

Quality Assessment of Onion and Beet Root Extract Powder Incorporated Chicken Patties during Refrigerated Storage

Shubhangi Nagare¹, Anita Chappalwar*¹, Sandeep Rindhe¹, Sanjay Londhe¹ and Mahalsakant Nikam²

¹Department of Livestock Products Technology, College of Veterinary and Animal Sciences, Parbhani and Maharashtra Animal and Fishery sciences University, Nagpur

²Department of Poultry Science, College of Veterinary and Animal Sciences, Parbhani and Maharashtra Animal and Fishery sciences University, Nagpur

Abstract

Trials were conducted to evaluate the quality of antioxidant added chicken patties during refrigerated storage. Chicken patties treated with 1.5% onion and 1.5% beetroot extract along with control were packed aerobically in HDPE packages and stored at refrigeration temperature to assess storage stability. Result revealed significantly ($P < 0.05$) lower pH, peroxide, TBA, tyrosine values and microbial count in 1.5% onion and 1.5% beetroot extract powder treated patties than control, which were increased with progression of storage period. Treated patties had higher titrable acidity and ash content while lower moisture, protein and fat content than control, however these values were decreased marginally in all patties during refrigerated storage. None of the sample was found positive for presence of *coliform*. Chicken patties added with 1.5% onion and 1.5% beetroot extract powder had significantly ($P < 0.05$) higher overall acceptability scores throughout storage period. From the study, it is concluded that incorporation of onion and beetroot extract powder in chicken patties inhibits the oxidative changes. All the patties could be stored upto 21st day at refrigeration temperature without affecting quality parameters.

Keywords: Onion extract, beetroot extract, chicken patties, refrigerated storage and storage stability

*Correspondence

Author: Anita Chappalwar

Introduction

Chicken patty is a most popular finely comminuted ready to eat meat product. It is prepared with 20-30g of fat per 100g of patty, as less fat content exhibits rubbery texture of product (Angor and Al-Abdullah, 2010). However, higher concentration of PUFA in poultry meat (Makiš et al. 2024), processing steps and higher fat content of chicken patties accelerates lipid oxidation, which leads to development of rancid flavour leading to rapid deterioration of the product (Domínguez et al., 2019). Antioxidants are the compound that effectively slows down lipid oxidation without compromising sensory or nutritional properties of food products. Application of natural antioxidants in food products could help to reduce possible toxic and carcinogenic consequences exhibiting due to consumption of synthetic additives (Ribeiro et al., 2018) with extension of shelf life of the product.

Natural antioxidants are derived from the majority of plant parts such as leaves, flowers, fruits, stems and roots. The plant portions are employed either as such or after extraction and purification of antioxidant compounds in food products for preservation (Manassis et al., 2020). Onion (*Allium cepa* L.) is a spice belongs to the family *Amaryllidaceae* and the genus *Allium*, which is grown as a main crop especially in the Asia. It is a potent source of antioxidants and phenolic compounds viz, polyphenols, anthocyanins, quercetin, kaempferol, flavonoids and their glycosides (Terao, 2023). Quercetin and its glycosides represent 70% of total flavonoids available in onion, which plays a prospective role in retardation of the lipid oxidation (Marija Lesjak et al. 2018). Sulfur-containing compounds, flavonoids and their excellent photochemistry property helps to reduce risk of cardiovascular diseases, diabetes, cancer and atherosclerosis [2]. Researcher Sadeghian et al (2020) explored moderate antimicrobial and interesting antioxidant activity of an onion essential oil. Red onion is a potent source of anthocyanin pigment having high antioxidative activity. Therefore, daily intake of onion is potentially good for human health (Zhu et al., 2022).

Beetroot (*Beta vulgaris*) belongs to the family *Beta vulgaris* subsp. *vulgaris conditiva*, and a genus of *Edible taproots*. Beet root generally comes to dining table in the form of salad or juice. It is a rich source of carbohydrates, proteins, lipids, dietary fiber, sugars and micro minerals such as potassium, sodium, phosphorous, calcium, magnesium,

copper, iron, zinc and manganese (Dey et al., 2023). It is also an abundant source of numerous biologically active phytochemicals including betalains, flavonoids, polyphenols, saponins (Mirmiran et al., 2020). Betalain is water-soluble nitrogenous pigments containing betacyanins (red pigment) and betaxanthins (yellow pigment), ratios of these pigments determine colour intensity of beetroot. Therefore, it is used as a colorant or additive in food products (Chhikara et al., 2019). Beetroot has a prospective in health promotion due to its anti-oxidant and anti-inflammatory, anti-carcinogenic, anti-diabetic, hepato-protective, hypotensive, and wound healing properties (Chen et al., 2021). It also helps to prevent lipid oxidation as well as improve sensory attributes of meat and meat products (Elif Aykin-Dincer et al., 2020). Considering the demand for convenience food, health benefits and antioxidant properties of onion and beetroot the present study is undertaken to explore the antioxidant effect of onion and beet root extract powder in chicken patties during refrigerated storage.

