e-ISSN 2320 –7876 www.ijfans.org
Vol.11,S Iss.2, 2022

Effect of Chemical Preservatives on Storage of Thermally Processed Banana Pulp

Poojitha P[1]*, Aishwarya R[1], Vyshnavi K[1], Sai Samyukktha J U[1], Keren Bharath S M[1], Cibi Sakthi Harees S[1], Jayanthan D[1], Nirmal Abraham Koshy[2], Gowrishankar L[1], K.A. Athmaselvi [3]

[1]Department of Food Technology, Bannari Amman Institute of Technology,Sathyamangalam, Tamil Nadu, India.

[2]Department of Quality, VKL seasoning private limited, Kochi, Kerala.

[3]IndianInstitute of Food Process Technology, Ministry of Food Process Industries, Government of India, Thanjavur-613005, Tamil Nadu, India.

Corresponding Author : Poojithapushparaj@gmail.com

Abstract:

Banana pulp is a perishable product, and the shelf life of pulp at ambient temperature is short (3-5 days), and at cold storage, it is hardly 2-4 weeks. Thus, the main objective is to preserve the pulp from quality retention and to extend the storage shelf life. The study utilized ohmic heating and conventional heating for banana pulp processing. Then it is followed by treatment with three different concentrations (500 ppm, 750 ppm, and 1000 ppm) of three preservatives (sodium benzoate, potassium metabisulphite, and sodium metabisulphite). The physicochemical properties of the treated pulp, such as pH, total soluble solids, acidity, color, and ascorbic acid content, were determined and monitored at an interval of 7 days throughout the storage period. Meanwhile, at an interval of 15 days, the microbial study was conducted. Among the evaluated chemical preservatives, the pulp samples treated with a high concentration of potassium metabisulphite show more stability compared to sodium benzoate and sodium metabisulphite.

Keywords: Banana pulp, Ohmic heating, Conventional heating, Chemical preservatives, Physiochemical properties, Shelf life studies.

PRACTICAL APPLICATION

The application of heat in food preservation s one of the most common methods. Heterogeneous heating occurs during the conventional method of processing, and a very high temperature is generated, which results in organoleptic changes and the loss of nutrients. These disadvantages can be overthrown by adopting new technology such as ohmic heating, in which the liquid or semi-solid foods are sterilized without any physical damage caused by conventional heating. The chemical preservatives are used to restrict the spoilage of foods by the microbial attack, and thus for better preservation, it was effectively used in combinations.

INTRODUCTION

The commonly used method for the preservation of food is heat processing and in many food industries it is being utilized for the processing and preservation of food. While the food is processed with heat, it gets nonresistant to nutrition and organoleptic losses because of the high temperature generation. These disadvantages could be swept over by taking up new technologies which includes ohmic heating, high pressure technology, ultrasound processing, pulsed electric field technology, Irradiation, hurdle technology, oscillating magnetic fields. When more new methods of heating such as microwave heating, inductive or ohmic heating are used, heat treatment for composite food fluids is substantially ameliorated. In these methods, heat will be generated inside the food and considers less on thermal convection and conduction thereby causing minimal temperature gradients. Ohmic heating, which is also known as Joule heating, direct electrical resistance heating, electrical resistance heating, electroconductive or electroheating heating, is specified as a thermal process in which alternating electric currents (AC) are being passed via the foods to heat them. Due to electrical resistance, heat is internally generated. Heating medium is not included in the Ohmic heating process (Saran and Choudhary, 2013). Ohmic heating can be considered as a high temperature short time (HTST) sterile process. In food industries, there are many applications of this Ohmic heating technique that includes blanching, evaporations, dehydration, fermentation and pasteurization (Haydar et al., 2007). The food products are of better quality which are treated with Ohmic heating process than those processed by conventional technologies (Saran and Choudhary, 2013; Bon et al., 2010). There are more benefits pertaining to this process of ohmic heating. This process gives extensive rapid heating rates and the heat passes all over the food product via which the electrical current passes, the heating process takes place to the whole volume and the product will not receive huge temperature variations with surfaces hotter than the fluid itself (Aviara et al., 2007). Being a high energy efficient system the Ohmic heating process can be conducted easily (Thompson, 2003), where it leads to less degradation of vitamins (Bon et al., 2010, Oyelade et al., 2005).

