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Effects of Anti-Browning Pretreatments on Browning of Banana Pulp

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A B S T R A C T

The present investigation was carried to examine the effects of different anti-browning agents on browning and sensory quality of extracted banana pulp. The banana fruit from ripe and over-ripe stages were separately peeled, sliced and pulped using different pre-treatments such as blanching in water (at 95^{0}C for 2 min), potassium meta-bisulphite (0.1%), potassium meta-bisulphite (0.2%), citric acid (1%), citric acid (2%), ascorbic acid (1%), 1% citric acid and 0.5% cysteine, 1% citric acid and 0.5% calcium chloride, 1% citric acid and 1% ascorbic acid and 0.5% cysteine. Sliced banana were mixed with small amount of water containing anti-browning agent and blended in mixer for pulping. Pretreated banana pulp from ripe and over-ripe fruit was analyzed for browning index and sensory (color and appearance, taste, aroma and overall acceptability) quality. Among the various treatments tried for preventing browning, the pre-treatment of the pulp with potassium metabisulphite (KMS) at the concentration of 0.1 and 0.2% was found to be the most effective treatment, where both of its concentrations were equally effective in controlling browning in ripe and over-ripe banana pulp. The effect of anti-browning pre-treatments were similar for ripe and over-ripe banana pulp, however the control of browning was more in ripe pulp than from over-ripe banana pulp.

Introduction

Fruits and vegetables are indispensable constituents of human diet, as they provide substantial quantities of functional components, especially vitamins, sugars, minerals, fiber and phytochemicals. Regular consumption of fruits and vegetables lessens the risk of cancer, heart disease, premature ageing, stress and fatigue chiefly due to the integrated action of oxygen radical scavengers such as β- carotene, ascorbic acid, polyphenols with calcium and dietary fibers present in them (Sindumathi *et al.*, 2013). India is the second largest producer of the fruits (90.534 million tons) and vegetables (166.467 million tons) in the world (National Horticulture Board, 2015-16) after China. India produces a wide range of fruits and vegetables due to its diverse agro-climatic conditions.

Banana (*Musa paradisiaca* L.), belongs to *Musaceae* family. It is one of the most widely cultivated fruits in tropical countries, being the second largest produced fruit after citrus with 108 million tons in 2013, contributing about 16% of the world’s total fruit production (FAO, 2016). India is the largest producer of banana with an annual production of 30.08 million tons from an area of 0.88 million ha, contributing to 27% of the world's banana production (National Horticulture Board, 2016). In India, Tamil Nadu is the leading producer state for banana, followed by Maharashtra. 'Dwarf Cavendish' and 'Robusta' are the most widespread banana varieties commonly grown in India and are the main stays of Indian banana industry for both internal and export trades (Tapre and Jain, 2012).

Banana is one of the cheapest, delicious and most nourishing of all fruits. It is preferred by people of all ages. It has also several medicinal properties. Many *in vitro* studies, animal model studies and clinical studies showed that various parts of banana act as food medicines for treatment of diseases like diabetes, hypertension, cancer, ulcers, diarrhoea, urolithiasis, Alzheimer's and infections (Jyothirmayi and Rao, 2015).

Banana is a climacteric fruit and after harvest it exhibits a respiratory peak during natural ripening at 20^0C. The quality of the fresh banana decreases drastically after harvesting as a result of deterioration in fruits' colour, flavour and texture. It has post-harvest shelf life of only 2-3 days during summer season. Hence, it has always being considered a problem fruit.

Exploring possibilities of converting banana into value added products is one of the approaches to solve this problem. Problem with processing of banana pulp is its enzymatic browning. It undergoes rapid enzymatic browning upon exposure to oxygen as a result of cellular disruption during peeling, slicing and pulping operations (Macdonald and Schaschke, 2000). Polyphenol oxidase is responsible for enzymatic browning of many edible plant products, especially of fruits and vegetables during processing. Several methods including addition of anti-browning agents and thermal processing have been used to inhibit enzymatic browning (Sun *et al.,* 2002). Anti-browning agents such as tartaric acid, ascorbic acid, calcium chloride, cysteine and citric acid are some of the generally regarded as safe (GRAS) chemicals that have potential for browning inhibition and control of enzymatic browning of fresh and vacuum fried slices of banana (Apintanapong *et al.,* 2007).