Material and Methods

The study was conducted in the department of Livestock Products Technology, COVAS, Parbhani. Raw chicken meat of 6 weeks old chicken obtained from authorized retail meat shop of Parbhani city within 1-2 h of slaughter. It is packed in pre-sterilized low-density polyethylene (LDPE) bags and brought to the laboratory within 20 min. Then meat was deboned, separable fat and connective tissue trimmed-off. It was kept for conditioning in a refrigerator at $4\pm 1^\circ\text{C}$ for 6-8 hrs and then frozen at $-18\pm 2^\circ\text{C}$ till further use. Food grade refined vegetable oil (FortuneVR), sodium tripoly phosphate (Hi Media Laboratories (P) Ltd, Mumbai), salt, condiments, refined wheat flour were purchased from the local market of Parbhani. For the preparation of the spice mix 2gm of Cloves, 20gm coriander, 11gm Capsicum, 20gm cumin seeds (Zeera), 5gm turmeric, 5gm cinnamon, 12gm aniseed, 8gm black papper, 8gm caraway seed, 3gm nutmeg, 5gm caradamom, 1gm small cardamom were procured from the local market of Parbhani city, dried at $45\pm 2^\circ\text{C}$ for 2 hrs followed by grinding and sieving through the mesh. The spice mix was stored in pre-sterilized low density polyethylene bags and used as per requirement (**Table 1**) during preparation of chicken patties. Onion (*Allium cepa*) and beetroot (*Beta vulgaris*) extract powder was supplied by M/s from 'World of Nature' B1104, Balewadi, Banwer, Pune - 411045, India.

Table 1 Formulation used for preparation of chicken patties

Sr. No.	Ingredient	Control	OE	BE
1	Chicken	70	68.50	68.50
2	Refined vegetable oil	8	8	8
3	Ice flakes	8	8	8
4	Salt	1.5	1.5	1.5
5	Dry spices mix	2.0	2.0	2.0
6	Condiments	3.0	3.0	3.0
7	Refined wheat flour	3.0	3.0	3.0
8	Whole eggs	4.2	4.2	4.2
9	STPP	0.3	0.3	0.3
10	Onion extract power	-	1.5	-
11	Beet root extract power	-	-	1.5
Total		100	100	
OE- Chicken patties incorporated with 1.5% onion extract powder				
BE- Chicken patties incorporated with 1.5% beetroot extract powder				

Preparation of chicken meat patties

Chicken meat patties were prepared as per method followed by Chappalwar et al (2020). Frozen deboned meat was thawed at refrigeration temperature overnight. Thawed lean meat was cut into smaller chunks and minced in meat mincer with 6 mm plate followed by 4 mm plate. Fine emulsion was prepared in bowl chopper with addition of common salt, vegetable oil, refined wheat flour, sodium tripolyphosphate, spice mixture condiment mixes and other ingredients. Temperature of emulsion was maintained below 18°C with addition of crushed ice, preparation of emulsion in cool hours as well as mixing of meat and other ingredients in partially thawed form. In the initial postgraduate experiment, chicken patties were developed using 0, 0.75%, 1.5%, and 2.25% levels of onion and beetroot extract powders. Physicochemical and sensory evaluations showed that the 1.5% level of each extract (used separately) achieved the highest consumer acceptability. The formulation of chicken patties with 1.5 % onion and beetroot extract powder is presented in Table 1.

Moulding and cooking of patties

About 50 g of emulsion was moulded in steel plate with circular ring (55 mm diameter and 20 mm height). Patties were cooked in a pre-heated convection oven at 160°C for 15 minutes (Chappalwar et al., 2020) after which they were turned upside down and cooked for another 5 min for adequate doneness and to improve the appearance and colour. Core temperature (74°C) was measured by using a probe thermometer (Labware Scientific, Inc, USA). The patties were packed in pre sterilized high-density polyethylene pouches and stored at refrigeration temperature (4±1°C). The stored products were evaluated for various quality characteristics viz, physico-chemical properties, proximate, microbiological quality and sensory attributes at regular interval of 7 days.