Among various methods that are being used for preservation, chemical preservation of pulp exists as the cheapest and most widely and commonly used all over the world. The chemical preservatives are being used for the protection of food from getting spoiled due to attack of microbes and thus is efficaciously used in combinations for better preservation. No single preservative is solely effective against every microorganism (Chipley, 1983). Potassium metabisulphite (PMS) and Sodium benzoate (SB) show better antimicrobial activity and are being used as a preservative of fruit pulp for long term storage (Manganelli & Casolari, 1983; Sofos & Busta, 1981; LuÈcK, 1990). The effect of SB on the growth and survival perspective of some food poisoning, yeast strains and spoilage organisms has been depicted to a great degree (Sofos *et al*., 1986; Warth, 1985). Concentration of SB have a direct effect on the microorganisms inhibition (Ogiehor & Ike Nebo Me Clearly, 2004) as the higher concentration of SB evidenced greater antimicrobial effect, practiced on various *Aspergillus* species (Ogunrinola *et al*., 1996; Gould, 1989;).

Additives can lend substantially to food preservation. Food additives have a logical use in food processing in enhancing the utilization of available foods. It plays a main role in holding the nutritional quality of a food and in enhancing the keeping quality with reduction in food losses. One of the food additives used is the chemical preservatives that support the processing technique and inhibit the growth of microorganisms. Potassium metabisulphite (KMS), sodium benzoate and sodium metabisulphite (NaMS) are few of the most used food grade preservatives. Commonly used staple sources of sulphur dioxide are KMS and NaMS. It is easier to use, as it is solid than liquid or gaseous sulphur dioxide. It reacts with the acid in the juice forming the potassium salt and sulphur dioxide, when fruit juice or squash is added, and is liberated and forms sulphurous acid with the water of the juice. Sulphur dioxide has a better preservative action than sodium benzoate against bacteria and moulds. The main advantage of sulphur dioxide over sodium benzoate is that it helps in retaining the color of the beverage for a longer time. Like sulphur dioxide, benzoic acid also has the ability to inhibit microbial growth. In water it is only partially soluble hence its salts, sodium benzoate, is used.

The antibacterial action of benzoic acid is increased in the presence of carbon dioxide and acids. Benzoic acid is more effective against yeasts than moulds. Considerably at pH 5.0 the action of benzoic acid is reduced.

The present work investigates the inhibitory effect of various preservatives like potassium metabisulphite, sodium benzoate and sodium metabisulphite at three different concentrations such as 500 ppm, 750 ppm, 1000 ppm to enhance the shelf life of ohmically heated and conventionally heated pulp.

MATERIALS AND METHODS:

Sample preparation:

Cavendish bananas were collected from the local market in Gudvancherry, India, and were washed, peeled, cut with a sterilized knife, and pulped.

Experimental equipment and procedure:

The ohmic heating system contains a rheostat, voltmeter, ammeter, power supply, and titanium electrodes. The area of the ohmic heating cell was 134.4 cm2, and the distance between the two electrodes was 6 cm. A Teflon-coated thermometer is utilized for measuring the temperature at different locations in the cell.

A specified amount of banana pulp is sandwiched between two electrodes in the test cell. Three different voltage gradients 13.33, 20, and 26.66 V/cm, are used to ohmically heat the sample. Ohmic heating continues till the pulp starts to bubble and to enhance the shelf life, it was on hold for 2 minutes. The physicochemical properties, such as pH, TSS, color, acidity, and ascorbic acid content, are analyzed before and after ohmic heat treatment.

Addition of preservatives:

Preservatives such as sodium benzoate, potassium metabisulphite, and sodium metabisulphite are added at various concentrations of 500 ppm, 750 ppm, and 1000 ppm to the ohmically heated and conventionally heated pulp.

pH measurement:

A digital pH meter (Cyber pH 14 L), initially calibrated with pH buffer 7 (Abid et al. 2013), is used to measure the pH of the banana pulp before and after heat treatment.

Total Soluble Solids:

A hand refractometer (ATAGO PAL -3, Japan), calibrated using distilled water, is used to determine the total Soluble Solids in the pulp. The principle of hand refractometer is total refraction of light. The pulp of 0.5 ml is spread on the plate surface, and the value is observed (Abid et al. 2013).

Acidity:

According to the method described (Cristina et al. 1999), total titratable acidity (TA) was measured, and 0.1N NaOH was used to filter and titrate the pulp. To calculate the percentage of total acid in terms of the predominant acid present in the pulp i.e. malic acid, the following formula was used (Ranganna 2001).

$$Acidity\% = \frac{Titre\ value\ X\ Normality\ of\ alkali\ X\ Volume\ made\ up\ X\ Equivalent\ weight\ of\ acid}{Volume\ of\ sample\ taken\ for\ estimation\ X\ weight\ of\ sample\ taken\ X\ 1000} X\ 100$$

Colour Analysis:

Utilizing a Hunter colourimeter, the L*, a*, and b* values were calculated (Colour Quest). The L* number indicates brightness, whereas a* and b* stand for the degree of redness or greenness and blueness or yellowness, respectively. Calculated the overall colour difference.

