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Effect of thermal treatment and storage on the quality of apple juice

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Abstract
Thermal processing of liquid foods is a widely utilized procedure in the food industry. Usually, the time and temperature required for a safe process depend upon the destruction of microbial spores and inactivation of enzymes. With regard to this fact, the influence of pasteurization temperature on quality of apple (*Malus domestica* V. Red Delicious) juice during 2 month refrigerated storage was studied. After extracting the juice from screw type juice extracting machine, it was divided into three lots. One lot was heat processed separately at 65 °C with 15, 25 and 35 min holding time. Other two lots were heat processed separately at 75 °C with 10, 20 and 30 min and 85 °C with 5, 10 and 15 min holding times in glass bottles. The experiment was laid out in FCRD with three replications. The results showed that the ascorbic acid and titratable acidity in thermally treated samples decreased with increase in storage period. Increase of TSS was due to hydrolysis of starch into sugar, due to dehydration and degradation of pectic substances of juice into soluble solids. From these results, the juice extracted with screw type juice extractor, processed at 65 °C for 15 minutes maintained better quality characteristics in terms of TSS, acidity, ascorbic acid and reducing sugars during 2 month refrigerated storage.

Keywords: Apple juice, pasteurization, quality characteristics, storage

Introduction

Fruit juices are important trade commodities in most countries (Vasada, 2003) [18]. They provide nutrients that are beneficial for health and are in high and continually increasing demand (Ashurst, 2005) [2]. Apple juice is a mixture of sugars (primarily fructose, glucose and sucrose), oligosaccharides and polysaccharides (starch) together with malic, quinic and citromalic acids, polyphenols, amides and other nitrogenous compounds, soluble pectin, vitamin C, minerals and a diverse range of esters that give the juice a typical apple like aroma (ethyl- and methyl-iso-valerate) (Caballero *et al*., 2003) [4]. It has been produced and consumed in most of the apple producing regions especially the United States for many years. Apple juice and apple cider are the traditional fall beverages in many parts of the country. Recent advancement in production and marketing has made year-round consumption of the beverage possible. It is often available in the areas where the apples are not traditionally grown. The presence of the low molecular weight polyphenols and high molecular weight procyanidins protect from diseases associated with aging due to antioxidant activity, which help reduce the likelihood of developing cancer and Alzheimer's disease (Koutsos *et al*., 2015) [9]. Literature data suggest that certain types of apple juice, in particular those referred to as cloudy juices, could provide protection against the risk of cancer (Barth *et al*., 2005) [3] but also against obesity, arteriosclerosis, and diabetes as a result of the combined presence of polyphenols and soluble fiber (Markowski *et al*., 2009) [10]. The literature also suggests that apple juice increases acetylcholine in the brain, possible resulting in improved memory. However, these products without an efficient processing may be potential source of microbial diseases, the low to middle acidity and high water activity can favor the growth of pathogenic microorganisms. Since many of the processes utilized to preserve food products depend on the addition of thermal energy. Most of the historical references to this method of food preservation were associated with canning, and the subject is most often referred as thermal processing. Although the processes developed were designed primarily to ensure safety of the food when consumed, the same concept applies to thermal processing of foods where extension of shelf life is an objective. Presently, thermal pasteurization is considered the most effective technology in inactivating microorganisms and enzymes to extend product shelf life (Noci *et al*., 2008) [13]. However, to the best of our knowledge, the effect of different time-temperature combinations on the quality of apple juice prepared using screw type juice extractor has not been compared. Hence, different time-temperature combinations (65 °C for 15, 25 and 35 min, 75 °C for 10, 20 and 30 min and 85 °C for 5, 10 and 15 min) were applied to the apple juice and the quality of the pasteurized juice was compared.

Material and Methods

The experiment was conducted in the Food Process Engineering Laboratory, Department of Food Process Engineering, Vaugh School of Agricultural Engineering and Technology, SHIATS, Allahabad, U.P, India. Fresh, matured and uniform sized fruits of apple (*Malus domestica* V. Red Delicious*)* were purchased from the local market of Allahabad (Mahewa) and brought to the Food Process Engineering Laboratory of the department on the same day.

Fruits were inspected thoroughly for any damage and spoilage. Selected fruits were thoroughly washed in tap water to remove dirt, dust particles and insecticidal residues. Juice was extracted after manually peeling. Screw type hand operated juice extractor was used in the study. The peeled fruits were fed into Screw type hand operated juice extractor. In the extractor, the juice and the pomace were separated and both were collected separately. The juice was filtered through a clean muslin cloth and kept for 24 h in refrigerator (4 °C) for sedimentation. Then the clear juice was divided into three lots. One lot was heat processed separately at 65 °C for 15, 25 and 35 min. Then, at that temperature juice was filled in the pre-sterilized bottles and sealed with crown cork. Similarly, other two lots were heat processed separately at 75 °C for 10, 20 and 30 min and at 85 °C for 5, 10 and 15 min. Therefore, total 18 treatment combinations were used for the study. The juice bottles were air cooled under fan. Then all bottled juices were stored at 3–4 °C and juices were used for physico-chemical analysis at 15 days interval for 2 months.

