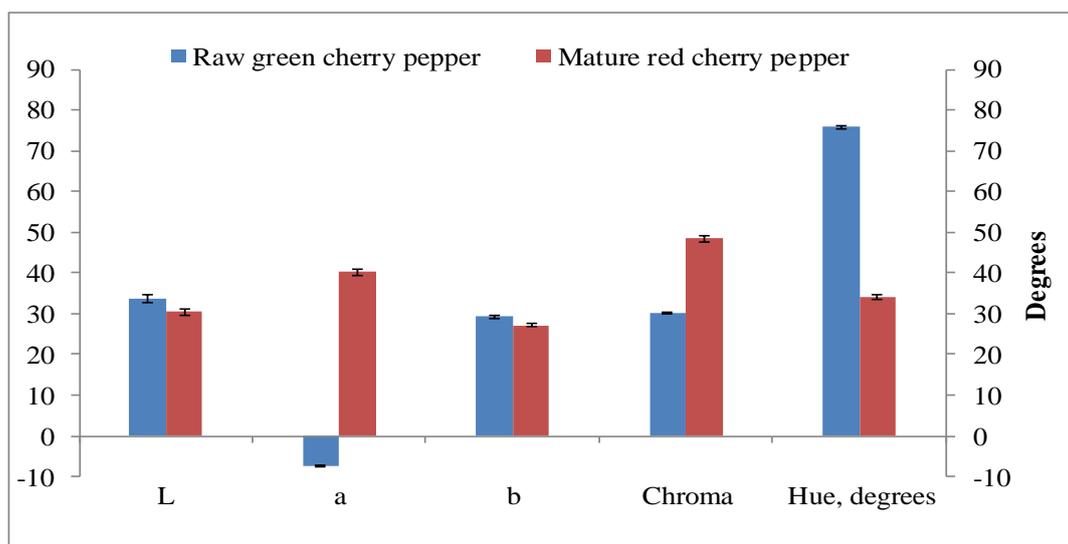


Fig. 1: Optical properties of raw green and mature red cherry pepper

CONCLUSIONS

Cherry pepper (Local 'Dallay' variety) was studied for various physical and optical properties. The moisture content of cherry pepper samples were significantly affected by the maturity stage. The geometric mean diameter values did not vary significantly with maturity stage of cherry peppers. Sphericity for both raw green and mature red cherry peppers was found to be more than 1 inferring its shape as spherical. Raw green cherry pepper showed lower porosity than mature red cherry pepper. The colour of green cherry pepper was found to be dark greenish-yellow

whereas the red cherry peppers were more of dark red-orange colour. The findings of the present study would be helpful in designing many post harvest processing machineries as well as development of different value added products from cherry pepper.

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