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Studies on Heat Pre-treatment on Mechanical Properties and Ascorbic Acid Content of Aonla *(Emblica Officinalis Gaertn)*

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Mechanical properties and ascorbic acid content of aonla *(Emblica Officinalis Gaertn)* on heat treatment during processing were studied. The hardness and toughness of aonla varieties ranged from 14-15.8 N and 104 to 123 N/mm, respectively. The surface hardness and toughness of the aonla fruits reduced with heat treatment either by means of boiling in water or by microwave heating. The time required for segmentation by boiling was ten minutes while by microwave it was 210 s, 150 s and 90 s at 300 W, 450 W and 600 W, respectively. These segments could be used for aonla preserves and candy. Microwave heat treatment helped in retention of ascorbic acid content in aonla to an extent of 77.45 per cent to 83.68 per cent depending upon the variety, microwave dosage and time for the segmentation process. By boiling in hot water for a period 10 minutes, the loss of ascorbic acid was as high as 74.5 to 76.5 per cent. Based on the type of end product required, the nature of heating method for segmentation could be adopted.

Key words: Aonla, Ascorbic acid, Hardness, Toughness, Textural analyser,

Aonla is an important fruit crop which is a rich source of vitamin C varying from 350-600 mg/100g. (Teaotia *et al.,* 1968; Kalra, 1988; Tripathi *et al.,* 1988; Barthakur and Arnold ,1991; James *et al.,* 2004; Sagar and Rajesh Kumar, 2006). It is also valued for its nutritional and medicinal properties (Kumar *et al.,* 2005; Hiwale and Singh 2006; Nayak *et al.,* 2011) . The deficiency of Vitamins 'C' leads to scurvy disease. Aonla fruit is available only for a short period and is highly perishable in nature. It is not consumed as fresh fruit due to its high acidic and astringent taste. Hence it's processing and storage is essential. A number of processed products are prepared from aonla fruits to improve their acceptability and exploit nutritional qualities (Singh *et al.,* 2005). Among the different products, aonla preserves and candy needs segmentation process, where in the segments of aonla are separated mostly by heat pretreatment. Boiling in hot water is the most common method used for segmentation of aonla (Arya *et al.,* 2004 and Goyal *et al.,* 2007). Microwave heating could also be used as source of heating leading to segmentation (Premakumar and Khurdiya, 2002; Dayandra Kumar and Krishna Kumar, 2004; Singh *et al.,* 2009). It is reported that prolonged brine treatment of aonla destroyed the ascorbic acid content to an extent of 93 per cent (Sastry and Siddappa, 1959; Singh *et al.,* 2004).

Materials and Methods

Sample preparation: Fruits of three aonla cultivars, namely Krishna, Kanchen and Chakaiya were harvested at correct maturity from commercial aonla plantations at Muthur and Erode, Tamil Nadu. Fruits without crack or skin injury having almost similar size and colour were chosen for experiment. Special care was taken during the transportation of the fruits to prevent any damage. The selected fruits were washed with potable water to remove any extraneous matter adhering to the fruits. All the experiments were conducted at room temperature (30 3°C; 70 % RH).

Mechanical properties

Mechanical parameters were studied for 25 randomly selected fruits from each cultivar. The surface hardness and toughness of fruits were measured using texture analyzer (Stable Micro systems, UK) with 2 mm dia. stainless steel probe. Initial force in compression, corresponding to the insertion of probe through the surface, was taken as the surface hardness (N) of the aonla fruits. The energy (N/mm) required to pass the probe through the sample was measured using the texture analyser, and is being reported as toughness (Sajeev et al, 2004; Goyal et. al, 2007).The operating conditions of the texture analyzer was kept as, pre-test speed: 1.5 mm/s, test speed: 0.5 mm/s, post-test speed: 10.0 mm/s and trigger force: 0.10 N.

Heat pre treatment

In the present study, for the blanching process, the aonla samples were boiled in hot water (sample to water ratio, 1:15, on volume basis) in a serological hot water bath stirrer (Scientific make; ISO 9001) till

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the segments got separated. The segments were cooled at room temperature (30 ± 3°C). The mechanical properties of aonla were measured at one minute interval to study the effect of boiling time on hardness and toughness of aonla. The measurements were made in two orientations i.e. vertical and radial direction with respect to the segments. Each experiment was replicated three times.

