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Assessment on quality attributes of mosambi extract in ohmic heat process

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Development of new technologies in thermal food treatments are showing promise for industrial and scientific processing of foods with minimum nutrient loss. Ohmic heating is an advanced thermal processing is based on the principle of Ohms' law where in the food material itself serves as an electrical resistor which is heated by passing current through it and heats the entire mass of the food product. Food quality preservation through this technology is useful for the treatment of protein rich perishable foods like fruits which tends to denature and coagulate when thermally processed. Ohmic heating has immense potential for achieving rapid and uniform heating in foods retaining the nutritional quality, providing microbiologically safe and high quality foods with less nutrient loss. Properly processed and packed fruit preparations are potential readymade energy sources for immediate consumption. In the present study Mosambi, rich in ascorbic acid essential for many bodily functions and plays an integral role in our overall health was subjected to thermal and Ohmic heat treatment and assessed for the quality attributes ascorbic acid and non-enzymatic browning index after packaged in three different packaging materials. Between treatments fruit juice exhibited a non-significant ascorbic acid degradation and for all packaging materials for the storage period of 60 days. The colour was expressed as L*(brightness), a*(redness) and b*(yellowness) and the hue a relative position of the colour between redness and yellowness and chroma the colour intensity were analysed. The non-enzymatic browning index calculations based on L,a,b colour values showed that the quality loss is less for the OH treatment of 50V/cm than other treatment.

Key Words : Mosambi extract, Ohmic heat, Ascorbic acid, Browning, Package, Quality

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INTRODUCTION

Present day energy conservation strategies focus mainly on novel low energy high efficient methods of food processing suitable for long storage with minimal nutrient loss. In ohmic process heating occurs in the form of internal energy generation within the material. Application of this energy saving electrical resistance of fruit based food processing in functional food preparation and its commercial exploitation is a promising superior strategy to the traditional power consuming methods such as heat exchangers used in pasteurization for fruit processing. Ohmic heating presents huge applications including its use in blanching, evaporation, dehydration, fermentation, sterilization of foods and heating of foods applied in military field and long term space missions (Kaur *et al.,* 2016). Even though the ohmic heating technology appears to be effective, there is little information regarding its effect on specific food product which is of huge commercial applications. A vast amount of work is still necessary to understand food properties in order to refine system design and maximize performance of this technology in the field of packaged

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foods and space food product development. Various studies will also play an important role in understanding the overall efficiency and viability of commercial application of this technology in food processing. In the present approach the Ohmic heat treatment has been tested for retaining the quality attributes of mosambi extract in designed and established (Perasiriyan, 2016) Ohmic heat process electrical resistance chamber for food processing at CFDT,TANUVAS.

Ascorbic acid, the main biologically active form of vitamin C is a natural antioxidant supplied by the fruits. Lee and Kader (2000) stated that the ascorbic acid content was used as a quality index because it was very sensitive to degradation during processing and storage. Increase in the loss in ascorbic acid content was recorded by extended storage, increased temperature, low relative humidity, physical damage and chilling injury. Garza *et al.* (1996) reported that various reactions to food during storage occur, among which pigment destructions and non-enzymatic browning reactions were indicators of quality that resulted during thermal processing of fruits under storage. Colour was used as a quality indicator to evaluate the extent of deterioration due to thermal processing (Avila and Silva, 1999).

Mosambi is a versatile fruit with a sweet and sour taste. Mosambi has a high content of flavonoids that stimulate the digestive system by increasing the secretion of digestive juices, acids and bile. It aids digestion by neutralizing the acidic digestive juices produced by the stomach and flushes out the toxins from the excretory system. The compounds found in this fruit are beneficial for peristaltic motion. Sweet lime also helps in controlling diarrhea, nausea and vomiting. Gopalakrishna *et al.* (2015) analyzed the changes for the physico-chemical characteristics such as pH values, vitamin C, acidity, density, water activity of orange and citrus juices and interpreted that the evaluation of the quality and determination of shelf life was based mainly on the progress of vitamin C during storage and concluded that the storage of these juices under refrigeration conditions had determined percentage reductions of vitamin C content.

