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Sustainable Packaging Strategies and Temperature Influence on the Shelf Stability of Chicken Barfi

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ABSTRACT

Barfi is a popular traditional dessert from the subcontinent, made primarily from milk concentrate and sugar and consumed by people of all ages. To develop a nutritionally dense alternative, chicken meat was mixed with khoa, sugar, butter oil, and coconut, and the shelf life of this newly produced chicken barfi was examined under various packing and storage settings. The aim was to assess physicochemical, microbiological, and sensory changes during storage as well as identify the best packaging for long-term preservation. They were stored at 4 and 30 °C. The samples were placed in vacuum-sealed zipper bags (T_3), cardboard boxes (T_2), plastic boxes (T_1), and metal boxes (T_4). The control was khoa barfi (T0). Proximate analysis showed significant ($P<0.05$) differences: T_1 had the highest moisture content (33.45±0.33%) and T_3 had the lowest peroxide value (1.37±0.01 meq/kg fat), while T_1 had the best retention of protein and fat (13.79±0.14% and 27.39±0.42%). Microbial counts increased during storage, however vacuum packaging (T_3) significantly inhibited E. coli and Salmonella. Total plate count remained lower in T_1 and T_3 compared to the control. Sensory study revealed a gradual decline in all treatments, although barfi preserved in plastic and vacuum packs still had higher acceptance scores for color, taste, flavor, and overall acceptability despite 40 days of refrigeration. Overall, packaging type and storage temperature significantly influenced the quality and stability of chicken barfi during storage. These results indicate the commercial potential of chicken barfi as a nutritious and consumer-acceptable food with an extended shelf life.

INTRODUCTION

Milk-based sweets play a major role in the food and culture of Pakistan and other South Asian countries, where they are consumed on special occasions, social events, and even as part of daily meals. Some of traditional products include barfi, gulab jamun, jalebi, kheer, kulfi, laddu, rasgulla, *etc.* (Arora *et al.,* 2010). Over time, production has developed from household production to an organized dairy sector, providing these sweets with both cultural and commercial importance (Menefee & Overman, 1940). The majority of sweets in Pakistan, is made by traditional halwais in unsanitary and unhygienic conditions, which not only affects quality but also contributes to short shelf life. These challenges emphasize the need for nutritional enhancements as well as effective preservation measures to improve quality and market potential (Sarkar *et al.,* 2002; Ramanna *et al.,* 1983).

Barfi is a popular traditional milk-based dessert. Barfi comes in a wide range of varieties, such as peanut barfi, coconut barfi, pista barfi, kaju barfi, and besan barfi (made from chickpea flour) (Gupta *et al.,* 2010; Khan *et al.,* 2008). The essential ingredients are khoa (milk concentrate) and sugar, although tastes like cardamom, rose water, cocoa powder, and dry fruits are frequently added (Sakate *et al.,* 2004). Traditionally, barfi is covered with silver foil (verk) or coated with nuts to provide it a festive appearance (Chetna *et al.,* 2010).

One main drawback of barfi is its limited shelf life. During storage, barfi undergoes physicochemical and microbiological changes such as surface drying, texture hardening, browning, sugar crystallization, and mold growth, most of which reduce customer acceptance. Packaging is crucial for increasing the shelf life of such products, however traditional packaging materials such as paperboard or cardboard boxes do not provide appropriate protection against moisture loss and microbiological contamination (Garg & Mandokhot, 1984). Advanced packaging materials like vacuum packaging, high-barrier pouches, and multilayer films have all been

recognized for their ability to improve shelf stability in dairy products (Jha *et al.,* 2015).

Consumer demand for healthy and nutritious foods encouraged improvements in traditional dairy products. Functional foods are those that provide health advantages in addition to basic nutrition and are commonly fortified with bioactive components such as proteins, vitamins, and minerals (Axten *et al.,* 2008). Adding animal protein to milk-based confections is a new strategy to increase their nutritional content. Chicken meat, which is widely consumed poultry globally, contains high-quality protein, vital amino acids, phosphorus, magnesium, and vitamins B-complex and D. It also promotes muscle growth, weight control, bone health, and immunological function. However, products made from chicken have a short shelf life of 14 to 15 days when refrigerated, making them highly perishable. Increasing the shelf life of such products requires optimal packaging and controlled storage conditions (Zaheer, 2015).

This study focuses on the production of chicken barfi, which combines traditional dairy ingredients with poultry meat to increase its nutritional content. The product's physicochemical and sensory qualities were assessed, and various packaging materials and storage temperatures were tested to see how they affected quality, microbiological stability, and shelf life. The results are expected to provide scientific suggestions for better preservation of traditional sweets. Such developments may also help to commercialize barfi by increasing its market range and consumer acceptance.

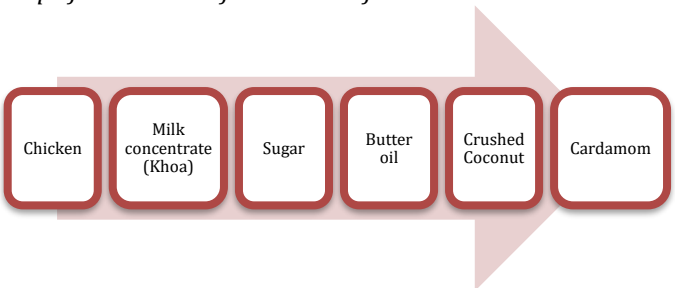
MATERIALS AND METHODS

Procurement of Raw Material

All the items for the formulation of chicken barfi were bought from the local market of Faisalabad. Nutrient agar, MacConkey agar, and Salmonella agar obtained from Food Microbiology and Biotechnology Laboratory at the National Institute of Food Science and Technology (NIFSAT), University of Agriculture, Faisalabad. Packaging materials were bought from the local market of Faisalabad.