Materials and Methods

The present study was carried out in Centre of Food Science and Technology, CCS HAU, Hisar during the year 2016-17. The study was conducted to identify the best anti-browning agent to control the browning of banana pulp during processing.

Procurement of materials

Banana fruit was procured from local orchards/ market, Hisar during 2016-2017.

Reagents

The chemicals used in investigation were analytical grade reagents (A.R.) from standard suppliers e.g. B.D.H., C.D.H., S.D. Fine Chemicals, Sisco Research Lab., etc.

Treatment and processing of banana

Ripe fruits of banana were procured from local market and divided into two lots. One lot was processed and other was allowed to ripe further to over-ripe stage under controlled condition and then processed.

Sorting, peeling and slicing

Healthy and diseased free ripe and over-ripe banana were separately sorted, peeled and sliced using stainless steel knives.

Anti-browning pre-treatments and pulp extraction

Before pulp extraction banana slices were subjected to anti-browning pre-treatments to control enzymatic browning. The pre-treatments tried were blanching in water (at 95^0C for 2 min), potassium meta-bisulphite (0.1% and 0.2%), citric acid (1% and 2%), ascorbic acid (1%), 1% citric acid + 0.5% Cysteine, 1% citric acid + 0.5% calcium chloride, 1% Citric acid + 1% ascorbic acid + 0.5% cysteine.

Sliced banana were mixed with small amount of water containing anti-browning agent and blended in mixer. The treatments were taken in three replicates. The procedure adopted for pulp extraction and anti-browning pretreatments is presented in Figure 1.

Extracted pulp from ripe and over-ripe fruits with anti-browning agent was passed from homogenizer, separately filled in polypropylene jars and stored in deep freezer for six days to analyze its browning index.

Evaluation of effectiveness of anti-browning treatments

Effectiveness of different anti-browning pretreatment on banana pulp from ripe and over-ripe stages were evaluated by measuring their browning index and sensory quality.

Browning index

Five gram of sample was macerated with 25 ml of 60 per cent aqueous ethyl alcohol and kept it overnight in the covered condition in dark. On the next day, sample was filtered to obtained clear solution. Absorbance of clear solution was taken at 440 nm using 60 per cent aqueous ethyl alcohol as blank with UV-VIS spectrophotometer. Browning index (A at 440 nm) was expressed as absorbance value.

Sensory evaluation (9 point hedonic scale)

Sensory evaluation of treated banana pulp from ripe and over-ripe fruit was evaluated by a panel of six judges up to 6 days using the 9-point hedonic scale as described by Ranganna (2014). Beaker containing 20 ml of the banana pulp was presented to the judges. It was evaluated for colour and appearance, taste, aroma and overall acceptability. The overall acceptability of RTS drink was calculated on the basis of mean scores obtained from all the sensory parameters. The samples with mean scores of 6 and above out of 9 were considered acceptable.

Statistical analysis

The data in the present investigation were subjected to analysis of variance (ANOVA) technique and analyzed according to two factorial completely randomized design (CRD). The critical difference (CD) value at 5 per cent level was used for making comparison among different treatments. Software OP stat (www.hau.ernet.in) was used to analyze the experimental results statistically.

Results and Discussion

Browning index

The pulp of banana fruit is highly susceptible to enzymatic browning when it comes in contact with air. Browning reaction is due to enzymatic oxidation of dopamine by polyphenol oxidase leading to the production of brown pigments (Ranveer *et al.*, 2010). In the present investigation, the data in Table 1 reveal the effect of different anti-browning pretreatments on browning of ripe and over-ripe banana pulp. It was observed from the data that there was progressive increase in browning of banana pulp with increasing storage period. In control, the browning at 0-

day was 0.185 and 0.211 that increased to 0.213 and 0.226 in ripe and over-ripe banana pulp respectively by 6 days of storage. There was significant reduction in browning by various treatments.

The browning was found maximum in control that increased during storage. There was significant reduction in browning by various treatments. The best pretreatment showing maximum reduction in browning was potassium metabisulphite (KMS), where both of its concentrations (0.1 and 0.2%) were equally effective in both ripe and over-ripe banana fruit pulp.

The interaction between treatments and storage was found to be significant. Similarly, Canu *et al.,* (1990) reported successful prevention of browning in banana by inactivation of enzyme polyphenol oxidase by addition of potassium metabisulphite.

