

PHYSICOCHEMICAL RESPONSE OF APPLE PULP TO CHEMICAL PRESERVATIVES AND ANTIOXIDANT DURING STORAGE

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ABSTRACT: A research was carried out to investigate the effect of chemical preservatives and antioxidants mixed in different concentrations on the overall quality of apple pulp packed in plastic containers, stored at ambient temperature (25-35°C) for 90 days. The treatments were T₀ (apple pulp) + T₁ (apple pulp + 0.1% sodium benzoate + 0.1% citric acid) + T₂ (apple pulp + 0.1% sodium benzoate + 0.5% citric acid) + T₃ (apple pulp + 0.1% potassium metabisulphite + 0.1% citric acid) + T₄ (apple pulp + 0.1% potassium metabisulphite + 0.5% citric acid) T₅ (apple pulp + 0.5% potassium metabisulphite+0.5% sodium benzoate + 0.1% citric acid) T₆ (apple pulp + 0.5% potassium metabisulphite+0.5% sodium benzoate + 0.5% citric acid). The samples were studied for ascorbic acid, % acidity, pH, total soluble solids (TSS), sugar acid ratio, minerals contents (Ca, Mg, Iron, Potassium and sodium) and for organoleptic evaluation (color, flavor and overall acceptability). A decrease was recorded in ascorbic acid content (25.98 to 21.45 mg/100g), sugar acid ratio (14.20 to 13.92), pH (3.62 to 3.28), calcium (12.12 to 4.74 mg/100g), magnesium (12.64 to 11.02), iron (31.22 to 15.65 mg/100g) and sodium (0.57 to 0.45 mg/100 g while an increase was recorded in titratable acidity (0.31 to 0.40), TSS (9.71° brix to 11.36° brix) and potassium (140.00 to 176.22 mg/100g). During organoleptic evaluation samples T₃ and T₄ were found most acceptable during storage. Statistical analysis showed that storage intervals and treatments had a significant (P<0.05) effect on physico-chemical and sensory analysis of apple pulp.

Keywords: Apple pulp, antioxidants, preservatives and minerals

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INTRODUCTION

Apple (*Pyrus malus*) belongs to the family Rosaceae, is an important fruit and is liked through out the world by all classes of the people due to its established nutritional and economical significance. In Pakistan its cultivation is limited to the northern hilly area of Punjab, NWFP and Balochistan (Chuahdhy, 1994).

The total area under apple cultivation in Pakistan was 112.6 thousand hectare which include 0.4 Punjab, 0.1 Sindh, 9.4 hectare in NWFP and 102.8 thousands hectare in Balochistan while total production in Pakistan was 348.3 thousand tons which includes 3.6 Punjab, 0.1 in Sindh, 125.2 in NWFP and 219.5 thousand tons in Balochistan (Agric. Stat. Pakistan, 2006-2007).

Apple contains water 84.7 %, 0.8g fiber, 13.9g carbohydrates, 0.4g proteins, 0.3g lipid, 0.3g ash, vitamin C 8mg/100gm, sodium 0.3mg/100g, potassium 145mg/100g, calcium 7mg/100g, magnesium 6mg/100gm, iron 480µg/100g, Phosphorus 12 mg and Iodine 2 µg (Hussain, 2001), (Vieths *et al* 1993),

Minerals are those that will be present in the ash when food or any living organism is creamed. They have two general functions in the body building and regulation. Calcium is necessary for the formation and development of bones and teeth. Sodium is essential in regulation of water content of the body. Potassium regulates pH and osmotic pressure of the cell contents. Magnesium acts as an activator of several enzymes. Iron is an intrinsic part of hemoglobin that carries oxygen from the lungs to muscles, brain and other parts of the body (J.A. Awan, 2001).

Apple has been widely used as a food from the earliest times and is well known for its curative characteristic, which are evident from the proverb, "an apple a day keeps the doctor away". It has cholesterol-reducing effect for many years particularly in Europe. Apple has been used to treat infant intestinal disorders such as diarrhea and dysentery (Considine,

1982).

Preservatives as a group of chemical compounds deliberately added to food or that appears in food as a result of pre-processing treatment, processing or storage. These include simple organic acids (such as propionic acid, sorbic acid, benzoic acid) *p*-hydroxyl benzoate alkylester (parabens), ethylene/propylene oxides, sulfides, ethylene oxide (as a gas sterilant), ethyl format and sodium nitrates (Prescott *et al* 2002). Benzoic acid and sodium benzoate are generally regarded as safe up to a maximum permitted level of 0.1%. In most countries, the maximum permissible quantities generally range between 0.15-0.25 percent. Sorbic acid and its salts are some of the most widely used food preservatives in the world. As food preservatives, sorbates have found wide application in various foods, especially as yeast and mold inhibitors. Effective antimicrobial concentrations of sorbates in most foods are in the range of 0.05% - 0.30%. In high sugar products (e.g. jams, jellies) smaller quantities of sorbic acid are adequate for preservation, because of synergistic action of sorbat with sugar (Lueck, 1980). The use of benzoic acid as a food preservative has been limited to those products which are acid in nature. It is used antimycotic agent, and most yeast and fungi are inhibited by 0.05-0.1% of the undissociated acid. Food poisoning and spore forming bacteria are generally inhibited by 0.01-0.02% undissociated acid, but many spoilage bacteria are much more resistant. Benzoic acid has been widely used to preserve beverages, fruit products, bakery products and other food products (Chichester and Tanner, 1981).

