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RESEARCH PAPER

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Effects of different pre-treatments on browning of frozen banana slices

■ ANURADHA SAINI* AND M.K. GARG

Department of Processing and Food Engineering, C.C.S. Haryana Agricultural University, HISAR (HARYANA) INDIA

*Author for Correspondence

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SUMMARY :

A study was undertaken to examine the effects of different pre-treatments on browning of frozen banana slices. The bananas were ripe at 21°C temperature with 91 per cent humidity upto the desired stage #4 (18-20°B) and different pre-treatments such as chemical dip in different concentrated solutions {0.1% (w/v) ascorbic acid + 0.05% (w/v) citric acid, 1% (w/v) ascorbic acid + 0.5% (w/v) citric acid and 10% (w/v) ascorbic acid + 5% (w/v) citric acid}, blanching (65°C/5min) and sugar solution dip (60°B/30 min), were used to prevent from browning before freezing at -33ºC for one hour. The browning rate was high initially when the respiration rate was highest and then decreased or increased according to the pre-treatments effectiveness. Different pre-treatments showed various patterns of browning. Therefore, qualitative results found that the oxidation process was the most inhibited by ascorbic acid + citric acid and the least inhibited by the blanching for storage of frozen banana slices at -20ºC.

KEY WORDS : Bananas, Freezing, Pre-treatment, Frozen banana slices, Sensory evaluation

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Banana is a highly perishable and one of the most important fruit crop grown in humid tropical regions. It is very susceptible to quality deterioration and requires processing into a more stable form. Fruits and vegetables develop the brown colour due to the enzymatic oxidation of phenols to quinones by polyphenol oxidase (PPO) and peroxidase in the presence of oxygen. Subsequently, these quinones condense and react non-enzymatically with other substances such as phenolic compounds and amino acids to produce complex brown polymers. Enzymatic browning diminishes not only the colour of fresh fruits but it affects flavour and the nutritive value also (Rigal *et al.*,2001). Generally, sulphate is an anti-browning agent and acts as PPO inhibitors by serving as reducing agents. It reacts with intermediates to prevent pigment formation. However, sulphites are known to induce adverse allergenic effects to human health. Various chemicals are known to be able to reduce enzymatic browning, including PPO inhibitors, reducing agents, acidulants and chelating agents.

Different physical and chemical techniques have been developed to prevent browning and extend the shelf-