Figure 1

Recipe formulation of chicken barfi



Preparation of Chicken Barfi

The required amount of butter oil was poured into the pan and heated until the desired temperature reaches, then cardamom powder was added for flavoring purposes. Then the required amount of milk concentrate was added and cooked until it turns light brown. After that, sugar was added, and boiled chicken, chopped dates, and little amount of crushed coconut was also added and mixed well until the desired results were obtained (Arora *et al.,* 2010). The mixture was hot and poured into pan or trays and cooled until it attains desired consistency. When it is cooled, then the mass was cut into the desired shapes and sizes (Arora *et al.,* 2007).

Packaging

The freshly prepared chicken barfi was cut into 5×5×1.5 cm pieces and packed in four distinct packaging materials: cardboard box, plastic box, metal box, and vacuum-sealed zipper pouch. The vacuum packaging was done at 0.70 kPa using a chamber machine. A local barfi made from 100% milk concentrate was utilized as a control sample for comparison.

Figure 2

Flow diagram of preparation of chicken barfi

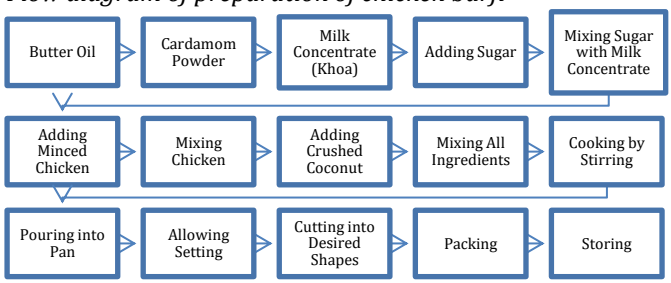


Table 1

Treatment Plan for the development of chicken barfi and packaging conditions

Treatments	Khoa: Chicken	Packaging Materials
T_0	100% (Khoa)	Cardboard
T1	20:80	Plastic Box Packaging
T_2	20:80	Cardboard Box Packaging
T_3	20:80	Vacuum Packaging
T_4	20:80	Metal Box Packaging

Proximate Analysis of Chicken Barfi

Crude Protein Content

The protocol described in the Kjeldahl method (AOAC 930.33) was followed to determine the protein contents in chicken barfi (AOAC, 2019). 2 g of shredded chicken barfi sample was taken in digestion flask with 30 mL concentrated sulphuric acid and catalyst mixture (K_2SO_4 100 g + $CuSO_4$ 10 g + $FeSO_4$ 5 g). Digestion was continued under fume hood until solution turned light green. After cooling, the digestion was diluted to 150 mL with distilled water. The digestion flask was rinsed 2 to 3 times for the complete removal of a digested sample. The distillate was titrated against 0.1N H_2SO_4. The following formula was used to determine the nitrogen content.

$$\text{Nitrogen (\%)} = \frac{\text{Volume of 0.1N suphuric acid used} \times 0.0014 \times 250}{\text{Sample weight} \times \text{Aliquot volume}} \times 100$$

% Protein = % Nitrogen x 6.25

Crude Fat Content

The total fat content of chicken barfi was determined using the Soxhlet extraction method. A 3 g sample was covered in filter paper to make a thimble, and the initial weight was recorded. The thimble was placed in a Soxhlet extractor equipped with a round-bottom flask containing n-hexane as a solvent. The solvent was heated with an isomantle, condensed, and washed over the sample 3-4 times until the fat was completely extracted. After extraction, the thimble was removed, dried in the oven for 10-15 minutes, and weighed again to measure crude fat concentration (AOAC, 2019).

$$\text{Crude fat (\%)} = \frac{\text{Weight of hexane extract (g)}}{\text{Sample weight (g)}} \times 100$$

Moisture Content

The moisture determination method (AOAC 950.46) was used to calculate the total moisture content in chicken barfi (AOAC, 2019). 5 g shredded chicken barfi sample was taken in china dish and weighed. It was then placed in the oven at 105 °C. After 3 to 4 hours, the dried sample was placed in a desiccator to cool down. After cooling, moisture content was calculated.

$$\text{Moisture (\%)} = \frac{\text{Fresh sample weight (g)-Dried sample weight (g)}}{\text{Fresh sample weight}} \times 100$$

Ash Content

The ash content of chicken barfi was determined using muffle furnace (AOAC, 2019). The ash content was tested in a muffle furnace. A 5 g sample of shredded chicken barfi was weighed into a crucible. The crucibles were then heated in a hot air oven at 105 °C for 1 hour. The samples in the crucible were heated to 550 °C for 5 to 6 hours in a muffle furnace, until the samples turned white or light grey. Then it was weighed after cooling in the desiccator. The ash was measured using the following formula.

$$\text{Ash (\%)} = \frac{\text{Weight of ash (g)}}{\text{Weight of sample (g)}} \times 100$$

Physicochemical Analysis

pH

The pH of chicken barfi was determined according to the AOAC method 973.41 (AOAC, 2019). A slurry was prepared by mixing 2 g of minced chicken barfi with 50 mL of distilled water. The pH meter was calibrated using standard buffer solutions of pH 4.0 and 7.0 before measurement. The electrode was rinsed with distilled water and then immersed in the sample slurry, and pH readings were recorded in triplicate at 28-30 °C.

