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Physicochemical properties of grape juice pasteurized by ohmic heating technology

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Abstract
Physicochemical properties are essential factors during processing and preservation of food. The changes in physicochemical properties of the product depend upon the processing technique. The effect of ohmic heating on the some physicochemical properties like pH, TSS, titratable acidity, ascorbic acid, total sugar and colour of grape juice were studied. Grape juice was pasteurized at different combinations of voltage gradient (10-40 V cm-1), temperature (55-85 °C) and holding time (1-5 min). Then the pasteurized juice samples were stored for 21 days at refrigerated condition. The changes in properties were less at low voltage gradient and less holding time. Ascorbic acid was observed to be degraded faster at higher voltage gradients. The pH, TSS and total sugar increased while the titratable acidity, ascorbic acid and colour decreased significantly as the voltage gradient, heating temperature and holding time were increased. Ohmic heating treatment aids in retaining the physicochemical properties for a long time. Based on overall quality of grape juice pasteurized by ohmic heating, the best treatment was 30 V cm-1:85 °C: 5 min.

Keywords: Ohmic heating, grape juice, voltage gradient, temperature, physicochemical properties

1. Introduction

Grapes (*Vitis vinifera* L.) are versatile fruits used in a wide range of popular food like fresh fruit, juices, raisins, jelly and wine. They are very good source of copper, vitamin K, B1 and B2 (Rolle *et al*., 2011) [15]. Grapes have cardiovascular, cognitive, anti-inflammatory, anti-microbial and anti-aging benefits (Chuang and McIntosh, 2011; Dohadwala and Vita, 2009) [5, 8]. India's overall production of grapes was 3.20 million tonnes in 2014-15 (NCAER, 2016).

As grapes are seasonal fruits and have short shelf life, so having it in the form of processed juice is a better alternative to enjoy the feeling of originality and lusciousness like fresh fruits anywhere and anytime. The rising number of health-conscious consumers is also giving a boost to fruit juices. In today's era minimal processing technologies, developing new products and specialized packaging and storage systems are increasingly being applied for the preservation of juices. These processing technologies focus on adding value with comparatively little product transformation. As a result, optimizing heat treatments during the processing is essential for maintaining equilibrium between the nutritional and main organoleptic quality of raw material. Conventional thermal treatments of juices are very heterogeneous in heating which results in notable loss of product quality. To overcome this problem, ohmic heating technology can be a good alternative. This technology provides a rapid and uniform heating and lesser thermal abuse to the product in comparison with conventional heating. Ohmic heating works on the principle of Joule effect. On the passage of an alternating current (AC) through a sample, it responds by generating heat internally due to its inherent resistance (Palaniappan and Sastry, 1991) [12]. The energy generation in ohmic heating is proportional to the square of the local electric field strength and the electrical conductivity of the product (Goullieux and Pain, 2005) [9]. The study was conducted to evaluate physicochemical properties of grape juice before and after the pasteurization by ohmic heating technology.

2. Materials and Methods

2.1 Sample preparation

Grapes (*Vitis vinifera* L.) were purchased from a local market in Bapatla, Andhra Pradesh (India) and stored at refrigeration conditions (4 °C) prior to experiments.

Berries were manually removed from bunches, washed in cold tap water and drained. The juice was extracted from grape berries using Sujata Powermatic juicer (Mittal Electronics, Delhi) and filtered with four-fold of new and clean muslin cloth.

2.2 Pasteurization process of juice

The ohmic heating system is shown in Figure 1. 150 mL samples of filtered grape juice were heated into the heating chamber by the AC electric current. Voltage gradient between electrodes for particular treatment was maintained with variable auto transformer. The juice was pasteurized at different combinations of voltage gradient 10, 20, 30 and 40 V cm-1 with temperature 55, 65, 75 and 85 °C and holding time 1, 3 and 5 min. The pasteurized juices were transferred into sterilized glass bottles and cooled immediately at very low temperature (10 °C). All the treated juice samples were stored at refrigerated temperature (4 ºC) for 21 days and the changes in their physicochemical properties were analyzed at an interval of 7 days,