life of the produce. Fresh-cut fruits undergo different changes such as enzymatic browning and softening, microbial contamination and undesirable volatile production which results in shorter shelf-life than the whole fruit (Soliva-Fortuny and Martin-Belloso, 2003). The combination of 2-5 per cent O_2 and 2-5 per cent CO_2 was found to slow down the ripening process and reduces the respiration and ethylene production rates of whole banana fruit (Kader, 2005). Antibrowning agents (citric and ascorbic acid) and calcium chloride showed the reduction in the browning of fresh-cut apples stored at 4°C for 5 days but the use of 1-methylcyclopropene was not effective to prevent from colour deterioration of the apple slices in cold storage (Chiabrando and Giacalone, 2012). 1-MCP had little effect on superoxide dismutase (SOD) activity or on total phenolics of two European pear cultivars 'Shahmiveh' and 'Sebri' stored at 0.5 °C (Yazdani *et al.,* 2014). Sucrose solution at the same sugar level as compared with the honey preparation showed the 23 per cent inhibition from browning (Oszmianski and Lee, 1990). Pineapple juice found that the browning inhibition to a similar extent as showed by 8 mM ascorbic acid but less than 4 mM sodium metabisulfite after storage of banana slices at 15°C for 3 days (Chaisakdanugull *et al.,* 2007). Postharvest essential oils including carvacrol, cinnamaldehyde, perillaldehyde and linalool treatment have positive effects on reducing decay and enhancing antioxidant capacities in Chinese bayberries (Jin *et al*., 2012). The combination (2.0% w/v $CaCl_2$ and 0.4 kGy irradiation) was helpful in extending the shelf-life of Red Delicious apples by around 20-25 days at 17± 2°C with R.H. 75 per cent, following 90 days of refrigeration (Hussain *et al*., 2012). In response to chilling stress, antioxidative protection systems operated efficiently during the first three week of cold storage (0°C) but by extending storage, the ability of protection system is decreased due to increasing levels of oxidative stress in Japanese plums (Singh and Singh, 2012). Fresh-cut pear stored in high O_2 (30 and 80%) packages have higher phenols and anthocyanin contents which suggest that it could be used to inhibit browning and prolong the shelf-life of fresh-cut Yaoshan pears (Li *et al.,* 2012). The Konjac glucomannan coating (KG) incorporated with pineapple core extract (PE) was also effective in maintaining the whiteness of the fresh-cut rose apple fruit during storage by retarding browning, enhancing total phenols and inhibiting both PPO and POD activities (Supapvanich *et al.*, 2012). The combination of calcium dip (1% w/v $CaCl_2$) + CA (3 kPa O_2 + 10 kPa CO_2) had no additional effect on firmness retention of fresh-cut strawberries compared to these two treatments when provided separately (Aguayo *et al.,* 2008).The methanolic extract obtained after 30 min of sonication proved to be the effective treatment for enhancing the antioxidant compounds in star fruit extracts (Annegowda *et al.*, 2012). 'Tommy Atkins' mangoes cubes pre-treated with AA-CA-Ca (Ascorbic acid + citric acid + $CaCl_2$) showed consistently better colour and firmness than the control and other two pre-treatments (sodium acid sulphate and 5-min infrared heat) (Siddiq *et al.,* 2013). Residual polyphenol oxidase (PPO) in the juice from High-pressure carbon dioxide (HPCD) treated banana pulp was lower than that from mild heat (MH) treated banana pulp (Yu *et al.*, 2013). Radiation treatment of litchi fruit pericarp increased the Phenylalanine ammonia-lyase (PAL) activity whereas PPO and POD activities were inhibited. This may explain the reduction in browning for irradiated fruits compared with non-irradiated fruits (Mishra *et al.,* 2012). Microwave treatment (MT) is proposed as an effective way to completely inactivate PPO without causing any significant damage to fruit tissues and shape; also include the preservation of colour, flavour and taste (Palma-Orozco *et al.,* 2012). Moreover, only a few research works have been conducted on pre-treatments of banana slices in which freezing was the final step of the preservation process. This research was carried out at Jain Irrigation Systems Limited, Jalgaon and the objective of the study was to maintain the quality of banana slices by using chemical dip, blanching and sugar syrup dip for the frozen product.

EXPERIMENTAL METHODS

Materials :

Raw bananas (Cavendish) were purchased from the local market at colour stage #1(3-4°B). Bananas were first ripened in the ripening chamber and suitable ripen stage was selected for blast freezing. Prior to freezing, the bananas were washed, peeled and cut into 5 mm slices. The banana slices were pre-treated using various methods including chemical dip, blanching and sugar solution.

Study of the ripening pattern of banana in ripening chamber :

Raw bananas were kept in a ripening chamber for

Table A : Study of the pattern of different characteristics during ripening at one day interval each

Stages	1	2	3	4	5	6
Images						
Brix (°B)	3.8	9.3	14.3	20.7	21.7	22.1
pH	5.25	4.90	4.57	4.67	4.58	4.76
% acidity	0.30	0.41	0.30	0.35	0.28	0.42

obtaining suitable colour stage at 21°C temperature with 91 per cent humidity as shown in Table A.

Selection of proper ripening stage :

The proper ripening stage is at colour stage #4 (18-20°B) for freezing of banana slices at -33°C for 1 hour.

Pre-treatments :

Three pre-treatments were applied to the bananas before freezing, and an untreated sample was taken as a control. The pre-treatments were the chemical dip, blanching and sugar solution dip. The details of each treatment are described as follows:

Control :

Bananas were peeled off, cut into slices and loaded directly on to a freezing tray without any pre-treatment.