$$TCD = \sqrt{(Lo - L)^2 + (ao - a)^2 + (bo - b)^2}$$

e-ISSN 2320 –7876 www.ijfans.org
Vol.11,S Iss.2, 2022

Ascorbic acid:

By titrating the filtered sample against the dye solution of sodium bicarbonate and dichlorophenol indophenols, it is possible to compare the ascorbic acid concentration of the pulp before and after processing. By titrating ascorbic acid diluted in 4% oxalic acid against the dye solution, dye is standardised.

$$Ascorbic\ acid\ content\ (mg/100g) = \frac{Amount\ of\ pulp\ X\ Titre\ value\ of\ pulp\ X\ 100}{Titre\ value\ of\ ascorbic\ acid\ X\ Volume\ taken\ X\ Weight\ of\ the\ sample} X\ 100$$

Microbial study :

Spread plating in potato dextrose agar was used to count the colonies in the pulp. A colony counter was used to determine the total number of colonies. The investigation was conducted over the course of 15 days.

$$\frac{CFU}{ml} = \frac{Number\ of\ colonies\ X\ reciprocal\ of\ dilution\ factor}{Volume\ of\ sample}$$

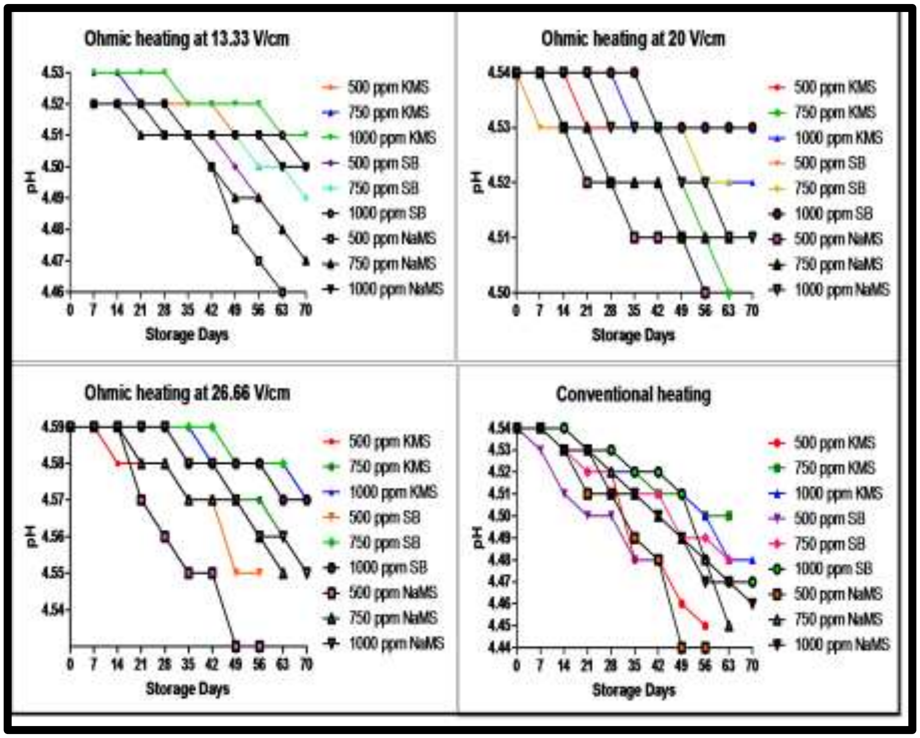
RESULTS AND DISCUSSION

The current study was led to examine the impact of three different preservatives for holding physicochemical Parameters of stored banana pulp. Therefore, pulp was treated by each preservative at different concentrations (500 ppm, 750 ppm and 1000 ppm) and its physicochemical and microbial analysis were examined.