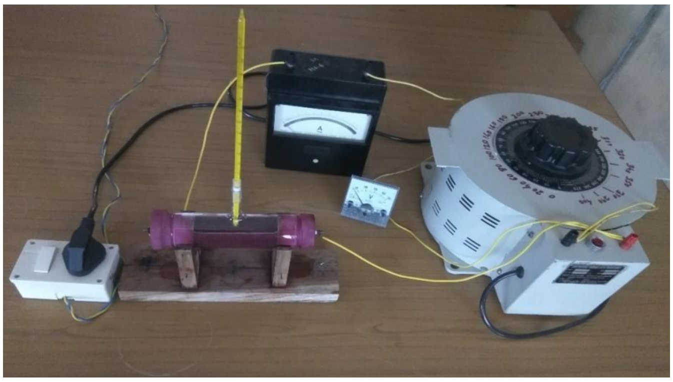

Fig 1: Ohmic heating system for pasteurization of grape juice

2.3 Determination of physicochemical properties

2.3.1 pH

The pH of grape juice samples was measured with a digital pH-meter (Systronics micro pH system-362, Ahmedabad, India) according to AOAC (2005) [2] method.

2.3.2 Total soluble solids

The total soluble solids (TSS) of the juice samples was determined using digital refractometer (Atago Pocket refractometer PAL-3, Japan) following the method given by AOAC (2005) [2] and expressed in terms of °Brix.

2.3.3 Titratable acidity

Titratable acidity of the juice samples was determined by titrating against 0.1N sodium hydroxide (NaOH) (AOAC, 2005) [2] and calculated using following formula

$$\%\ \text{Acidity} = \frac{\text{Titre value} \times \text{Normality of NaOH} \times \text{Volume made up} \times \text{eq. wt. of acid} \times 10}{\text{Vol. of sample taken for estimation} \times \text{Volume of sample taken} \times 1000}$$

2.3.4 Ascorbic acid

Ascorbic acid of the samples was determined by titration against 2, 6-dichlorophenol indophenol dye (AOAC, 2005) [2]. The ascorbic acid (mg/100 mL juice) was calculated as follows:

$$\text{Ascorbic acid} = \frac{\text{Titre value} \times \text{Dye factor} \times \text{Volume made up} \times \text{eq. wt. of acid} \times 100}{\text{Volume of sample taken for estimation} \times \text{Volume of sample taken} \times 1000}$$

2.3.5 Total sugar

Total sugar was determined using Lane and Eynon method (AOAC, 2005) [2]. The formulae used were as follows:

$$\text{Total sugar}\ (\%) = \frac{\text{Factor} \times \text{dilution} \times 100}{\text{Titre value} \times \text{Volume of sample}}$$

2.3.6 Colour

The colour of the juice was measured by using a colourimeter (Lovibond PFX-995 Tintometer, The Tintometer, UK). The colour was expressed as red (R), yellow (Y) and blue (B) units as per the standard procedure (AOAC, 2000) [1]

1. Results and discussion

1.1 Effect of Ohmic Heating on pH of Grape Juice

It was noted that the pH of grape juice had significantly increased when voltage gradient, temperature and holding time were increased (Figure 2). This behaviour was probably due to hydrolysis and electrochemical reaction of the electrode material with the juice; such reaction was lower at low voltage gradient. Similar finding was reported by Darvishi *et al*. (2013) [6] for ohmic heating of pomegranate juice. At high temperature, the organic acids are converted into sugars and the acidity decreases (Chattopadhyay *et al*., 1992) [4]. pH of grape juice significantly decreased during storage period. Decrease in pH may be due to conversion of pectin into pectenic acid, which increases acidity.