Microwave treatment

The aonla samples were subjected to microwave treatment, to study the effect of microwave heating on the blanching to obtain the segmentation process and to assess the impact on selected mechanical properties. The samples were exposed to microwave in a microwave oven (Samsung, 103 FL model). The aonla fruits were treated with different microwave power viz., 600,450, 300 watts and exposed to 60, 90, 120 , 150,180 and 210 seconds. The mechanical properties in both vertical and horizontal directions with respect to segments were recorded at each treatment till the segmentation took place. Each experiment was replicated three times.

Ascorbic acid

Ascorbic acid was determined by dye method (Sadasivam and Manickam, 1992). The reagents used were 4 per cent oxalic acid, standard vitamin C solution in 4 per cent oxalic acid and dye solution (42 mg sodium bicarbonate and 52 mg dye in 200 ml distilled water).

Results and Discussion

Effect of Boiling on mechanical properties of aonla fruits

The aonla fruits, *viz.,* Krishna, Kanchen and Chakaiya varieties under investigation, were boiled in hot water, mainly done to separate the segments, and the mechanical properties were studied simultaneously at an interval of one minute. It took 10 minutes for separation of segments from the fruits by hot water boiling treatment in all the three varieties

The surface hardness in the vertical direction decreased, with increase in boiling time (Fig. 1) for all the varieties. It is observed that for variety Krishna, the hardness reduced from 14 N at the starting to 1.6 N at the end of 10 min, when the segmentation took place. For variety Kanchen and Chakaiya, the initial hardness was 15.2 and 14.8 N, respectively and the corresponding hardness at the end of 10 min of blanching was 2.0 and 1.90 N, respectively. (Fig. 1). This is due to the softening of the tissue along with the removal of relatively hard glossy peel of the fruit during boiling. Similar observations were also reported by Goyal *et. al*. (2007).

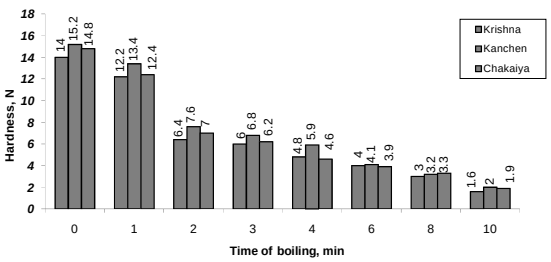

Fig. 1. Effect of boiling time on hardness of aonla segments in vertical direction

The surface hardness of the fruits in the horizontal direction decreased with the increase in boiling time (Fig. 2). The hardness in horizontal direction decreased with the increase in the boiling time, which is similar to that of in the vertical direction of the segments. It is seen that the surface hardness in the horizontal position at a given time, was more than that of vertical position for all the three varieties. Among the three varieties under investigation, Kanchen had higher initial surface hardness (15.6 N) compared to Krishna (14.6 N) and Chakaiya (15 N). The similar trend of hardness was observed at the end of boiling time of 10 min with the corresponding values as 4, 3.4 and 3.8 N respectively. This may be due to the orientation of fiber in the pulp of the fruits and the similar trend of higher firmness in radial orientation is found in apple fruits (Wang, 2004), taro (Sajeev *et al.,* 2004) and aonla (Goyal *et al*., 2007).

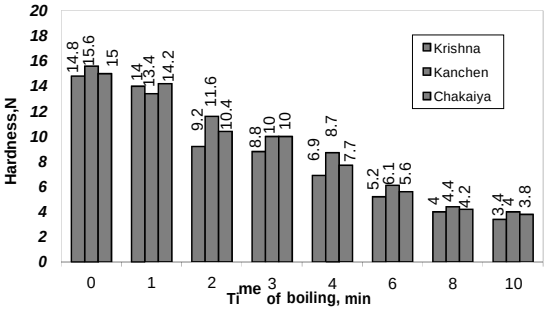

Fig. 2. Effect of boiling time on hardness of aonla segments in horizontal direction