Effect of pH and acidity during storage

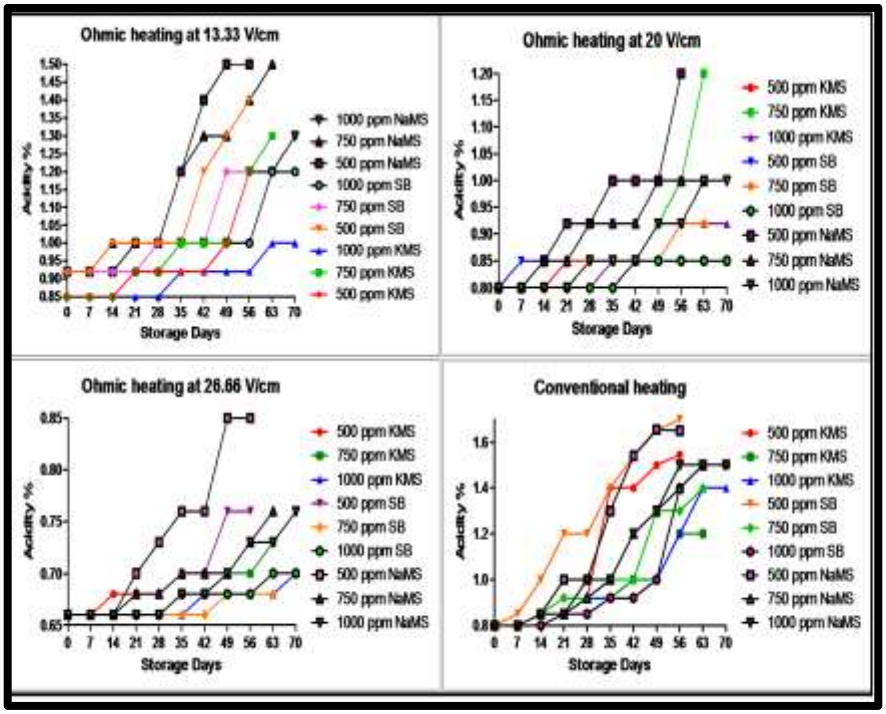
After the addition of preservatives in varying concentrations, the pulp's pH was found to remain steady for the first 14 days of storage. After the addition of preservatives, the pulp's pH remained constant when treated with KMS at a concentration of 1000 ppm, as shown in figure 1, but it could only do so for roughly 21 days when treated with SB and NaMS at the same concentration. .It was discovered that the pulp's pH remained constant for the first 14 days of storage after the addition of preservatives at various quantities. Figure 1 displays the pH stability of the pulp after preservative addition when treated with KMS at a concentration of 1000 ppm, but only for about 21 days when treated with SB and NaMS at the same concentration. After being ohmically heated at 13.33 V/cm and treated with 500 ppm, 750 ppm, and 1000 ppm of KMS, SB, and NaMS, the pulp reduced by 0.66%, 0.55%, and 0.4%, but by 0.88%, 0.66%, and 0.54% in the case of SB. When the pulp was heated ohmically at 13.33 V/cm and then treated with 500 ppm, 750 ppm, and 1000 ppm of KMS, SB, and NaMS, it showed a decrease of 0.66%, 0.55 ppm, and 0.4%; however, SB showed a decrease of 0.88%, 0.66 ppm, and 0.54%; and NaMS showed a decrease of 1.32%, 1.1%, and 0.66%; leading to the Figure 2 illustrates how an increase in acidity results from a fall in pH. The temperature and storage conditions are the main causes of this pH decline. Numerous researches have demonstrated that the pH of fruit pulp samples decreases according to the increase in acidity. (M. Ayub and others, 2007) According to research by Anwar et al. from 1999, the accumulation of carbohydrates in the juice is what causes the acidity of some orange cultivars to diminish with time.

Figure 1. Representation of the pulp in storage during change in pH



e-ISSN 2320 –7876 www.ijfans.org
Vol.11,S Iss.2, 2022

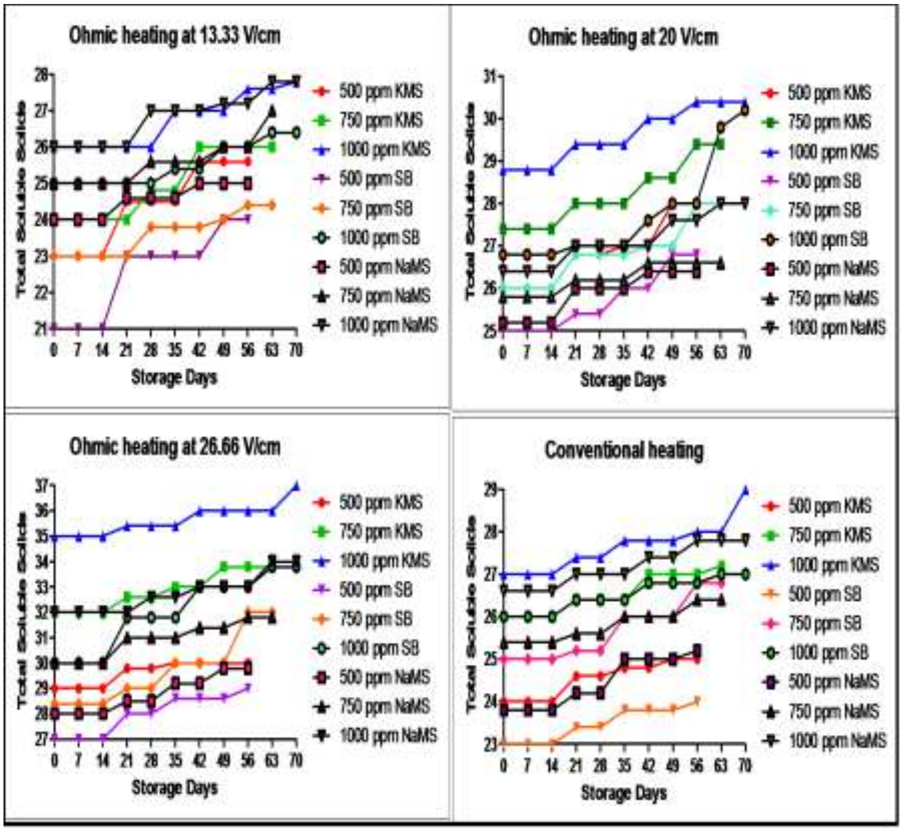
Figure 2. Representation of the pulp in storage during Change in acidity percentage.



