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# Impact of Beetroot Pulp on Physico-Chemical and Sensory Properties of Apple-Based Spread

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***Authors' contributions***

*This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.*

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## ABSTRACT

Spread is a nutritious and flavourful alternative to the jams and butters. The current study's goal was to create a functional spread based on apples by adding beetroot pulp and evaluating its physico-chemical, microbial and sensory properties under ambient storage conditions. The control spread was made exclusively of apple pulp. The remaining five functional spread samples comprised of apple pulp and beetroot pulp in the proportions of 90:10, 80:20, 70:30, 60:40 and 50:50, respectively. The spread samples were stored in glass jar and evaluated at 0, 2, 4 and 6 months of storage. The spread's moisture content (24.97-19.79%) was reduced while TSS (60.00-63.44ºBrix), titratable acidity (0.500-0.648%), reducing sugars (24.30-28.15%) and total sugars

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(55.76-58.78%) were increased with the increase in storage duration. The microbial count remained below the permissible limit for the entire six months of storage. Colour, texture, taste and mouthfeel ratings showed that the spread with 60% apple pulp and 40% beetroot pulp performed better than the other blends of apple-beetroot spread.

*Keywords: Apple; beetroot; microbial count; spread.*

## 1. INTRODUCTION

Fruits and vegetables are valuable asset to any diet as it include nearly every nutrient needed for the body's growth and development, which promotes a healthy body and mind. They also have the unique ability to protect against a variety of deficiency disorders, making them a ready source of energy (Tambe et al., 2022). One of the most widely grown and commercially important fruits in temperate climate is the apple (*Malus domestica* Borkh.) The crisp texture and sweet-tart flavour of apples make them one of the most beloved fruits in the world (Chen et al., 2021). Apples contain a lot of polyphenols, especially flavonoids, which have anti-inflammatory and antioxidant qualities. Apples are good for blood sugar control because of their low glycemic index. Vitamin C, which is abundant in the fruit, supports healthy skin and a strong immune system.

Beetroot (*Beta vulgaris* L.) is a nutrient-dense root vegetable recognized for its deep red colour and earthy flavour. It is also referred as garden beet, chard, spinach beet, beet and *chukander*. Beets are exceptionally good for the heart as they contain nitrate, which lowers blood pressure. Minerals such as magnesium, manganese, potassium, salt, iron and copper are abundant in beets (Gupta et al., 2024). Additionally, this vegetable promotes digestive health, liver cleansing and even enhances athletic performance (Chauhan et al., 2020). It's an ideal pick for general health and wellbeing due to its nutritional profile.

Spread is a food made from fruit or vegetable or their mixture, sugar and pectin. Spread is made from fruit or vegetable pulp and set using naturally occurring pectin present in the particular ingredient or by adding pectin if it is inadequate. Flavouring and colouring is also added in order to enhance the quality and acceptability of the product (Chaudhary et al., 2014). The sweetness of the apple pairs wonderfully with the earthy flavour of the beetroot, creating balanced and refreshing products. Thus, apple and beetroot pulp can be blended for developing functional spread highly enriched with different nutrients.

## 2. MATERIALS AND METHODS

The modifications made to the blended spread preparation procedure in compliance with Hameed's, (2021) methodology. $T_1$ (100:00::AP:BP), $T_2$ (90:10::AP:BP), $T_3$ (80:20::AP:BP), $T_4$ (70:30::AP:BP), $T_5$ (60:40::AP:BP) and $T_6$ (50:50::AP:BP) were the six different combinations of apple and beetroot pulp that were blended to prepare spread. Total soluble solids and the spread's acidity were adjusted to 60°Brix and 0.5%, respectively, using sugar and citric acid. 1.0% pectin was added to the fruit spread to make sure it set accurately. The pulp, sugar and citric acid combination were combined and cooked while being constantly stirred to get the proper consistency. After dissolving in lukewarm water, pectin was added to the cooking mix and cooked until 60ºBrix concentration was reached. The TSS was calculated using a hand refractometer. The product eventually poured into glass jars having a capacity of 250 g that had been cleaned, cooled, sealed and labeled. For six months, the samples were stored at room temperature (23.6±5.10ºC) with a relative humidity of 60±4%. The physico-chemical, microbiological and organoleptic characteristics of the samples were periodically assessed, at intervals of every two months.