Toughness of three varieties of aonla in vertical and horizontal directions with respect to boiling time is given in Figs. 3 and 4, respectively. The toughness of the chakaiya fruits (123 N/mm) was higher compared to Kanchen (119 N/mm) and Krishna (104 N/mm) varieties. The effect of boiling was less on chakaiya fruits (123 to 24 N/mm), than on Kanchan (119 to 12 N/mm) and Krishna (104 to 20 N/mm) varieties at the end of 10 minutes of boiling, when subjected to mechanical load in the vertical direction of segments. The mechanical properties showed that the fruits of different cultivars/ varieties are not homogenous, and also have behaved differently under treatment to boiling water at given load conditions. The non homogenous anisotropic behaviour is also found in apples (Abbott and Lu, 1996), pear (Wang, 2004), taro (Sajeev *et al.,* 2004) and aonla (Goyal *et al.,* 2007). During boiling the fruits have become softer, but the decrease in

strength of fruits was not uniform in all the three cultivars. It could be attributed to the fiber content in the different varieties. Similar trend was observed

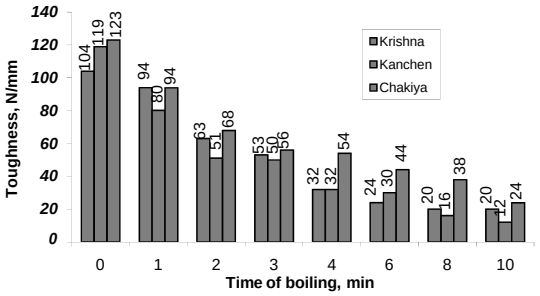

Fig. 3. Effect of boiling time on toughness of aonla segments in vertical direction

when the fruits were subjected to the load in the horizontal direction to the segments. It was seen at any period of time under boiling, the toughness of the fruits in horizontal direction was more than that in the vertical direction. This may be due to the orientation of the fibres in the fruits in different orientations. The same trend was reported in apple by Wang (2004). At the end of the boiling period, the toughness for Chakaiya, Kanchen and Krishna was in horizontal direction 30, 18 and 22 N/mm, respectively.

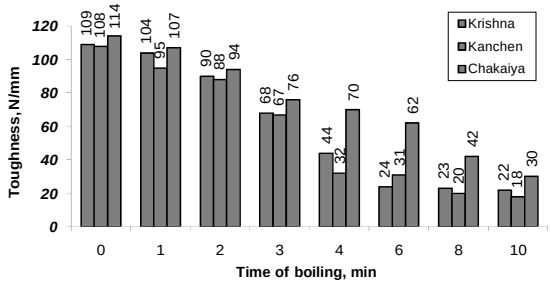

Fig. 4. Effect of boiling time on toughness of aonla in horizontal direction

Effect of microwave heat treatment on mechanical properties of aonla fruits

Aonla fruits under investigation were subjected to different levels of microwave heat treatment. It was observed that the time required for segmentation varies with the level of microwave heat treatments. In general for all the three varieties, a microwave heating time of 210 s, 150 s and 90 s was required at 300 W, 450 W and 600 W, respectively for the segmentation process. (Figs. 5, 6, 7 and 8).

Fig 5 depicts the effect of various levels of microwave heating at varying exposure time on the hardness of three varieties of aonla under investigation in the vertical direction of the segments. It is seen that for Krishna variety, hardness in the vertical direction of the segments at 300, 450 and 600 W of microwave heating, was 1.56 N (at 210 s), 1.61 N (at 150 s) and 1.56 N (at 90 s), respectively from the initial value of 14 N . A similar trend was observed for Kanchen and Chakaiya varieties also. For Kanchen variety, hardness in the vertical direction at the time of segmentation was about 2.6 to 2.7 N from the initial hardness of 15.2 N, while in the case of Chakaiya variety, the hardness reduced from of 14.8 N to 1.6-1.8 N

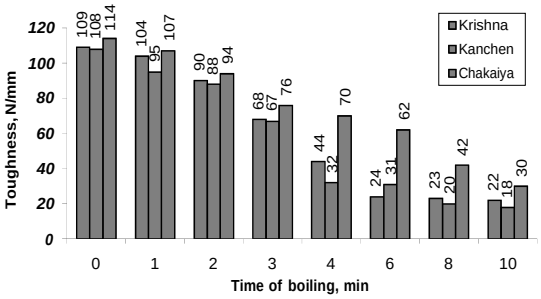

Fig. 5. Effect of microwave heat treatment on hardness of aonla in vertical direction

