Determination of some physical properties of Plum (cv. Kala Amritsari) fruits

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Abstract

The present study was carried out to determine the physical properties of plum (cv. Kala Amritsari) which will be helpful for the design of fruit processing machineries. The fruits were graded in two categories viz., smaller (S) and bigger (B) on the basis of physical appearance. Moisture content of the fruit pulp was 85.19±0.54 % (w.b). Linear dimensions of ‘S’ fruits were: major intercept (19.41±1.96 mm), minor intercept (16.79±1.46 mm), geometric mean diameter (18.48±1.72 mm), arithmetic mean diameter (3.31±0.12 mm), sphericity (0.79±0.03), surface area (1082.59±120.81 mm²) and aspect ratio (1.15±0.17), while the corresponding values for ‘B’ fruit were, 25.15±0.77 mm, 23.61±0.30 mm, 24.49±0.41 mm, 3.17±0.08 mm, 0.98±0.02 mm, 1901.98±66.93 mm², 1.08±0.15, respectively. The density values in terms of bulk density were 660±27.54 kgm⁻³ (S), 473±18.69 kgm⁻³ (B), true density 1213±58.3 kgm⁻³ (S), 1120±74.28 kgm⁻³ (B) and porosity 45.6±5.30 (S), 56.8±7.28 (B) were also recorded. Colour values in terms of L (33.62±2.04), a (66.87±6.75), b (10.24±2.62) for ‘S’ fruits and for ‘B’ fruits L (37.38±1.88), a (61.25±5.91) and b (12.28±2.66) were observed. The average fruit weight, pulp weight and seed weight for ‘S’ grade fruits was 32.35±4.25 g, 28.74±3.50 g, 1.09±0.32 g, while for ‘B’ grade fruits it was 38.14±5.33 g, 33.57±6.53 g, 1.73±0.26 g, respectively.

Keywords: Grade, plum, physical properties, moisture content

Introduction

Physical characteristics of agricultural products are the most important parameters in design of grading, conveying, processing and packaging systems. Among these physical characteristics, mass, volume, projected areas and center of gravity are the most important ones in sizing systems. Axial dimensions viz., length, width and thickness are also basic and important parameters considered for machine design (Mohsenin, 1986) [6].

Plums (Prunus domestica) are the stony fruits widely produced within the Asians countries. In India, plum has been cultivated on 0.23 million hectare area with production of 0.89 million tons (Anonymous, 2019) [1]. The major plum growing states include Jammu and Kashmir, Himachal Pradesh, Uttar Pradesh, Uttarakhand, Arunachal Pradesh, Nagaland, Meghalaya, Manipur and Sikkim. They are available in an exceedingly wide variety of size and colours like yellow, white, green or red pulp. The fruits are typically of medium size (1-3 inches in diameter) and are usually spherical/oval in shape with firm pulp and juicy nature. Plum fruit is rich in Vitamin A, B, (Thiamine), riboflavin and some minerals like calcium, phosphorus and iron. Plums are considered to be an ample source of nutrients and health beneficial compounds (Rop et al. 2009) [8]. The well blended acidity with sugars is helpful in the preparation of jams and squashes. Plums are considered a source of phytochemical compounds with helpful effects on health. Plums cv. Kala Amritsari are medium in size, dark brown at maturity while pulp is slightly yellowish and juicy most suitable for preparation of jam.

Several reports are available concerning the quality as well as estimation of physico-chemical properties and anthocyanin content of various plum cultivars (Rop et al. 2009; Usenik et al. 2009; Ionica et al. 2013) [8, 9, 3]. The aim of this paper was to evaluate the physico-chemical properties of plum cv. Kala Amritsari with a function of its grade in order to obtain the data helpful for the design of relevant post-harvest machineries.
Materials and Methods

Raw material

Plum fruits cv. Kala Amritsari was harvested at optimum maturity from the orchard of ICAR-CIPHET Abohar (Punjab). The healthy fruits were selected, washed and graded subsequently as big (B) and small (S) based upon the diameter (Fig. 1a and 1b). The fruits were stored in polythene bags in cold storage at 8± 2 °C until use.