Peroxide Value

The peroxide value of chicken barfi was determined by the iodometric method according to the AOAC 965.33 (AOAC, 2019). 80-100 mL of chloroform was used to extract a 30 g sample, and then allowed to stand for 4-5 hours with intermittent shaking and filtered using Whatman No. 1 paper. Fat was obtained by evaporating the filtrate in a vacuum oven. A 100 mL conical flask containing 1 gram of extracted fat, 0.1 g of potassium iodide, and 20 mL of a solvent mixture (glacial acetic acid: chloroform, 2:1 v/v) were combined and heated gradually. The mixture was then cooled and transferred into a 250 mL flask with 30 mL of distilled water and 20 mL of a 5% potassium iodide solution. As an indicator, a 1% starch solution was used to titrate the released iodine using 0.002 N sodium thiosulphate. Under the same conditions, a fat-free blank was created.

$$\text{Peroxide Value (meq } O_2\text{/kg fat)} = \frac{2 \times \text{mL of 0.002 N } Na_2S_2O_3 \text{ used}}{\text{Weight of fat (g)}}$$

Microbial Analysis

Total Plate Count

The microbial growth is the most important factor for spoilage of chicken barfi and other dairy products.

Sample Preparation for TPC

To dilute the sample, sodium chloride peptone buffer solution was used for the test. A 10 g sample of chicken barfi was taken and mixed well with peptone water with the help of a stomacher at 300 rpm for 30 to 60 s. This blend was used as a research fluid. This research fluid was used within one hour of preparation (Prijana *et al.,* 2016; Warren *et al.,* 2006).

Media Preparation

A conical flask was taken and nutrient agar 28 g/1,000 mL added with distilled water and mixed well. Then another flask was taken for saline solution, 8.5 g salt, and 1 liter of distilled water was added and mixed. Again, another flask for peptone water was taken, and 28 g of powder with 1 liter of distilled water was added and mixed well. Washed test tubes were taken as per requirements. All the material was autoclaved at 121 °C at 15 psi for 15 minutes (Prijana *et al.,* 2016).

Pour Plate Method

Nine test tubes were taken, two test tubes for each treatment to dilute the sample. 0.1 mL of the prepared sample was taken and added in the 1st test tube, then 0.1 mL of the diluted sample was taken from the 1st test tube and added in the 2nd test tube and so on. Petri plates of diameter 9 to 10 cm were used. 18 petri plates were used for each treatment as for test tubes. Sterilized nutrient agar media was added in each plate as a medium and allowed to solidify at 45 °C. 0.1 mL of the diluted sample was taken from the 1st test tube and poured in Petri plate number 01, and then the sample was taken from the 2nd test tube and poured in the 2nd Petri plate and so on. The Petri plates were then inverted and put for 24 to 48 hours in an incubator (Prijana *et al.,* 2016; Warren *et al.,* 2006).

Colony Counting

Then colonies were counted through colony counter present in the laboratory after incubation. Colonies in the range of 30-300 were considered and multiplied by the dilution factor. The statistical average was counted as a cumulative count of plate per gram.

Total Coliform Count

For this purpose, the number of coliforms was used to indicate the micro-organism content of the product (Karthikeyan & Pandiyan, 2013).

Preparation of Normal Saline Solution

A normal saline solution was prepared with 8.5 g/L (sodium chloride) to dilute the sample.

Media preparation

Escherichia Coli

A conical flask was taken, and MacConkey agar 46.4 g/1,000 mL was added with distilled water and mixed well. Then another flask was taken for saline solution, 8.5 g salt, and 1 liter of distilled water was added and mixed. Again, another flask for peptone water was taken, and 28 g of powder with 1 liter of distilled water was added and mixed well. Washed test tubes were taken as per requirements. All the material was autoclaved at 121 °C at 15 psi for 15 minutes (Cheesbrough, 2002).

Salmonella

A conical flask was taken, and *Salmonella shigella* agar (specific medium) 63 g/1,000 mL was added with

distilled water and mixed well. Then another flask was taken for saline solution, 8.5 g salt, and one liter of distilled water was added and mixed. Again, another flask for peptone water was taken, and 28 g of powder with one liter of distilled water was added and mixed well. Washed test tubes were taken as per requirements. All the material was autoclaved at 121 °C at 15 psi for 15 minutes (Basu *et al.,* 2015).

Sample Preparation for Salmonella

The autoclaved test tubes were withdrawn, and 10^{-1} and 10^{-2} were named. Each test tube was fed 9 mL of the normal saline solution. On the first test tube, 0.1 mL of the homogenized sample was applied, and gentle agitation mixed the contents well. The sample was then transferred, and thoroughly mixed, from the 1st test tube to the 2nd. Also, other serial dilutions were carried out according to the above procedure. The dilutions had been as follows:

Pouring the plate

Diluted 0.1 mL sample was drawn from each tube and distributed on the top of the MacConkey agar medium. Then the Petri plates were incubated for 24-48 hours at 37-40 °C (Cheesbrough, 2002; Basu *et al.,* 2015).