The AOAC, (2012) methodology was used in order to estimate moisture content. Using a hand refractometer (0-32°Brix), the total soluble solid (TSS) was measured in accordance with the standard protocol provided by Ranganna, (2014). Fehling solution was used to determine sugars using Ranganna's, (2014) methodology. By titrating a known volume of sample (10 ml) against a standard NaOH solution, titratable acidity was calculated (AOAC, 2012). The standard FSSAI, (2011) procedure was used for evaluating the microbiological count. A panel of ten semi-trained judges used a nine-point hedonic rating scale to organoleptically evaluate apple-beetroot blended spread, as outlined by Amerine et al., (1965). Factorial completely randomized design (FCRD) was used to statistically analyze the data (Gomez & Gomez, 1984).

## 3. RESULTS AND DISCUSSION

### 3.1 Proximate Composition

The data pertaining to the physical properties of the raw materials in Table 1 revealed that the moisture, water activity and TSS in fresh apple were depicted as 86.35%, 0.971 and 14.59°Brix, respectively which are closely related to the findings of Leahu et al., (2013), Doryanizadeh et al., (2017) and Sharma, (2020). The fresh apple contained 0.383% titratable acidity which coincides with the results of Leahu et al., (2013), Kumar et al., (2018) and Sharma, (2020). The total sugar and reducing sugar in fresh apple were found to be 11.81 and 8.27%, respectively which concurred with the outcomes of Sharma, (2017), Sharma, (2020) and Dinkecha et al., (2021). The calcium and phosphorus content of 81.20 and 0.71 mg/100g, respectively were recorded in fresh apple which are supported by the observations of Doryanizadeh et al., (2017) and Sharma, (2020).

The moisture content, water activity and total soluble solids content in fresh beetroot were recorded as 85.91%, 0.953 and 10.37°Brix, respectively which concur with the conclusions reached by Bhos et al., (2019), Sakhare et al., (2019), Kaur & Singh, (2016) and Sharma, (2023) who worked on development of product using beetroot. The titratable acidity recorded in fresh beetroot was 0.228% which coincides with the observations of Bhos et al., (2019), Kaur & Singh, (2016) and Sharma, (2023). The total sugars and reducing sugars in fresh beetroot were found to be 7.04 and 5.85%, respectively and the findings of Bhos et al., (2019), Kaur & Singh, (2016) and Sharma, (2023) corroborated the results. The calcium content of 13.98 mg/100g and phosphorus content of 39.74 mg/100g were found in fresh beetroot which corresponded with the observations of Kaur & Singh, (2016) and Sharma, (2023).

### 3.2 Moisture Content

The statistical data revealed that (Table 2) the highest mean moisture content of 24.01% was found in $T_1$ (100:00::AP:BP) followed by $T_2$ (90:10::AP:BP) with value of 23.17% and lowest mean moisture content of 20.76% was recorded in $T_6$ (50:50::AP:BP). There was significant decrease in moisture content of blended spread from 24.97 to 19.79% with the advancement of storage period. The decrease in moisture content of spread during storage might be due to evaporation of moisture from the samples and utilization of free water in converting polysaccharides into mono and disaccharides. Similar results are reported by Bishnoi, (2015) in spread variants formulated from stored aonla pulp and Sharma, (2020) in the development of aloe-vera fortified low calorie functional apple spread.

### 3.3 Total Soluble Solid

The maximum mean TSS of 61.88ºBrix was found in $T_1$ (100:00::AP:BP) and minimum mean TSS of 61.64ºBrix was recorded in $T_6$ (50:50::AP:BP). There was an increase in TSS (Table 2) of blended spread from initial month to 6 months of storage *i.e.* from 60.00 to 63.44ºBrix. The increase in TSS during storage could be attributed to reduction in the product's moisture content, solidification of pulp constituents during storage and conversion of polysaccharides like pectic substances and starch into soluble sugars by acid hydrolysis. The TSS content of the blended spread increases with the advent of storage period which are quite similar with the findings of Bishnoi, (2015), Dobhal & Awasthi, (2019) and Sharma, (2022) in spread variants prepared from the stored aonla pulp, in beetroot jam and in the kiwi spread, respectively.