The success of most preservation methods depends on how well the processed food is protected from adverse environmental conditions, which is mostly accomplished by packaging. There is a growing pressure in the fruits and vegetables packaging sector to use effective packaging materials with the aim of enhancing the shelf-life. Packaging plays an important role in determining the stability of foods by influencing those factors which cause or contribute to food deterioration during storage. The nature of a package determines the composition of air inside the package, which in turn is known to affect the rate and extent of nutrient loss and microbial activity among other things. The most commonly used materials in beverage packaging as defined by American Beverage Association include aluminum, plastic and glass.

METHODOLOGY

The fruit sample processing was carried out using a continuous flow pilot OHP unit designed and developed (Perasiriyan, 2016) at College of Food and Dairy Technology, Koduvalli, Tamil Nadu Veterinary and Animal Sciences University, Chennai. The unit consists of acrylic processing 750 ml capacity tank having two platinized titanium electrodes with stainless steel storage tank of 5L capacity. Fresh food grade tested quality Mosambi fruits suitable for processing was purchased from local market. To maintain the uniformity in sample and minimising individual sample error the prepared fruit sample were adjusted for a uniform standard (codex-FAO) initial Brix value (12.5) and pH (3.5) with sterile distilled water and citric acid. FAO recommends pH 3.5 as suitable for thermal processing that avoids gelation and hence based on the recommendations of FAO the pH of the fruit samples were stabilized to 3.5.

Thermal pasteurization (FAO) was done conventionally using a constant-temperature serological water bath. A stainless steel vessel having a capacity of 5000 ml was filled with 1000 ml water. The individual fruit sample was filled in a 200 ml sterile glass bottle and sealed and placed in the SS vessel. Treatment given was direct heating of SS vessel using induction platform at 95-100^{o}C for 10 min. Sample temperatures were measured by means of a thermometer. Ohmic treatment was given to the fruit extract placed in between the two electrodes at an optimized 30v/cm, 40v/cm, 50v/cm for the holding time 60 sec. Processed samples were filled with 3 different types of packaging materials such as retort pouch, glass bottle and polyethylene pouches. The experiments were conducted in triplicate. Physico-chemical properties and nutritional quality of the fruit samples before and after ohmic heating at regular intervals (0, 15, 30, 45 and 60 days) were analysed in comparison with thermal processing.

Colour of the sample was tested using Hunter lab Mini scan XE plus Spectro colorimeter (Model No:45/O-L, Reston Virgenia, USA) with geometry of diffuse/80 . The instrument was calibrated with black and white tile (L*=94, A*=1.10 and B* =0.6) every time before the colour measurement was taken. The colour was expressed as L*(brightness), a*(redness) and b* (yellowness). The hue (relative position of the colour between redness and yellowness) and chroma (colour intensity) was calculated as follows:

$$\text{Hue} = \tan^{-1}(b^*/a^*) \quad \text{Chroma} = \sqrt{(a^*)^2 + (b^*)^2}$$

Average value for each colour parameter was determined by taking observation from the samples.

Colour values were obtained as L*, a*, b* values. Maximum value for L is 100 which would be a perfect reflecting diffuser. The minimum value for L is 0 which would be black. Chromatic portion of the solids is defined by: a (+) redness, a (-) greenness, b(+) yellowness and b(-) blueness.

a* takes positive values for reddish colour and negative values for greenish ones,

b* takes positive values for yellowish colour and negative values for bluish ones.

L* is an approximate measurement of luminosity.

Browning analysis - Non-enzymatic browning index (NEBI):

Browning index represents the purity of brown colour and is considered as an important parameter associated with browning. Non-enzymatic browning is considered as one of the major causes of quality loss and therefore, a useful indicator of temperature abuse. Browning reactions are of great significance in food stability and play an important role in quality losses. NEBI was calculated based on colour index values L*, a* and b* values as per the method of Hoang *et al.* (2014).