Colony Counting

Then colonies were counted through colony counter present in the laboratory after incubation. Colonies in the range of 30-300 were considered and multiplied by the dilution factor. The statistical average was counted as a cumulative count of plate per gram.

$$\text{Total Plate Count (cfu/g)} = \frac{\text{Colonies per plate} \times \text{Dilution number}}{\text{Dilution factor} \times \text{Volume plated}}$$

Shelf-life Study

The shelf life of chicken barfi was studied in different packaging materials under different temperatures. The packaging materials used were cardboard boxes, plastic boxes, zipper bags for vacuum packaging, and tin/metal containers. Chicken barfi samples were placed in these packaging materials, with some stored at room temperature and others stored in a refrigerator at 4±1 °C. At 10-day intervals, the samples were assessed to evaluate the shelf life at both room and refrigerated temperatures. Storage was stopped when yeast and mold growth produced surface deterioration. All the readings of the analyses performed to study shelf life were recorded for statistical evaluation.

Sensory Evaluation

The sensory evaluation of chicken barfi was conducted by a panel of ten employee judges from the National Institute of Food Science and Technology, University of Agriculture, Faisalabad, using a 9-point hedonic scale (Appendix-1). Samples were served in boxes marked with a three-digit number. Chicken barfi evaluation was performed every 10th day for different sensory attributes such as odour, colour, texture, appearance, taste, flavour, and overall acceptability, following the proforma of the 9-point hedonic scale given to the panellists for recording scores (Nicolas *et al.,* 2010).

Statistical Analysis

The data was analyzed statistically for the determination of the level of significance. All the treatments were conducted in triplicates and the mean values of the treatments were obtained to determine the standard deviation. Statistical analysis was performed using Statistix version 8.1. The variance analysis (ANOVA) was applied to get significant differences (Montgomery, 2017).

RESULTS AND DISCUSSION

The research was carried out to assess the growth and storage behavior of chicken barfi utilizing various packing materials under both ambient and refrigerated circumstances. Physicochemical, microbiological, and sensory studies were performed on fresh samples at set intervals to observe quality changes over time. The results indicated that packaging type and temperature have a significant impact on the shelf life of chicken barfi, with significant variations in moisture, fat, protein, ash, pH, and peroxide levels during storage. Microbial load gradually increased, whereas sensory scores decreased over time, especially at room temperature. On the other hand, effective preservation occurred through refrigeration and appropriate packing, particularly vacuum sealing and plastic boxes.

Proximate Analysis of Chicken Barfi

Crude Protein

Protein content differed significantly ($P<0.05$) across treatments and storage intervals as shown in Table 2. At day 0, T_0 (control) recorded 10.61±0.11%, while T_2 (cardboard) showed the highest, 13.89±0.14%. At the 20th day, T1 (plastic) and T_2 were statistically non-significant ($P>0.05$), but differed from T_0, T_3 (vacuum), and T4 (metal). By day 30, all treatments were highly significant, whereas at day 40, T_0, T_3, and T_4 became non-significant with each other, with T1 (13.79±0.14%) retaining the maximum protein.

According to a study the protein content in sapota pulp burfi ranged between 14.04% and 12.19% (Wakchaure, 1998). Another study reported the impact of pineapple pulp on the sensory and chemical compositions of burfi and the protein content observed from 14.91% to 12.10%. (Kamble *et al.,* 2010). Navale *et al*. (2014) have recorded a substantial decrease in the protein content of the wood apple burfi from 13.52%, 14.35%, and 14.88% in T1, T_2, and T_3, respectively.

Table 2

Means for protein content of chicken barfi

Treatments	Storage Days				
	0	10	20	30	40
T_0	10.61±0.11^{jk}	10.7±0.11^{j}	10.53±0.11^{jk}	10.47±0.1^{kl}	10.39±0.1^{l}
T1	13.85±0.14^{a}	12.89±0.13^{d}	12.78±0.13^{de}	12.37±0.12^{gh}	13.79±0.14^{ab}
T_2	13.89±0.14^{a}	12.35±0.12^{gh}	12.75±0.13^{de}	12.47±0.12^{fg}	13.12±0.13^{c}
T_3	12.46±0.12^{fg}	13.87±0.14^{a}	13.25±0.13^{c}	12.19±0.12^{hi}	12.37±0.12^{gh}
T_4	12.39±0.12^{gh}	12.12±0.12^{i}	12.31±0.12^{gh}	13.6±0.14^{b}	12.6±0.13^{ef}

Fat Content

Fat content showed significant changes (P<0.05) during storage. The mean values are given in Table 3. Initially, T_3 (vacuum) contained the highest fat (37.70±0.38%), and T_0 (control) the lowest (27.48±0.27%). By the 20th day, treatments remained significantly different, while at day 30, T1 and T_2 became non-significant. At the end of storage, T_0, T_3, and T_4 were non-significant (P>0.05) with each other, whereas T1 (plastic) maintained the highest fat at 27.39±0.42%, showing better stability.

The fat content slightly decreases in all the treatments from 0 day storage period to the end of the storage period. Statistically, the difference was highly significant. The results are in accordance with the results reported by (Shrivas *et al.,* 2018; Reddy *et al.,* 1985). Ripnar (2015) reported a slight decrease in fat content in his findings.