Analysis of product

Chicken patties were assessed for various quality parameters as per following standard procedures. The moisture, fat and protein contents of fried quail meatballs were determined by following standard methods of AOAC (1995). The pH of chicken patties was evaluated as per Troutt et al (1992) method. Tyrosine value of chicken patties was estimated by the method described by Strange et al (1977). Titrable acidity was determined as per the method given by Shelf and Jay, (1970). The peroxide value was measured as per the method described by Koniacko (1979). TBARS value was estimated as per procedure given by Witte et al (1970). Microbiological analysis was done as per the procedure described in APHA (1992). The DPPH (1,1-diphenyl-1,2-picrylhydrazyl) radical scavenging activity of onion and beetroot extract powder was determined following the method described by Singh et al. (2002). The total phenolic content of the onion and beetroot extracts was estimated using the method of Singleton and Rossi (1965). Sensory evaluation was carried out using eight-point hedonic scale with 8= extremely desirable and 1= extremely poor (Keeton,1983). A semi trained sensory panel of seven judges having academic staff members and post graduate students of the College of Veterinary and Animal Sciences, Parbhani were requested to evaluate the quality of chicken nuggets by using 8 point descriptive scale for different sensory attributes viz., color and appearance, flavour, juiciness, texture and overall acceptability. Chicken patties were served for sensory evaluation at around 40°C temperature in sensory evaluation room at late afternoon around 4:00 p.m. Sensory panellists were not allowed to communicate with each other and plain lukewarm water was given for mouth rinsing in between sensing two samples.

Statistical analysis

The data obtained in the study on various parameters were statistically analyzed by analysis of variance technique as suggested by Snedecor and Cochran (1989). Duplicate samples were drawn for each parameter and the experiment was replicated thrice (n=6). Sensory evaluation was performed by a panel of seven member judges three times, so total observations being 21 (n=21).

Results and Discussion***Antioxidant activity of onion extract powder and beetroot extract powder***

The total phenolic content and antioxidant activity (Mean±SE) of onion and beetroot extract powder is presented in **Table 2**.

Total phenolic content (TPC) is a key indicator of antioxidant capacity, showing a direct correlation with antioxidant activity, as phenolics act as primary free radical scavengers (Lim et al., 2007). In the present study, beetroot and onion extract powders showed TPC values of 393.1 ± 21.55 and 445.4 ± 53.13 µg GAE/g dry weight, with DPPH scavenging activity of 41.74 ± 0.07% and 38.99 ± 0.44%, respectively, indicating higher antioxidant activity in beetroot. These findings align with reports by Bedrnick et al. (2019), Hossain et al. (2018), Zhang et al. (2016), Maqbool et al. (2019), and Kathiravan et al. (2014), who also documented considerable variations in TPC and DPPH activity in onion and beetroot extracts. The phenolic content and DPPH activity of natural extracts are mainly attributed to the presence of bioactive phenolic compounds (Maraie et al., 2014).

Table 2 Total phenolics content and antioxidant activity of beetroot extract powder and onion extract powder

Natural tracts	Beetroot Extract powder	Onion Extract powder
Phenolics (µgGAE/g)	445.4±53.13 ^a	393.1±21.55 ^b
DPPH (%SA)	41.74±0.07 ^a	38.99±0.44 ^b
n=6 Overall means bearing different superscripts in a row (a, b, c, d...) differ significantly (P<0.05)		

Physicochemical properties

The mean physicochemical properties of refrigerated stored chicken patties added with beet root and onion extract powder are presented in **Table 3**.

pH

Result revealed that OE and BE had significantly ($P < 0.05$) lower pH values than C possibly due to acidic nature of incorporated onion and beetroot extract powder. There was no significant difference for pH values between OE and BE throughout the storage period. Present findings are in agreement with result presented by Kurt et al., (2019) also reported reduced pH value for onion skin powder incorporated chicken meat patties. Similar findings were noted by Habib et al. (2018) for pomegranate rind powder incorporated carabeef nuggets. Firuzi et al. (2019) also noted that lowered the pH values in pomegranate juice and pomegranate rind powder added frankfurter to control. During storage, pH values increased significantly ($P < 0.05$) in C, while the values were increased marginally in OE and BE. A slight reduction in pH was observed during cold storage, expected due to the production of acids by acid-forming bacteria (Ahmead et al 2022) as well as liberation of protein metabolites mainly amines due to action of proteolytic bacteria (Rathour et al. 2017). Maqbool et al. (2019) recorded marginal increase the pH value of beetroot peel extract treated masher streak during refrigerated storage.

