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Gel Textural Properties of *Aloe vera*

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Aloe vera is a very important crop extensively used for food, medicinal and cosmetic industry. The gel obtained from aloevera is a very important product. Studies were carried to understand the relation between textural properties like penetration and cutting force with respect to gel distribution in aloevera leaves. The gel distribution percentage was 24.11 per cent, 27.30 per cent and 38.40 per cent, respectively in top, middle and bottom regions of aloevera plant, indicating that leaves from bottom region of the plant only needs to be harvested for increased gel extraction. The study using the textural analyzer revealed that during the process of removal of the spikes from the aloevera leaves, the cutting of outer spikes in vertical direction required only 9 to 11 per cent of cutting force when compared to the horizontal direction, which would be helpful in developing a suitable cutting tool for mechanization. Low temperature storage of 5 ± 1°C for 24 h made the aloe vera leaves harder requiring greater penetration and cutting forces.

Key words: Aloe vera, gel content, penetration force, cutting force, textural analyser.

Aloe vera L, a perennial succulent plant with green leaves joined at the stem in rosette pattern, belongs to synonym *Aloe barbadensis Miller* of liliaceae family (Kaufman *et al.,* 1989). Aloe, native to Africa, is also known as “lily of the desert”, the “plant of immortality”, and the “medicinal plant”. Aloe leaf gel contains over 75 nutrients and 200 active compounds (Davis, 1997; Chang *et al.,* 2006) including 20 minerals, 18 amino acids, and 12 vitamins. More importantly, it provides 7 out of the 8 essential amino acids which the body cannot synthesis (Morgan *et al.,* 1987). It is rich in all vitamins excluding Vitamin D, especially the antioxidant Vitamins A (beta-carotene), C and E and traces of Vitamin B_{12} (Coats, 1979). Calcium, sodium, potassium, manganese, magnesium, copper, zinc, chromium and the anti-oxidant selenium are also present in Aloe vera (Blumenthal *et al.,* 1998; Chen *et al.,* 2009; Muhammad *et al.,* 2009). Sugars are derived from the mucilage layer of the plant which surrounds the inner gel and are known as mucopolysaccharides, which enhance the immune system and help to detoxify the unwanted components like ammonia (Gowda *et al*., 1979; Segovia *et al.,* 2009). Twelve phenolic compounds are found exclusively in the plant sap. Saponins form about 3% of the gel (Saha *et al.,* 2005; Xiu, *et al.,* 2006; Vega-Gálvez *et al.,* 2007; Vega-Gálvez *et al.,* 2009). The extraction of gel from leaf is a tedious process and efficient equipments are required for easier and hygienic extraction by mechanization (Ramachandra and Srinivasa Rao, 2008). Studies were carried out at Central Institute of Agricultural Engineering, Regional Centre, Coimbatore to determine the textural properties of Aloe vera leaf against its gel distribution, for designing suitable equipment for gel extraction which works on the principle of peeling the outer and the inner rinds of leaf.

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Materials and Methods

Dindigal variety was taken up for study. The leaves were collected separately from the top, middle and bottom regions of the plants and washed in clean water before subjecting them for experimentation. All the experiments were conducted at room temperature 30 ± 2°C (RH = 60%). The samples which were subjected to low temperature storage were kept at 5 ± 1°C (RH = 90%) for 24 h.

Physical properties

Aloe vera leaf mass was measured by using an electronic balance of 0.001 g sensitivity. The volume was determined by the water displacement method (Mohsenin, 1986). It was determined by filling a predefined container from a constant height, striking off the top level and then weighing the contents (Deshpande *et al.,* 1993; Gupta and Das, 1997). Gel was separated manually using a sharp knife. Gel percentage was calculated by separating and weighing the internal gel part alone. Surface area was calculated by manually by graphical method (Anon, 2012).

Textural properties

The universal stable texture analyser (Stable microsystem, UK) was used for textural analysis (Bourne, 2002). Probes such as P/2N needle and HSK blade were used for testing penetration and cutting force, respectively. Whole leaves were divided into eight sections (Fig. 1) and subjected to textural analysis. Each part of the leaves collected from the bottom of plants were abbreviated as HB1; HB2; HB3; HB4; HB5; HB6; HB7 and HB8

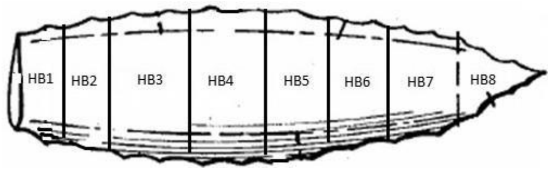

Fig. 1. Different sections of leaf

The following experiments were conducted and the observations recorded.

1. Textural profile in terms of penetration force along the leaf length (Fig. 2).
2. Textural profile in terms of cutting force required along the leaf length (Fig. 3).
3. Cutting force required to remove the outer spikes in vertical (Fig. 4) and horizontal axes (Fig. 5).

