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Research article

Physiochemical, sensorial and rheological characteristics of puree developed from Kashmiri peaches: influence of sugar, KMS and storage conditions

Shefali Wani[a], Rayees Ahmad Bakshi[b], Zakir S. Khan[a,*], Shemilah Fayaz[a], Khalid Muzaffar[a], B.N. Dar[a,**]

[a] Department of Food Technology, Islamic University of Science and Technology, Awantipora, Pulwama, 192122, Jammu and Kashmir, India
[b] Department of Food Science and Technology, University of Kashmir, JK, India

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ABSTRACT

The present investigation was undertaken to develop puree from peaches and to study the effect of peel, sugar, KMS concentrations and storage conditions on the acidity, pH, total soluble solids, total sugar and rheological behavior of purees. Two types of Purees (Peeled and unpeeled) were prepared by adding sugar (10% and 15%) and KMS (100ppm, 200ppm, 300ppm). A decrease in viscosity with an increase in shear rate was observed. The developed purees were stored at refrigerated and ambient conditions for 45 days and were analyzed at 15 days interval. During the storage period, there was a change in G′ and G″and the changes in pH and TSS were observed. The highest decrease in G′ and G″ was observed in $P_{1\ and}$ P_0 at ambient storage. The overall organoleptic score of all samples was acceptable, however, the organoleptic score of the P_7 at refrigerated conditions was highest.

1. Introduction

In India, the peach is cultivated in an area of 18,000 ha with an annual production of 107,000 MT (Horticulture Report, 2018). Peaches are consumed throughout the world however availability of peaches is limited by the shelf life of peaches (Colantuono et al., 2012). Nutritionally peaches are considered as important fruits as peaches contain good amounts of carotenoids (β-carotene), leutin and β-cryptoxanthin. India lacks efficient post-harvest systems which lead to the loss of around 30% of the agricultural and horticultural produce, therefore, conversion to related processed products can be the best option to minimize the losses (Bhardwaj and Pandey, 2011). Availability of peaches for longer periods can be made by converting peaches into processed products like a peach puree. Globally trade of fruit purees is increasing and is estimated at 26 billion US dollars per annum. Processed products like fruit purees are considered a big turn in the food industry and are an important part of the infant diet. These processed products are a valuable source of micronutrients, antioxidants and fibre fostering health benefits for infants (Patras et al., 2009). The market acceptance of fruit purees has increased to a great extent in recent times because of nutritional importance particularly for infants and easy handling (Alvarez et al., 2008). Puree forms an important ingredient of jams, marmalades spreads and other related food products (Alvarez et al., 2008). Fruit Purees can be defined as fruit particle food spreading where soft fruit particles (pulp) are dispersed into a watery solution of sugars, acids and fruit pectin (Rao, 1992). Besides being a rich source of nutrients these purees must be acceptable to the consumers from the sensory point of view. Nowadays consumers are apprehensive about the quality attributes of processed food product, therefore, it is necessary to have an understanding of physicochemical changes and rheological parameters as processing (cooking) and storage can modify the characteristic parameters of the processed product (Nindo et al., 2007). Furthermore, there is limited research literature available on Indian peach puree therefore considering the above facts the study was undertaken to analyze the effect of peel, sugar, potassium metabisulphite (KMS) concentrations and storage conditions on the acidity, pH, total soluble solids, total sugar colour, sensory characteristics and rheological behaviour of purees.

* Corresponding author.
** Corresponding author.
E-mail addresses: khanzakir204@gmail.com (Z.S. Khan), darnabi@gmail.com (B.N. Dar).

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2. Materials and methods

2.1. Procurement of raw material

Fresh, ripe and sound fruits of peach cultivar *Glo heaven* devoid of any microbial infection or mechanical fissures were procured from the local market and then bought to the Food processing and Training Centre of Islamic University of Science and Technology, Awantipora for further processing. Thirty kilograms of fruit were purchased and were kept under freezing conditions for further study. Chemicals used were of analytical grade and provided by Agilent.

$$Acidity\ \% = \frac{Titre\ value\ \times Normality\ of\ alkali\ \times Vol\ made\ up\ \times Equivalent\ wt.\ of\ acid\ \times 100}{volume\ of\ Sample\ taken\ for\ estimation\ \times wt\ or\ vol.\ of\ sample \times 1000 \times 100} \quad (1)$$

2.2. Preparation of peach puree

The raw material of approximately 10kg was weighed, washed, blanched, cooled in water by instant dipping and destoning (Figure 1). The fruit pulp is then subjected to cooking with different treatments of sugar and KMS(Table 1).

2.3. Physicochemical analysis of the puree

2.3.1. Determination of pH

The pH of the peach puree was determined using a digital pH meter (the pH meter, mod. Cyberscan 510). The calibration of the pH meter was done before sample analysis, then the required amount of sample was taken and brought into contact with the electrode of the pH meter and reading was taken.

2.3.2. Determination of titrable acidity

The method used for calculating titrable acidity was done as per the AOAC method (1990). The percentage of titrable acidity was expressed in terms of malic acid (Eq1):

2.3.3. Determination of total solid soluble solids (TSS)

Calibrated refractometer (Atago, Japan) was used for estimation of total soluble solids that provided the degree Brix value. The TSS was measured by placing a drop of puree on the prism of the refractometer.

2.3.4. Determination of total sugars (TS)

Estimation of total sugars was carried out using phenol-sulphuric acid method (Sadasivam and Manickam, 1996).

2.3.5. Determination of color

The colour of the peach puree samples was determined by colour-spectrophotometer (Colorflex, Hunterlab), the equipment was calibrated before using. All the readings of L, a and b were taken in triplicate.