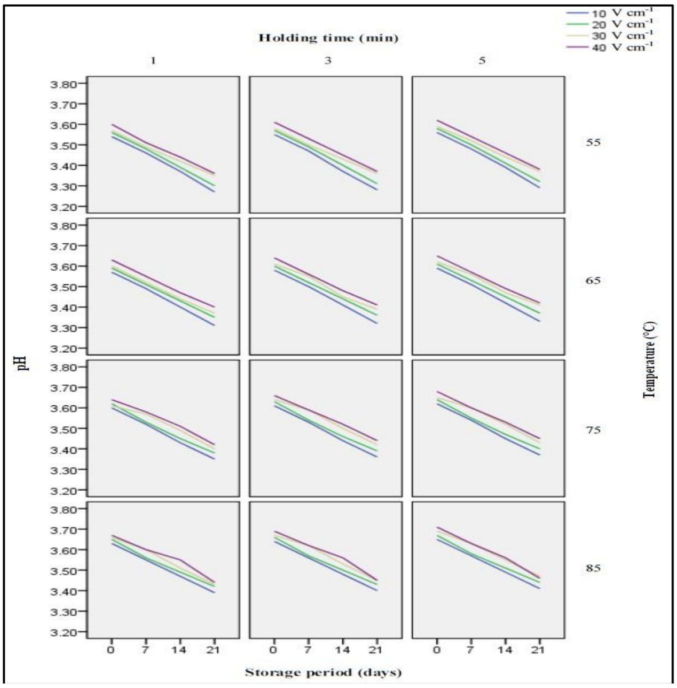

Fig 2: Effect of ohmic heating on pH of grape juice

.1 Effect of Ohmic Heating on Total soluble solids (TSS) of Grape Juice

TSS of grape juice increased with increase in the voltage gradient, temperature and holding time as well as days of storage period (Figure 2). The increment may be because of higher rate of heating at higher voltage gradient and temperature holding for long time, which would have resulted in more evaporation of water. Similar result was found by Delfiya and Thangavel (2016) [7] for tender coconut water. Increasing of TSS during storage may be due to hydrolysis of polysaccharides into monosaccharides (Pareek *et al.*, 2011) [13].

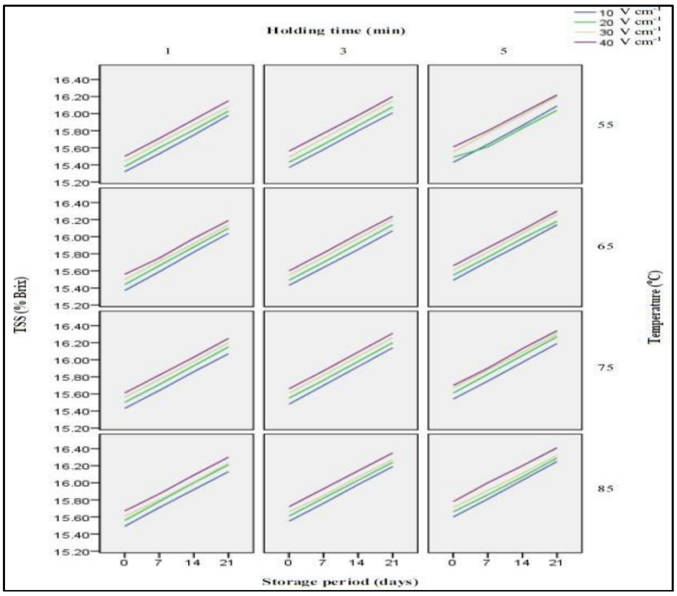

Fig 3: Effect of ohmic heating on TSS of grape juice

3.3 Effect of Ohmic Heating on Titratable acidity of Grape Juice

Titratable acidity of grape juice decreased when the voltage gradient, temperature and holding time increased (Figure 3). It may be due to higher rate of heating which results in conversion of organic acids into sugars in large extent. The findings of Chakraborty and Athmaselvi (2014) [3] for guava juice are good agreement with this result. It was found that titratable acidity of grape juice for all treatment was significantly increased during storage period. Increasing acidity during the storage period may probably be due to activity of some acid-producing bacteria.

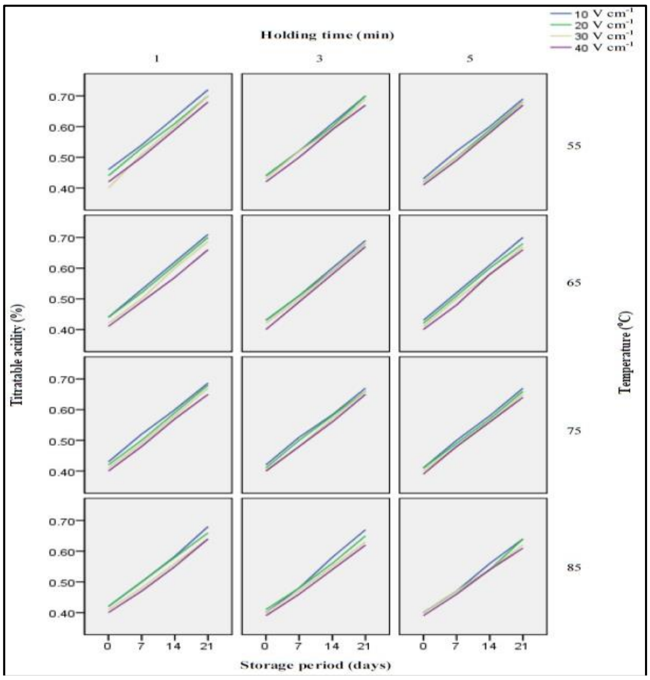

Fig 4: Effect of ohmic heating on titratable acidity of grape juice

3.4 Effect of Ohmic Heating on Ascorbic acid of Grape Juice

The ascorbic acid of grape juice decreased significantly with increase in voltage gradient, temperature and holding time as well as days of storage period (Figure 4). This might be due to electrochemical reactions, such as electrolysis of water. The reduction in ascorbic acid during storage might be due to oxidation by residual oxygen in the glass bottle.