Fig. 6 depicts the effect of microwave heating at varying exposure time on the hardness of the three varieties of aonla in the horizontal direction of the segments. Here also, as in the case of treatment with boiling water for segmentation, at any given time the hardness in the horizontal direction was more than that in the vertical direction. This may be due to the distribution of the fibres in the fruit pulp. The similar results was reported by Wang (2004) in apples . In Krishna variety, hardness in the horizontal direction at 300, 450 and 600 W of microwave heating was 3.2 N (at 210 s), 3.2 N (at 150 s) and 3.8 N (at 90 s), respectively from the initial value of 14 N. A similar trend was observed for Kanchen and Chakaiya varieties also. For Kanchen variety, the hardness in the horizontal direction at the time of segmentation was about 3.4 to 3.9 N from the initial hardness of 15.2 N, while in the case of Chakaiya variety, the hardness reduced from of 14.8 N to 3.1 to 3.6 N. Similar results were obtained by Kubilay and Faruk Ozguvan (2004) in apricot.

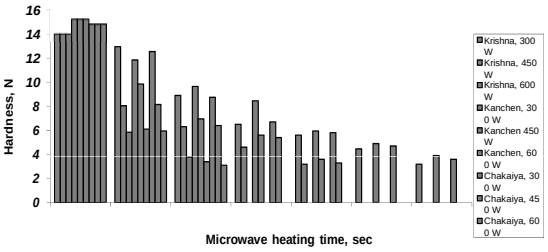

Fig. 6. Effect of microwave heat treatment on hardness of aonla in horizontal direction

Fig. 7 depicts the effect of various levels of microwave heating at varying exposure time on the toughness of the three varieties of aonla under investigation in the vertical direction of the segments. It is seen that for Krishna variety, the toughness in the vertical direction at 300, 450 and 600 W of microwave heating, was 20 N/mm (at 210 s), 21N/mm (at 150 s) and 21 N/mm (at 90 s), respectively from the initial value of 104 N/mm. A

similar trend was observed for Kanchen and Chakaiya varieties. For Kanchen variety, the toughness in the vertical direction at the time of segmentation was about 13 to 15 N/mm from the initial toughness of 119 N/mm, while in the case of Chakaiya variety, the toughness reduced from of 123 N/mm to 22 to 24 N/mm .

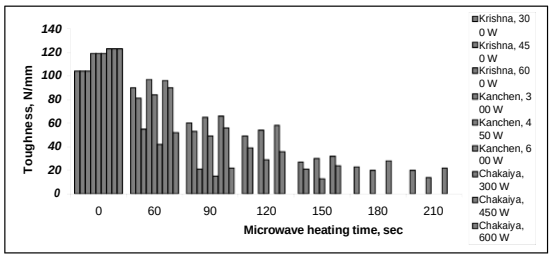

Fig. 7. Effect of microwave heat treatment on toughness of aonla in vertical direction

Fig. 8 depicts the effect of microwave heating at varying exposure time on the toughness of the three varieties of aonla in the horizontal direction of the segments. Here also, like in the case of treatment with boiling water for segmentation, at any given time the toughness in the horizontal direction was more than that of in the vertical direction. This may be attributed to the distribution of the fibres in pulp. The similar results were reported by Wang (2004) in apples. In Krishna variety, the toughness at the time of segmentation in the horizontal direction at 300, 450 and 600 W of microwave heating was 22 N/mm (at 210 s), 23 N/mm (at 150 s) and 23 N/mm (at 90 s), respectively from the initial value of 109 N/ mm. A similar trend was observed for Kanchen and Chakaiya varieties also. For Kanchen variety the toughness in the horizontal direction at the time of segmentation was about 18 to 19 N/mm from the initial toughness of 108 N/mm, while in the case of Chakaiya variety, toughness reduced from of 114 N/ mm to 26 to 28 N/mm.