In Pakistan apple is used in fresh form, but at the

peak harvesting time the production of apple is very high and become abundant in market. Lack of storage facility and perishable nature can result in severe post harvest losses of this fruit. In keeping with recent health professional's recommendations to increase servings of fruits and vegetables and reduce the amount of fat in the diet as well as minimize post harvest losses by product development, the present study was undertaken. This can make an important contribution to a well balanced diet in one way and increase the earning of the farmers on the other way.

This research is initiated to evaluate suitability of different chemical preservatives and antioxidants on the quality evaluation of apple pulp. This will help the food processors to get apple pulp through out the year.

MATERIALS AND METHODS

This research was initiated in the Department of Food Science and Technology, Faculty of Nutrition Sciences NWFP Agricultural University Peshawar, Pakistan. The apple was purchased from the local market of Peshawar. The undesirable and small fruits were sorted, peeling, coring and cutting was carried out using stainless steel knife. After cutting the fruits were put into 0.1% citric acid solutions to prevent discoloration. The apple pulp was extracted through pulper machine. Chemical preservatives i.e. sodium benzoate, potassium metabisulphite, and antioxidant i.e. citric acid were added. Each sample was stored in plastic jars at ambient temperature. The product was analyzed for chemical and for sensory evaluation at 15 days interval for a total period of 90 days.

The treatments were as follow,

| Treatments | Preservatives (g/kg) of pulp |
|----------------|--|
| T ₀ | Control(no preservatives) |
| T ₁ | 0.1% sodium benzoate + 0.1% citric acid |
| T ₂ | 0.1% sodium benzoate + 0.05% citric acid |
| T ₃ | 0.1% potassium metabisulphite + 0.1% citric acid |
| T ₄ | 0.1% potassium metabisulphite + 0.05% citric acid |
| T ₅ | 0.05% potassium metabisulphite+0.05% sodium benzoate + 0.1% citric acid |
| T ₆ | 0.05% potassium metabisulphite+0.05% sodium benzoate + 0.05% citric acid |

Physicochemical Analysis: Ascorbic acid content, Total acidity, Total soluble solids were determined by the method as reported in AOAC (2000). pH of the samples was determined by using INOLAB DIGITAL pH meter according to the manual instruction of apparatus.

Sugar-Acid Ratio: Sugar and acid ratio was determined by the following formula:

$$\text{Sugar/Acid} = \text{TSS}/\% \text{Acidity}.$$

Estimation of total K and Na: Total K and Na in the apple pulp were determined by wet

digestion method of U.S.D.A. Handbook 60 methods (1954). In this method, 1g sample was digested with 10ml conc HNO₃ (overnight treatment) and 4ml perchloric acid at 100 to 550 °C for about 1 hr. after cooling, the digest was filtered and diluted to 50ml and then read for potassium and sodium on flame photometer.

Estimation of total Fe, Ca and Mg: Total Fe, Ca and Mg in apple pulp were determined by wet digestion method of U.S.D.A. Handbook 60 methods (1954). In this method, 1g sample was digested with 10ml conc HNO₃ (overnight treatment) and 4ml perchloric acid at 100 to 550 °C for about 1 hr. after cooling, the digest was filtered and diluted to 50ml and then read for iron, calcium and magnesium on atomic absorption spectrophotometer (Perkin Elmer Model 2380, USA).

Ascorbic acid: Initially the ascorbic acid content of samples (T₀ to T₆) was 16.20, 16.52, 17.00, 26.11, 25.91, 20.51 and 19.10 which was gradually decreased to 8.11, 11.01, 11.59, 21.02, 19.51, 17.05 and 14.01 mg/100g respectively during 90 days of storage period. The mean values of ascorbic acid content significantly (P<0.05) decrease from 20.19 to 14.61 mg/100g during storage. For treatments maximum mean values were recorded in sample T₃ (23.10) followed by T₄ (22.19) mg/100g, while minimum mean values were recorded in sample T₀ (10.45) followed by T₁, (12.64) mg/100g. Maximum decrease was observed in sample T₀ (49.93%) followed by T₁ (33.35%), while minimum decrease was recorded in sample T₅ (16.86%) followed by T₃ (19.49%) (Table 1). The statistical analysis showed that storage intervals and treatments had a significant (P<0.05) effect on the ascorbic acid content of apple pulp during storage (Appendix I). These results are in agreement with the finding of Kinh *et al.* (2001), who recorded a decrease in ascorbic acid content in apple pulp. The losses in ascorbic acid may be due to high temperature and light during storage. Our results showed that sample T₃ having potassium metabisulphite and citric acid retain maximum ascorbic acid. Negi and Roy (2000) showed that application of potassium metabisulphite reduces the loss of ascorbic acid during storage.