Effect of Total soluble solids during storage

With every increase in the voltage gradient, the TSS climbed considerably. When compared to pulp heated conventionally, the TSS of the ohmic heated pulp fluctuated less. Based on the length of treatment and storage. The release of soluble substances caused by the breakdown of cellulose, hemicelluloses, and pectin from the fruit cell wall affects TSS. Increased TSS may also result from the solubilization of cell water as a result of enzyme activity (Woraworan et al., 2013). Total Soluble Solids (TSS) of all samples exhibited a minor decrease after preservative addition during the first few days of treatment, however an increase in TSS of pulp samples was seen during the entire storage period. In comparison to 1000 ppm SB and NaMS, which exhibited increases of 6.25% and 7.33%, and when the pulp was ohmically heated at 26.66V/cm and treated with 1000 ppm KMS, it showed an increase of 5.71%. Several researches have confirmed that fruits' TSS increased as they were being stored (Arthey & Phillip 2005; Saeed Akhter et al., 2010).

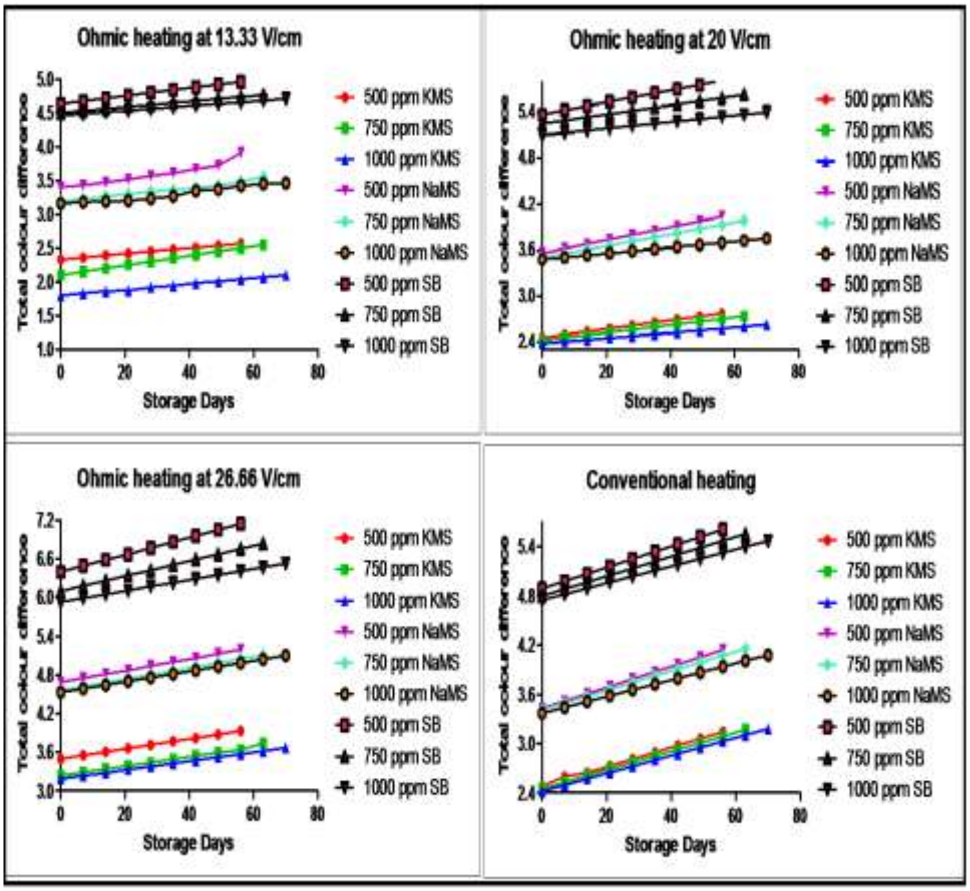
Figure 3. Representation of the pulp in storage during Change in Total soluble solids