Sims *et al.,* (1994) studied the effect of bisulphite and ascorbic acid treatments on the color and polyphenol oxidase activity of clarified juice from ripe bananas and observed that the sulfited juice had the lightest color and least amount of browning. Ruthra *et al.,* (2014) studied the effect of pretreatment on minimally processed banana with citric acid (CA), ascorbic acid (AA) and potassium meta-bisulphite (KMS) with varying concentration and their combinations. They observed that KMS at 0.2% and combination of KMS and AA were most effective in control of browning. Siriwardana *et al.,* (2015) reported that sodium metabisulphite most effectively controlled the browning of sliced banana. The control of browning could be due to oxidative nature of sulphites and their derivatives (sulfur dioxide, sulphite, bisulphite and metabisulphite) which act as color stabilizer. It has been reported that potassium and sodium sulphites, prevent enzymatic browning by reducing o-quinones to colorless diphenol (Grotheer *et al.,* 2008) or by reacting irreversibly with o-quinones to form stable colorless products (Marshall *et al.,* 2000).

Sensory evaluation

The data regarding the effect of different anti-browning pretreatments on sensory quality of ripe and over-ripe banana pulp is presented in Table 2.

It was observed from the data that potassium metabisulphite (0.1 and 0.2%) treated banana pulp from ripe and over-ripe fruit ranked better overall acceptability score than other. Sensory score for color and appearance was maximum for banana pulp with potassium metabisulphite at the concentration of 0.1 and 0.2%, followed by ascorbic acid, citric acid +cysteine, citric acid +$CaCl_2$, citric acid + ascorbic acid +cysteine while minimum was recorded for control sample.

The highest score with KMS is due to their effectiveness in controlling the browning and maintained the original color of banana pulp (Plate 1). Result of present investigation was in conformity with the findings of Sakhale *et al.,* (2012) who reported that treatment of mango pulp with KMS retained original color and appearance than sodium benzoate treated pulp. Similarly Durrani *et al.,* (2011) reported that mango pulp stored with KMS treatment retained overall color stability during 90 days of storage period than potassium sorbate, ascorbic acid and sodium benzoate.

Similar to color and appearance score, taste score was better for banana pulp with potassium metabisulphite followed by control. The treatment of banana pulp with citric acid and ascorbic acid increase the acidity and cysteine, $CaCl_2$ impart unpleasant taste to the banana pulp which was not liked by panelist.

Fig.1 Flow sheet for extraction of banana pulp

Banana fruit
↓
Peeling
↓
Slicing
↓
Addition of anti-browning agent
↓
Blending
↓
Filled in polypropylene jars
↓
Stored in deep freezer (- 20^0C)