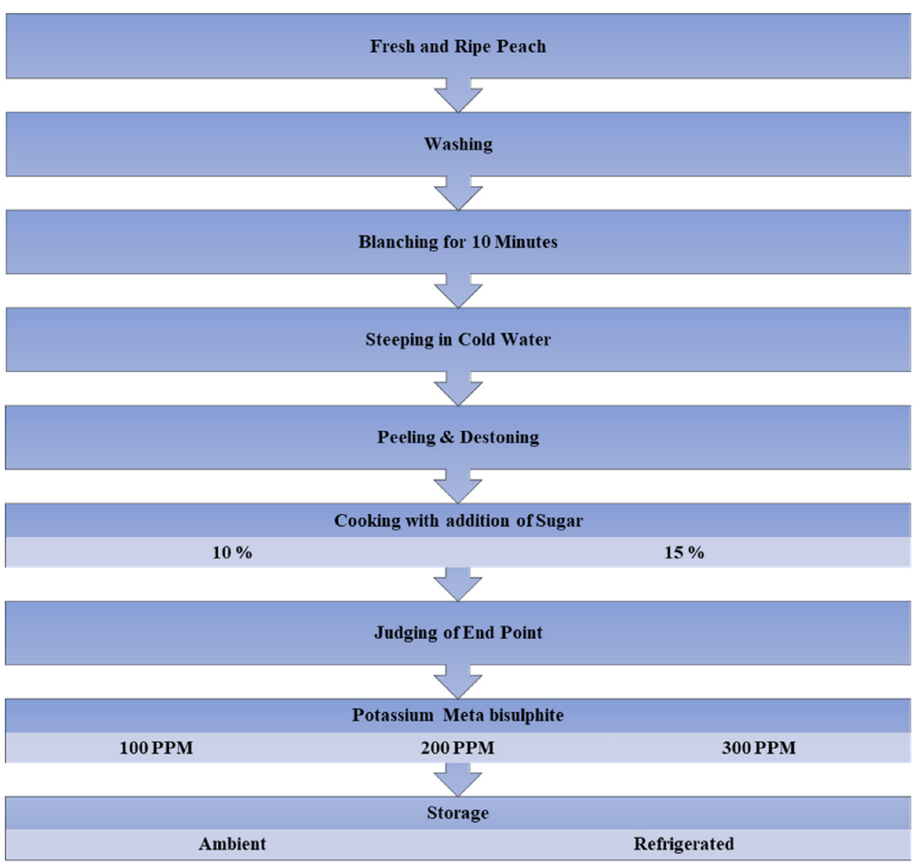

Figure 1. Flowchart of puree made by varying sugar and KMS concentration.

Table 1. Treatment formulations for the development of peach puree.

S.No	Formulation	Treatment
1	Unpeeled	P0
2	Peeled	P1
3	10% Sugar and 100 ppm KMS	P2
4	10% Sugar and 200 ppm KMS	P3
5	10% Sugar and 200 ppm KMS	P4
6	15% Sugar and 100 ppm KMS	P5
7	15% Sugar and 200 ppm KMS	P6
8	15% Sugar and 300 ppm KMS	P7

* KMS (Potassium meta bisulphite)

Table 2. Physiochemical analysis of peach puree with different treatments under different storage conditions.