Effect of low temperature on gel penetration and cutting force

In order to study the effect of low temperature storage on the textural properties *i.e*. penetration and cutting force required, the leaf samples were stored at low temperature (5 ± 1°C ; RH = 90%). The penetration and cutting force were recorded after 24 h of storage and compared with the freshly harvested leaf. Each experiment was repeated three times and the data were analysed.

Fig. 2. Penetration test of Aloe vera leaf sample

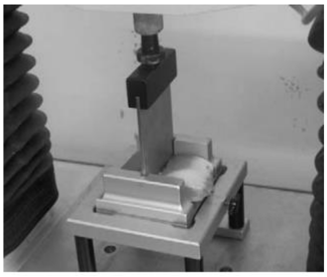

Fig.3. Cutting test of Aloe vera leaf sample

Results and Discussion

Gel distribution pattern in Aloe vera leaf from different regions of plant profile

The gel obtained from top, middle and bottom regions was 24.11 per cent, 27.30 per cent and 38.40 per cent, respectively. The difference in gel obtained

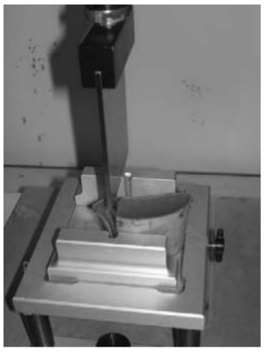

Fig.4. Spikes removal on vertical axis of Aloe vera leaf sample

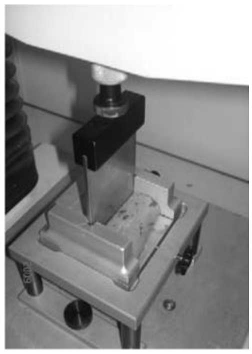

Fig.5. Spikes removal on horizontal axis of Aloe vera leaf sample

can be attributed to the difference in specific gravity of the gel taken from various regions. The specific gravity of the gel was found to be 0.91. 0.95, 1.02 g/cm2 for top, middle and bottom regions, respectively. This clearly indicates that as the leaves mature, the specific gravity of the gel also increases, thereby resulting in higher percentage of gel content at the bottom region of the leaves. The rind to gel ratio was higher in the leaves harvested at the bottom region. The leaves in the bottom were harvested for processing (Ravindra Naik *et al*., 2009; Anon., 2012) and hence leaves from this region alone were taken up for the experimentation.

Textural analysis of Aloe vera leaves with respect to penetration and cutting

The penetration and the cutting trials were conducted using textural anlayser. The leaf was divided into eight sections as shown in Fig.1. The leaf sections were subjected to penetration and cutting tests using the P/2 N needle and HSK blade probe. The results of penetration test are depicted in Fig 6. The penetration force required was maximum at the upper end of the leaf (2.92 N at HB8 which was on par with 2.86 N at HB7) which might be due to lower content of gel at the leaf tip. This was followed by the lower end which was attached to the main stem (2.54 N at HB1), which can be contributed to the thicker portion of the rind near this portion (Anon., 2012). The portion at the middle required lower penetration force due to the combination of high gel content and medium rind thickness (2.12 N at HB3 to 2.31N at HB6).

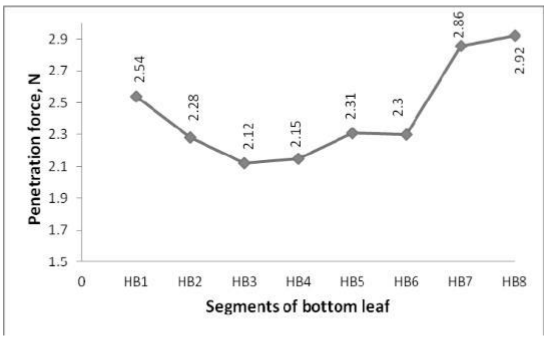

Fig. 6. Variation of penetration force in different sections of Aloe vera leaf

The results of cutting force required are shown in Fig 7. The cutting force reduced constantly with the distance of the leaf from the stem. It varied from 116.78 N at HB1 to 19.84 N at HB8. The constant reduction in the cutting force from HB1 to HB8 might be attributed to lower rind thickness from HB1 to HB8 and lower gel content from the base to the tip of the leaf. Similar trend was observed for the leaves harvested from middle and top regions. However, these are not reported as these data are not relevant in the design of the equipment since the leaves from middle and top regions of the plant are not recommended for harvesting for the processing of gel (Anon., 2012).

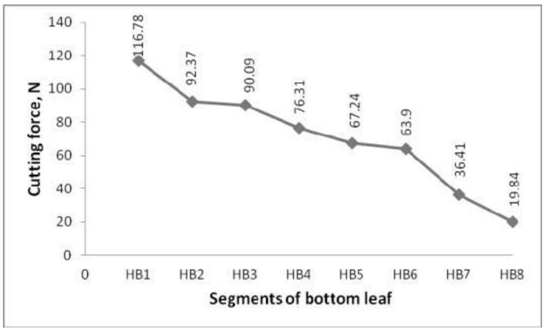

Fig. 7. Variation of cutting force in different sections for the Aloe vera leaf

Cutting force required for removing of the spikes in vertical and horizontal position