Titrateable acidity (%): The titrateable acidity of samples (T₀ to T₆) on day first was 0.31, 0.33, 0.31, 0.31, 0.29, 0.33 and 0.31, which were gradually increased to 0.42, 0.42, 0.41, 0.40, 0.39, 0.42 and 0.39 respectively during 90 days of storage. The mean values for titrateable acidity significantly (P<0.05) increased from 0.31 to 0.40 during storage. Maximum mean values were recorded in sample T₀ (0.38) followed by

Organoleptic evaluation: Selected samples of the product were evaluated organoleptically for color, flavor and overall acceptability by a panel of 10 judges. The evaluation was carried out by 9-point hedonic scale of Larmond (1977).

Statistical Analysis: The results of various treatments were analyzed statistically by Randomized Complete Block Design (RCBD) as described by Gomez (1984) and the means were separated by applying LSD test as described by Steel and Torrie (1997).

RESULTS AND DISCUSSION

The samples were studied for ascorbic acid, acidity, pH, TSS, sugar acid ratio, minerals analysis (calcium, magnesium, iron, sodium, potassium) and for sensory analysis i.e. color, flavor and overall acceptability.

T₁, T₅ (0.37), while minimum mean values were observed in sample T₄ (0.34) followed by T₂, T₃, T₆ (0.35). During storage maximum increase was observed in sample T₀ (35.48%) followed by T₄ (34.48%), while minimum increase was observed in T₆ (25.80%) followed by T₁, T₅ (27.27%) (Table 2). The statistical analysis showed that storage intervals and treatment had a significant effect (P<0.05) on titrateable acidity of apple pulp during storage (Appendix-II). These results are in agreement with the findings of Kinh *et al.* (2001), who reported an increase in titrateable acidity of apple pulp during storage. This increase might be due to the break down of pectin in to pectenic acid. The results are confirmed by the findings of Riaz *et al.* (1988).

pH: Initially the pH value of the samples (T₀ to T₆) was 3.63, 3.55, 3.59, 3.60, 3.60, 3.69 and 3.74, which were gradually decreased to 3.10, 3.31, 3.29, 3.28, 3.32, 3.43 and 3.38 respectively during 90 days of storage. The mean pH value significantly (P<0.05) decreased from 3.62 to 3.28 during storage. For treatment maximum mean values were observed in sample T₅ and T₆ (3.56) followed by T₄ (3.47), while minimum mean values were observed in sample T₀ (3.32) followed by T₁ (3.42). During storage maximum decrease was observed in sample T₀ (14.60%) followed by T₆ (9.62%), while minimum decrease was observed in sample T₁ (6.76%) followed by T₅ (7.04%) (Table 3). The statistical analysis showed that storage intervals and treatments had a significant (P<0.05) effect on pH of apple pulp (Appendix III). Our results are in agreement with the finding of Cecilia and Maia (2002) who observed a decrease in pH of high pulp content apple juice during storage. This decrease may be due to the formation of free acids and pectin hydrolysis (Imran *et al.* 2000).

Total soluble solids (TSS): The TSS values of samples (T₀ to T₆) on day first was 10, 10, 10, 9, 9, 10 and 10° brix, which were gradually increased to 11.91, 10.75, 11.4, 11.5, 11.3, 11.6 and 11.1° brix respectively during 90 days storage. The mean TSS values significantly (P<0.05) increased from 9.71°brix to 11.36 °brix during storage. For treatments maximum mean values were recorded in sample T₀ (11.20) followed by T₅ (10.84) °brix, while minimum mean values were observed in sample T₁ (10.41) followed by T₄ (10.48). During storage maximum increase was observed in sample T₃ (27.77%) followed by T₄ (25.55%), while minimum increase was recorded in sample T₁ (7.5%) followed by T₆ (11.00%) (Table 4). The statistical analysis showed that storage intervals and treatments had a significant (P<0.05) effect on TSS of apple pulp (Appendix IV). These results are in agreement with the finding of Kinh *et al.* (2001) who reported an increase in TSS of apple pulp preserved with chemical preservative. Shah *et al.* (1975) mentioned that increase in soluble content of the product may be due to the solubilization of fruit constituents during storage.