Treatments	Refrigerated					Ambient				
	0 day	15 day	30 day	45 day	Mean	0 day	15 day	30 day	45 day	Mean
Effect on TSS (°Brix) with different treatments and storage conditions										
P0	7.01 ± 0.05^{cA}	7.06 ± 0.01^{dA}	5.06 ± 0.01^{bA}	4.83 ± 0.15^{aA}	**5.99**	7.01 ± 0.05^{cA}	7.18 ± 0.02^{dB}	6.06 ± 0.01^{bA}	5.63 ± 0.15^{aA}	**5.97**
P1	7.01 ± 0.01^{bA}	7.05 ± 0.01^{cA}	7.11 ± 0.03^{dB}	5.01 ± 0.01^{aB}	**6.54**	7.01 ± 0.01^{bA}	7.07 ± 0.01^{dA}	6.73 ± 0.15^{bB}	5.90 ± 0.10^{aB}	**6.42**
P2	8.07 ± 0.01^{aB}	8.12 ± 0.06^{bB}	8.06 ± 0.01^{aC}	9.09 ± 0.15^{cC}	**8.33**	8.07 ± 0.01^{aB}	8.14 ± 0.01^{bC}	8.97 ± 0.04^{cC}	9.27 ± 0.03^{dC}	**8.40**
P3	8.66 ± 0.05^{aC}	8.86 ± 0.05^{bC}	9.03 ± 0.02^{cD}	9.60 ± 0.04^{dE}	**9.03**	8.66 ± 0.05^{aC}	8.90 ± 0.15^{bD}	9.06 ± 0.15^{cD}	9.70 ± 0.05^{dE}	**9.08**
P4	8.70 ± 0.20^{aD}	8.93 ± 0.30^{bD}	9.06 ± 0.20^{cD}	9.53 ± 0.23^{dD}	**9.05**	8.70 ± 0.20^{aD}	8.83 ± 0.05^{bC}	9.10 ± 0.17^{cE}	9.57 ± 0.06^{dD}	**9.00**
P5	9.30 ± 0.26^{aF}	9.50 ± 0.10^{bF}	9.65 ± 0.032^{cG}	9.76 ± 0.03^{dG}	**9.55**	9.30 ± 0.26^{aF}	9.60 ± 0.20^{bG}	9.73 ± 0.05^{cF}	9.87 ± 0.03^{dF}	**9.65**
P6	9.33 ± 0.32^{aF}	9.40 ± 0.17^{bE}	9.60 ± 0.10^{cF}	9.76 ± 0.15^{dG}	**9.52**	9.33 ± 0.32^{aF}	9.46 ± 0.20^{bF}	9.70 ± 0.10^{cF}	9.83 ± 0.05^{dE}	**9.57**
P7	9.26 ± 0.15^{aE}	9.26 ± 0.05^{aD}	9.43 ± 0.15^{bE}	9.73 ± 0.50^{cF}	**9.42**	9.26 ± 0.15^{aE}	9.23 ± 0.15^{aE}	9.70 ± 0.10^{bF}	10.00 ± 0.10^{cG}	**9.54**
Mean	**8.42**	**8.52**	**8.37**	**8.41**		**8.42**	**8.55**	**8.50**	**8.47**	
Effect on Total sugars (%) with different treatments and storage conditions										
P0	10.96 ± 0.15^{dA}	10.56 ± 0.15^{cA}	8.73 ± 0.15^{bA}	8.40 ± 0.20^{aA}	**9.66**	10.96 ± 0.15^{dA}	11.26 ± 0.15^{dC}	9.50 ± 0.10^{bA}	8.60 ± 0.20^{aA}	**10.08**
P1	11.03 ± 0.15^{bB}	11.13 ± 0.15^{bA}	10.64 ± 0.06^{bC}	9.06 ± 0.15^{aB}	**10.47**	11.03 ± 0.15^{bB}	11.16 ± 0.15^{cA}	10.76 ± 0.15^{bB}	9.80 ± 0.10^{aB}	**10.93**
P2	12.70 ± 0.10^{aC}	12.83 ± 0.15^{aA}	13.06 ± 0.15^{aB}	13.16 ± 0.15^{aC}	**12.93**	12.70 ± 0.10^{aC}	12.96 ± 0.15^{cD}	13.13 ± 0.05^{aC}	13.19 ± 0.05^{dC}	**12.99**
P3	12.60 ± 0.10^{aC}	12.73 ± 0.11^{bA}	12.96 ± 0.05^{cC}	13.23 ± 0.11^{dD}	**12.88**	12.60 ± 0.10^{aC}	12.89 ± 0.15^{bC}	13.16 ± 0.05^{cF}	13.26 ± 0.05^{dD}	**12.98**
P4	12.76 ± 0.20^{aD}	12.93 ± 0.30^{bD}	13.06 ± 0.20^{cD}	13.23 ± 0.03^{dD}	**12.99**	12.76 ± 0.20^{aD}	12.93 ± 0.05^{bC}	13.10 ± 0.17^{cE}	13.22 ± 0.06^{dD}	**13.00**
P5	14.16 ± 0.26^{aF}	14.50 ± 0.10^{bF}	14.65 ± 0.032^{cG}	14.76 ± 0.03^{dG}	**14.51**	14.16 ± 0.26^{aF}	14.21 ± 0.20^{bG}	14.43 ± 0.05^{cF}	14.71 ± 0.03^{dF}	**14.38**
P6	14.03 ± 0.32^{aF}	14.40 ± 0.17^{bE}	14.60 ± 0.10^{cF}	14.96 ± 0.15^{dG}	**14.50**	14.03 ± 0.32^{aF}	14.26 ± 0.20^{bF}	14.40 ± 0.10^{cF}	14.63 ± 0.05^{dE}	**14.33**
P7	14.06 ± 0.15^{aE}	14.36 ± 0.05^{aD}	14.59 ± 0.15^{bE}	14.92 ± 0.50^{cF}	**14.48**	14.06 ± 0.15^{aE}	14.23 ± 0.15^{aE}	14.44 ± 0.10^{bF}	14.67 ± 0.10^{cG}	**14.35**
Mean	**12.79**	**12.93**	**12.79**	**12.72**		**12.79**	**12.99**	**12.86**	**12.76**	
Effects on pH with different treatments and storage conditions										
P0	3.72 ± 0.02^{aA}	3.76 ± 0.05^{bB}	3.81 ± 0.02^{cC}	3.85 ± 0.01^{dC}	**3.78**	3.72 ± 0.02^{aA}	3.78 ± 0.015^{bD}	3.82 ± 0.006^{cC}	3.87 ± 0.01^{dE}	**3.79**
P1	3.71 ± 0.02^{aA}	3.76 ± 0.02^{bB}	3.79 ± 0.01^{cBC}	3.80 ± 0.01^{cB}	**3.76**	3.71 ± 0.02^{aA}	3.76 ± 0.01^{bBC}	3.81 ± 0.017^{cC}	3.82 ± 0.01^{cD}	**3.78**
P2	3.74 ± 0.01^{aB}	3.75 ± 0.01^{aB}	3.76 ± 0.01^{aA}	3.79 ± 0.01^{bB}	**3.76**	3.74 ± 0.01^{aB}	3.76 ± 0.01^{abBC}	3.78 ± 0.005^{bB}	3.80 ± 0.01^{cBC}	**3.77**
P3	3.74 ± 0.01^{aB}	3.75 ± 0.01^{aB}	3.76 ± 0.01^{abA}	3.78 ± 0.01^{bA}	**3.75**	3.74 ± 0.01^{aB}	3.76 ± 0.005^{aAC}	3.78 ± 0.01^{abB}	3.80 ± 0.01^{bBC}	**3.77**
P4	3.76 ± 0.01^{aC}	3.76 ± 0.01^{aB}	3.77 ± 0.02^{aB}	3.77 ± 0.01^{aA}	**3.76**	3.76 ± 0.01^{aC}	3.77 ± 0.01^{aCD}	3.78 ± 0.01^{aB}	3.78 ± 0.01^{aB}	**3.77**
P5	3.71 ± 0.01^{aA}	3.72 ± 0.01^{aA}	3.76 ± 0.01^{bA}	3.78 ± 0.01^{bA}	**3.74**	3.71 ± 0.01^{aA}	3.73 ± 0.01^{abA}	3.76 ± 0.02^{bA}	3.80 ± 0.02^{cBC}	**3.75**
P6	3.72 ± 0.02^{aA}	3.73 ± 0.02^{aA}	3.75 ± 0.01^{abA}	3.77 ± 0.05^{bA}	**3.74**	3.72 ± 0.02^{aA}	3.74 ± 0.01^{aAB}	3.76 ± 0.01^{abA}	3.78 ± 0.01^{bB}	**3.75**
P7	3.75 ± 0.01^{aBC}	3.75 ± 0.01^{aB}	3.75 ± 0.01^{aA}	3.75 ± 0.05^{aA}	**3.75**	3.75 ± 0.01^{aBC}	3.74 ± 0.01^{aAB}	3.75 ± 0.01^{aA}	3.75 ± 0.01^{aA}	**3.74**
Mean	**3.73**	**3.75**	**3.77**	**3.79**		**3.73**	**3.75**	**3.78**	**3.80**	
Effects on Titrable acidity(%) with different treatments and storage conditions										
P0	0.52 ± 0.01^{bA}	0.51 ± 0.02^{bA}	0.50 ± 0.01^{bA}	0.38 ± 0.011^{aA}	**0.48**	0.52 ± 0.01^{bA}	0.50 ± 0.20^{cA}	0.46 ± 0.02^{bA}	0.38 ± 0.015^{aA}	**0.47**
P1	0.53 ± 0.01^{dA}	0.50 ± 0.02^{cA}	0.47 ± 0.02^{bA}	0.41 ± 0.015^{aAB}	**0.47**	0.53 ± 0.01^{dA}	0.52 ± 0.015^{cA}	0.46 ± 0.02^{bA}	0.40 ± 0.015^{aA}	**0.47**
P2	0.53 ± 0.01^{cA}	0.51 ± 0.02^{bcA}	0.49 ± 0.02^{bA}	0.43 ± 0.011^{aBC}	**0.49**	0.53 ± 0.01^{cA}	0.52 ± 0.026^{cA}	0.48 ± 0.02^{bA}	0.43 ± 0.015^{aBC}	**0.49**
P3	0.53 ± 0.015^{cA}	0.51 ± 0.026^{bcA}	0.49 ± 0.02^{bA}	0.45 ± 0.02^{aC}	**0.49**	0.53 ± 0.015^{cA}	0.51 ± 0.02^{bA}	0.48 ± 0.02^{bA}	0.42 ± 0.011^{aB}	**0.48**
P4	0.52 ± 0.01^{cA}	0.51 ± 0.025^{cA}	0.48 ± 0.03^{bA}	0.45 ± 0.011^{aC}	**0.49**	0.52 ± 0.01^{cA}	0.51 ± 0.026^{bA}	0.49 ± 0.02^{abA}	0.46 ± 0.011^{aE}	**0.50**
P5	0.54 ± 0.015^{cA}	0.50 ± 0.025^{bA}	0.48 ± 0.02^{bA}	0.45 ± 0.011^{aC}	**0.49**	0.54 ± 0.015^{cA}	0.51 ± 0.026^{cA}	0.46 ± 0.03^{bA}	0.42 ± 0.015^{aB}	**0.48**
P6	0.55 ± 0.017^{cA}	0.52 ± 0.026^{bA}	0.5 ± 0.043^{bA}	0.46 ± 0.011^{aC}	**0.51**	0.55 ± 0.017^{cA}	0.51 ± 0.02^{bA}	0.47 ± 0.032^{aA}	0.44 ± 0.011^{aC}	**0.49**
P7	0.55 ± 0.017^{cA}	0.53 ± 0.026^{cA}	0.49 ± 0.037^{bA}	0.46 ± 0.005^{aC}	**0.51**	0.55 ± 0.017^{cA}	0.51 ± 0.02^{bA}	0.48 ± 0.04^{bA}	0.44 ± 0.020^{aC}	**0.49**
Mean	**0.53**	**0.51**	**0.49**	**0.43**		**0.53**	**0.51**	**0.47**	**0.42**	

Values are mean ± standard deviation (n = 3).
a-b: Within a row, for each type of conditioning (refrigerated/ambient) different letters indicate significant differences among the storage period ($p < 0.05$).
A-B: Within a column, different letters indicate significant differences among different Treatments ($p < 0.05$).