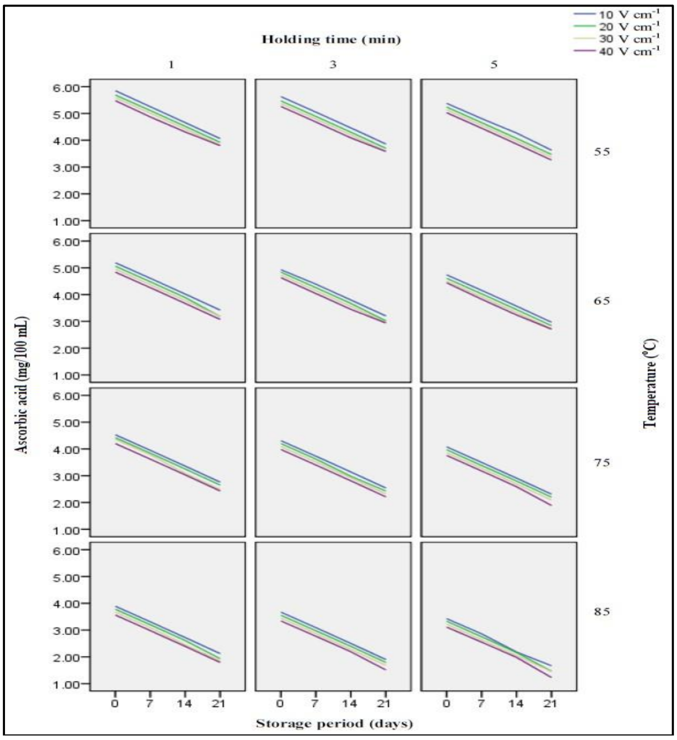

Fig 5: Effect of ohmic heating on ascorbic acid of grape juice

3.5 Effect of Ohmic Heating on Total Sugar of Grape Juice

Total sugar is very important component for a processed product with respect to quality, shelf life, taste, and discoloration during storage. The total sugar of juice samples increased significantly with voltage gradient, temperature and holding time and storage time (Figure 5). Increase in total sugar may be attributed to increased rate of water evaporation and hydrolysis of polysaccharides like pectin, cellulose and its conversion into simple sugars at higher voltage gradient. Pareek *et al*. (2011) [13] observed similar result for mandarin juice.

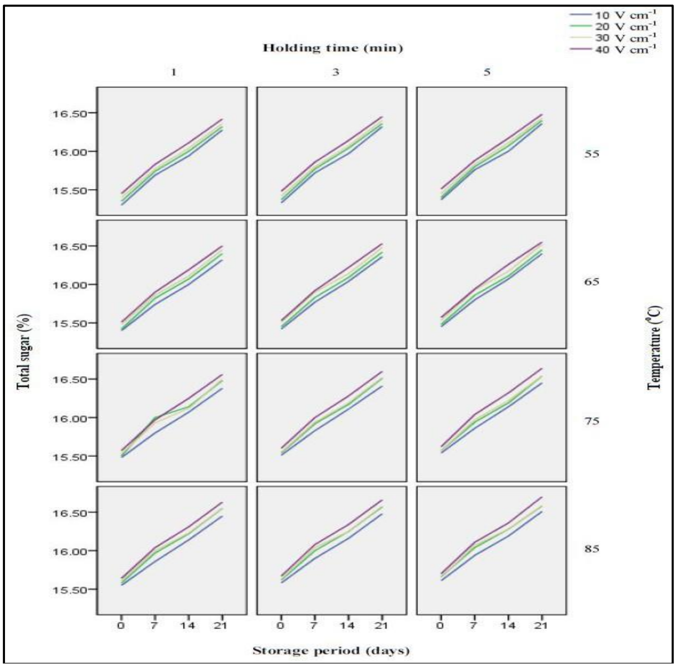

Fig 6: Effect of ohmic heating on total sugar of grape juice

3.6 Effect of Ohmic Heating on Colour of Grape Juice

Colour can be used as a quality indicator to evaluate the extent of deterioration due to thermal processing. Initially, the tintometer colour unit (R, Y, B) of grape juice were observed to be (2.63R, 0Y, 1.51B). The value of yellow colour unit of grape juice was 0 during entire storage period. The colour of grape juice samples were observed to be decreased significantly with increase in voltage gradient, temperature and holding time and storage time (Figure 6, 7). Decrease in colour may probably be due to degradation of anthocyanin pigment which is responsible for colour in grape. The presence of some oxygen inside the bottle might also lead to browning of juice.