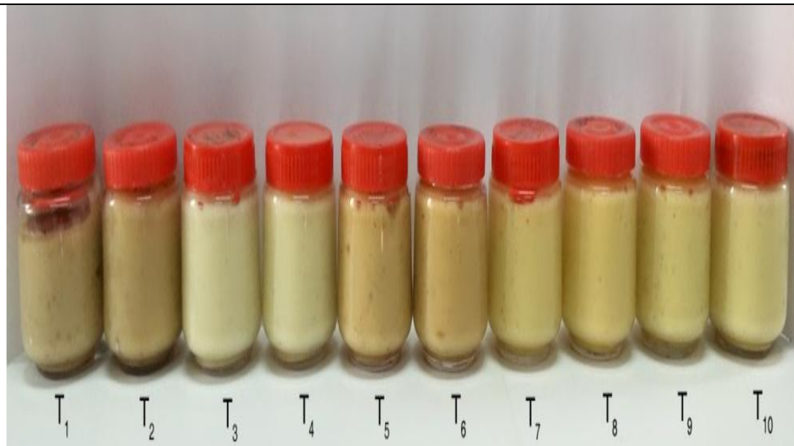
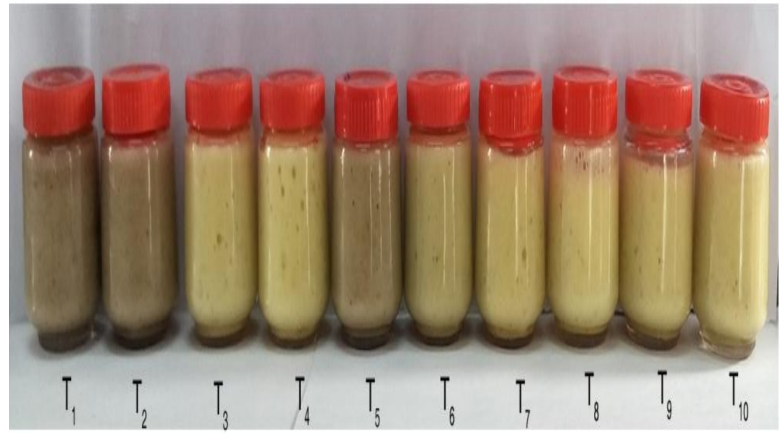
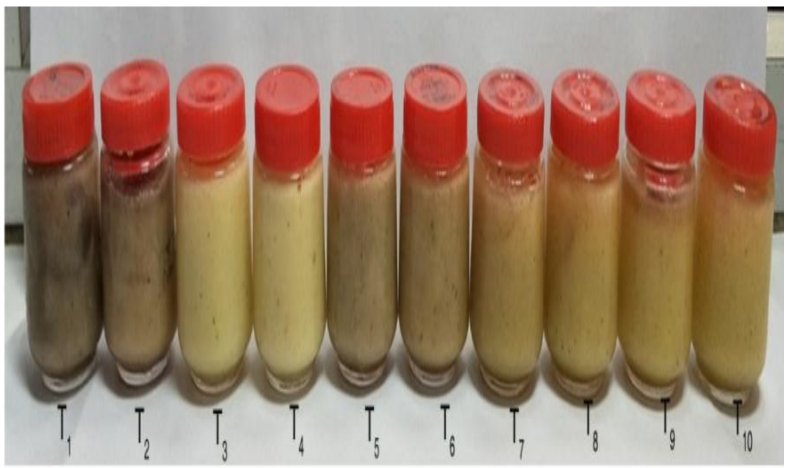
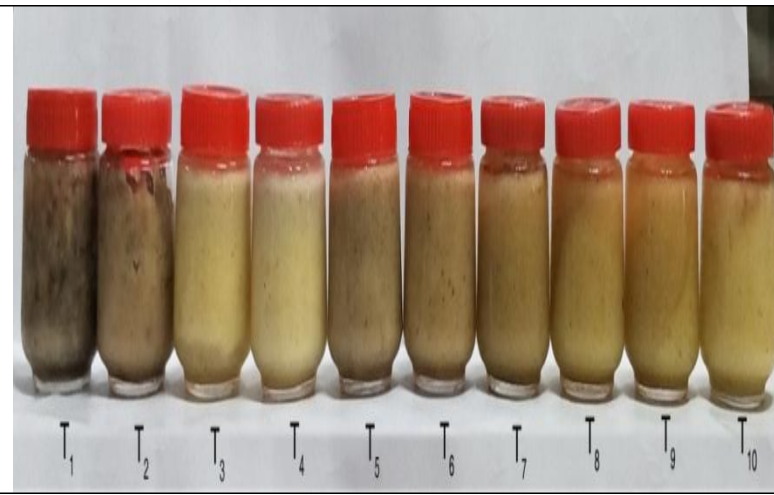
Table.1 Effect of anti-browning pre-treatments on browning (O.D. at 440 nm) of ripe and over-ripe (values in parentheses) banana pulp

Treatments	Period of storage (days)			
	0	3	6	Mean
Control	0.185 (0.211)	0.192 (0.221)	0.213 (0.226)	**0.197 (0.219)**
Blanched	0.047 (0.070)	0.059 (0.079)	0.074 (0.082)	**0.060 (0.077)**
KMS (0.1 %)	0.028 (0.032)	0.029 (0.032)	0.030 (0.034)	**0.029 (0.032)**
KMS (0.2 %)	0.025 (0.029)	0.026 (0.031)	0.026 (0.031)	**0.026 (0.031)**
Citric acid (1 %)	0.043 (0.058)	0.058 (0.065)	0.062 (0.069)	**0.054 (0.064)**
Citric acid (2 %)	0.039 (0.056)	0.049 (0.063)	0.054 (0.063)	**0.047 (0.061)**
Ascorbic acid (1 %)	0.081 (0.091)	0.095 (0.098)	0.103 (0.112)	**0.093 (0.103)**
1% Citric acid +0.5% Cysteine	0.038 (0.051)	0.040 (0.057)	0.045 (0.064)	**0.041 (0.057)**
1% Citric acid + 0.5% $CaCl_2$	0.042 (0.056)	0.045 (0.062)	0.066 (0.073)	**0.051 (0.064)**
1% Citric acid + 1% Ascorbic acid +0.5% Cysteine	0.114 (0.129)	0.123 (0.132)	0.126 (0.133)	**0.121 (0.131)**
Mean	**0.064 (0.078)**	**0.072 (0.084)**	**0.081 (0.089)**	
C.D. at 5%	Treatment (T) = 0.005; Storage (S) = 0.003; T×S= 0.009			