Removing spikes is an important and essential step in the processing of aloevera leaves for gel extraction (Ravindra Naik *et al.,* 2009). The spikes can be removed either in vertical or horizontal position. In the horizontal position, the cutting force required varied from 86.04 N to 61.44 N from the lower base to the upper tip of leaf (HB1 to HB8) (Fig.8). When the spikes were cut in the vertical position, the force required was very less; it varied from 9.54 N at the base end to 5.62 N at the tip of the leaves. Thus the force required in the vertical

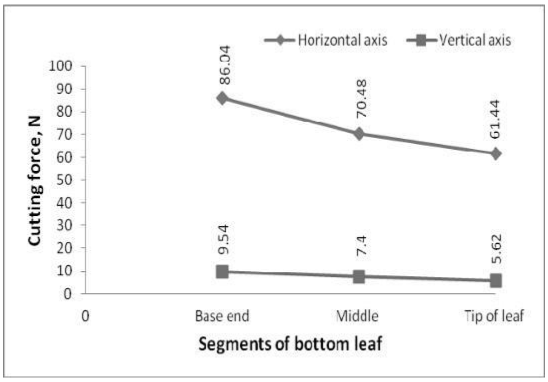

Fig. 8. Effect of cutting force to remove the spikes of Aloe vera leaf

position to remove the spike was only 9-11 per cent to that in the horizontal position. This may be due to the fact that the knife entered through the gel and moved along the gel during the cutting action. While cutting in the horizontal axis, the knife has to cut the rind of the leaves throughout and thus, required higher cutting force due to its thick and hard structure. It was observed that the cutting force required at the lower base end (HB1 to HB2) was higher than that of the middle section (HB3 to HB6) and upper tip section of the leaf (HB7 to HB8) due to the fact that the basal end of the leaf attached to the plant stem has thicker rind than that of the upper tip portion (Anon., 2012).

Effect of low temperature on gel penetration and cutting force

The aloe vera leaves have to be processed within 24-36 h after harvesting to get the best product (Ravindra Naik *et al.,* 2009). Some of the processing industries store it at low temperature to increase the shelf life. In view of the above, study was conducted to assess the effect of low temperature storage (5 ± 1°C; RH = 90%) for a period of 24 h on the penetration and cutting force by using a textural anlayser (Anon, 2012).

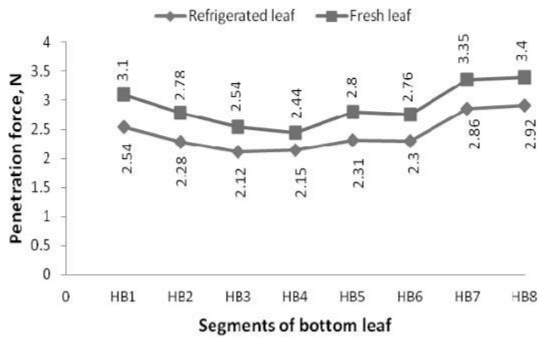

Fig. 9. Penetration force (N) of fresh Aloe vera leaves Vs leaves stored at 5 ± 1◦C for 24 h

The comparison in penetration force between freshly harvested leaves to the leaves stored at 5± 1◦C for 24 h is given in Fig 9. From the figure it is seen that the variable is same as fresh leaves not with storage. In freshly harvested samples at ambient conditions, it was reduced from 2.54 N to 2.12 N and then increased to 2.92 N. The leaves stored at low temperature in refrigerator followed similar trend (3.1 N, 2.44 N and 3.4 N, respectively) as that of freshly harvested samples (Anon, 2012).

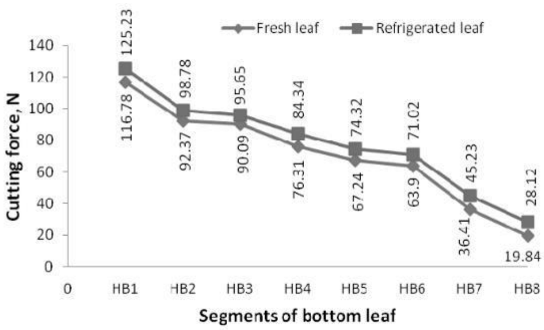

Fig. 10. Cutting force (N) of fresh Aloe vera leaves Vs leaves stored at 5± 1◦C for 24 h

In the case of cutting force, the freshly harvested samples at ambient conditions, the force reduced from 116.78 N to 19.84 N, whereas the same for low temperature stored leaf was from 125 N to 28.12 N (Fig 10). The leaves stored at the low temperature followed the similar trend as that of fresh leaves. Thus it is found that there is a significant increase in penetration and cutting force in low temperature stored samples when compared to fresh samples. This may be due to the hardening of leaves when exposed to lower temperature during storage (Anon, 2012).

Conclusion

On the basis of the results obtained in the present investigation, it is concluded that the bottom leaves alone need to be harvested for increased gel extraction as it yielded higher gel percentage of 38.40 percent when compared to top region (24.11) and middle region (27.30). Further, the cutting tool for removal of the spikes from the aloevera leaves, should be designed in vertical direction as it required only 9-11 per cent of the cutting force that is required in the horizontal direction.

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