### 3.4 Reducing Sugar

On assessing the treatment means (Table 3), maximum and minimum mean reducing sugar of 27.02 and 25.32% were found in treatment $T_1$ (100:00::AP:BP) and $T_6$ (50:50::AP:BP), respectively. There was a significant increase in the mean reducing sugar of blended spread from initial value of 24.30 to 28.15%, during 6 months of storage duration. The increase in reducing sugar of spread with storage could be due to inversion of sucrose to glucose and fructose, partial hydrolysis of complex carbohydrates into simple sugars and moisture loss. The increase might also be attributed to conversion of non-reducing sugars into reducing sugars (Munaza, 2018). Bishnoi, (2015) and Sharma, (2022) also recorded similar increasing trend in reducing sugar of aonla spread variants and kiwi spread, respectively during entire storage period.

### 3.5 Total Sugar

The maximum mean total sugar (59.59%) was recorded in treatment $T_1$ (100:00::AP:BP) whereas minimum mean total sugar (55.07%) was recorded in treatment $T_6$ (50:50::AP:BP). The mean total sugar (Table 3) increased from

55.76 to 58.78% during 6 months of storage. Bishnoi, (2015) also reported an increase in total sugars of aonla spread variants because of moisture loss from the products, inversion of sugars and acid hydrolysis of pectic substances and starch into simple sugars. Similar outcomes have been documented by Kaur & Singh, (2016) and Sharma, (2022).

## 3.6 Titratable Acidity

It was apparent from Table 4 that treatment exerted a considerable effect on the titratable acidity of blended spread. The highest and lowest treatment mean titratable acidity of 0.597% and 0.556% were found in $T_1$ (100:00::AP:BP) and $T_6$ (50:50::AP:BP), respectively. The lowest mean titratable acidity of 0.500% was recorded at initial month of storage whereas highest value of 0.648% was recorded after storage period of 6 months. The increase in titratable acidity during storage might be assigned to the inter-conversion of sugars that result in the formation of acids, conversion of proteins to amino-acids and degradation of polyphenols (Munaza, 2018). Conversely, comparable results have been determined by Meera, (2019) in sweet avocado fruit spread and Sharma, (2020) in aloe-vera fortified low calorie functional apple spread.

## 3.7 Microbial Load

Initially no microbial growth (Table 4) was observed upto 2nd months of storage at ambient conditions, but after 6 months of storage, highest microbial count of $0.71\times10^4$cfu/g was observed in treatment $T_1$ (100:00::AP:BP) while the lowest microbial growth of $0.55\times10^4$cfu/g was recorded in $T_6$ (50:50::AP:BP). The high TSS in blended spread might have created high osmotic pressure and low water activity, thereby limiting the microbial load (Hameed, 2021). However, the blended spread showed acceptable limit with respect to bacterial count upto their respective storage period ($10^6$cfu/g) (FSSAI, 2011). Sutwal et al., (2019), Chaurasiya et al., (2014) and Bishnoi, (2015) also reported an increase in the bacterial count during storage of apple spread, palm spread and aonla spread, respectively.

## 3.8 Colour

The maximum and minimum mean value of colour score (Fig. 1a) of 7.93 and 7.13 were recorded in $T_5$ (60:40::AP:BP) and $T_1$ (100:00::AP:BP), respectively. Significant decrease in colour score was observed from 8.17 to 6.83 with the progress in storage period in the blended spread. Although, browning might be attributed to copolymerization of organic acids, enzymatic oxidation of polyphenols and non-enzymatic oxidation of vitamin C. Identical results have been documented by Gaikwad, (2016) and Ullah et al., (2018) in sapota-beetroot blended jelly and in carrot-apple blended jam, respectively.

## 3.9 Texture

The maximum mean texture score (Fig. 1b) was recorded in $T_5$ (60:40::AP:BP) with score of 7.87 and the minimum mean score of 7.24 was recorded in $T_1$ (100:00::AP:BP). The texture scores decreased with the progression of storage period from 8.03 to 7.06 which might be due to loss of moisture, breakdown of complex metabolites into simpler ones and degradation of cell wall and middle lamella by enzymes such as β-galactosidase, pectin methylesterase and polygalacturonase. Our results are in conformity with the results discussed by Hameed, (2021) in jamun-bael spread and Sharma, (2022) in kiwi spread.