Table 3 Physicochemical properties of antioxidant treated chicken patties stored at refrigeration temperature ($4 \pm 1^\circ\text{C}$)

Treatments	Storage Periods (days)			
	1 day	7day	14day	21day
pH				
Control	6.29 \pm 0.00 ^{bA}	6.32 \pm 0.02 ^{bA}	6.36 \pm 0.03 ^{abA}	6.43 \pm 0.04 ^{aA}
OE	6.22 \pm 0.00 ^{aB}	6.25 \pm 0.02 ^{aB}	6.26 \pm 0.01 ^{aB}	6.27 \pm 0.07 ^{aB}
BE	6.20 \pm 0.01 ^{aB}	6.22 \pm 0.01 ^{aB}	6.23 \pm 0.01 ^{aB}	6.23 \pm 0.01 ^{aB}
TBA (mg malonaldehyde kg⁻¹)				
Control	0.24 \pm 0.00 ^{dA}	0.38 \pm 0.00 ^{cA}	0.62 \pm 0.04 ^{bA}	1.42 \pm 0.11 ^{aA}
OE	0.23 \pm 0.00 ^{cAB}	0.30 \pm 0.02 ^{bcB}	0.37 \pm 0.00 ^{bB}	0.62 \pm 0.11 ^{aB}
BE	0.22 \pm 0.00 ^{cB}	0.27 \pm 0.00 ^{bcB}	0.33 \pm 0.00 ^{bB}	0.53 \pm 0.00 ^{aB}
Tyrosine (mg/g)				
Control	0.56 \pm 0.03 ^{cA}	0.63 \pm 0.01 ^{cA}	0.74 \pm 0.02 ^{bA}	0.88 \pm 0.05 ^{aA}
OE	0.54 \pm 0.01 ^{cA}	0.57 \pm 0.02 ^{cB}	0.62 \pm 0.01 ^{bB}	0.66 \pm 0.00 ^{aB}
BE	0.53 \pm 0.00 ^{cA}	0.57 \pm 0.01 ^{cB}	0.61 \pm 0.01 ^{bB}	0.64 \pm 0.01 ^{aB}
Peroxide value (meq kg⁻¹)				
Control	5.27 \pm 0.17 ^{dA}	9.80 \pm 0.08 ^{cA}	19.26 \pm 0.22 ^{bA}	33.84 \pm 0.15 ^{aA}
OE	3.50 \pm 0.20 ^{dB}	6.49 \pm 0.02 ^{cB}	10.59 \pm 1.09 ^{bB}	14.81 \pm 0.0 ^{aB}
BE	3.17 \pm 0.21 ^{dB}	5.73 \pm 0.49 ^{cB}	8.56 \pm 0.03 ^{bC}	12.73 \pm 0.37 ^{aC}
Titration Acidity %				
Control	0.051 \pm 0.00 ^{aB}	0.050 \pm 0.001 ^{aC}	0.042 \pm 0.001 ^{bB}	0.033 \pm 0.00 ^{cB}
OE	0.058 \pm 0.00 ^{aAB}	0.056 \pm 0.00 ^{aB}	0.051 \pm 0.00 ^{abA}	0.044 \pm 0.00 ^{baB}
BE	0.060 \pm 0.00 ^{aA}	0.059 \pm 0.00 ^{aA}	0.054 \pm 0.00 ^{abA}	0.048 \pm 0.00 ^{baB}
n=6 Overall means bearing different superscripts in a row (a, b, c, d...) differ significantly ($P < 0.05$)				
Overall means bearing different superscripts in a column (A, B, C, D) differ significantly ($P < 0.05$)				

Thiobarbituric Acid Value

Present findings showed significant ($P < 0.05$) lower TBARS values for OE and BE than C patties during refrigerated storage. Lower TBARS values in the treated cookies during storage may be attributed to the phenolic compounds in onion (rich in quercetin) and beetroot (rich in betalains), which effectively inhibit lipid oxidation by acting as powerful antioxidants that neutralize and stabilize free radicals. Present findings are in close agreement with result obtained by Verma and Sahoo (2000) during refrigerated storage of chevon patties treated with guava powder and BHT. Ibrahim and Salem (2013) also reported significantly ($P < 0.05$) lower TBARS values in lemongrass and lime peel extract treated meat patties than control. The TBARS values followed a significantly ($P < 0.05$) increasing trend from day 1st to 21st day in control and treatment patties. However, BE exhibited lowest TBARS values than OE and C throughout the storage period as beetroot is rich in bioactive compounds such as polyphenols, carotenoids, nitrates, and betalains, thus, it is recognized as one of the top ten vegetables for its remarkable antioxidant potential, frequently exceeding that of onions

(Natalia et 2020). The increase in TBARS values on storage might be attributed to oxygen permeability of aerobic packaging material which lead to lipid oxidation and production of volatile metabolites (Nauman et al., 2022). Present findings are in agreement with Sharma and Yadav et al (2020) for chevon and chicken patties treated with different natural antioxidant extracts. Similar results were presented by Rranawana et al, (2018) who reported significant improvement in the antioxidant and polyphenol profiles of sponge cake on addition of beetroot.