BI= [100(X-0.31)]/(0.17)

X= (a+1.75L)/(5.645L+a-3.012b).

Ascorbic acid estimation:

Working standard solution 5 ml was pipetted into a 50 ml conical flask. 5 ml of four per cent oxalic acid was added and titrated against the dye. The end point was repeated to get concordant values. The amount of dye consumed was equal to the amount of ascorbic acid present in the working standard solution. Then 5 ml of ascorbic acid extract was pipetted out and 5 ml of oxalic acid was added. It was then titrated against the dye. The titration was done for each sample in triplicate to obtain concordance in values.

Amount of ascorbic acid in mg present in 100 ml of sample

$$= \frac{0.5}{V1} \times \frac{V2}{5} \times \frac{100}{\text{Weight of sample}} \times 100$$

where,

V1 - Amount of dye consumed by ascorbic acid present in the working standard solution

V2- Amount of dye consumed by sample.

Data and statistical analysis:

All experiments were performed in triplicates. Statistical analysis was performed for the determination of significant difference in the process treatments. Statistical analysis was done for all experiments and the results were tabulated.

OBSERVATIONS AND ASSESSMENT

Novel low energy or energy efficient methods of food processing are important aspects of present day need towards energy conservation strategies. Development of new technologies in thermal food treatments are showing promise for industrial and scientific processing of foods with minimum nutrient loss. Citrus fruits among other uses are sources of food and medicine. Fruits are divided into climacteric and non-climacteric classes based on their respiration pattern during ripening. In non-climacteric category are the grapefruit, lemon, orange, melon, pineapple and the strawberry. In these fruits the respiratory pattern show slow drift downwards after detachment from the parent plant while climacteric classes undergo a distinct ripening phase e.g. bananas, pears and avocados. Orange, lemon and grapefruit have the same morphology, fruit development and maturation except in the percentage composition of ascorbic acid and sugars. Ascorbic acid content of citrus fruits is never constant but varies with some factors which include climatic/environmental conditions, maturity state and position on the tree, handling and storage, ripening stage, specie and variety of the citrus fruit as well as temperature (Gopalakrishna *et al.*, 2015).

In the present study, the processed samples packaged in polyethylene sachets (PE), retort pouch (RP) and glass bottles (GB) stored at 5°C refrigerated atmosphere had significant effect ($P<0.05$) on response variables during 45-60 days of storage in quality parameters. Glass bottles and retort pouch do not show any significant difference with nutrient qualities compared to thermal process. But PE packed fruit samples showed significant change in their quality attributes during storage after 60 days in refrigeration.

Ascorbic acid content in mg/100ml in thermally processed and OH processed treated at three different voltage gradient of 30V/cm, 40V/cm and 50V/cm, of Mosambi extract samples stored at 5°C for the storage period of 60 days at 15 days intervals were shown to be have least variation in the packaging materials (Table 1,2 and 3). But It was found that between treatment the processed samples were highly non-significant ($p<0.01$) in all the treatments when compared to the thermal treatment after 60 days of storage. It was found that the processed samples were not significant ($p>0.05$) in all the packaging materials for different duration of storage.

The effects of ohmic heating on the stability of orange juice in comparison to conventional pasteurization was analyzed by Leizerson and Shimoni (2005). It was observed that there was no significant difference between heating methods for the degradation of vitamin C concentrations or residual pectin esterase activity, although the particle size of the cloud was noticeably less in the ohmic heated sample. The results suggested that a thermal treatment by continuous ohmic heating, could be used to extend the sensorial shelf-life of pasteurized freshly squeezed orange juice. Louarme and Billaub (2012) studied the effects of conventional heating and Ohmic heating treatment on the degradation of sugar and

Table 1: Ascorbic acid in OHP treated mosambi juice samples stored at 5°C for polyethylene sachets