Sugar acid ratio: Initially the sugar acid ratio of the samples (T₀ to T₆) was 32.25, 30.30, 32.25, 29.03, 37.50, 30.30 and 32.25, which were gradually decreased to 28.35, 25.59, 27.8, 28.75, 28.97, 27.61 and 28.46 respectively during 90 days of storage. The mean sugar acid ratio significantly (P<0.05) decreased from 32.41 to 27.37 during storage. For treatment maximum mean values were observed in sample T₄ (32.02) followed by T₂ (30.42), while minimum mean values was observed in sample T₁ (27.75) followed by T₅ (28.81). During storage maximum decrease was observed in sample T₄ (22.74%) followed by T₁ (15.54%), while minimum decrease was observed in sample T₃ (0.96%) followed by T₅ (8.87%) (Table 5). The statistical analysis showed that storage intervals and treatments had a significant (P<0.05) effect on sugar acid ratio of apple pulp (Appendix V). These results are in an agreement with the findings of Daurance *et al.* (1986) who reported a decrease in sugar acid ratio of apple pulp during storage.

Iron: Initially the iron content of samples (T₀ to T₆) was 32.6, 35.35, 28.60, 30.80, 26.50, 31.20 and 33.50 mg/100g which were gradually decreased to 14.55, 25.31, 11.91, 12.95, 10.91, 15.41 and 18.57 mg/100g respectively during 90 days of storage. The mean iron values significantly (P<0.05) decreased from 31.22 to 15.65 mg/100 g during storage. For treatment maximum mean values were observed in sample T₁ (27.33) followed by T₆ (20.79) mg/100g, while minimum mean values was observed in

Calcium: Initially the calcium content of samples (T₀ to T₆) was 9.76, 12.88, 9.68, 11.98, 10.80, 14.69 and 15.10 which were gradually decreased to 3.62, 5.76, 3.51, 3.05, 3.01, 5.99 and 8.21 mg/100g respectively during 90 days of storage. The mean calcium values significantly (P<0.05) decreased from 12.12 to 4.74 mg/100g during storage. For treatment maximum mean values were observed in sample T₆ (10.73) followed by T₂ (9.37) mg/100g, while minimum mean values was observed in sample T₄ (4.80) followed by T₃ (5.17) mg/100g. During storage maximum decrease was observed in sample T₃ (74.54%) followed by T₄ (72.12%), while minimum decrease was observed in sample T₆ (45.62%) followed by T₁ (59.27%) (Table 6). The statistical analysis showed that storage intervals and treatments had a significant (P<0.05) effect on calcium of apple pulp (Appendix VI). These results are in an agreement with the findings of Oluwaliana *et al* (2006) who reported a decrease in minerals contents (Iron, Calcium, Sodium and magnesium) with increase in storage days in ripening of fruits.

Magnesium: Initially the magnesium content of samples (T₀ to T₆) was 8.51, 13.2, 6.51, 17.71, 16.95, 13.52 and 12.10 mg/100g which were gradually decreased to 4.83, 11.90, 4.89, 16.98, 15.50, 12.51 and 11.7 mg/100 g 9 respectively during 90 days of storage. The mean magnesium values significantly (P<0.05) decreased from 12.64 to 11.02 mg/100g during storage. For treatment maximum mean values were observed in sample T₃ (17.20) followed by T₄ (15.50) mg/100g, while minimum mean values was observed in sample T₀ (5.36) followed by T₂ (5.16) mg/100g. During storage maximum decrease was observed in sample T₀ (43.24%) followed by T₂ (24.88%), while minimum decrease was observed in sample T₃ (4.12%) followed by T₆ (4.88%) (Table 7). The statistical analysis showed that storage intervals and treatments had a significant (P<0.05) effect on magnesium of apple pulp (Appendix VII). These results are in an agreement with the findings of Oluwaliana *et al* (2006) who reported a decrease in minerals contents (Iron, Calcium, Sodium and magnesium) with increase in storage days in ripening of fruits.

sample T₄ (13.20) followed by T₂ (14.57) mg/100g. During storage maximum decrease was observed in sample T₄ (58.83%) followed by T₂ (58.35%), while minimum decrease was observed in sample T₁ (28.40%) followed by T₆ (44.56%) (Table 8).

The statistical analysis showed that storage intervals and treatments had a significant (P<0.05) effect on iron of apple pulp (Appendix

VIII). These results are in an agreement with the findings of Oluwaliana *et al* (2006) who reported a decrease in minerals contents (Iron, Calcium, Sodium and magnesium) with increase in storage days in ripening of fruits.

Sodium: Initially the sodium content of samples (T₀ to T₆) was 0.61, 0.71, 0.69, 0.59, 0.41, 0.51 and 0.47 mg/100g which were gradually decreased to 0.35, 0.60, 0.57, 0.49, 0.32, 0.49 and 0.36 mg/100g respectively during 90 days of storage. The mean sodium values significantly (P<0.05) decreased from 0.57 to 0.45 mg/100g during storage. For treatment maximum mean values were observed in sample T₁ (0.66) followed by T₂ (0.63) mg/100g, while minimum mean values was observed in sample T₄ (0.37) followed by T₆ (0.40) mg/100g. During storage maximum decrease was observed in sample T₀ (42.62%) followed by T₅ (23.52), while minimum decrease was observed in sample T₁ (15.49%) followed by T₃ (16.94%) (Table 9). The statistical analysis showed that storage intervals and treatments had a significant (P<0.05) effect on sodium of apple pulp (Appendix IX). These results are in an agreement with the findings of Oluwaliana *et al* (2006) who reported a decrease in minerals

contents (Iron, Calcium, Sodium and magnesium) with increase in storage days in ripening of fruits.