Table 3

Means for fat content of chicken barfi

Treatments	Storage Days				
	0	10	20	30	40
T_0	27.48±0.27^{e}	25.82±0.26^{g}	23.89±0.24^{j}	25.67±0.26^{g}	25.39±0.25^{gh}
T1	34.75±0.35^{d}	21.85±0.2^{m}	25.08±0.25^{h}	21.52±0.22^{mn}	27.39±0.42^{e}
T_2	35.45±0.35^{c}	22.46±0.22^{l}	25.15±0.25^{h}	22.39±0.22^{l}	26.66±0.27^{f}
T_3	37.7±0.38^{a}	23.26±0.23^{k}	24.35±0.24^{i}	21.17±0.21^{n}	25.65±0.26^{g}
T_4	36.39±0.36^{b}	23.92±0.24^{ij}	26.33±0.26^{fk}	22.98±0.23^{k}	25.74±0.26^{g}

Moisture Content

Moisture content varied significantly (P<0.05) among treatments and storage days as shown in mean Table 4. The lowest values were recorded in T_0 (control, 15.35±0.15%), while the maximum was in T_3 (vacuum, 33.76±0.34%) at day 0. Moisture decreased slightly in the control (ending at 14.44±0.14%), whereas plastic and vacuum packs showed minor increases, with T_1 (33.45±0.33%) and T_3 (33.42±0.33%) retaining higher levels by day 40. At 20th day, T_1 and T_2 were non-significant; at 30th day, all treatments were highly significant.

The moisture content slightly decreases in T_0 and increase in other treatments T_1, T_2, T_3, and T_4. Previously, Vijayalakshmi *et al.* (2005) reported a slight decrease in moisture content in his findings. An increase in the moisture content of chicken barfi during storage were in accordance with findings of research workers from the subcontinent (Kamble *et al.,* 2010; Navale *et al.,* 2014).

Table 4

Means for moisture content of chicken barfi

Treatments	Storage Days				
	0	10	20	30	40
T_0	15.35±0.15^{h}	15.62±0.16^{h}	15.55±0.16^{h}	14.84±0.15^{i}	14.44±0.14^{i}
T_1	32.38±0.32^{de}	33.02±0.33^{bc}	33.49±0.33^{ab}	33.45±0.33^{ab}	33.45±0.33^{ab}
T_2	31.33±0.31^{g}	32.52±0.33^{d}	32.72±0.33^{cd}	32.47±0.32^{d}	32.48±0.32^{d}
T_3	32.32±0.32^{de}	33.76±0.34^{a}	33.44±0.33^{ab}	33.46±0.33^{ab}	33.42±0.33^{ab}
T_4	32.33±0.32^{de}	32.72±0.33^{cd}	32.69±0.33^{cd}	31.93±0.32^{ef}	31.76±0.32^{fg}

Ash Content

Ash content mean values are given in Table 5. Ash showed significant (P<0.05) differences due to packaging and storage. At day 0, T_0 had the lowest, 2.22±0.04%, while T_4 (metal) recorded 2.70±0.05%. A gradual increase was observed in metal packaging, reaching 2.91±0.06% at day 40. In contrast, plastic, cardboard, and vacuum treatments showed slight decreases, while the control increased modestly to 2.32±0.05%. During the 20th day, T_1 and T_2 were non-significant, but by day 30 all treatments were significantly different.

The ash content slightly increases in T_0 and decrease in other treatments T_1, T_2, T_3, whereas ash content increase for treatment T_4 at the end of the storage period. Statistically, the difference was highly significant. Bankar *et al.* (2013) reported a slight decrease in ash content in his findings. An increase in the ash content of chicken barfi during storage was in accordance with the findings of Kamble *et al.* (2010), Khan *et al*. (2008), Shrivas *et al.* (2018).

Table 5

Means for ash content of chicken barfi

Treatments	Storage Days				
	0	10	20	30	40
T_0	2.22±0.04^{g}	2.27±0.05^{fg}	2.26±0.05^{fg}	2.29±0.05^{f}	2.32±0.05^{f}
T_1	2.86±0.04^{b-e}	2.84±0.04^{c-e}	2.85±0.03^{b-e}	2.88±0.06^{a-d}	2.85±0.04^{b-e}
T_2	2.86±0.03^{b-e}	2.89±0.04^{a-c}	2.81±0.03^{e}	2.85±0.03^{b-e}	2.85±0.06^{b-e}
T_3	2.85±0.04^{b-e}	2.82±0.03^{de}	2.86±0.03^{b-e}	2.82±0.03^{de}	2.84±0.03^{c-e}
T_4	2.82±0.03^{de}	2.87±0.03^{a-e}	2.9±0.04^{a-c}	2.93±0.03^{a}	2.91±0.06^{ab}

Physicochemical Analysis of Chicken Barfi

pH

pH values differed significantly (P<0.05) among treatments and storage intervals and mean values are shown in Table 6. The highest pH was recorded in T_4 (metal, 6.72±0.07), while the lowest was in T_2 (cardboard, 6.32±0.06) at day 40. Overall, pH declined across storage in most treatments, though metal maintained more stability. On the 20th day, T_1 and T_2 were non-significant, while by day 30, treatments differed significantly. At the

final day, T_0, T_3, and T_4 became non-significant with each other.

The pH slightly decreases in all the treatments from 0 day storage period to the end of the storage period. Statistically, the difference was highly significant. Chawla *et al*. (2015) reported the same decreasing trend in his research work.