Tyrosine value

Tyrosine value was found significantly ($P<0.05$) higher in C patties than treatments during refrigerated storage. Lower tyrosine value in OE and BE might be due to effectiveness of phenolic compounds present in onion and beetroot extract powder as The hydroxyl hydrogen of phenolic compounds present in beetroot and onion extracts acts as a hydrogen donor, establishing hydrogen bonds with the carbonyl (C=O) groups of amide linkages and with oxygen or nitrogen atoms in amino acid side chains and forms stable covalent bonds between phenolics and proteins, thereby slowing protein degradation (Wang et al 2024). Wu et al. (2025) reported that plant polyphenols react with myofibrillar proteins, reducing total sulfhydryl and free amino groups and thereby altering their secondary and tertiary structures. Similarly, LU et al (2022) reported non-covalent molecular interactions between rosmarinic acid and whey proteins (β -LG/ α -LA/BSA). However, this value increased significantly ($P<0.05$) in control as well as treatment patties with advancement of storage period. Increase in tyrosine value with advancement of storage period could occur due to increase in microbial load and production of proteolytic enzymes, indicating higher protein degradation in control patties than treatments. The findings are corroborated with changes occur in pH values and protein content of patties during storage study of present work. Similar increasing trend was reported by Reddy et al (2020) for natural antioxidant incorporated turkey meat sausage and restructured goat meat products respectively. Lonarkar *et al.* (2021) also found significantly ($p<0.05$) lower tyrosine values in custard apple peel powder-treated chicken samosa as compared to the control and BHT treated chicken samosa.

Peroxide value

Control had significantly ($P<0.05$) higher peroxide values as compared to OE and BE during storage. Lower peroxide values of treatments might be due to antioxidant activity of onion and beetroot extract estimated by Nagre et al. (2023). Present findings are in close agreement with observations reported by Nayak et al. (2019) during refrigerated storage of functional chevon patties. The peroxide values of control as well as treatments increased significantly ($P<0.05$) with progression of storage period. Similar findings were reported by Yaqoob et al (2020) for papaya guava leaves extract treated shrimp patties throughout refrigerated storage period. Kaviani, and Karami (2024) also reported increase in peroxide value during frozen storage of Burger (Grass Carp-Red Meat) at $-18\text{ }^{\circ}\text{C}$. Disparity in peroxide values in stored chicken patties may result from fluctuating lipid oxidation rates, as addition of polyphenol-rich natural extracts in treatment patties limits oxidation and improve microbial safety (Babaoğlu et al., 2022), with demonstrating their potential to extend the shelf life of meat and meat products (Dai et al., 2022).

Titration acidity

Titration acidity was significantly ($P<0.05$) higher in onion and beet root extract powder treated patties due to the acidic nature of added extracts. Likewise, Singh *et al.*, (2014) observed higher titration acidity in clove powder, ginger and garlic paste treated chicken emulsion than control throughout storage period. Titration acidity of C decreased significantly ($P<0.05$) from 14th day onwards, however there was gradual decrease in titration acidity of OE and BE with advancement of storage period. Changes in titration acidity across treatments and storage periods aligned with the corresponding pH values observed in this study. The inclusion of natural phenolic compounds in treated chicken patties enhanced antioxidant activity during refrigerated storage and helped maintain a lower pH by slowing spoilage-related increases in pH and titration acidity. Similarly, Deshpande (2022) observed increase in acidity with advancement of refrigerated storage period of carrot and radish powder in chicken nuggets. Porto et al., (2017) observed increased titration acidity in beet juice during refrigerated storage.

Microbiological analysis

The mean microbial count of refrigerated stored chicken patties added with onion and beetroot extract powder are presented in **Table 4**.

Total plate count

Total plate count did not differ significantly ($P < 0.05$) between control and treatment upto 14th day of storage, however at the end of storage OE and BE had significantly ($P < 0.05$) lower TPC than C. This effect is due to the hydroxyl groups of flavonols in onion and beetroot extracts, which penetrate microbial cell membranes and exert antibacterial activity by binding to enzyme active sites, causing membrane disruption (Sarvinehbaghi et al., 2021). The total plate count of control as well as treatment patties increased significantly ($P < 0.05$) with the progression of storage period, which might be due to multiplication of microorganisms during storage (Bawa et al., 1988). The microbial load remained within the safety limit upto 21st day of storage in all stored patties, indicating that the products stored up to 21 days were microbiologically safe. Similar results for TPC during storage were reported by Pachpor (2014) for guava extract treated chicken nuggets. Rajkumar et al (2016) reported higher anti-microbial activity in terms of TPC for aloe vera gel incorporated chevon nuggets than control.