2.3.6. Microbial analysis

Specific media was used to detect the presence of yeast and mold count. The microbial enumeration of the samples during the storage study was performed as per the procedure described by (APHA, 2001).

2.4. Determination of rheological characteristics

The rheological properties were studied using Rheometer Physica MCR 101 (Anton Paar, Ostfildern, Germany). The parallel plate geometry with a 0.5 mm gap was used, and tests were conducted at a constant temperature of 25 °C. To evaluate visco-elastic characteristics (loss modulus, G″ and storage modulus, G′), the dynamic oscillatory frequency sweep test with a frequency range of 0.1–100 rad s^{-1} at a strain value of 2% (within the linear visco-elastic region) was conducted. Following parameters were observed during the rheological study 1. Storage modulus (G′) 2. Loss modulus (G″) 3. Shear Stress 4. Shear rate 5.Apparent viscosity.

2.5. Sensory evaluation

Sensory quality attributes such as colour, flavour, taste and overall acceptability of puree were evaluated by a semi-trained panel of 10 members drawn from staff members and the purpose of the study were explained to the panellist. Panellists were screened for oral lesions, specific anosmia, and cigarette use. Formal consent was acquired from the sensory panellists. A positive response to any of the questions results in exclusion. Each panellist was provided with eight samples of puree in random order and was requested to assign scores based on colour, flavour, taste and overall acceptability using 5 point scale. The panellist was given a glass of water and a break of twenty minutes after each sample test in order to minimize the bias towards sensory evaluation and to mitigate the after taste of the sample done earlier. The results were presented as a mean and standard deviation of two values.

2.6. Statistical analysis

The data were analyzed by analysis of variance (ANOVA) using statistical software SPSS 20. A multiple comparison procedure of the means was performed by Post Hoc Test. The significance of the differences was defined at ($p \leq 0.05$).

3. Results and discussion

3.1. Composition of raw materials

The raw materials used for the preparation of peach purees were analyzed for TSS, TS, Titrable acidity and colour analysis. The value of TSS, Total Sugar, Titrable acidity and L value was found to be 9.32, 6.54, 0.44 and 40.33 respectively. Similar findings were obtained by (Brooks et al., 1993; Deshmukh et al., 2017).

3.2. Storage studies of peach purees

3.2.1. TSS and TS

It is evident from Table 2 that TSS, in general, showed an increasing trend with the increase in storage period under refrigerated conditions. P3, P4, P5, P6 and P7 showed a statistically significant difference in TSS under refrigerated conditions throughout the storage period. The TSS of peeled and unpeeled samples do not show any significant change during ambient conditions. However, P3, P4, P5, P6 and P7samples stored at ambient conditions, the TSS content shows a significant increase generally throughout the storage period. Unpeeled (P0) and peeled (P1) samples show the gradual decrease in total soluble solids towards the end of the storage period (30–45 days) and the decrease is statistically significant, which can be related to the fact that fungal growth can use sugars for metabolism thus can decrease TSS during later stages of storage (Bian et al., 1994). While as the purees treated with 10% sugar and 15% sugar with KMS treatments does not show any decrease in TSS during the whole storage period, which may be due to the presence of preservatives. The increase in TSS and TS can be explained by the fact that during the storage period breakdown of higher sugars into lower or simpler sugars takes place (Hussain et al., 2013). The decrease in TSS at the end of the storage period for peeled and unpeeled samples can be explained by the fact that the growth of microorganisms utilizes simple sugars as substrates which results in a decrease in TSS (Hussain et al., 2013). However, such a condition does not arise in sugar and KMS treated samples due to their preservative effect. Similar findings were reported by (Colantuono et al., 2012; Balestra et al., 2011). Using higher concentration of sugar in puree formulation showed significant increase in TSS and TS of purees (Table 2).

3.2.2. pH and titrable acidity

It is clear from Table 2 that with the advancement of the storage period, there occurs a decrease in the acidity of purees during which pH increases. The pH of puree's increased with an increase in storage periods. Effects of 10% and 15% sugar on chemical parameters of purees are comparable but the KMS concentration plays a significant role in maintaining the acidity of the purees having the highest KMS concentration. The pH values for all treated puree's (10% sugar, 15% sugar with 100, 200, 300 ppm KMS) were lower than control and unpeeled purees, which indicates that these treatments may help in maintaining the acidity of purees during storage.

The highest increase in pH has been observed in P0 refrigerated, and P0 ambient samples (Unpeeled purees) at the end of the storage period thus showing low shelf stability. The increase in pH as compared to other samples can be attributed to the fact that in peach puree (P0), no preservative has been added and thus these are enough chances of microbial growth that might be linked with the increase in pH. An increase in pH at the end of the storage period is statically significant in both ambient and refrigerated samples.

3.2.3. Color

From the Table3 it is clear that the ‘L*’ value of puree shows a gradual decrease during the storage period for both refrigerated and ambient samples and decrease is statically significant for all the samples, the cause for that may be that with the storage time peach purees becomes darker which corresponds to the decrease in ‘L*’ value of the colour scale (Avila and Silva, 1999). The main change under storage for longer periods is colour change and usually, browning takes place. Browning of the peach puree increased during the storage period which resulted in a decrease in ‘L*’ values of purees. However, refrigerated storage significantly reduced the browning of the samples (González-Buesa et al., 2011; Schweiggert et al., 2011). The Colour parameters of peach purees show similarity with the findings of (Avila and Silva, 1999).

3.2.4. Sensory analysis

From Table 4 it is clear that the sensory scores recorded were higher than the average. The average overall acceptability of peach puree varies from 3.53 to 3.15 at 45 days of storage period for refrigerated and ambient conditions respectively. The overall acceptability is almost the same for all the samples at zero-day storage. The highest overall acceptability was found for samples P4 (4.15) and P7 (3.45) for both refrigerated and ambient conditions at 45 days of storage. Among P4 and P7 samples for both refrigerated and ambient conditions, the overall acceptability was highest for refrigerated conditions with a value of 4.15.