Table 6

Means for pH of chicken barfi

Treatments	Storage Days				
	0	10	20	30	40
T_0	6.62±0.07^{a-c}	6.72±0.07^{a}	6.53±0.07^{c-e}	6.46±0.06^{d-g}	6.37±0.06^{gh}
T_1	6.5±0.07^{d-f}	6.49±0.06^{d-f}	6.55±0.07^{b-e}	6.37±0.06^{gh}	6.45±0.06^{e-g}
T_2	6.65±0.07^{ab}	6.45±0.06^{e-g}	6.55±0.07^{b-e}	6.47±0.06^{d-g}	6.32±0.06^{h}
T_3	6.46±0.06^{d-g}	6.7±0.07^{a}	6.67±0.07^{a}	6.55±0.07^{b-e}	6.37±0.06^{gh}
T_4	6.48±0.06^{d-f}	6.52±0.07^{c-e}	6.41±0.06^{f-h}	6.56±0.07^{b-d}	6.46±0.06^{d-g}

Peroxide Value

Peroxide value increased significantly (P<0.05) with storage. Mean values are given in Table 7. At day 0, T_3 (vacuum) values ranged from 1.40±0.01 meq/kg fat to T1 (plastic) 1.65±0.01 meq/kg fat. At the 20th day, T_1 and T_2 were non-significant, but remained significant against other treatments. By day 40, peroxide value was lowest in T_3 (1.37±0.01 meq/kg fat) and highest in T_1 (1.79±0.02 meq/kg fat), confirming the influence of packaging on oxidative changes.

The peroxide value slightly decreases in the treatments T_2, T_3, and increase for the treatment T_1 and T_4 from 0 day storage period to the end of the storage period. Bankar *et al.* (2013) also reported in his research work that the decrease in peroxide value of fig barfi during storage for 50 days in different packaging. Shrivas *et al.* (2018) stated that in his findings, peroxide value increases during storage.

Table 7

Means for peroxide value of chicken barfi

Treatments	Storage Days				
	0	10	20	30	40
T_0	1.61±0.02^{e}	1.53±0.02^{hi}	1.53±0.02^{hi}	1.47±0.01^{j}	1.59±0.02^{ef}
T_1	1.65±0.02^{d}	1.59±0.02^{ef}	1.78±0.02^{a}	1.67±0.02^{cd}	1.79±0.02^{a}
T_2	1.69±0.02^{c}	1.55±0.02^{gh}	1.75±0.02^{b}	1.47±0.01^{j}	1.42±0.01^{k}
T_3	1.46±0.01^{j}	1.57±0.02^{fg}	1.25±0.01^{m}	1.39±0.01^{ll}	1.37±0.01^{e}
T_4	1.39±0.01^{l}	1.42±0.01^{k}	1.51±0.02^{i}	1.6±0.02^{e}	1.56±0.02^{g}

Microbial Analysis of Chicken Barfi

Enumeration of Total Plate Count (TPC) of Chicken Barfi

TPC increased significantly (P<0.05) across treatments and storage days as shown in mean Table 8. At day 0, T_0 had 3.78±0.04 log CFU/g, while T_4 (metal) recorded 3.55±0.04 log CFU/g. By day 40, T_0 rose to 3.96±0.04, whereas T_3 (vacuum) showed the highest count at 4.94±0.05. At the 20th day, T_1 and T_2 were non-significant, but all treatments differed significantly at day 30.

The total plate count increase in all the treatments from 0 day storage period to the end of the storage period. But statistically the difference was highly significant. The increasing trend of *salmonella sp.* in chicken barfi during storage was also described by Garg and Mandokhot (1984), Sawhney *et al.* (1997).

Table 8

Means for enumeration of total plate count (log cfu/g) of chicken barfi

Treatments	Storage (Days)				
	0	10	20	30	40
T_0	3.78±0.04^{l}	3.81±0.04^{kl}	3.83±0.04^{kl}	3.88±0.04^{k}	3.96±0.04^{j}
T_1	3.56±0.04^{m}	4.14±0.04^{i}	4.32±0.04^{g}	4.47±0.04^{f}	4.65±0.07^{e}
T_2	3.59±0.04^{m}	4.66±0.05^{e}	4.75±0.05^{d}	4.83±0.05^{bc}	4.89±0.05^{ab}
T_3	3.53±0.04^{m}	4.23±0.04^{h}	4.52±0.05^{f}	4.63±0.05^{e}	4.94±0.05^{a}
T_4	3.55±0.04^{m}	4.64±0.05^{e}	4.76±0.05^{cd}	4.83±0.05^{bc}	4.89±0.05^{ab}

Enumeration of Escherichia Coli of Chicken Barfi

E. coli was not detected at day 0 in any treatment (Table 9). Growth appeared at the 20th day in T_0 1.10±0.01 and T_4 1.00±0.02, while T_1, T_2, T_3 remained free. At day 30, T_0 2.10±0.02 increased further, whereas T_3 continued to show no detection. By day 40, T_0 2.90±0.03 was maximum, confirming faster spoilage under control packaging.

The reading of Escherichia coli increases in all the treatments from 0 day storage period to the end of the storage period. Statistically, the difference was highly significant. The increasing trend of Escherichia coli in barfi during storage was also described by Garg and Mandokhot (1984), Warren *et al*. (2006), Sawhney *et al.* (1997).