Effect of colour during storage

Minimal change in colour occurs in Ohmic heating treatment in prolonged storage. Due to browning of juice, colour change can occur (Hosain et al., 2013). But increasing rate is low when related to pulp is conventionally heated. Polyphenol oxidase enzyme is inhibited by KMS which plays an important role in fruits browning. Hence, the colour of the beverage is retained by the help of KMS for a longer period of time when it is compared to sodium benzoate. Increase in concentration of KMS with a negligible degradation of colour during storage shown in figure 4. Browning rate is affected by the storage condition. The presence of oxygen and metal ions and may also lead a way to browning of fruits. Because of the oxidative enzyme activities like POD, the fruit juice could discoloured (Icier et al., 2004).

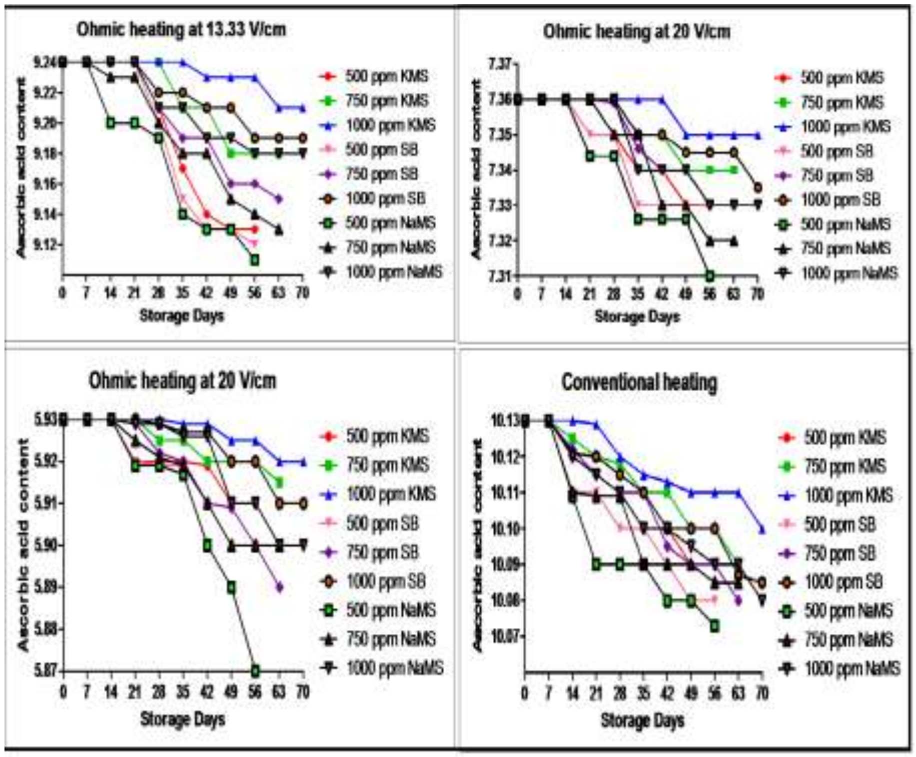
Figure 4. Representation of Total colour difference of the pulp during storage



Effect of ascorbic acid content on storage

The deprivation rate of ascorbic acid as in figure 5 is more in the pulp treated with NaMS of 500 ppm concentration when compared to sodium benzoate and KMS. When the fleshy tissue was ohmic heat at 26.66 V/cm and treat with 500 ppm NaMS, it presented a decrease of 1% when compared to KMS and sodium benzoate which showed a decrease of 0.3% and 0.5%. Vitamin C is heat labile which causes it to degrade through thermal pasteurization. But during storage the degradation rate of ascorbic acid is less in ohmic heat pulp than in conventionally heat pulp. During the 70 day storage period, the ascorbic acid content decreased from 7.36 to 7.35 mg/100 ml pulp in case of pulp heated at 20 V/cm and treated with 1000 ppm KMS. Whereas, for conventional heated pulp the ascorbic acid content decreased from 10.13 to 10.10 mg/ml pulp.

Figure 5. Representation of modification in ascorbic acid content of the pulp during storages



Effect of different preservatives on microbial growth in ohmic heated banana pulp.