Table 4 Microbial count of control and beet root and onion extract powder incorporated chicken patties stored at refrigeration temperature ($4 \pm 1^\circ\text{C}$)

Treatments	Storage Periods (days)			
	1 day	7day	14day	21day
Total Plate Count (log CFU/g)				
Control	2.31±0.01 ^d	2.47±0.03 ^c	2.66±0.04 ^b	3.16±0.05 ^{aA}
OE	2.23±0.01 ^d	2.41±0.01 ^c	2.60±0.00 ^b	2.83±0.01 ^{aB}
BE	2.23±0.00 ^d	2.38±0.02 ^c	2.58±0.02 ^{bA}	2.80±0.03 ^{aB}
Psychrophilic Count (log CFU/g)				
Control	ND	1.30±0.00 ^{cA}	2.20±0.01 ^{bA}	2.64±0.06 ^{aA}
OE	ND	1.25±0.00 ^{cB}	2.03±0.02 ^{bB}	2.33±0.01 ^{aB}
BE	ND	1.25±0.00 ^{cB}	1.98±0.02 ^{bB}	2.29±0.04 ^{aB}
Yeast & Molds (log CFU/g)				
Control	ND	ND	ND	1.51±0.04
OE	ND	ND	ND	ND
BE	ND	ND	ND	ND
Coliform (log CFU/g)				
Control	ND	ND	ND	ND
OE	ND	ND	ND	ND
BE	ND	ND	ND	ND

n=6 Overall means bearing different superscripts in a row (a, b, c, d...) differ significantly ($P < 0.05$)
Overall means bearing different superscripts in a column (A, B, C, D...) differ significantly ($P < 0.05$)

Psychrophilic count

The psychrophilic count was absent in control and treatments on 1st day due to effect of cooking temperature, however the growth of psychrophiles was detected on 7th day onwards in all stored chicken patties. C had significantly ($P < 0.05$) higher psychrophilic count than treatments from 7th to 21th day. The psychrophilic count of control as well as treatments increased significantly ($P < 0.05$) with the progression of storage period. Present findings are in close agreement with Zargar et al (2014) who also detected no psychrophilic growth on day 0 of storage in control as well as pumpkin treated sausage, thereafter the counts followed a significant ($P < 0.05$) increasing trend in control and treatments with progression of refrigerated storage. Pachpor (2014) also observed much lower psychrophilic count in guava extract treated chicken nuggets than control nuggets. The hydroxyl group in phenolic compounds of red onion such as quercetin and kaempferol has the ability to form hydrogen bonds with the active site of microbial enzymes, causing inhibition of enzymes important in the metabolism of many gram-negative and gram-positive bacteria as well as weakening bacterial cell membranes (Baquer et al., 2024).

Yeast and mould count

The yeast and mould count was not detected in OE and BE throughout the storage period as decrease in emulsion particle size increases the surface area, thereby enhancing the penetration of added natural extracts with antibacterial properties into microbial cells (Manzoor et al., 2021). However, 1.51±0.04 yeast and mould count were observed in C patties on 21st day of storage. Absence of yeast and mould count in treatments might be due to antimicrobial activity of natural extracts added in chicken patties. Present finding corroborated with the observation of Reddy et al (2020) who

also not detected yeast and mould counts in carrot and radish treated turkey meat sausage throughout the refrigerated storage period.

Coliform count

Coliforms were not detected throughout the storage period in control as well as treatments. The absence of coliform could be due to their destruction of organisms during cooking at 160°C for 20 min which was much above their death point i.e., 57°C as well as due to the hygienic conditions maintained during processing and analysis of product. Kumar et al (2007) and Singh et al (2014) also observed complete absence of *coliforms* respectively in chicken patties and cutlets throughout period of refrigeration storage. Lower microbial count viz, TPC, Psychrophilic count and Yeast and mould count in treatment patties than control patties during storage is obviously due to the availability of phenolic compounds in added extract which act as natural preservatives by damaging cell membranes, DNA, and proteins, inhibiting ATP synthesis through ROS generation, inducing lipid oxidation, disrupting pH gradients, and ultimately causing cell death (Downs et al., 2022). Since the storage stability of chicken patties added with onion and beetroot extract had extended storage stability than control. Likewise, Zahid et al. (2020) observed that the incorporation of clove extract and essential oil into beef patties improved their stability during refrigerated storage. However, meat and meat products is packaged in High-density polyethylene (HDPE), the material allows a measurable amount of oxygen to permeate due to its moderate oxygen transmission rate (OTR). This oxygen availability significantly influences both lipid oxidation and microbial dynamics in meat.

Proximate composition

The mean proximate composition of refrigerated stored chicken patties added with onion and beetroot extract powder are presented in **Table 5**.