Table 9

Means for enumeration of Escherichia coli (log cfu/g) of chicken barfi

Treatments	Storage Days				
	0	10	20	30	40
T_0	3.69±0.04^{j}	3.98±0.04^{h}	4.53±0.05^{e}	5.3±0.05^{b}	5.71±0.06^{a}

T_1	3±0.03^{m}	3.9±0.04^{i}	4.3±0.04^{f}	4.79±0.05^{d}	5.25±0.08^{b}
T_2	4.14±0.04^{g}	4.55±0.05^{e}	4.78±0.05^{d}	5.3±0.05^{b}	5.69±0.06^{a}
T_3	3.57±0.04^{k}	4±0.04^{h}	4.32±0.04^{f}	4.55±0.05^{e}	4.95±0.05^{c}
T_4	3.3±0.03^{l}	3.57±0.04^{k}	4.3±0.04^{f}	4.78±0.05^{d}	5.32±0.05^{b}

Enumeration of Salmonella of Chicken Barfi

Salmonella counts differed significantly (P<0.05) among treatments and storage intervals. The mean values are displayed in Table 10. At day 0 and 20, all treatments showed no detection. By the 30th day, growth appeared only in T_0 (control) and T_4 (metal), while T_3 (vacuum) remained free from contamination. A similar trend was recorded at day 40, with T_0 and T_4 showing the presence of Salmonella, whereas T_1, T_2 remained comparatively lower and T_3 consistently showed no growth throughout storage.

The reading of *salmonella sp.* increase in all the treatments from 0 day storage period to the end of the storage period. The increasing trend of *salmonella sp.* in chicken barfi during storage was in accordance with the findings of Karthikeyan and Pandiyan (2013), Sawhney *et al.* (1997).

Table 10

Means for enumeration of Salmonella sp. (log cfu/g) of chicken barfi

Treatments	Storage Days				
	0	10	20	30	40
T_0	3.65±0.04^{kl}	4.12±0.04^{i}	4.47±0.04^{f}	4.93±0.05^{b}	5.33±0.05^{a}
T_1	3.3±0.03^{n}	3.85±0.04^{j}	4.14±0.04^{i}	4.38±0.04^{g}	4.78±0.07^{c}
T_2	3.3±0.03^{n}	4.36±0.04^{gh}	4.55±0.05^{e}	4.95±0.05^{b}	5.3±0.05^{a}
T_3	3.47±0.03^{m}	3.69±0.04^{k}	4.47±0.04^{f}	4.77±0.05^{cd}	4.93±0.05^{b}
T_4	3.3±0.03^{n}	3.6±0.04^{l}	3.9±0.04^{j}	4.3±0.04^{h}	4.7±0.05^{d}

Sensory Evaluation

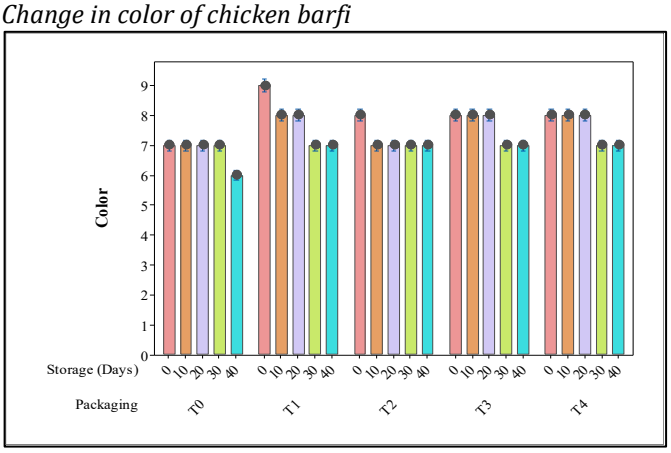
Color

Color scores declined with storage and differences were significant (P<0.05) as presented in Figure 3. The highest score at the start was in T_1 (8.40±0.10), while the lowest was in T_0 (7.50±0.09). By the 40th day, T_0 dropped to 4.20±0.08, whereas T_1 (7.00±0.12) and T_3 (6.90±0.11) retained better appearance. On the 20th day, T_1 and T_2 were non-significant, but at the 30th day all treatments became distinct.

The readings for change in color of chicken barfi decreases in all the treatments from 0 day storage period to the end of the storage period. The fall in flavor scores can be related to a significant loss of freshness present in any product. The decreasing trend of change in taste of chicken barfi during storage was also described by Navale *et al.* (2014), and Kamble *et al.* (2010).

Figure 3

Change in color of chicken barfi



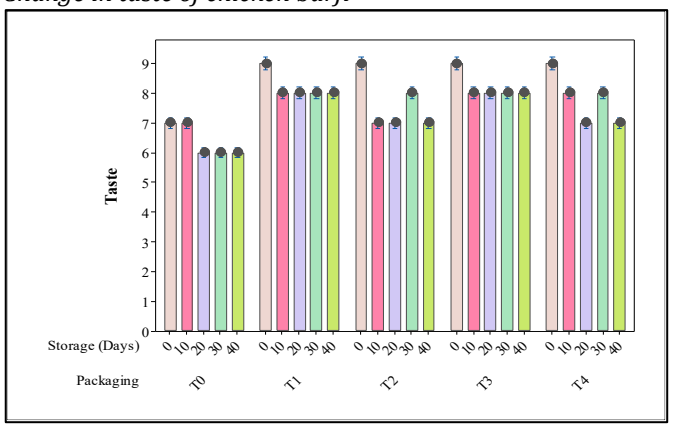
Taste

Taste scores (Figure 4) also showed significant (P<0.05) differences. At day 0, T_1 (8.40±0.11) had the best score compared to T_0 (7.60±0.08). By the 40th day, taste in T_0 declined to (4.10±0.07), while T_1 (6.80±0.12) and T_3 (6.70±0.10) retained higher values.