Microbial inactivation is necessary to enhance the storage period of a food product. It comes under the category of food safety and quality management. Microorganism present over-the-limit causes deterioration and affect the colour, texture and taste of the product. According to FSSAI regulation, the total plate count for the thermally processed vegetable pulp is limited to the level of 50 CFU/ml. microbial analysis of the ohmic heated banana pulp was done for every 15 days consistently. As pulp of banana was ohmically heated at 13.33 V/cm and preserved with potassium metabisulphite at 500 ppm. The conventionally heated pulp which is treated with 500 ppm NaMS shows the highest level of contamination. There was no microbial development in the pulp when it is ohmic heated at 26.66 V/cm and treated with KMS at 1000 ppm, which shows shelf life for 70 days. From microbial study it is concluded that, when the KMS used at high level concentration, it significantly helped to maintain the quality attributes as related to an NaMS and sodium benzoate like shown in Table 1. Both potassium metabisulphite and Sodium benzoate (concentration at 1000 ppm) which is identified as suitable preservative for extend storage shelf life and retain the quality of the pulp upto 70 days.

During ohmic heating, pores form and the membrane permeability increases thereby causing electro osmosis which leads to diffusion of material throughout the membrane. This phenomenon is known as electroporation. The cell membranes of living cell contain proteins yuand lipids.

Some living cells such as prokaryotes contain a layer over the membrane referred as cell wall. During ohmic heating, with application of electric field charges are built up in the cell membrane causing dielectric strength, leading to formation of pores. It is related to the lipid content present in the cell membrane. Excessive exposure of electric field causes more outflow of intracellular components through electroporation. Hence by electroporation, ohmic heating promote the lethal effects.

Treatment/ Preservative	**Storage days**	**Ohmic heating at 13.33 V/cm**	**Ohmic heating at 20 V/cm**	**Ohmic heating at 26.66 V/cm**	**Conventional heating**
500 ppm KMS	15	3 ± 5.70[a]	-	-	8 ± 5.70[b]
	30	10.00± 3.50[a]	7.00±1.50[c]	4.00[d]	13± 3.50[a]
	45	17 ± 5.70[a]	13± 3.50[b]	10± 5.70 [a]	25.00[c]
750 ppm KMS	15	-	-	-	6.00
	30	2.00±2.00[b]	-	-	11[a]
	45	5.00±1.50[c]	3.00±1.50[c]	-	23 ± 5.70 [a]
	60	11 ± 5.70 [a]	7.00[c]	4.00±2.00[b]	34.00[d]
1000 ppm KMS	15	-	-	-	3.00±1.00[a]
	30	-	-	-	5.00±5.40[a]
	45	-	-	-	9.00±2.20[a]
	60	-	-	-	14
	75	3± 1.51 [a]	2± 5.70 [a]	-	18± 3.25 [b]
500 ppm SB	15	5.00[b]	3 ± 5.70 [a]	-	10.00± 1.35 [c]
	30	12± 5.70 [a]	10.00[a]	6± 5.70 [a]	16± 5.70 [a]
	45	19 ± 5.70 [a]	15± 5.70 [a]	11.00[b]	27± 7.70[c]
750 ppm SB	15	-	-	-	7
	30	3±3.95[a]	2±1.22[a]	-	13±12.11[c]
	45	6±2.1[b]	5±1.22[d]	4±1.22[c]	24 ± 5.70 [a]
	60	10.00[a]	8.00[a]	7±2.1[b]	32± 5.70[c]
1000 ppm SB	15	-	-	-	5
	30	-	-	-	8
	45	-	-	-	12± 5.70

	60	-	-	-	16
	75	4	3	-	19± 5.70
500 ppm NaMS	15	7 ± 10.00[b]	5± 10.00[b]	2.00[a]	13.00[b]
	30	15.00[c]	12± 10.00[b]	8± 10.00 [b]	18.00[c]
	45	21± 5.70[a]	18± 10.00 [b]	10[c]	26± 10.00[b]
750 ppm NaMS	15	5.00[a]	3± 5.70[b]	1±3.11[c]	10.00[d]
	30	8± 11.20[a]	7.00[b]	4.00[b]	14± 5.70[a]
	45	13± 5.70[a]	10± 5.70[a]	7.00[b]	19± 3.70[c]
	60	20.00[a]	14± 5.70[b]	13± 5.70 [b]	23.00 [a]
1000 ppm NaMS	15	No	No	No	7
	30	No	No	No	12± 5.70
	45	No	No	No	17± 5.70
	60	3± 5.70[a]	1± 5.70[b]	No	24.00[c]
	75	7.00[a]	5±3.22[c]	2±3.11[b]	29± 5.70[d]

Table 1. Effect of chemical preservatives on microbial growth in banana pulp.