Moisture

Table 4 indicated decrease in moisture, protein, and fat content while increased in ash content on incorporation of onion and beetroot extract powder and progression of storage period. Lower moisture content in OE and BE than C is due to addition on onion and beetroot extract in powder form. There was no significant ($P < 0.05$) difference in moisture content upto 7th day of storage, thereafter C had significantly lower moisture content than treatments. Decrease in moisture content during storage, possibly due to evaporation of moisture content through aerobic packaging (HDPE) as well as higher microbial activity in control patties than treatments. Similar trend for moisture content was reported by Pachpor (2014) for guava fruit extract added in chicken nuggets during the refrigerated storage period.

Table 5 Proximate composition of control and beet root and onion extract powder incorporated chicken patties stored at refrigeration temperature ($4 \pm 1^\circ\text{C}$)

Treatments	Storage Periods (days)			
	1day	7day	14day	21day
Moisture (%)				
Control	62.98±0.16 ^a	62.54±0.10 ^a	61.43±0.37 ^{bB}	60.21±0.59 ^{cB}
OE	62.93±0.10 ^a	62.73±0.06 ^a	62.67±0.06 ^{aA}	61.22±0.58 ^{bA}
BE	62.79±0.05 ^{aA}	62.65±0.18 ^a	62.56±0.12 ^{aA}	61.49±0.47 ^{bA}
Protein (%)				
Control	17.29±0.02 ^a	17.24±0.01 ^{ab}	17.16±0.01 ^b	16.88±0.06 ^{cB}
OE	17.23±0.02 ^a	17.20±0.04 ^a	17.18±0.05 ^a	17.10±0.08 ^{aA}
BE	17.24±0.04 ^a	17.22±0.10 ^a	17.19±0.08 ^{aA}	17.12±0.08 ^{aA}
Fat (%)				
Control	16.70±0.13 ^a	16.57±0.09 ^a	15.81±0.20 ^{bB}	15.32±0.12 ^{cB}
OE	16.44±0.19 ^a	16.40±0.0 ^a	16.29±0.08 ^{aA}	16.14±0.02 ^{aA}
BE	16.42±0.18 ^a	16.39±0.31 ^a	16.30±0.07 ^{aA}	16.16±0.02 ^{aA}
Ash (%)				
Control	3.14±0.07	3.15±0.10	3.15±0.07	3.15±0.13
OE	3.50±0.15	3.56±0.14	3.65±0.19	3.76±0.22
BE	3.44±0.21	3.50±0.20	3.61±0.28	3.70±0.24
n=6 Overall means bearing different superscripts in a row (a, b, c, d...) differ significantly ($P < 0.05$)				
Overall means bearing different superscripts in a column (A, B, C, D...) differ significantly ($P < 0.05$)				

Protein

The protein content had no significant changes between control and treatment upto 14th day of refrigerated storage. Thereafter, C had significantly ($P<0.05$) lower protein content than treatment patties, this could be due to denaturation of protein at $4\pm 1^{\circ}\text{C}$. Kashyap et al., (2012) also noted similar finding for natural antioxidant incorporated chicken patties. Protein denaturation governed by enzyme concentration and presence of other compounds in the product (Rahman 1999). Protein content of C decreased significantly ($P<0.05$) from 14th day of storage period. However, there was gradual decrease in protein content of OE and BE during entire storage time. Haque et al (2020) also observed slight decrease in protein content of orange peel extract treated beef muscle during frozen storage.

Fat

Decline in fat content was found on incorporation of natural extract and advancement of refrigerated storage period. There was no significant difference in the fat content of control and treatment patties for 7 days, while from 14th day onward control had significantly ($P<0.05$) lower fat content than treatment. This indicated faster lipid oxidation in control patties than treatment, which might be inhibited in OE and BE by phenolic compounds available in onion and beetroot extract added respectively. Similar trend was observed by Kokare (2013) for chicken nuggets treated with natural antioxidant. During storage, fat content declined significantly ($P<0.05$) in C, while non-significantly in OE and BE. Wani et al (2014) reported a non-significant change in protein during storage.

Ash

Ash content of chicken patties increased non-significantly with onion and beetroot extract powder incorporation as well as storage period enhancement. Higher ash content of treatment patties than C might due to be the presence of minerals in onion and beetroot extract powder. Ceclu and Nistor (2020) reported higher mineral content in tuberous root of the beetroot. Present findings are corroborated with findings of Haque et al (2020) for orange peel extract treated beef muscle during storage period. Sharma and Yadav (2020) also reported significantly ($P<0.05$) higher ash content for pomegranate by-products extract incorporated chicken meat patties than control during refrigerated storage stored.

Sensory evaluation

The mean sensory characteristics of onion and beetroot extract powder added chicken patties stored refrigeration temperature are presented in **Table 6**.