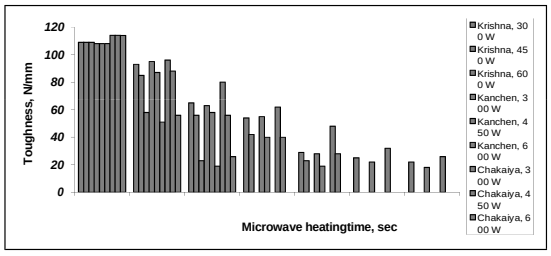

Fig. 8. Effect of microwave heat treatment on toughness of aonla in horizontal direction

Effect of heat treatment of ascorbic content

Effect of heat treatment viz., boiling and microwave treatment on ascorbic acid content of the three varieties of aonla in terms of loss of ascorbic acid is depicted in Fig. 9 and the corresponding retention of ascorbic acid is depicted in Fig. 10. The initial ascorbic acid content recorded for Krishna, Kanchan and Chakaiya varieties were 510, 380 and 402 mg/100 g of fruits, respectively. From Fig. 9, it is seen that loss of ascorbic acid content in Krishna, Kanchan and Chakaiya varieties were 76.57, 75.13 and 74.50 per cent, respectively when boiled for 10 min during segmentation process.

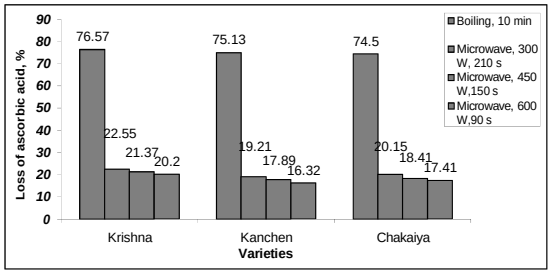

Fig. 9. Loss of ascorbic acid in aonla fruits subjected to heat treatment

When the segmentation was carried out with the help of microwave heat treatment, the loss in ascorbic acid was very low due to higher ascorbic retention percentage. Ascorbic acid retention percentage was recorded as 77.45 per cent (loss of 22.55 per cent), 78.63 per cent (loss of 21.37 per cent) and 79.80 per cent (loss of 20.2 per cent) for Krishna variety when segmentation was carried out with 300 W for 210 s, 450 W for 150 s and 600 W for 90 s microwave treatment, respectively (Fig. 10). For the same microwave heating treatment, the retention in ascorbic acid content in Kachnen variety was 80.79 (loss of 19.21per cent), 82.11 (loss of 17.89 per cent) and 83.68 per cent (loss of 16.32 per cent), while for chakaiya variety it was 79.85 (loss of 20.51 per cent), 81.59 (loss of 18.41 per cent) and 82.59 per cent (loss of 16.32 per cent) respectively.

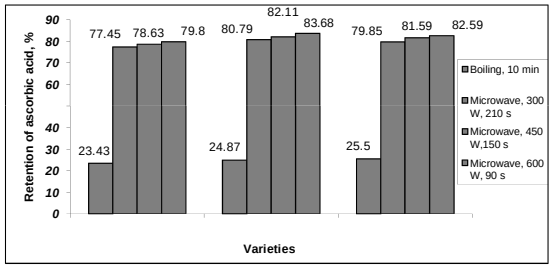

Fig. 10. Retention of ascorbic acid in aonla fruits subjected to heat treatment

This clearly depicts that microwave is an effective source of heat treatment when the need of processing requires the segmentation of the aonla to be carried out with the retention of ascorbic acid. This can be attributed to the combination of absence of water as heating media and lower heating time when microwave is used during the segmentation process. (Tandon *et al.,* 2003 and Beharilal *et al.,* 2007)

Conclusion

The analysis of mechanical properties of the aonla fruits showed that, aonla fruits of different cultivars are not homogenous in terms of hardness and toughness. Mechanical properties reduced

with increase in heating time when the fruits were heated either by means of boiling water or microwave heating. The time taken for segmentation was ten minutes by boiling in water and ranged from 210 s to 90 s when microwave heating was varied from 300 to 600 W. Microwave heating could be used as an effective means of segmentation of aonla fruits with high retention of ascorbic acid in the aonla segments.

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