**Table 1. Physico-chemical composition of raw materials**

| Parameters | Apple Pulp | Beetroot Pulp |
|---|---|---|
| Moisture (%) | 86.35 | 85.91 |
| Water activity ($a_w$) | 0.971 | 0.953 |
| TSS (°Brix) | 14.59 | 10.37 |
| Titratable acidity (%) | 0.383 | 0.228 |
| Reducing sugar (%) | 8.27 | 5.85 |
| Total sugar (%) | 11.81 | 7.04 |
| Calcium (mg/100g) | 81.20 | 13.98 |
| Phosphorous(mg/100g) | 0.71 | 39.74 |

**Table 2. Effect of treatment and storage period on moisture content (%) and TSS (°Brix) of apple-beetroot blended spread**

| Treatment | Moisture content (%) | | | | Mean (Treatment) | TSS (°Brix) | | | | Mean (Treatment) |
|---|---|---|---|---|---|---|---|---|---|---|
| | Storage period (Months) | | | | | Storage period (Months) | | | | |
| | **0** | **2** | **4** | **6** | | **0** | **2** | **4** | **6** | |
| **$T_1$ (100:00::AP:BP)** | 26.75 | 25.12 | 23.05 | 21.11 | **24.01** | 60.00 | 61.31 | 62.59 | 63.60 | **61.88** |
| **$T_2$ (90:10::AP:BP)** | 25.83 | 24.20 | 22.28 | 20.36 | **23.17** | 60.00 | 61.26 | 62.52 | 63.54 | **61.83** |
| **$T_3$ (80:20::AP:BP)** | 25.17 | 23.45 | 21.61 | 20.17 | **22.60** | 60.00 | 61.20 | 62.45 | 63.46 | **61.78** |
| **$T_4$ (70:30::AP:BP)** | 24.58 | 22.84 | 21.03 | 19.64 | **22.02** | 60.00 | 61.17 | 62.41 | 63.39 | **61.74** |
| **$T_5$ (60:40::AP:BP)** | 24.04 | 22.31 | 20.60 | 19.35 | **21.58** | 60.00 | 61.12 | 62.36 | 63.37 | **61.71** |
| **$T_6$ (50:50::AP:BP)** | 23.42 | 21.59 | 19.92 | 18.13 | **20.76** | 60.00 | 61.08 | 62.23 | 63.25 | **61.64** |
| **Mean (Storage)** | **24.97** | **23.25** | **21.41** | **19.79** | | **60.00** | **61.19** | **62.43** | **63.44** | |
| **Effects** | **C.D. ($p \leq 0.05$)** | | | **C.D. ($p \leq 0.05$)** | | AP | Apple Pulp | | | |
| Treatment (T) | 0.14 | | | 0.05 | | BP | Beetroot Pulp | | | |
| Storage (S) | 0.17 | | | 0.07 | | | | | | |
| T × S | 0.34 | | | 0.13 | | | | | | |

**Table 3. Effect of treatment and storage period on reducing sugar (%) and total sugar (%) of apple-beetroot blended spread**

| Treatment | Reducing sugar (%) | | | | Mean (Treatment) | Total sugar (%) | | | | Mean (Treatment) |
|---|---|---|---|---|---|---|---|---|---|---|
| | Storage period (Months) | | | | | Storage period (Months) | | | | |
| | **0** | **2** | **4** | **6** | | **0** | **2** | **4** | **6** | |
| **$T_1$ (100:00::AP:BP)** | 25.17 | 26.33 | 27.61 | 28.96 | **27.02** | 58.09 | 59.02 | 60.10 | 61.14 | **59.59** |
| **$T_2$ (90:10::AP:BP)** | 24.84 | 26.06 | 27.38 | 28.72 | **26.75** | 57.14 | 58.07 | 59.13 | 60.12 | **58.61** |
| **$T_3$ (80:20::AP:BP)** | 24.49 | 25.64 | 26.92 | 28.37 | **26.36** | 56.21 | 57.16 | 58.15 | 59.20 | **57.68** |
| **$T_4$ (70:30::AP:BP)** | 24.16 | 25.33 | 26.65 | 28.01 | **26.04** | 55.25 | 56.18 | 57.23 | 58.27 | **56.73** |
| **$T_5$ (60:40::AP:BP)** | 23.72 | 24.90 | 26.17 | 27.54 | **25.58** | 54.33 | 55.21 | 56.24 | 57.35 | **55.78** |
| **$T_6$ (50:50::AP:BP)** | 23.44 | 24.61 | 25.93 | 27.29 | **25.32** | 53.57 | 54.53 | 55.57 | 56.61 | **55.07** |
| **Mean (Storage)** | **24.30** | **25.48** | **26.78** | **28.15** | | **55.76** | **56.70** | **57.74** | **58.78** | |
| **Effects** | **C.D. ($p \leq 0.05$)** | | | **C.D. ($p \leq 0.05$)** | | AP | Apple Pulp | | | |
| Treatment (T) | 0.02 | | | 0.05 | | BP | Beetroot Pulp | | | |
| Storage (S) | 0.03 | | | 0.06 | | | | | | |
| T × S | 0.05 | | | 0.11 | | | | | | |