Determination of physical properties

The properties including axial dimensions, geometric mean diameter, moisture content, true density, bulk density, sphericity index (Sp) and surface area (S) were estimated following the standard procedures. To determine physical properties of plum fruits are separated by visual appearance and 30 fruits were randomly selected for both small and big fruit group. Axial dimensions (major and minor intercept) were measured using digital vernier calipers (M/s Mitutoyo, ±0.01mm) as shown in Fig. 2.

The moisture content of the pulp was measured using hot air oven method 70±5 °C for 24 h. The mass of the fruit was determined using digital balance (M/s Metler Toledo, ±0.001 g) by taking the weight of 100 randomly selected fruits and then extrapolated to weight of 1000 fruits. The arithmetic mean diameter (AMD) and the geometric mean diameter (GMD), sphericity index (Sp) and surface area (S) was calculated using following formulae (Mohsenin 1986 [6], Mahawar et al. 2017, Mahawar et al. 2019) [6, 4, 5]

\[
\text{AMD} = \frac{\text{LWT}}{3} \tag{1}
\]

\[
\text{GMD} = \left( \frac{\text{LWT}}{3} \right)^{1/3} \tag{2}
\]

\[
\text{Sp} = \frac{\text{GMD}}{\text{L}} \times 100 \tag{3}
\]

\[
\text{S} = \pi \left( \frac{\text{GMD}}{2} \right)^2 \tag{4}
\]

The aspect ratio (AR) of the fruit was calculated using following formula (Pathak et al. 2019) [7].

\[
\text{AR} = \frac{\text{W}}{\text{L}} \tag{5}
\]

Results and Discussion

Moisture content

Moisture content of fruit pulp was found 85.19% (w.b). Ertekin et al. (2006) [2] reported the moisture content for Stanley and Frenze 90 plums as 89% (w.b) and 87% (w.b), respectively.

Axial dimensions and surface area

For smaller grade fruits, the values observed for major intercept (16.83 to 22.76 mm), minor intercept (22.17 to 29.61 mm), arithmetic mean diameter (3.12 to 3.52 mm), geometric mean diameter (16.36 to 21.47 mm) and surface area (842.25 to 1449.65 mm²). However, for bigger fruits the corresponding values are 14.69 to 19.13 mm, 19.41 to 29.76 mm, 2.72 to 3.64 mm, 21.41 to 28.80 mm and 1141.46 to 2049.65 mm².
Bulk and True density
Bulk density and true density were 615.33 to 680.36 kg/m$^3$ and 1050 kg/m$^3$ respectively. Frenze 90, respectively.

Sphericity, Aspect Ratio and Porosity
The average value of sphericity index was 0.78% and 0.96% for smaller and bigger grade fruits. The mean porosity values of smaller and bigger plums were observed to be 45.58 and 57.76. The aspect ratio value for smaller and bigger plums was in the range of 1.05 to 1.26 and 0.86 to 1.31, respectively. Ertekin et al. (2006) [2] reported that the sphericity index, porosity and aspect ratio were 0.76%, 38.99% and 0.69 for cv. Stanley and 0.858%, 44.25% and 0.821% for cv. Frenze 90, respectively.

Fruit mass, Pulp and Stone weight
Fruit mass was in range of 14.32 to 26.52 g (S) and 34.71 to 45.38 g (B) fruits. The pulp weight and stone weight was varied from 13.50 to 28.56 g and 3.63 to 9.33 g for ‘S’ grade of fruits. Similarly, the corresponding values were 28.56 to 36.60 g (pulp weight) and stone weight (5.86 to 9.33 g) for ‘B’ grade of plums. Ertekin et al. (2006) [2] reported that the average stone mass was 1.93 g for cv. Stanley and 2.64 g for cv. Frenze 90, respectively.