Chemical dip :

Bananas were peeled off, sliced, weighed and then the chemical dip was used in three different concentration solutions of 0.1 % (w/v) ascorbic acid + 0.05% (w/v) citric acid, 1% (w/v) ascorbic acid + 0.5% (w/v) and 10% (w/v) ascorbic acid + 5% (w/v) citric acid.

Blanching :

Bananas were peeled off, sliced, weighed and then blanched at 65°C for 1 min and drained on stainless steel mesh. During blanching, bananas were completely submerged under the blanching medium.

Sugar solution dip :

Bananas were peeled off, sliced, weighed and then dip in sugar solution at 60°B for 30 min and drained on stainless steel mesh. During sugar solution dip, bananas were completely submerged under the sugar solution medium.

Freezing procedure :

Pre-treated banana slices were placed on stainless steel trays. The trays were randomly placed into the blast freezer at -33°C for 1 hour. The samples were frozen completely and stored in the blast freezer at -20°C.

EXPERIMENTAL FINDINGS AND ANALYSIS

The results obtained from the present investigation as well as relevant discussion have been summarized under following heads :

Sensory evaluation :

Different sensory parameters were evaluated by an expert panel in which the most appealing attributes were fresh-like appearance, taste and flavour. The results of sensory analysis of banana slices from all of the pre-treated samples are presented in Table 1. The preference

Table 1 : Sensory parameters of banana slices by using hedonic scale*after the application of pre-treatments

Treatments	Colour	Texture	Flavour	Taste	Overall acceptability
Control	7	6	6	6	6.2
0.1% A.C.+ 0.05% C.A.	4	5	5	5	4.7
1% A.C.+ 0.5% C.A.	5	5	5	5	5.0
10% A.C. + 5% C.A.	6	5	4	5	5.0
Blanching	3	4	5	4	4.2
Sugar solution dip	5	3	5	3	4.0

* Nine point hedonic scale, 1- Dislike extremely and 9 – Like extremely

rating for the colour of chemical dip was significantly higher as compared to all other treatments. The highest texture score was observed in the control banana samples whilst the lowest score was found in the sugar solution dip. The score for flavour was highest in the chemical dip and lowest in the sugar solution dip samples. The preference rate of control samples for flavour, colour, texture and taste with overall acceptability of the samples was highest during the short term cold storage but quality parameters degraded quickly due to enzymatic browning when samples stored for long period of time under cold storage.

The frozen banana slices were examined for visible changes in their physical properties through the images by observing the browning and comparing with control sample as presented in Fig. 1 and 2 during short term storage.

Fig. 1 : Effect of different pre-treatments on day 1

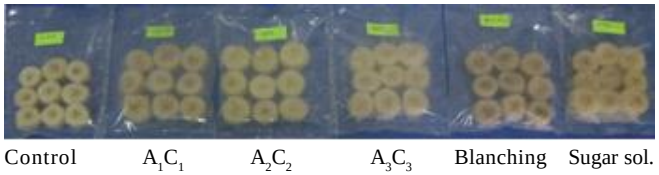

Fig. 2 : Effect of different pre-treatments on day 7

Ascorbic acid, pH, per cent acidity and ºBrix :

Results concluded in Fig. 3, 4, 5 and 6 show the value of different parameters after short term storage. During the seven days of cold storage, no significant difference in parameters such as ascorbic acid, pH, acidity and ºBrix was observed in the samples. It may be concluded that lower changes in pH, titratable acidity (TA) and total soluble sugars (TSS) due to reduced respiration rate (Olivas and Barbosa-Canovas, 2005). Chemical dip showed the browning according to the dip concentration such as 0.1% (w/v) ascorbic acid + 0.05% (w/v) citric acid, 1% (w/v) ascorbic acid + 0.5% (w/v) and 10% (w/v) ascorbic acid + 5% (w/v) citric acid and it may be due to the inactivation of enzymes which are responsible for browning reactions (Turhan and Sahbaz, 1988). Sugar solution dip produced the less browning along with time in short term cold storage could suggest that decrease in respiration rate through coating of sugar (sugar solution dip). Blanching was not feasible technique as a pre-treatment for frozen banana slices due to its undesirable taste and texture of the product.