Potassium: Initially the potassium content of samples (T₀ to T₆) was 180, 170, 112, 136, 149, 101 and 132 mg/100g which were gradually increased to 305.2, 212, 134.5, 155.2, 164.2, 116.3 and 145.2 mg/100g respectively during 90 days of storage. The mean potassium values significantly (P<0.05) increased from 140.00 to 176.22 mg/100g during storage. For treatment maximum mean values were observed in sample T₀ (282.1) followed by T₁ (202.0) mg/100g, while minimum mean values was observed in sample T₅ (109.6) followed by T₃ (123.6) mg/100g. During storage maximum increase was observed in sample T₀ (70.11%) followed by T₁ (24.70%), while minimum increase was observed in sample T₆ (10.00%) followed by T₄ (10.20%) (Table 10). The statistical analysis showed that storage intervals and treatments had a significant (P<0.05) effect on potassium of apple pulp (Appendix X). These results are in an agreement with the findings of Amusa *et al* (2003) who reported that potassium, calcium and sodium increased compared to the freshly harvested fruits.

Table 1. Effect of storage period and treatments on ascorbic acid content (mg/100 g) of apple pulp.

| Treatments | Storage intervals (Days) | | | | | | | % Decrease | Mean |
|----------------|--------------------------|---------|---------|---------|----------|----------|---------|------------|---------|
| | Initial | 15 | 30 | 45 | 60 | 75 | 90 | | |
| T ₀ | 16.20 | 11.02 | 10.21 | 9.61 | 9.11 | 8.91 | 8.11 | 49.93 | 10.45 f |
| T ₁ | 16.52 | 14.19 | 12.63 | 11.93 | 11.16 | 11.05 | 11.01 | 33.25 | 12.64 e |
| T ₂ | 17.00 | 15.11 | 12.23 | 12.11 | 12.02 | 11.91 | 11.59 | 31.82 | 13.13 e |
| T ₃ | 26.11 | 25.15 | 24.12 | 22.21 | 21.96 | 21.16 | 21.02 | 19.49 | 23.10 a |
| T ₄ | 25.91 | 25.12 | 23.51 | 21.21 | 20.21 | 19.91 | 19.51 | 24.70 | 22.19 b |
| T ₅ | 20.51 | 19.61 | 19.11 | 18.90 | 18.15 | 17.99 | 17.05 | 16.86 | 18.76 c |
| T ₆ | 19.10 | 18.21 | 16.02 | 15.21 | 14.99 | 14.31 | 14.01 | 26.64 | 15.97 d |
| Mean | 20.19 a | 18.34 b | 16.83 c | 15.88 d | 15.37 de | 15.03 de | 14.61 e | | |

Values followed by different letters are significantly (P< 0.05) different from each other.

LSD value for treatments means = 0.8220

LSD value for storage interval means = 0.8220

Table 2. Effect of storage period and treatments on titratable acidity (%) of apple pulp.

| Treatments | Storage intervals (Days) | | | | | | | % Increase | Mean |
|----------------|--------------------------|------|------|------|------|------|------|------------|--------|
| | Initial | 15 | 30 | 45 | 60 | 75 | 90 | | |
| T ₀ | 0.31 | 0.35 | 0.38 | 0.39 | 0.4 | 0.41 | 0.42 | 35.48 | 0.38 a |
| T ₁ | 0.33 | 0.35 | 0.36 | 0.38 | 0.39 | 0.41 | 0.42 | 27.27 | 0.37 a |
| T ₂ | 0.31 | 0.32 | 0.34 | 0.35 | 0.36 | 0.4 | 0.41 | 32.25 | 0.35 b |
| T ₃ | 0.31 | 0.33 | 0.34 | 0.35 | 0.36 | 0.39 | 0.4 | 29.03 | 0.35 b |
| T ₄ | 0.29 | 0.31 | 0.33 | 0.34 | 0.36 | 0.38 | 0.39 | 34.48 | 0.34 c |

| | | | | | | | | | |
|----------------|--------|--------|--------|--------|--------|--------|--------|-------|---------|
| T ₅ | 0.33 | 0.34 | 0.37 | 0.38 | 0.39 | 0.41 | 0.42 | 27.27 | 0.37 a |
| T ₆ | 0.31 | 0.32 | 0.34 | 0.35 | 0.37 | 0.38 | 0.39 | 25.80 | 0.35 bc |
| Mean | 0.31 a | 0.33 b | 0.35 c | 0.36 d | 0.37 e | 0.39 f | 0.40 g | | |

Values followed by different letters are significantly (P< 0.05) different from each other.