Reference:

- Abid, M., Jabbar, S., Tao Wu, Hasim, M., Bing Hu, Shichenglei, Zhang, X And Zeng, X. (2013). Effect of ultrasound on different quality parameters of apple juice. *Ultrasonics Sonochemistry*, 20:1182 – 1187.
- Akhter, S., Riaz, M., Ahmad, A., & Nisar, A. (2010). Physico chemical, Microbiological and sensory stability of chemically preserved Mango pulps. Pakistan journal of Botany, 42 (2): 853-862.
- Anwar, S.A., Ahmad, B., Sarfaraz, M., Hussain, K., Bhatti, K. M., & Saqib, M. (1999). Effect of picking time on physical and chemical characteristics of sweet orange. *International Journal of Agriculture and Biology*. 1560-8530/99/01-1/2-059-061.
- Arthey, D. & Philip, R.A. (2005). Fruit Processing Nutrition, Product, and Quality Management, Ed 2 Brijbasi Art Press Ltd. India, pp: 45.
- Aviara, N. A., Shittu, S. K., & Haque, M. A. (2007). Physical Properties of Guna Fruits Relevant in Bulk Handling and Mechanical Processing. *International Agrophysics*, 21, pp. 7-16.

- Ayub, M., Durrani, T., Zeb, A., & Ullah, J. (2007). Effect of Sucrose and Potassium Metabisulphite on the Physicochemical and Microbial Analysis of Apricot Pulp. *Pakistan Journal of Science and Industrial Research.* 50(4) 251-253.
- Bon, J., Vaquiro, H., Benedito, J., & Telis-Romero, J. 2010. Thermophysical Properties of Mango Pulp. *Journal of Food Engineering*, 97(4), pp. 563-568.
- Chiply, J. R. (1983). Sodium benzoate and benzoic acid, In: *Antimicrobials in Foods* (Eds.), A.C. Branen and P.M. Davidson. Marcel Dekker Inc., New York, USA, p. 16.
- Cristina, S.C., Moura, D.R. & Vitali, A.D.A (1999). A Study of Water Activity and Electrical Conductivity in Fruit Juices: Influence of Temperature and Concentration. *Brazilian Journal Food Technology*, 2: 31-38.
- Gould, G.W. (1989). Mechanisms of Action of Food Preservation procedures. *Elsevier Applied Science* London UK.
- Haydar, H., Ibrahim, G., Mehmet, M., & Bayram, M. (2007). "Post Harvest Chemical and Physical–Mechanical Properties of Some Apricot Varieties Cultivated in Turkey," *Journal of Food Engineering*, 49, pp. 303-310.
- Hosain Darvishi, Adel Hosainpour & Farzad Nargesi. (2012). Ohmic Heating Behaviour and Electrical Conductivity of Tomato Paste. *Journal of Nutrition and Food Science*, 4-5.
- Icier, F & Coskan, I. (2005). The effects of concentration on electrical conductivity of orange juice concentrates during ohmic heating. *European Food Research Technology*., 220, 406-414.
- Luèck, F. (1990). Food applications of sorbic acid and its salts. *Food Additives and Contaminants*, 7:711-715.
- Manganelli, E. & Casolari, A. (1983). Sensitivity of yeasts to sorbic and benzoic acids and their salts. *Indian Conserve*., 58: 23-25.
- Ogiehor, S. I. & Ikenebomehclearly, M.J. (2004). Antimicrobial effects of sodium benzoate on the growth, survival and aflatoxin production potential of some species of *Aspergillus* in *Garri* during storage. *Pakistan Journal of Nutrition*, 3: 300-30.
- Ogunrinola, O. A., Fung D.Y.C., & Jeon, I. J. (1996). *E. Coli* 0157: 117 growth in laboratory media as affected by phenolic antioxidants. *Journal of Food Science*, 61: 1017-1020.

- Oyelade, O. J., Odugbenro, P. O., Abioye, A. O., & Raji, N. L. (2005). "Some Physical Properties of African Star Apple (*Chrysophyllum Alibidum*) Seeds," *Journal of Food Engineering*, 67(4), pp. 435-440, 2005.
- Ranganna 2001: Hand book of Food Analysis.
- Saran, P. L., & Choudhary, R. (2013). "Drug Bioavailability and Traditional Medicaments of Commercially Available Papaya: A Review," *African Journal of Agricultural Research*, 8(25), pp. 3216-3223.
- Sofos, J.N. & Busta F. F.(1981). Antimicrobial activity of sorbate. *Journal of Food Protection*, 44: 614-622.
- Sofos, J. N., Pierson, M. D., Blocher J. C., & Busta, F. F. (1986). Mode of action of sorbic acid on bacterial cells and spores. *International Journal of Food Microbiology*, 3: 1-17.
- Thompson, A. K. (2003). *"Fruit and vegetables: Harvesting, handling and storage. Postharvest technology of fruits and vegetables* (second edition.)," UK: Blackwell Publishing Limited, pp. 234-238, Chap-12.
- Warth, A.D. (1985). Resistance of yeast species to benzoic and sorbic acids and to sulfur dioxide. *Journal of Food Protection*, 48: 564-569.