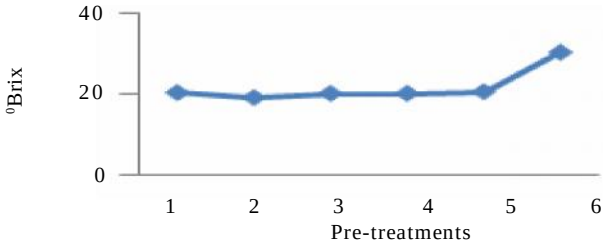

Fig. 3 : °Brix of frozen banana slices

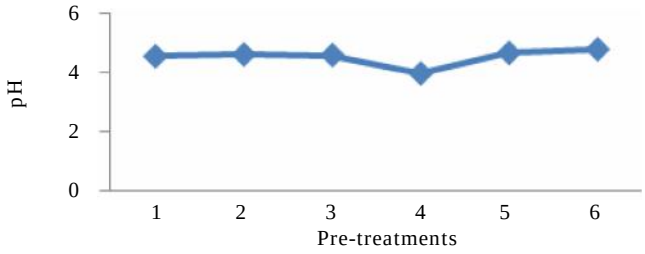

Fig. 4 : pH of frozen banana slices

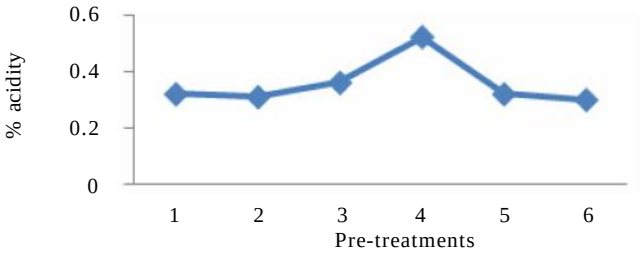

Fig. 5 : Per cent acidity of frozen banana slices

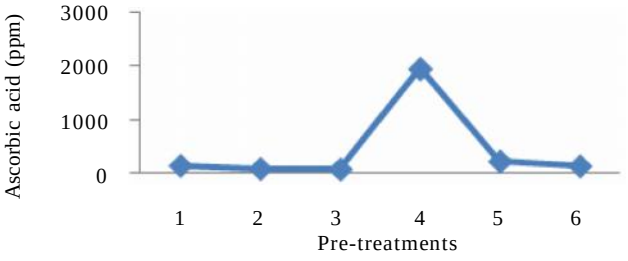

Fig. 6 : Ascorbic acid (ppm) of frozen banana slices

Pre-treatments: 1 (Control), 2 (Dip contains 0.1% Ascorbic acid + 0.05% Citric acid), 3 (Dip contains 1% Ascorbic acid + 0.5% Citric acid), 4 (Dip contains 10% Ascorbic acid + 5% Citric acid), 5 (Blanching at 65°C for 1 min), 6 (Dip contains 65°B Sugar solution for 30 min) at 20ºC after 7 days of storage

Conclusion :

Banana is a highly perishable and cultivated crop which needs intense processing to sustain the qualitative parameters. Western market demands the frozen sliced bananas which have good nutritive value and easy to consume as ready to eat products. Different concentrated chemical dip solutions presented the lowest rate of browning whilst blanching was found the highest browning rate. Blanching increased the browning rate at 65°C/5 min and it is not a feasible pre-treatment for frozen banana slices. Dipping in organic acid solutions (Ascorbic and citric acid) were found suitable results at high concentrations but some sensory parameters were not acceptable e.g. taste. Sugar solution dip produced the yellowish colour pattern and formed the lumps of banana slices due to the high concentration of sugar solution dip. Therefore, organic acids solution showed better sensory results at low concentrations and it is a good method to preserve the frozen product for long storage period by minimising the browning and maintaining the product quality.

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