Table.2 Effect of anti-browning pre-treatments on sensory quality (9-point hedonic scale) of banana pulp from ripe and over-ripe (values in parentheses) fruit

Treatments	Sensory score			
	Color and appearance	Taste	Aroma	Overall Acceptability
Control	2.0 (2.0)	7.0 (7.0)	7.5 (8.0)	5.5 (5.7)
Blanched	6.0 (4.0)	5.0 (5.0)	5.0 (5.0)	5.3 (4.7)
KMS (0.1 %)	8.0 (7.5)	7.5 (8.0)	7.0 (7.0)	7.5 (7.5)
KMS (0.2 %)	8.0 (7.5)	7.5 (8.0)	7.0 (7.0)	7.5 (7.5)
Citric acid (1 %)	6.0 (4.0)	4.0 (4.0)	4.0 (5.0)	4.7 (4.3)
Citric acid (2 %)	6.0 (5.0)	4.0 (4.0)	4.0 (5.0)	4.7 (4.7)
Ascorbic acid (1 %)	6.5 (6.0)	5.0 (5.0)	5.5 (5.5)	5.7 (5.5)
1% Citric acid +0.5% Cysteine	7.0 (7.0)	4.0 (4.0)	4.0 (4.0)	5.0 (5.0)
1% Citric acid + 0.5% $CaCl_2$	7.0 (7.0)	4.0 (4.0)	5.0 (5.0)	5.3 (5.3)
1% Citric acid + 1% Ascorbic acid +0.5% Cysteine	7.0 (7.0)	4.0 (4.0)	4.0 (4.0)	5.0 (5.0)

Plate.1 Effect of different pretreatments on non-enzymatic browning of pulp from (A) ripe and (B) over-ripe banana

	(A) Ripe Banana Pulp	**(B) Over-ripe Banana Pulp**
0-day pulp		
6-days pulp		

T_1 =Control, T_2=Blanched, T_3=KMS (0.1%), T_4=KMS (0.2%), T_5=Citric acid (1%), T_6=Citric acid (2%), T_7=Ascorbic acid (1%), T_8=Citric acid (1%) + Cysteine (0.5%), T_9=Citric acid (1%) + Calcium chloride (0.5%), T_{10}=Citric acid (1%) + Ascorbic acid (1%) + Cysteine (0.5%)

Result of present investigation are in conformity with the findings of Luna-Guzman and Barrett (2000) who reported that treatment of fresh-cut cantaloupe with $CaCl_2$ gives bitter taste than untreated samples or those dipped in calcium lactate. Durrani *et al.*, (2011) reported that KMS treated mango pulp scored maximum for taste than potassium sorbate, ascorbic acid and sodium benzoate.

Sensory score for aroma was highest for control followed by potassium metabisulphite treatment. KMS treated banana pulp ranked slightly less than control because of pungent smell of sulfite when sniffed immediately after processing but it lost after 4-5 hours of pulping. The other chemical treatments (citric acid, ascorbic acid, cysteine and $CaCl_2$) imparts unpleasant aroma to pulp of banana. The result of present investigation are in accordance with the findings of Queiroz *et al.*, 2008 who reported that cysteine produces an undesirable odour, limiting its use in food processing. Hashmi *et al.*, (2007) reported that KMS treated mango pulp scored maximum for taste than potassium sorbate and sodium benzoate treated. The effect of anti-browning pre-treatments on sensory quality were similar for ripe and over-ripe banana pulp, however the sensory score was more in ripe pulp than from over-ripe banana pulp.

It can be concluded from the results of the present study that the pre-treatment of the pulp with potassium metabisulphite (KMS) at the concentration of 0.1 and 0.2% was found to be the most effective treatment, where both of its concentrations were equally effective in controlling non-browning in ripe and over-ripe banana pulp. Sensory score (Color and appearance, taste and overall acceptability) was also higher for banana pulp treated with potassium metabisulphite than other chemical treatments. By controlling the browning of banana pulp, we can reduce the spoilage, stored it for months and utilize for processing into various products.

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