The values for change in taste of chicken barfi decreases in all the treatments from 0 day storage period to the end of the storage period. The fall in taste scores can be related to a significant loss of freshness present in any product. The similar trend of change in taste of chicken barfi during storage was also reported by Dey and Amin, (2017); Harker *et al.,* (2006).

Figure 4

Change in taste of chicken barfi



Flavor

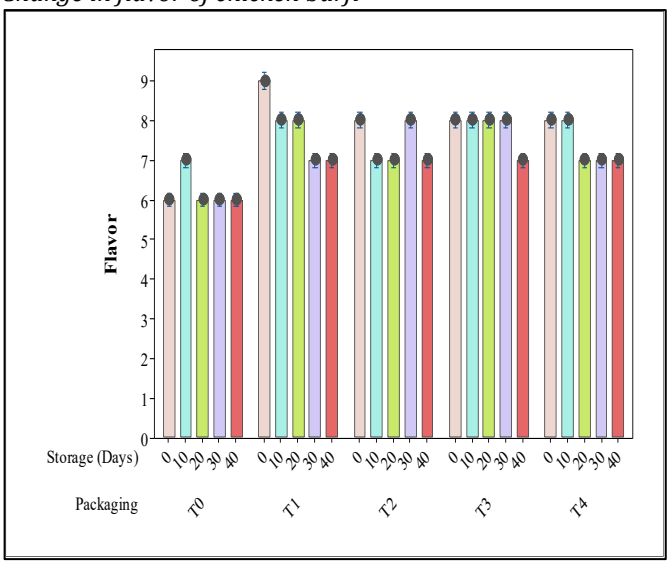
The influence of packaging on flavor is shown in Figure 5. At day 0, T_1 (8.50±0.09) was most preferred, while T_0 (7.60±0.07) scored lower. A steady reduction occurred with time, reaching T_0 (4.00±0.08) at day 40, whereas T_1 (7.00±0.10) and T_3 (6.80±0.11) still maintained acceptable flavor. On the 20th day, T_1 and T_2 were non-significant, but by the 30th day all treatments showed significant variation.

The flavor of chicken barfi declined noticeably in all treatments as storage advanced. This decrease was mainly due to the loss of freshness and desirable aroma with time. Samples dropped from acceptable to unacceptable once panel scores reached the range of 5 (neither like nor dislike) to 6 (liked slightly). The similar decreasing trend

of change in taste of chicken barfi during storage was also reported by Vijayalakshmi *et al.* (2005).

Figure 5

Change in flavor of chicken barfi



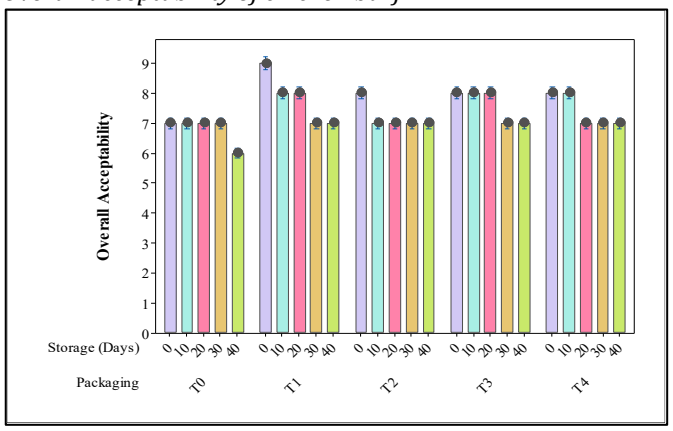
Overall Acceptability

Overall acceptability results are displayed in Figure 6, showing a progressive decline with storage and significant differences (P<0.05). At day 0, T_1 (8.50±0.12) was highest, while T_0 (7.60±0.10) recorded the lowest. By the 40th day, acceptability of T_0 fell to 4.20±0.08, whereas T_1 (7.10±0.09) and T_3 (6.90±0.11) maintained higher ratings.

Overall acceptability scores of chicken barfi showed a continuous decline across all treatments from the start of storage to the end. This reduction was linked to the gradual deterioration in freshness and quality typically associated with prolonged storage. Similar trends of decreasing acceptability in burfi during storage have also been reported by Stone *et al*. (2004) and Shete *et al.* (2012).

Figure 6

Overall acceptability of chicken barfi



CONCLUSION

The research demonstrated that packing and storage temperature significantly affected the nutritional, microbiological, and sensory characteristics of chicken barfi. Proximate analyses showed a gradual decrease in protein and fat, whereas moisture and ash levels varied by packaging type. pH values decreased during storage, while peroxide levels increased, with vacuum packaging indicating the least oxidative effects. Microbial growth increased over time, although vacuum-sealed samples remained unaffected by E. coli and Salmonella during storage. Sensory values for color, taste, flavor, and overall acceptability gradually declined although products stored within plastic and vacuum packs under refrigeration remained acceptable after 30 days. T_1 (plastic) and T_3 (vacuum) were especially effective in maintaining the quality of chicken barfi. This indicates that using appropriate packaging and refrigeration can increase shelf life up to 40 days whilst assuring consumer safety and product acceptance.

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