3.2.5. Microbial analysis

The microbial load of all the samples was within the acceptable limits.

Table 3. Effect of different treatments under different storage conditions on color of peach puree.

Treatments	Refrigerated					Ambient				
	0 day	15 day	30 day	45 day	Mean	0 day	15 day	30 day	45 day	Mean
Changes in 'L*' with different treatments and storage conditions										
P0	42.68 ± 0.13^{dA}	41.18 ± 0.06^{cA}	39.75 ± 0.11^{bA}	37.71 ± 0.15^{aA}	**40.33**	42.68 ± 0.13^{dA}	41.10 ± 0.08^{cA}	39.06 ± 0.03^{bA}	36.35 ± 0.11^{aA}	**39.79**
P1	43.91 ± 0.06^{dB}	42.64 ± 0.12^{cB}	40.19 ± 0.07^{bB}	38.65 ± 0.11^{aB}	**41.35**	43.91 ± 0.06^{dB}	42.18 ± 0.06^{cD}	39.48 ± 0.14^{bB}	38.06 ± 0.05^{aB}	**40.91**
P2	43.63 ± 0.06^{dC}	42.24 ± 0.07^{cC}	40.58 ± 0.37^{bC}	38.60 ± 0.07^{aC}	**41.26**	43.63 ± 0.06^{dC}	42.08 ± 0.04^{cB}	40.29 ± 0.65^{bD}	38.17 ± 0.03^{aC}	**41.07**
P3	43.62 ± 0.02^{dC}	42.29 ± 0.17^{cD}	40.89 ± 0.07^{bE}	38.33 ± 0.09^{aD}	**41.28**	43.62 ± 0.02^{dC}	42.06 ± 0.04^{cB}	40.38 ± 0.03^{bE}	38.07 ± 0.05^{aB}	**41.04**
P4	43.75 ± 0.05^{dD}	42.28 ± 0.07^{cD}	40.68 ± 0.04^{bD}	38.76 ± 0.16^{aE}	**41.36**	43.75 ± 0.05^{dD}	42.11 ± 0.03^{cC}	40.14 ± 0.07^{bC}	38.19 ± 0.02^{aC}	**41.03**
P5	44.22 ± 0.07^{dE}	43.24 ± 0.05^{cE}	41.54 ± 0.07^{bF}	39.90 ± 0.06^{aF}	**42.22**	44.22 ± 0.07^{dE}	43.1 ± 0.06^{cE}	41.06 ± 0.04^{bF}	39.65 ± 0.10^{aF}	**42.01**
P6	44.33 ± 0.11^{dF}	43.40 ± 0.03^{cF}	41.76 ± 0.11^{bG}	39.86 ± 0.08^{aG}	**42.34**	44.33 ± 0.11^{dF}	43.07 ± 0.05^{cE}	41.08 ± 0.04^{bF}	39.39 ± 0.04^{aD}	**41.96**
P7	44.78 ± 0.016^{dG}	43.37 ± 0.04^{cF}	41.82 ± 0.06^{bH}	39.77 ± 0.08^{aH}	**42.43**	44.78 ± 0.016^{dG}	43.28 ± 0.12^{cF}	41.35 ± 0.05^{bG}	39.56 ± 0.19^{aE}	**42.23**
Mean	**43.86**	**42.58**	**40.90**	**38.95**			**42.37**	**40.35**	**38.43**	
Changes in 'a*' with different treatments and storage conditions										
P0	4.17 ± 0.03^{aA}	4.18 ± 0.04^{aA}	4.18 ± 0.070^{aA}	4.18 ± 0.081^{aA}	**4.18**	4.17 ± 0.03^{aA}	4.20 ± 0.065^{aA}	4.21 ± 0.072^{aA}	4.21 ± 0.05^{aA}	**4.20**
P1	4.26 ± 0.0^{aB}	4.29 ± 0.068^{aC}	4.29 ± 0.066^{aB}	4.30 ± 0.10^{aB}	**4.28**	4.26 ± 0.0^{aB}	4.28 ± 0.07^{aB}	4.28 ± 0.07^{aB}	4.28 ± 0.070^{aB}	**4.28**
P2	4.72 ± 0.15^{aF}	4.85 ± 0.102^{bG}	4.85 ± 0.095^{bG}	4.86 ± 0.105^{bF}	**4.82**	4.72 ± 0.15^{aF}	4.57 ± 0.259^{aE}	4.74 ± 0.066^{cF}	4.74 ± 0.077^{cF}	**4.66**
P3	4.44 ± 0.11^{aE}	4.45 ± 0.130^{aE}	4.46 ± 0.131^{aE}	4.46 ± 0.130^{aD}	**4.45**	4.44 ± 0.11^{aE}	4.49 ± 0.06^{aD}	4.49 ± 0.066^{aD}	4.50 ± 0.07^{aD}	**4.49**
P4	4.30 ± 0.10^{aC}	4.31 ± 0.12^{abC}	4.34 ± 0.08^{bcC}	4.36 ± 0.08^{cC}	**4.33**	4.30 ± 0.10^{aC}	4.35 ± 0.09 ^{aC}	4.35 ± 0.12^{aC}	4.36 ± 0.13^{aC}	**4.35**
P5	4.25 ± 0.06^{aB}	4.25 ± 0.06^{aB}	4.26 ± 0.06^{aB}	4.28 ± 0.14^{aB}	**4.26**	4.25 ± 0.06^{aB}	4.27 ± 0.06^{aB}	4.28 ± 0.05^{aB}	4.29 ± 0.06^{aB}	**4.27**
P6	4.37 ± 0.10^{aD}	4.37 ± 0.11^{aD}	4.38 ± 0.12^{aD}	4.38 ± 0.14^{aC}	**4.37**	4.37 ± 0.10^{aD}	4.34 ± 0.12^{aC}	4.36 ± 0.14^{aC}	4.36 ± 0.16^{aC}	**4.35**
P7	4.76 ± 0.05^{aG}	4.77 ± 0.04 ^{aF}	4.78 ± 0.03 ^{aF}	4.78 ± 0.02^{aE}	**4.77**	4.76 ± 0.05^{aG}	4.61 ± 0.06^{abF}	4.62 ± 0.08^{bE}	4.62 ± 0.09^{bE}	**4.61**
Mean	**4.41**	**4.43**	**4.44**	**4.45**		**4.41**	**4.38**	**4.41**	**4.42**	
Changes in 'b*' with different treatments and storage conditions										
P0	26.66 ± 0.10^{aA}	26.67 ± 0.10 ^{aA}	26.68 ± 0.09 ^{aA}	26.69 ± 0.09^{aA}	**26.67**	26.66 ± 0.10^{aA}	26.65 ± 0.09^{aA}	26.67 ± 0.10^{aA}	26.67 ± 0.12 ^{aA}	**26.66**
P1	27.40 ± 0.18 ^{aD}	27.41 ± 0.17 ^{aD}	27.41 ± 0.16 ^{aD}	27.42 ± 0.15 ^{aD}	**27.41**	27.40 ± 0.18 ^{aD}	27.40 ± 0.05 ^{aE}	27.41 ± 0.04 ^{aE}	27.41 ± 0.03 ^{aE}	**27.40**
P2	27.27 ± 0.08 ^{aC}	27.27 ± 0.08 ^{aC}	27.27 ± 0.08 ^{aC}	27.28 ± 0.09 ^{aC}	**27.27**	27.27 ± 0.08 ^{aC}	27.33 ± 0.10 ^{aD}	27.33 ± 0.10^{aD}	27.33 ± 0.11 ^{aD}	**27.33**
P3	27.28 ± 0.07 ^{aC}	27.28 ± 0.05 ^{aC}	27.29 ± 0.04 ^{aC}	27.29 ± 0.03 ^{aC}	**27.28**	27.28 ± 0.07 ^{aC}	27.33 ± 0.02 ^{aD}	27.33 ± 0.04 ^{aD}	27.33 ± 0.06 ^{aD}	**27.32**
P4	27.79 ± 0.03 ^{aF}	27.79 ± 0.04 ^{aE}	27.79 ± 0.06 ^{aE}	27.80 ± 0.08 ^{aE}	**27.79**	27.79 ± 0.03 ^{aF}	27.78 ± 0.04 ^{aF}	27.79 ± 0.06 ^{aF}	27.79 ± 0.08 ^{aF}	**27.78**
P5	27.12 ± 0.08 ^{aB}	27.13 ± 0.08 ^{aB}	27.13 ± 0.08 ^{aB}	27.14 ± 0.09 ^{aB}	**27.13**	27.12 ± 0.08 ^{aB}	27.16 ± 0.05 ^{aB}	27.16 ± 0.07^{aB}	27.17 ± 0.09 ^{aB}	**27.17**
P6	27.45 ± 0.09 ^{aE}	27.42 ± 0.05 ^{aD}	27.42 ± 0.04 ^{aD}	27.43 ± 0.03 ^{aD}	**27.43**	27.45 ± 0.09 ^{aE}	27.41 ± 0.11 ^{aE}	27.42 ± 0.09^{aE}	27.42 ± 0.09 ^{aE}	**27.42**
P7	27.14 ± 0.06 ^{aB}	27.14 ± 0.07 ^{aB}	27.14 ± 0.08 ^{aB}	27.15 ± 0.09 ^{aB}	**27.14**	27.14 ± 0.06 ^{aB}	27.22 ± 0.03aC	27.22 ± 0.03 ^{aC}	27.22 ± 0.04 ^{aC}	**27.22**
Mean	**27.26**	**27.26**	**27.27**	**27.27**		**27.26**	**27.28**	**27.29**	**27.29**	