**Table 4. Effect of treatment and storage period on titratable acidity (%) and total plate count ($\times10^4$cfu/g) of apple-beetroot blended spread**

| Treatment | Titratable acidity (%) | | | | Mean (Treatment) | Total plate count ($\times10^4$cfu/g) | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Storage period (Months) | | | | | Storage period (Months) | | | |
| | **0** | **2** | **4** | **6** | | **0** | **2** | **4** | **6** |
| **$T_1$ (100:00::AP:BP)** | 0.500 | 0.568 | 0.632 | 0.689 | **0.597** | ND | ND | 0.46 | 0.71 |
| **$T_2$ (90:10::AP:BP)** | 0.500 | 0.557 | 0.616 | 0.671 | **0.586** | ND | ND | 0.42 | 0.68 |
| **$T_3$ (80:20::AP:BP)** | 0.500 | 0.550 | 0.609 | 0.656 | **0.579** | ND | ND | 0.39 | 0.64 |
| **$T_4$ (70:30::AP:BP)** | 0.500 | 0.542 | 0.597 | 0.633 | **0.568** | ND | ND | 0.35 | 0.62 |
| **$T_5$ (60:40::AP:BP)** | 0.500 | 0.535 | 0.591 | 0.628 | **0.563** | ND | ND | 0.30 | 0.58 |
| **$T_6$ (50:50::AP:BP)** | 0.500 | 0.527 | 0.584 | 0.612 | **0.556** | ND | ND | 0.27 | 0.55 |
| **Mean (Storage)** | **0.500** | **0.547** | **0.605** | **0.648** | | | | **0.37** | **0.63** |
| **Effects** | | | **C.D.** $_{(p\leq0.05)}$ | | | | | AP | Apple Pulp |
| Treatment (T) | | | 0.009 | | | | | BP | Beetroot Pulp |
| Storage (S) | | | 0.011 | | | | | ND | Not Detected |
| T $\times$ S | | | 0.022 | | | | | | |