LSD value for treatments means = 0.01084

LSD value for storage interval means = 0.018084

Table 3. Effect of Storage period and Treatments on pH of apple pulp.

| Treatments | Storage intervals (Days) | | | | | | | %Decrease | Mean |
|----------------|--------------------------|--------|--------|--------|--------|--------|--------|-----------|---------|
| | Initial | 15 | 30 | 45 | 60 | 75 | 90 | | |
| T ₀ | 3.63 | 3.4 | 3.36 | 3.31 | 3.28 | 3.2 | 3.1 | 3.1 | 3.32 d |
| T ₁ | 3.55 | 3.5 | 3.46 | 3.4 | 3.4 | 3.36 | 3.31 | 3.31 | 3.42 c |
| T ₂ | 3.59 | 3.54 | 3.5 | 3.44 | 3.39 | 3.33 | 3.29 | 3.29 | 3.44 bc |
| T ₃ | 3.6 | 3.53 | 3.5 | 3.43 | 3.38 | 3.34 | 3.28 | 3.28 | 3.43 c |
| T ₄ | 3.6 | 3.57 | 3.52 | 3.48 | 3.43 | 3.39 | 3.32 | 3.32 | 3.47 b |
| T ₅ | 3.69 | 3.64 | 3.6 | 3.57 | 3.52 | 3.47 | 3.43 | 3.43 | 3.56 a |
| T ₆ | 3.74 | 3.68 | 3.62 | 3.56 | 3.5 | 3.44 | 3.27 | 3.27 | 3.54 |
| Mean | 3.61 f | 3.55 e | 3.50 d | 3.45 c | 3.41 b | 3.36 a | 3.28 a | | |

Values followed by different letters are significantly (P< 0.05) different from each other.

LSD value for treatments means = 0.03428

LSD value for storage interval means = 0.3428

Table 4. Effect of Storage period and Treatments on TSS of apple pulp.

| Treatments | Storage intervals (Days) | | | | | | | % Increase | Mean |
|----------------|--------------------------|---------|---------|---------|---------|----------|---------|------------|-----------|
| | Initial | 15 | 30 | 45 | 60 | 75 | 90 | | |
| T ₀ | 10 | 10.50 | 11.1 | 11.51 | 11.61 | 11.79 | 11.91 | 19.10 | 11.20 a |
| T ₁ | 10 | 10.20 | 10.31 | 10.51 | 10.55 | 10.61 | 10.75 | 7.50 | 10.41 d |
| T ₂ | 10 | 10.20 | 10.40 | 10.90 | 11.20 | 11.30 | 11.40 | 14.00 | 10.77 bc |
| T ₃ | 9 | 10.30 | 10.40 | 10.80 | 11.20 | 11.40 | 11.50 | 27.77 | 10.65 bcd |
| T ₄ | 9 | 10.10 | 10.30 | 10.60 | 10.90 | 11.20 | 11.30 | 25.55 | 10.48 d |
| T ₅ | 10 | 10.20 | 10.40 | 10.90 | 11.30 | 11.50 | 11.60 | 16.00 | 10.84 b |
| T ₆ | 10 | 10.10 | 10.2 | 10.5 | 10.8 | 11.00 | 11.10 | 11.00 | 10.52 cd |
| Mean | 9.71 e | 10.22 d | 10.44 d | 10.81 c | 11.08 b | 11.25 ab | 11.36 a | | |

Values followed by different letters are significantly (P< 0.05) different from each other.

LSD value for treatments means = 0.2677

LSD value for storage interval means = 0.2677

Table 5. Effect of Storage period and Treatments on Sugar Acid Ratio of pulp.

| Treatments | Storage intervals (Days) | | | | | | | % Decrease | Mean |
|----------------|--------------------------|-------|-------|-------|-------|-------|-------|------------|----------|
| | Initial | 15 | 30 | 45 | 60 | 75 | 90 | | |
| T ₀ | 32.25 | 30.00 | 29.21 | 29.51 | 29.02 | 28.65 | 28.35 | 12.09 | 29.57 bc |
| T ₁ | 30.30 | 29.14 | 28.63 | 27.65 | 27.05 | 25.87 | 25.59 | 15.54 | 27.75 d |
| T ₂ | 32.25 | 31.87 | 30.58 | 31.14 | 31.11 | 28.25 | 27.8 | 13.79 | 30.42 b |
| T ₃ | 29.03 | 31.21 | 30.58 | 30.85 | 31.11 | 29.23 | 28.75 | 0.96 | 30.10 b |
| T ₄ | 37.50 | 35.58 | 31.21 | 31.17 | 30.27 | 29.47 | 28.97 | 22.74 | 32.02 a |
| T ₅ | 30.30 | 30.00 | 28.1 | 28.68 | 28.97 | 28.04 | 27.61 | 8.87 | 28.81 cd |

| | | | | | | | | | |
|----------------|---------|---------|---------|---------|---------|--------|---------|-------|---------|
| T ₆ | 32.25 | 31.56 | 30.00 | 30.00 | 29.18 | 28.2 | 28.46 | 11.75 | 30.09 b |
| Mean | 32.41 a | 31.66 a | 29.54 b | 29.59 b | 30.31 b | 27.8 c | 27.37 c | | |