a-b: Within a row, for each type of conditioning (refrigerated/ambient) different letters indicate significant differences among the storage period ($p < 0.05$).
A-B: Within a column, different letters indicate significant differences among different Treatments ($p < 0.05$).Values are mean ± standard deviation ($n = 3$).

Table 4. Sensory analysis of peach puree for different treatments under different storage conditions.

Treatments	Refrigerated						Ambient					
	Color	Taste	Aroma	Apperance	Overall accetability	Mean	Color	Taste	Aroma	Apperance	Overall accetability	Mean
Zero day sensory analysis												
P0	-	-	-	-	-	-	4.63 ± 0.11	4.56 ± 0.11	4.76 ± 0.05	4.33 ± 0.30	4.57 ± 0.07	**4.57**
P1	-	-	-	-	-	-	4.83 ± 0.05	4.76 ± 0.05	4.76 ± 0.05	4.73 ± 0.05	4.77 ± 0.02	**4.77**
P2	-	-	-	-	-	-	4.86 ± 0.05	4.66 ± 0.05	4.83 ± 0.05	4.80 ± 0.01	4.79 ± 0.01	**4.78**
P3	-	-	-	-	-	-	4.86 ± 0.10	4.83 ± 0.05	4.70 ± 0.10	4.79 ± 0.10	4.79 ± 0.06	**4.79**
P4	-	-	-	-	-	-	4.80 ± 0.10	4.83 ± 0.05	4.83 ± 0.05	4.70 ± 0.10	4.79 ± 0.06	**4.79**
P5	-	-	-	-	-	-	4.80 ± 0.10	4.86 ± 0.05	4.80 ± 0.10	4.73 ± 0.05	4.80 ± 0.04	**4.79**
P6	-	-	-	-	-	-	4.80 ± 0.10	4.86 ± 0.05	4.80 ± 0.10	4.83 ± 0.05	4.82 ± 0.04	**4.82**
P7	-	-	-	-	-	-	4.86 ± 0.05	4.86 ± 0.05	4.83 ± 0.05	4.86 ± 0.05	4.85 ± 0.01	**4.85**
Mean	-	-	-	-	-	-	**4.80**	**4.78**	**4.79**	**4.72**	**4.76**	
45 day sensory analysis												
P0	3.03 ± 0.05	2.9 ± 0.05	2.76 ± 0.05	2.76 ± 0.05	2.86 ± 0.02	**2.86**	2.66 ± 0.15	2.76 ± 0.05	2.73 ± 0.05	2.63 ± 0.15	2.7 ± 0.05	**2.69**
P1	3.73 ± 0.20	3.23 ± 0.05	3.70 ± 0.10	3.16 ± 0.05	3.33 ± 0.07	**3.43**	3.40 ± 0.10	3.10 ± 0.1	3.03 ± 0.05	2.96 ± 0.05	3.12 ± 0.05	**3.12**
P2	3.26 ± 0.05	3.26 ± 0.05	3.23 ± 0.15	3.20 ± 0.10	3.24 ± 0.02	**3.24**	3.13 ± 0.05	2.96 ± 0.05	2.86 ± 0.05	2.93 ± 0.05	2.97 ± 0.02	**2.97**
P3	3.43 ± 0.15	3.40 ± 0.10	3.43 ± 0.05	3.43 ± 0.11	3.42 ± 0.02	**3.42**	3.13 ± 0.05	3.10 ± 0.1	3.13 ± 0.05	3.20 ± 0.10	3.14 ± 0.07	**3.14**
P4	3.90 ± 0.10	4.10 ± 0.10	4.26 ± 0.05	4.36 ± 0.05	4.15 ± 0.06	**4.15**	3.60 ± 0.10	3.50 ± 0.1	3.40 ± 0.10	3.30 ± 0.10	3.45 ± 0.04	**3.45**
P5	3.40 ± 0.1	3.30 ± 0.10	3.30 ± 0.17	3.43 ± 0.11	3.35 ± 0.05	**3.35**	3.23 ± 0.05	3.20 ± 0.1	3.20 ± 0.10	3.13 ± 0.05	3.19 ± 0.14	**3.19**
P6	3.60 ± 0.15	3.50 ± 0.11	3.70 ± 0.10	3.70 ± 0.11	3.66 ± 0.06	**3.63**	3.36 ± 0.05	3.26 ± 0.05	3.30 ± 0.10	3.30 ± 0.10	3.30 ± 0.01	**3.30**
P7	4.23 ± 0.05	4.20 ± 0.10	4.20 ± 0.10	4.33 ± 0.05	4.26 ± 0.03	**4.24**	3.15 ± 0.1	3.36 ± 0.15	3.30 ± 0.10	3.13 ± 0.05	3.33 ± 0.07	**3.25**
Mean	**3.57**	**3.49**	**3.57**	**3.54**	**3.53**		**3.21**	**3.15**	**3.12**	**3.07**	**3.15**	