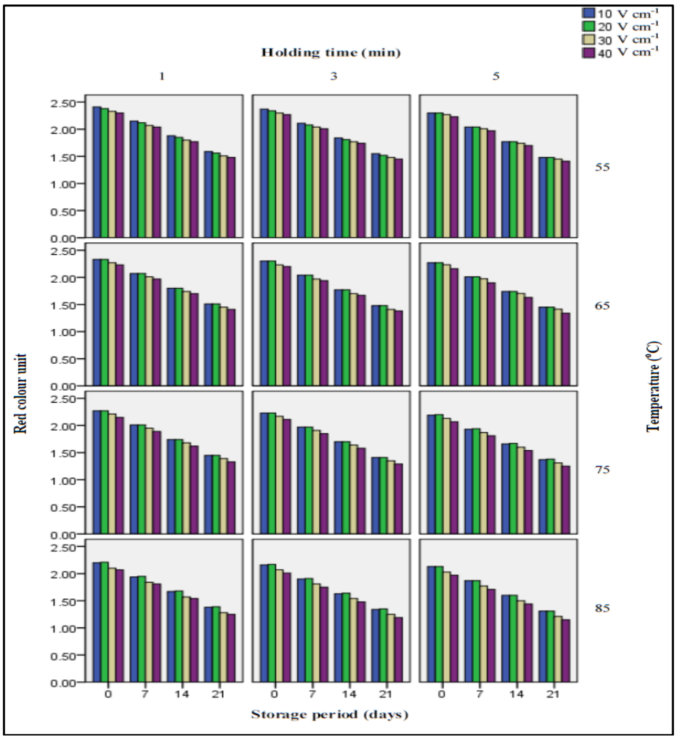

Fig 7: Effect of ohmic heating on red colour unit of grape juice

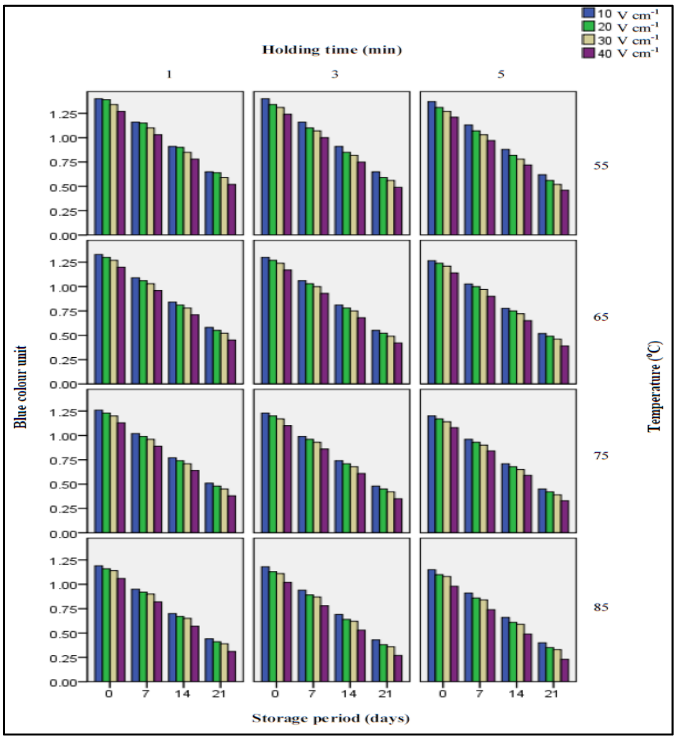

Fig 8: Effect of ohmic heating on blue colour unit of grape juice

4. Conclusions

The key points that were drawn from the finding of the present investigation are summarized as following:

- The pasteurized grape juice showed the higher retention of pH and colour for samples treated at 30 V cm-1:85 °C:5 min.
- TSS, titratable acidity and total sugar of ohmically treated grape juice showed the lowest increase for treatment 30 V cm-1:85 °C:5 min during storage.

On the basis of overall quality of pasteurized grape juice, treatment 30 V cm-1:85 °C:5 min was found to be the best. In conclusion, it may be stated that using ohmic heating technology for pasteurization of grape juice could be effective and advantageous to maintain its physicochemical quality and to lengthen the shelf life.

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