Days	Thermal	30V/cm	40V/cm	50V/cm	F value
0	10.45±0.03 ^{aC}	12.03±0.06 ^{bB}	12.01±0.06 ^{bB}	12.10±0.08 ^{bA}	168.67**
15	10.48±0.04 ^{aB}	12.01±0.05 ^{bB}	12.06±0.05 ^{bC}	12.10±0.00 ^{bB}	299.28**
30	10.25±0.03 ^{aB}	11.93±0.04 ^{bA}	11.09±0.05 ^{bA}	12.01±0.05 ^{bA}	293.22**
45	10.16±0.04 ^{aA}	11.86±0.04 ^{bA}	11.85±0.03 ^{bA}	11.91±0.06 ^{bA}	351.73**
60	10.10±0.02 ^{aA}	11.90±0.00 ^{bA}	11.90±0.00 ^{bA}	12.00±0.00 ^{cA}	505.00**
F value	20.53**	2.41^{NS}	3.90*	1.60^{NS}	

* and ** indicante significance of values at $P>0.05$ and $P<0.01$, respectively NS= Non-significant

Table 2 : Ascorbic acid in OHP treated mosambi juice stored at 5°C in retort pouches

Days	Thermal	30V/cm	40V/cm	50V/cm	F value
0	10.75 ± 0.27 ^{aB}	12.03±0.06 ^{bB}	11.95±0.07 ^{bA}	12.06±0.05 ^{bB}	18.90**
15	10.45±0.03 ^{aA}	12.10±0.03 ^{bB}	12.01±0.05 ^{bA}	12.05±0.03 ^{bA}	299.0**
30	12.03±0.03 ^{aA}	11.96±0.04 ^{bB}	12.06±0.05 ^{bA}	12.00±0.02 ^{bA}	357.0**
Days	11.93±0.03 ^{aA}	11.86±0.04 ^{bA}	11.85±0.03 ^{bA}	11.91±0.06 ^{bA}	127.0**
60	10.20±0.02 ^{aA}	11.90±0.02 ^{bA}	11.93±0.03 ^{bA}	11.96 ±0.03 ^{bA}	104.0**
F value	3.39*	4.54**	0.754^{NS}	1.67^{NS}	

* and ** indicante significance of values at $P>0.05$ and $P<0.01$, respectively NS= Non-significant

Table 3 : Ascorbic acid in OHP treated mosambi juice samples stored at 5°C for glass bottles

Days	Thermal	30V/cm	40V/cm	50V/cm	F value
0	11.98±0.03 ^{aA}	12.03±0.02 ^{bA}	11.98±0.03 ^{aA}	11.98±0.01 ^{bA}	178.0**
15	11.96±0.03 ^{aA}	12.00±0.02^{bA}	11.98±0.03 ^{aA}	12.01±0.03b^{aA}	263.0**
30	11.85±0.03 ^{aA}	11.88±0.01 ^{Ba}	11.83±0.01^{bA}	11.78±0.01 ^{bA}	547.0**
45	11.85±0.03 ^{aA}	11.83±0.03 ^{aA}	11.80±0.03 ^{bA}	11.85±0.02 ^{bA}	604.0**
60	11.71±0.01 ^{aA}	11.83±0.04 ^{aA}	11.83±0.03 ^{bA}	11.83 ±0.03 ^{bA}	653.0**
F value	1.05^{NS}	3.44*	0.64^{NS}	0.99^{NS}	

* and ** indicante significance of values at $P>0.05$ and $P<0.01$, respectively NS= Non-significant

ascorbic acid in chunky fruit desserts prepared with apple puree and chunky peach pieces. Results predicted that the ascorbic acid degradation during apple products processing mainly depended on oxidative reactions pathway. The browning index (Table 4) for the fresh juice, with thermally processed, OH processed treated at three different voltage gradient of 30V/cm, 40V/cm and 50V/cm of mosambi juice samples stored at 5°C during 60 day storage period for three packaging materials revealed that there no significant difference between the packaging materials. It was observed that the quality loss is less for the OH treatment of 50V/cm than other treatment.