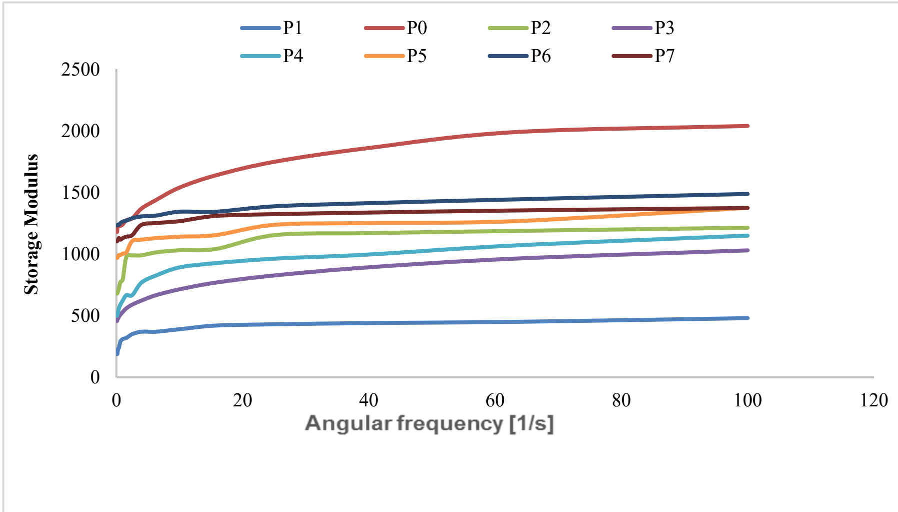

Figure 2. Zero day frequency sweep data of storage modulus (G″) of ambient stored peach puree.

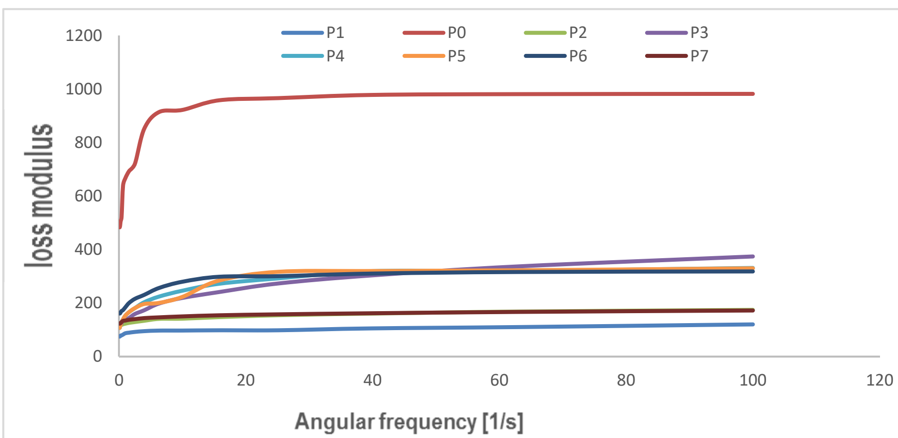

Figure 3. Zero day frequency sweep data of loss modulus (G″) of ambient stored peach purees.

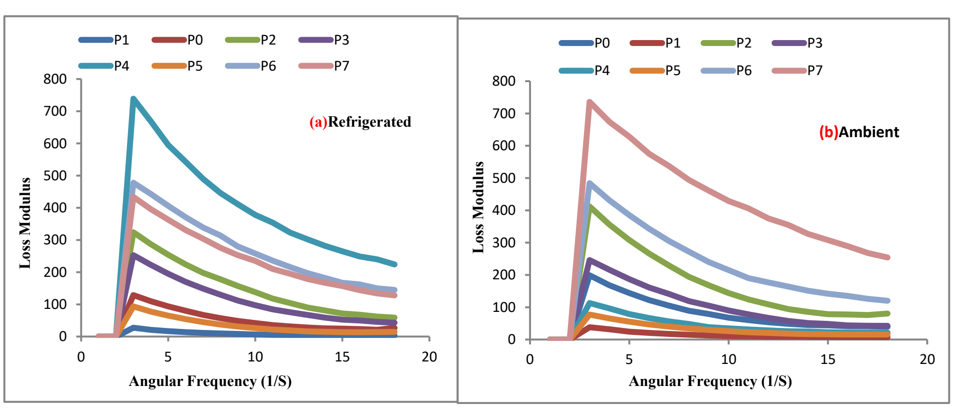

Figure 4. Frequency sweep data of loss modulus (G″) of both (a)refrigerated and (b)ambient stored peach purees at the end of storage period (45 days).

3.3. Rheological evaluation

Rheological properties are measurements of deformation (G′) and flow (G″) of foods when stress is applied to them. As is represented by the Figures 2, 3, 4, and 5 the elastic modulus (G′) is greater than the viscous modulus (G″) for almost all the samples, therefore, it is a clear indication that Peach puree is more elastic as compared to viscous nature. Thus the product can be classified as a weak gel. Similar observations were noted for jabuticaba pulp by (Sato and Cunha, 2009; Tonon et al., 2009)for Acai pulp. Purees made from unpeeled fruits were found to have significantly higher G′ and G″ values than the equivalent purees made from peeled peaches. The dermal tissue has a high resistance to the environment and is strong tissue which might affect flow and deformation behaviour, as well as

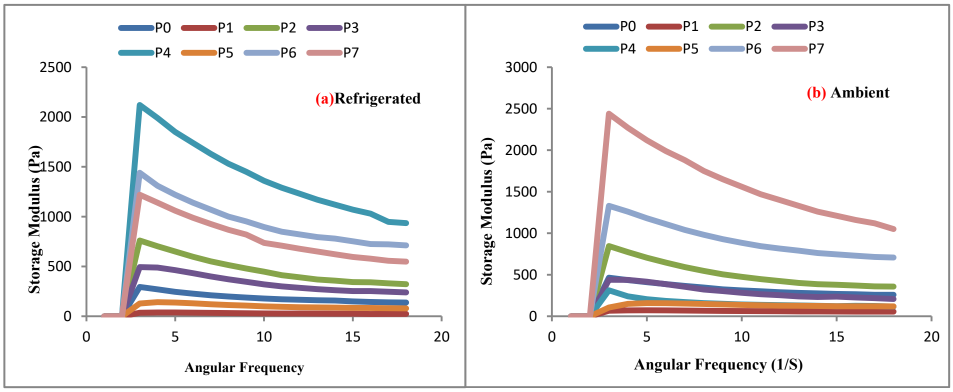

Figure 5. Frequency sweep data of Storage Modulus (G′) of both (a)refrigerated and (b) ambient stored peach purees at the end of storage period (45 days).