Values followed by different letters are significantly (P< 0.05) different from each other.
LSD value for treatments means = 1.221
LSD value for storage interval means = 1.221

Table 6. Effect of Storage period and Treatments on Calcium content (mg/100 g) of apple pulp.

| Treatments | Storage intervals (Days) | | | | | | | % Decrease | Mean |
|----------------|--------------------------|--------|--------|--------|---------|---------|--------|------------|---------|
| | Initial | 15 | 30 | 45 | 60 | 75 | 90 | | |
| T ₀ | 9.76 | 7.92 | 6.66 | 5.45 | 4.44 | 4.18 | 3.62 | 62.90 | 6.00 c |
| T ₁ | 12.88 | 11.63 | 10.61 | 9.50 | 8.40 | 6.79 | 5.79 | 55.27 | 9.36 b |
| T ₂ | 9.68 | 8.40 | 7.10 | 5.85 | 4.64 | 3.54 | 3.51 | 63.73 | 6.10 c |
| T ₃ | 11.98 | 6.46 | 4.00 | 3.91 | 3.71 | 3.10 | 3.05 | 74.54 | 5.17 cd |
| T ₄ | 10.80 | 6.40 | 3.60 | 3.51 | 3.21 | 3.10 | 3.01 | 72.12 | 4.80 d |
| T ₅ | 14.69 | 12.00 | 9.80 | 7.10 | 6.91 | 6.10 | 5.99 | 59.22 | 8.94 b |
| T ₆ | 15.10 | 14.12 | 10.4 | 9.50 | 8.99 | 8.76 | 8.21 | 45.62 | 10.72 a |
| Mean | 12.12 a | 9.56 b | 7.45 c | 6.40 d | 5.75 de | 5.08 ef | 4.74 f | | |

Values followed by different letters are significantly (P< 0.05) different from each other.
LSD value for treatments means = 0.9457
LSD value for storage interval means = 0.9457

Table 7. Effect of Storage period and Treatments on Magnesium content (mg/100 g) of apple pulp

| Treatments | Storage intervals (Days) | | | | | | | % Decrease | Mean |
|----------------|--------------------------|---------|---------|---------|---------|---------|---------|------------|----------|
| | Initial | 15 | 30 | 45 | 60 | 75 | 90 | | |
| T ₀ | 8.51 | 5.04 | 5 | 4.91 | 4.9 | 4.85 | 4.83 | 43.24 | 5.43 e |
| T ₁ | 13.20 | 12.24 | 12.10 | 12.02 | 11.99 | 11.91 | 11.90 | 9.84 | 12.19 cd |
| T ₂ | 6.51 | 4.98 | 4.96 | 4.93 | 4.92 | 4.90 | 4.89 | 24.88 | 5.15 e |
| T ₃ | 17.71 | 17.4 | 17.21 | 17.10 | 17.05 | 17.00 | 16.98 | 4.12 | 17.20 a |
| T ₄ | 16.95 | 15.6 | 15.41 | 15.31 | 15.15 | 15.10 | 15.01 | 11.44 | 15.50 b |
| T ₅ | 13.52 | 12.54 | 12.51 | 12.50 | 12.31 | 12.16 | 12.06 | 10.79 | 12.51 c |
| T ₆ | 12.10 | 11.96 | 11.76 | 11.78 | 11.71 | 11.69 | 11.51 | 4.88 | 11.78 d |
| Mean | 12.64 a | 11.39 b | 11.27 b | 11.22 b | 11.14 b | 11.08 b | 11.02 b | | |

Values followed by different letters are significantly (P< 0.05) different from each other.
LSD value for treatments means = 0.4403
LSD value for storage interval means = 0.4403

Table 8. Effect of Storage period and Treatments on Iron content (mg/100 g) of apple pulp

| Treatments | Storage intervals (Days) | | | | | | | % Decrease | Mean |
|----------------|--------------------------|-------|-------|-------|-------|-------|-------|------------|---------|
| | Initial | 15 | 30 | 45 | 60 | 75 | 90 | | |
| T ₀ | 32.60 | 16.10 | 15.60 | 15.10 | 14.91 | 14.61 | 14.55 | 55.36 | 17.63 c |
| T ₁ | 35.35 | 27.00 | 26.20 | 26.10 | 25.93 | 25.40 | 25.31 | 28.40 | 27.32 a |
| T ₂ | 28.60 | 12.60 | 12.50 | 12.30 | 12.10 | 12.01 | 11.91 | 58.35 | 14.57 d |
| T ₃ | 30.80 | 13.10 | 13.02 | 12.99 | 12.98 | 12.97 | 12.95 | 57.95 | 15.54 d |
| T ₄ | 26.50 | 11.10 | 11.01 | 11.00 | 10.95 | 10.93 | 10.91 | 58.83 | 13.20 e |