Conclusion
• Moisture content of the plum fruit was 85.19±0.54% (w.b).
• Linear dimensions of smaller fruits were: major intercept (19.41±1.96 mm), minor intercept (16.79±1.46 mm), geometric mean diameter (18.48±1.72 mm), arithmetic mean diameter (3.31±0.12 mm), sphericity (0.79±0.03), surface area (1082.59±120.81 mm$^2$) and aspect ratio (1.15±0.17). Whereas, corresponding values for bigger fruit were, 25.15±0.77 mm, 23.61±0.30 mm, 24.92±0.41 mm, 3.17±0.08 mm, 0.96±0.02, 1901.98±66.93 mm$^2$, 1.08±0.15, respectively.
• The density values in terms of bulk density (S: 660±27.54 kg/m$^3$, B: 473±18.69 kg/m$^3$), true density (S: 1213±58.3 kg/m$^3$, B: 1120±47.28 kg/m$^3$) and porosity (S: 45.6±5.30, B: 56.8±7.28) were observed.
• The average fruit weight, pulp weight and seed weight for ‘S’ grade fruits was 32.35±4.25 g, 28.74±3.50 g, 1.09±0.32 g, while for ‘B’ grade fruits it was 38.14±5.33 g, 33.57±6.53 g, 1.73±0.26, respectively.
• Colour values in the form of L, a, b values for ‘S’ fruits (33.62±2.04, 66.87±6.75, 10.24±2.62) and for ‘B’ fruits (37.38±1.88, 61.25±5.91, 12.28±2.66) were observed.

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Table 1: Some physical properties of plum cv. Kala Amritsari

| Properties                        | Min | Max | Mean | Standard Deviation |
|-----------------------------------|-----|-----|------|--------------------|
|                                   | Small | Big | Small | Big | Small | Big | Small | Big |
| Major intercept (mm)              | 16.83 | 22.17 | 22.76 | 29.61 | 19.41 | 25.15 | 1.96 | 3.71 |
| Minor intercept (mm)              | 14.69 | 19.41 | 19.13 | 29.76 | 16.78 | 23.60 | 1.45 | 2.26 |
| Arithmetic mean diameter          | 3.12 | 2.72 | 3.52 | 3.64 | 3.31 | 3.17 | 0.12 | 0.29 |
| Geometric mean diameter (mm)      | 16.36 | 21.41 | 21.47 | 28.80 | 18.48 | 24.49 | 1.72 | 2.23 |
| Surface area (mm$^2$)             | 842.25 | 1441.46 | 1449.65 | 2607.52 | 1082.58 | 1901.97 | 120.81 | 66.98 |
| Bulk density (kg/m$^3$)           | 615.33 | 373.78 | 680.36 | 496.35 | 660.00 | 473.00 | 27.54 | 18.69 |
| True density (kg/m$^3$)           | 1150.36 | 978.34 | 1315.37 | 1237.36 | 213.00 | 1120.00 | 58.90 | 47.28 |
| Sphericity index (%)              | 0.73 | 0.90 | 0.83 | 0.98 | 0.78 | 0.96 | 0.03 | 0.09 |
| Aspect ratio                      | 1.05 | 0.86 | 1.26 | 1.31 | 1.15 | 1.08 | 0.06 | 0.14 |
| Porosity (%)                      | 46.50 | 61.79 | 48.27 | 59.88 | 45.58 | 57.76 | 5.3 | 7.28 |
| Fruit weight (g)                  | 14.32 | 34.71 | 26.52 | 45.38 | 19.83 | 40.10 | 4.25 | 5.33 |
| Pulp weight (g)                   | 13.50 | 28.56 | 22.89 | 36.60 | 18.74 | 33.57 | 3.50 | 6.53 |
| Stone weight (g)                  | 0.79 | 5.86 | 3.63 | 9.33 | 1.09 | 6.53 | 0.32 | 0.26 |

Fruit colour
L* | 32.28 | 30.88 | 36.75 | 53.11 | 34.61 | 39.04 | 2.04 | 1.88 |
a* | 59.78 | 52.88 | 74.69 | 67.74 | 66.61 | 60.48 | 6.75 | 5.91 |
b* | 8.49 | 8.63 | 14.14 | 13.94 | 11.08 | 11.22 | 2.62 | 2.66 |

Values are represented as average of 30 replications.
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