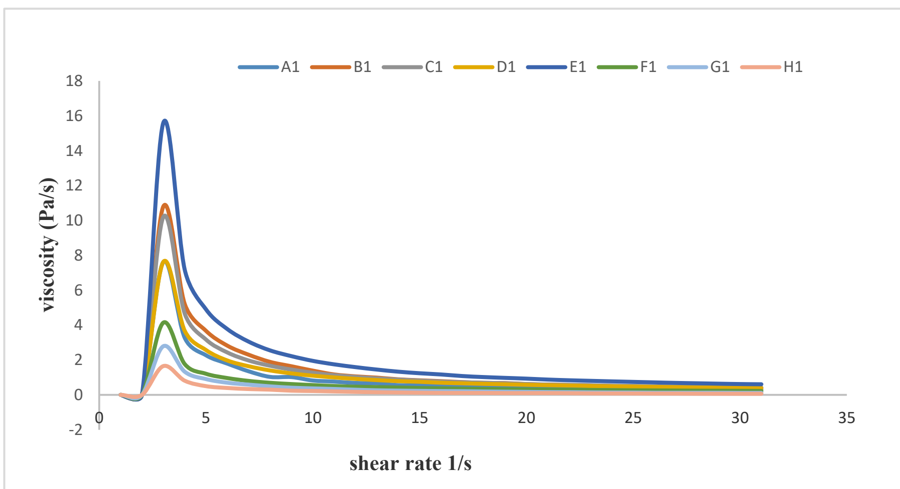

Figure 6. Zero day analysis Apparent Viscosity of ambient stored peach purees.

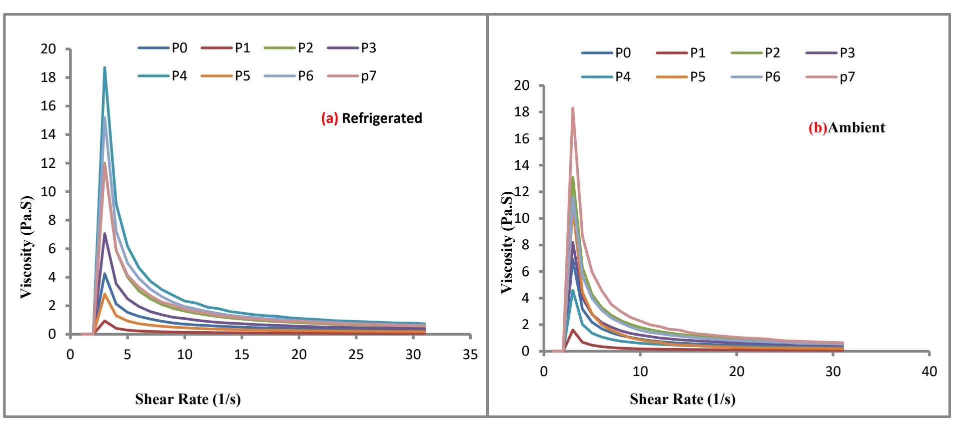

Figure 7. Forty five days analysis of Apparent Viscosity of both (a) refrigerated and (b) ambient stored peach puree.

increase the rigidity of the peach puree structure. Similar responses were observed by (Van Buren, 1991). The rheological curves for the 10% sugar or for the 15% sugar purees with different KMS concentrations were comparable. With the advancement of the storage period, there is a change in G′ and G″ and the change can be associated with the changes in PH and TSS during storage. The highest decrease in G′ and G″ has been observed in P1, & P0 purees, because these puree's show the highest change in chemical parameters during storage (Ditchfield et al., 2004; Guerrero and Alzamora, 1998; Abd-Elhady, 2014).

3.3.1. Shear rate vs viscosity

From the graphical representations Figures 6 and 7 it is clear that when shear rate increases apparent viscosity decreases and the decrease in viscosity shows a linear trend with respect to shear rate, therefore, samples can be classified as shear-thinning samples. The reason behind the decrease in viscosity can be attributed to the fact that heating during the puree preparation can modify cellular structure especially cell wall structure which can result in the softening of the pectin thus changing the rigidity of cells, however (Abd-Elhady, 2014; Redgwell et al., 2008), in his study on apple pulp reported that the decrease in viscosity can be explained by the fact that during the preparation of peach puree heating can destabilize the cellulose network which results in the decrease in viscosity of peach samples. It was observed that samples containing more sugar show a direct relation with shear stress. With the advancement of storage period control samples of puree, both refrigerated as well as ambient show almost linear behaviour with the change in shear rate and reason might be that chemical changes were more pronounced in these samples (TSS and pH changes), therefore we can state that rheological parameters of peach puree are storage time and total soluble solids dependent (Guerrero and Alzamora, 1998).

4. Conclusion

Only minor compositional changes in the product occurred during 45 days of storage, it appears that the addition of KMS and Sugar may be valuable for holding processed peach purees. The puree prepared has a mean overall acceptability of 4.76 at zero-day storage and 3.15 at 45 days storage on 5 points hedonic scale indicating puree is acceptable for consumption even after 45 days of storage. Peach puree with peel is a very perishable product and has a very low shelf life, such purees show very high chemical degradation both in ambient storage as well as in refrigerated storage. Frequency sweep tests demonstrated that the elastic modulus (G′) is greater than the viscous modulus (G″) for all the samples, therefore, it is a clear indication that peach puree is more elastic as compared to viscous nature. *Elastic modulus and viscous modulus were found highest in the unpeeled purees*.

Declarations

Author contribution statement

Shefali Wani: Performed the experiments; Analyzed and interpreted the data; Wrote the paper.

Rayees Ahmad Bakshi, Shemilah Fayaz, Khalid Muzaffar, B. N. Dar: Analyzed and interpreted the data; Wrote the paper.

Zakir S. Khan: Conceived and designed the experiments; Analyzed and interpreted the data; Wrote the paper.

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Data included in article/supplementary material/referenced in article.

Declaration of interests statement

The authors declare no conflict of interest.

Additional information

No additional information is available for this paper.

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