Routine measurement of ascorbic acid in fruit juices is imperative for substantiating its nutritional claims. During thermal treatment of fruits, reactions contribute to the formation of a brown pigment that undesirable with respect to colour, flavour and market value was reported (Damasceno *et al.*, 2007 and Nuria *et al*., 2008). The present research finding with reference to mosambi juice OH process show no significant difference with package materials and storage upto 60 days at 5^{0}C. The browning index difference was lesser for the treatment 50V/cm than the treatment 40V/cm, 30 V/cm and thermal treatment. These correlates to the reports of Somboonsilp *et al.*(2011), conducted a study on ohmic pasteurization system with a static ohmic heater on four fruit juices namely orange, pineapple, guava and coconut juices. The system was operated in a batch mode with a capacity of 400 ml and electric field strength of about 23 V/cm. It was inferred that, ohmic pasteurized fruit juice could be stored at 5°C for 7 days like the conventional pasteurized fruit juice but with a minimum deterioration in colour and flavour. The non-enzymatic browning is a Maillard reaction between an amino acid and a reducing sugar, usually requiring the addition of heat. Like caramelization, it is a form of non-enzymatic browning. The reactive carbonyl group of the sugar interacts with the nucleophilic amino group of the amino acid and interesting but poorly characterized odor and flavour molecules result. This process accelerates in an alkaline environment because the amino groups do not neutralize. This reaction is the basis of the flavoring industry, since the type of amino acid determines the resulting flavour (melanoidins) (Dauberte *et al*., 1990). Woodroof and Luh (1986) stated that the most common changes in fruit juices and concentrates colour by browning reactions were enzymatic browning which involved different hydroxylation – oxidation reactions of phenol compounds with the result of the formation of brown compounds.

The colour value L, a, b changes were not significant during the storage period. At lower voltage levels not much variation was observed. This findings are in alliance with the reports of Julia *et al*. (2013), evaluated the anthocyanin degradation in blueberry pulp after thermal treatment using ohmic and conventional heating. It was reported that the lower the voltage levels used, the percentage of degradation was lower or equivalent to conventional heating. The higher the voltage level anthocyanin degradation was higher in ohmic processing.

The major factor involved in colour change includes, the presence of HMF due to glucose degradation is practically absent in fresh food, but it is naturally generated in sugar-containing food during heat-treatments.HMF was a recognized indicator of reduced quality in numerous foods that contain carbohydrate (Rattanathanalerk *et al.*, 2005). Along with many other flavour and colour related substances, HMF is formed in the Maillard reaction as well as during caramelization. In protein rich foods HMF is slowly generated during storage. It was reported that acid conditions favoured generation of HMF (Arribas-Lorenzo and Morales., 2010). This cyclic aldehyde was reported to be formed through the dehydration of hexoses and hexuloses in an acidic environment, or as the result of Maillard reactions and caramalisation. HMF can be used as an indicator for excess heat-treatment. As there was no significant difference in colour changes HMF would presumably low in OHP fruit samples. Maryam and Ansari (2015) stated that the 5-Hydroxymethylfurfural was as an indicator of quality deterioration in a wide range

Table 4 : Browning index values of mosambi juice for different packaging materials

Packaging materials	Fresh	Thermal	30V/cm	40V/cm	50V/cm	F value
Polyethylene	15.74±0.00 ^{d}	15.17±0.02 ^{a}	15.28±0.00 ^{b}	15.42±0.00 ^{c}	15.80±0.00 ^{e}	486**
Retort pouch	15.74±0.00 ^{d}	15.17±0.02 ^{a}	15.28±0.00 ^{b}	15.41±0.00 ^{c}	15.80±0.00 ^{e}	511**
Glass bottle	15.74±0.00 ^{d}	15.18±0.02 ^{a}	15.28±0.00 ^{b}	15.41±0.00 ^{c}	15.80±0.00 ^{e}	414**

* and ** indicante significance of values at P>0.05 and P<0.01, respectively NS= Non-significant

of foods through study which included 70 samples taken from domestically produced foods and drinks. Therefore, it was suggested that the monitoring of HMF levels in foods would be necessary as a quality indicator.

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