Quality evaluation

The total soluble solids (TSS) content of the fruit juice was determined by using 'Zeiss-Hand' refractometer of 0–32% range. The values obtained were corrected at 20 °C with the help of temperature correction chart and expressed as per cent TSS of fruit juices (AOAC, 1980) [1]. For acidity, a known volume of clean juice was diluted with distilled water and titrated against 0.1N NaOH using phenolphthalein as indicator. The ascorbic acid content was determined by diluting known volume of juice with 3% metaphosphoric acid as buffer and titrating it against 2,6-dichlorophenol indophenol dye solution (AOAC, 1980) [1] until the stable faint pink color was obtained. The results were expressed as mg ascorbic acid/100 ml of fruit juice. Reducing sugar content was measured by following Lane and Eyon method (Rangana, 1991) [15].

Statistical Analysis

The experiment was laid out in a factorial with completely randomized design (CRD). Total number of treatment combinations was 18 with three replications and each treatment combination has three units. To test the significance of variation in the data, analysis of variance technique was adopted as suggested by Fisher. Significance of the difference due to the treatment effect was tested through 'F' test.

Results and Discussion

Effect of processing temperature-time on TSS of apple juice during storage

The TSS of juice increased during storage. The maximum TSS at the end of experimentation was recorded in T_9 treatment (14.0 °B) while minimum in T_1 treatment (11.8 °B). TSS content in T_9 treatments was found to be higher over other treatments except T_8, T_4, T_2, T_3 and T_1treatments which were at par (Table 1). This might be due to the evaporation of water which causes concentration of juice to some extent by heat processing. Similar opinions were put forth by pareek *et al*. 2011 [14]. Increase of TSS in storage was due to hydrolysis of polysaccharides (starch) into monosaccharides (sugars), increase in concentration of juice due to dehydration and degradation of pectic substances of juice in soluble solids. A similar increase in TSS content with the increase in storage period was observed in juice of mandarin, Sweet orange and lemon by Mehta and Bajaj (1983) [11].

Effect of processing temperature-time on titratable acidity of apple juice during storage

The minimum decrease in acidity from 0.90 % to 0.44 % was recorded in juice processed at 85 °C with 15 min of holding time (T_9), while maximum decrease from 0.96 % to 0.46 % was recorded in juice processed at 65 °C with 35 min of holding time (T_3) from 0^{th} month to 2^{th} months of storage. But the maximum acidity was retained in T_1 and T_2 treatments, and minimum in T_9 treatment at the end of storage. However, T_9 treatment was statistically at par with T_6, T_7 and T_8 treatments (Table 1). The decrease in acidity during storage could be attributed to the chemical interaction between the organic constituents of the juice induced by temperature and action of enzymes. The high acidity levels in high temperature processing might be due to the inactivation of enzymes and other reactions responsible for decrease in acidity. Pareek *et al*. (2011) [14] observed decrease in acidity of mandarin throughout the storage period of 6 months. A slight decrease in titratable acidity was observed in Kinnow juice during 74 days of storage (Singh *et al*. 2009) [16].

Table 1: Effect of processing temperature-time on total soluble solids (TSS) and titratable acidity of juice during storage

Treatments	TSS, °B					Acidity, %				
	Storage period, days					Storage period, days				
	0	15	30	45	60	0	15	30	45	60
T_1 - 65 °C-15 min	11.80	11.90	12.20	12.50	13.00	0.97	0.86	0.72	0.63	0.49
T_2 - 65 °C-25 min	11.90	12.10	12.40	12.70	13.10	0.96	0.86	0.72	0.64	0.49
T_3 - 65 °C-35 min	12.00	12.30	12.50	12.70	13.20	0.96	0.84	0.69	0.61	0.46
T_4 - 75 °C-10 min	12.00	12.20	12.40	12.60	13.20	0.95	0.83	0.69	0.62	0.47
T_5 - 75 °C-20 min	12.10	12.40	12.60	12.90	13.30	0.94	0.81	0.68	0.60	0.46
T_6 - 75 °C-30 min	12.30	12.50	12.70	13.10	13.50	0.93	0.79	0.68	0.60	0.46
T_7 - 85 °C-5 min	12.20	12.50	12.70	13.10	13.50	0.92	0.79	0.67	0.60	0.45
T_8 - 85 °C-10 min	12.50	12.70	12.80	13.20	13.60	0.91	0.77	0.65	0.59	0.46
T_9 - 85 °C-15 min	12.60	12.80	13.30	13.60	14.00	0.90	0.77	0.64	0.58	0.44
		F-test	S. Ed. (±)	C.D. at 5 %			F-test	S. Ed. (±)	C.D. at 5 %	
Due days		S	0.6842	0.3227			S	0.0190	0.0403	
Due time		S	0.0589	0.0278			S	0.0036	0.0076	
Due to Temperature		S	0.0589	0.0278			S	0.0036	0.0076	