| | | | | | | | | | |
|----------------|---------|---------|---------|---------|---------|---------|---------|-------|---------|
| T ₅ | 31.20 | 15.90 | 15.60 | 15.50 | 15.48 | 15.46 | 15.41 | 50.60 | 17.79 c |
| T ₆ | 33.50 | 18.90 | 18.70 | 18.65 | 18.61 | 18.60 | 18.57 | 44.56 | 20.79 b |
| Mean | 31.22 a | 16.38 b | 16.09 b | 15.94 b | 15.85 b | 15.71 b | 15.65 b | | |

Values followed by different letters are significantly (P< 0.05) different from each other.
LSD value for treatments means = 1.181
LSD value for storage interval means = 1.181

Table 9. Effect of Storage period and Treatments on sodium content (mg/100 g) of apple pulp

| Treatments | Storage intervals (Days) | | | | | | | % Decrease | Mean |
|----------------|--------------------------|------|------|------|------|------|------|------------|----------|
| | Initial | 15 | 30 | 45 | 60 | 75 | 90 | | |
| T ₀ | 0.61 | 0.52 | 0.42 | 0.41 | 0.39 | 0.36 | 0.35 | 42.62 | 0.45 bc |
| T ₁ | 0.71 | 0.69 | 0.68 | 0.67 | 0.65 | 0.62 | 0.60 | 15.49 | 0.66 a |
| T ₂ | 0.69 | 0.67 | 0.66 | 0.61 | 0.60 | 0.59 | 0.57 | 17.39 | 0.62 ab |
| T ₃ | 0.59 | 0.57 | 0.56 | 0.54 | 0.52 | 0.51 | 0.49 | 16.94 | 0.54 abc |
| T ₄ | 0.41 | 0.40 | 0.39 | 0.37 | 0.36 | 0.35 | 0.32 | 21.95 | 0.37 c |
| T ₅ | 0.51 | 0.49 | 0.45 | 0.42 | 0.41 | 0.40 | 0.39 | 23.52 | 0.43 bc |
| T ₆ | 0.47 | 0.43 | 0.42 | 0.39 | 0.38 | 0.37 | 0.36 | 23.40 | 0.40 c |
| Mean | 0.57 | 0.53 | 0.51 | 0.48 | 0.47 | 0.45 | 0.44 | | |

Values followed by different letters are significantly (P< 0.05) different from each other.
LSD value for treatments means = 16.73
LSD value for storage interval means = 16.73

Table 10. Effect of Storage period and Treatments on potassium content (mg/100 g) of apple pulp

| Treatments | Storage intervals (Days) | | | | | | | %Decrease | Mean |
|----------------|--------------------------|---------|---------|---------|---------|---------|---------|-----------|-----------|
| | Initial | 15 | 30 | 45 | 60 | 75 | 90 | | |
| T ₀ | 180 | 291 | 295.2 | 299 | 301.2 | 302.5 | 306.2 | 70.11 | 282.15 a |
| T ₁ | 170 | 201 | 205.4 | 207.2 | 209 | 210.2 | 212 | 24.70 | 202.11 b |
| T ₂ | 112 | 115 | 120 | 121.5 | 130.3 | 132 | 134.5 | 20.08 | 123.61 ef |
| T ₃ | 136 | 140 | 141.5 | 143.2 | 149.2 | 154.8 | 155.2 | 14.11 | 145.70 cd |
| T ₄ | 149 | 155 | 157.8 | 158.6 | 160.8 | 161.5 | 164.2 | 10.20 | 158.12 c |
| T ₅ | 101 | 106 | 107.2 | 109.2 | 112 | 115.7 | 116.3 | 15.14 | 109.62 f |
| T ₆ | 132 | 135.1 | 137.2 | 139.4 | 142.5 | 173.2 | 145.2 | 10.00 | 143.51 de |
| Mean | 140 b | 163.3 a | 166.3 a | 168.3 a | 172.1 a | 178.5 a | 176.2 a | | |

Values followed by different letters are significantly (P< 0.05) different from each other.
LSD value for treatments means = 0.1878
LSD value for storage interval means = 0.1878

CONCLUSIONS

In present research apple pulp was preserved with chemical preservatives and antioxidant, stored in plastic containers at ambient temperature (25-35°C) for a total period of 90 days. The physico-chemical and sensory evaluation were carried out at 15 days interval. The study showed that the samples T₃ (0.1%

potassium metabisulphite + 0.1% citric acid) and T₄ (0.1% potassium metabisulphite + 0.5% citric acid) were found most acceptable during physico-chemical and sensory evaluation.

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