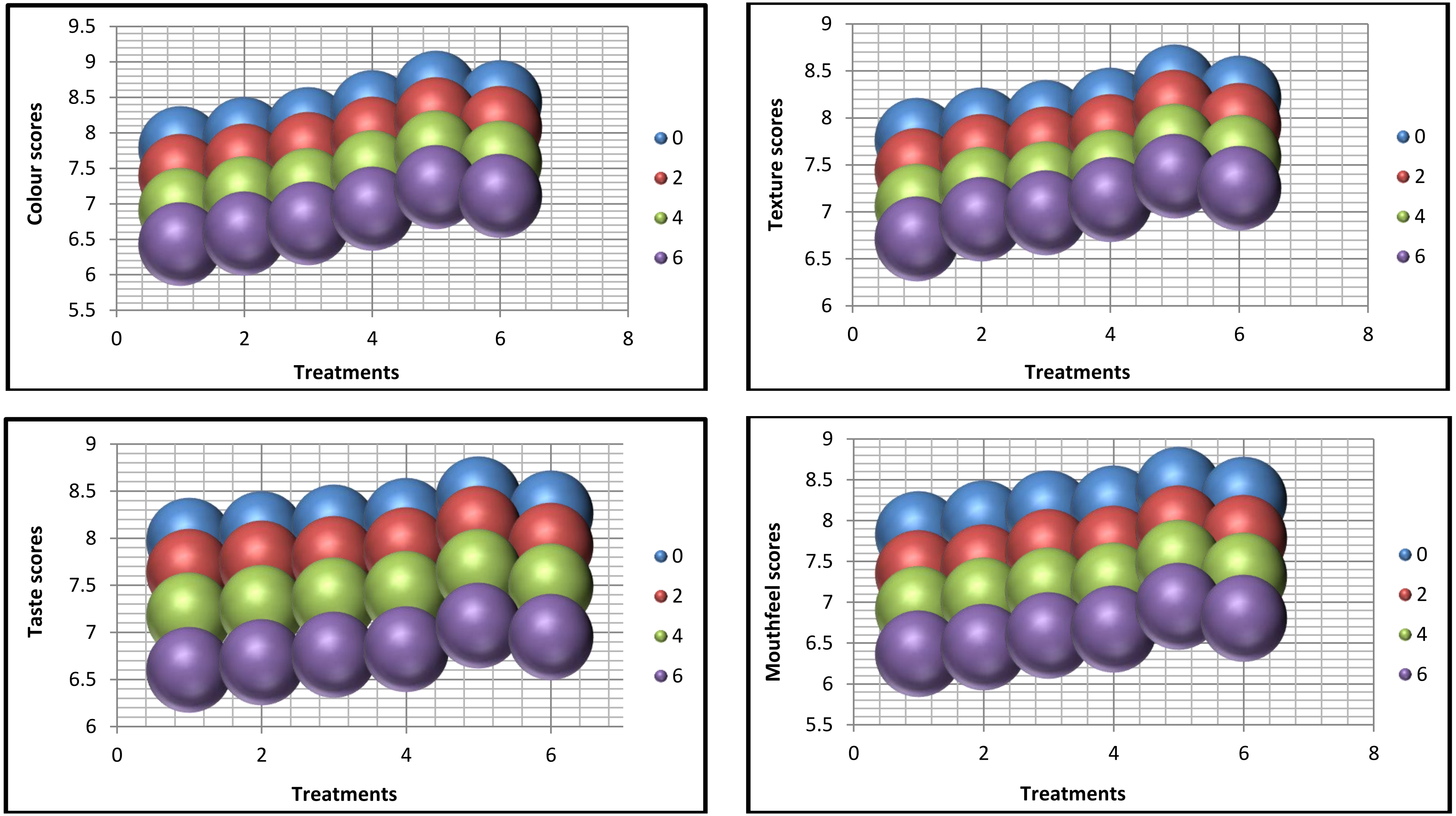


**Fig. 1. Effect of treatment and storage period on a) colour b) texture c) taste and d) mouthfeel (hedonic score) of apple-beetroot blended spread**

### 3.10 Taste

The maximum and minimum mean value of taste score was recorded in $T_5$ (60:40::AP:BP) as 7.80 and $T_1$ (100:00::AP:BP) as 7.35, respectively. Significant decrease in taste score (Fig. 1c) from 8.16 to 6.81 was observed with progress in storage period of the blended spread. The decrease in taste scores during storage might be due to the some chemical changes such as break down of complex metabolites into simpler one leading to volatilization of flavouring components, which might affect taste perception. Similar decrease in taste score was also reported by Kumari, (2012) in kainth spread and Gupta, (2019) in Karonda-beetroot RTS. Bishnoi, (2015) who evaluated the quality of spread prepared from aonla during storage of six months and Hameed, (2021) who worked on quality assessment of jamun and bael blended spread for six months of storage period also recorded similar results.

### 3.11 Mouthfeel

It was evident from Fig. 1d that the maximum mean value of mouthfeel score was recorded in $T_5$ (60:40::AP:BP) with value of 7.68 and the minimum mean value of 7.11 was recorded in $T_1$ (100:00::AP:BP). Significant decrease in mean mouthfeel score in blended spread from 8.10 to 6.64 was experienced during storage period of six months. The decline in mouthfeel scores might be due to moisture loss and some chemical changes in the product during storage under ambient conditions. Bishnoi, (2015) and Hameed, (2021) also reported similar scores in aonla spread and ladoo and in jamun-bael spread, respectively during their entire storage.

## 4. CONCLUSION

The apple-beetroot blended spread is ideal for consumer usage since it exhibits an appropriate balance of favourable physico-chemical qualities, such as moisture content, total soluble solids, titratable acidity, total sugar and reducing sugars. The addition of beetroot pulp to the apple spread subsequently reduced its acidity, sugar concentration and moisture content. The sensory results showed that the treatment $T_5$ (60:40:: AP:BP) had highly acceptable mean scores for colour (7.93), texture (7.87), taste (7.80) and mouthfeel (7.68). Therefore, to develop a high-quality spread, 60% apple pulp and 40% beetroot pulp is an ideal combination. Due to the low rate of microbial load in the apple-beetroot blended spread, stable properties were observed upon storage of six months. Thus, the findings imply that the apple-beetroot spread is a viable substitute in the market for functional foods in addition to being nutritionally beneficial.

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Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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