Effect of processing temperature-time on ascorbic acid of apple juice during storage

The ascorbic acid content decreased in all the treatments during storage (Table 2). At the end of storage the minimum ascorbic acid content was found in T_9 (14.00 mg/100 ml), whereas, it was maximum in T_1 (19.80 mg/100 ml), during 2 months of storage. This loss of ascorbic acid might be due to heat processing and the presence of air at the headspace of glass bottles during storage. Besides that, enzymes like, cytochrome oxidase, ascorbic acid oxidase, and peroxidase are also responsible for oxidation of ascorbic acid and subsequent loss of vitamins C potency (Nagy, 1980) [12]. The incorporation of air into the juice during extraction, finishing and bottle filling have long been recognized by investigators (Farnworth *et al*. 2001) [5] as causing ascorbic acid loss. The results are also in conformity with the findings of Jain and Khurdiya (2009) [8]. They observed the loss in vitamin C during storage of aonla juice and also found that low temperature pasteurization, sulphitation and low temperature storage minimize the loss in ascorbic acid.

Effect of processing temperature-time on reducing sugar of apple juice during storage

The reducing sugar content increased during storage and the maximum value was recorded in T_9 treatment, while minimum recorded in T_1 treatment on 2 month of storage (Table 2). An increase in reducing sugar with the increasing period of storage in all the treatments could be attributed to gradual inversion of non-reducing sugar and acids into reducing sugars in acidic medium. The substantial increase in sugars levels in heat processed juices during storage might be due to the inactivation of enzymes, which might play an important part in the reactions responsible for decreasing acidity and conversion of polysaccharides into simple sugars (Ghorai and Khurdiya 1998) [7]. Garg *et al*. (2008) [6] also observed the increase in reducing and total sugar content during storage in blended aonla juices.

Table 2: Effect of processing temperature-time on ascorbic acid and reducing sugar of juice during storage

Treatments	Ascorbic acid, mg/100ml					Reducing sugar, %				
	Storage period, days					Storage period, days				
	0	15	30	45	60	0	15	30	45	60
T_1 - 65 °C-15 min	19.80	17.90	15.20	13.50	11.80	3.40	3.80	4.40	5.30	5.60
T_2 - 65 °C-25 min	18.90	16.10	14.40	12.70	11.10	3.50	3.90	4.50	5.30	5.60
T_3 - 65 °C-35 min	17.00	16.30	14.50	12.70	11.20	3.70	4.10	4.70	5.50	5.80
T_4 - 75 °C-10 min	17.90	16.20	15.40	13.60	12.20	3.70	4.10	4.70	5.50	5.80
T_5 - 75 °C-20 min	16.10	14.40	13.60	12.90	12.30	3.80	4.30	4.90	5.80	6.10
T_6 - 75 °C-30 min	15.90	13.50	12.70	12.50	12.00	4.00	4.40	5.00	5.80	6.10
T_7 - 85 °C-5 min	14.20	13.50	12.70	12.10	11.50	4.10	4.60	5.20	6.00	6.30
T_8 - 85 °C-10 min	13.50	12.60	12.00	11.80	11.00	4.30	4.70	5.30	6.10	6.40
T_9 - 85 °C-15 min	12.60	12.80	13.30	13.60	14.00	4.50	5.00	5.60	6.40	6.70
		F-test	S. Ed. (±)	C.D. at 5 %			F-test	S. Ed. (±)	C.D. at 5 %	
Due days		S	0.6842	0.3227			S	0.2935	0.6222	
Due time		S	0.0589	0.0278			S	0.0199	0.0423	
Due to Temperature		S	0.0589	0.0278			S	0.0199	0.0423	

Conclusion

The shelf life of apple juice is very short and also quality deteriorated during storage. In this processing temperature-time was optimized. Apple juice (*Malus domestica* V. Red Delicious) juice extracted with screw type extractor and processed at 65 °C for 15 min maintained better quality measured in terms of total soluble solids, ascorbic acid and sugars during 2 months storage at 3-4 °C. The application of heat gave the juice a longer shelf life. Thus a juice manufacturer or retailer can keep the thermally treated apple juice at the refrigerated temperature at 4 °C for 2 months.

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