Table 6 Sensory characteristics of control as well as beet root and onion extract incorporated powder chicken patties stored at refrigeration temperature ($4\pm 1^{\circ}\text{C}$)

Treatments	Storage Periods (days)			
	1day	7day	14day	21day
Colour and Appearance				
Control	6.86 \pm 0.31 ^{aB}	6.75 \pm 0.25 ^{aB}	6.56 \pm 0.19 ^{aB}	5.58 \pm 0.15 ^{bC}
OE	7.40 \pm 0.20 ^{aA}	7.27 \pm 0.18 ^{aA}	7.03 \pm 0.23 ^{abA}	6.61 \pm 0.15 ^{bA}
BE	7.33 \pm 0.33 ^{aA}	7.20 \pm 0.30 ^{aA}	7.00 \pm 0.24 ^{aA}	6.10 \pm 0.10 ^{bB}
Flavour				
Control	6.77 \pm 0.30 ^a	6.54 \pm 0.18 ^a	6.04 \pm 0.34 ^{ab}	5.58 \pm 0.20 ^{bB}
OE	6.83 \pm 0.60	6.62 \pm 0.20	6.54 \pm 0.33	6.35 \pm 0.15 ^A
BE	6.75 \pm 0.17	6.49 \pm 0.18	6.16 \pm 0.30	6.20 \pm 0.16 ^A
Juiciness				
Control	6.46 \pm 0.21 ^a	6.33 \pm 0.17 ^{ab}	6.11 \pm 0.08 ^{ab}	5.95 \pm 0.13 ^{bB}
OE	6.35 \pm 0.17	6.26 \pm 0.24	6.18 \pm 0.17	6.06 \pm 0.16 ^A
BE	6.39 \pm 0.18	6.30 \pm 0.16	6.21 \pm 0.10	6.10 \pm 0.23 ^A
Texture				
Control	6.57 \pm 0.18	6.53 \pm 0.33	6.48 \pm 0.18	6.43 \pm 0.32
OE	6.53 \pm 0.21	6.50 \pm 0.42	6.46 \pm 0.18	6.40 \pm 0.20
BE	6.54 \pm 0.18	6.52 \pm 0.21	6.48 \pm 0.19	6.42 \pm 0.31
Overall Acceptability				
Control	6.50 \pm 0.22 ^a	6.20 \pm 0.40 ^{ab}	5.95 \pm 0.27 ^{abB}	5.40 \pm 0.19 ^{bB}
OE	6.68 \pm 0.31	6.54 \pm 0.26	6.58 \pm 0.19 ^A	6.23 \pm 0.16 ^A

BE	6.66±0.33	6.50±0.22	6.33±0.21 ^A	6.16±0.21 ^A
n=21 Overall means bearing different superscripts in a row (a, b, c, d) differ significantly (P<0.05)				
Overall means bearing different superscripts in a column (A, B, C, D) differ significantly (P<0.05)				

Colour and appearance

The OE and BE had significantly (P<0.05) higher colour and appearance score than C throughout the storage study, due to presence of water-soluble anthocyanin (Zhang et al., 2016) and betanin (Singh and Hathan, 2014) pigment in onion and beet root respectively. Increase in redness value was observed by Jin et al (2014) for red beet powder and Kurt et al (2019) for onion skin powder incorporated meat products. Colour and appearance scores of both control and antioxidant treated chicken patties decreased gradually with increase in storage period. The decrease in colour and appearance scores with the progression of storage period might be due to loss of water-soluble pigment as well as occurrence of lipid oxidation during storage (Pachpor 2014). Similar results were reported by Reddy et al (2020) for refrigerated stored carrot and radish paste treated turkey meat sausage. Porto et al (2017) also reported increase in color value of beet juice during refrigerated storage.

Flavour

Flavour is a complex sensation comprising mainly of odor and taste of product and sensed collectively by oral and olfactory senses. The OE and BE patties had significantly (P<0.05) higher flavour score than C throughout the storage period, due to addition of natural antioxidants in chicken patties which imparts pleasant flavor as well as slows down the rate of lipid oxidation. Mohamed and Mansour (2012) also reported higher flavour scores for various antioxidants incorporated beef patties than C during storage. However, flavour scores of C as well as treatment patties decreased significantly (P<0.05) with the progression of storage period. Present findings are in close agreement with Gadekar et al (2014) for natural antioxidant treated restructured goat meat products stored at 4±1⁰C.

Juiciness

Juiciness marginally decreased in treatment chicken patties as well as with progression of storage period. However, the juiciness scores of controls decreased the progression of storage period, while the declined non significantly in treatment patties. The decrease in juiciness scores could be attributed to surface dehydration and gradual moisture loss due to aerobic packaging (HDPE) of chicken patties (Bhat et al., 2011). Ibrahim et al (2012) also reported significant (P<0.05) decrease in juiciness score in beef patties during refrigerated storage.

Texture

Texture scores decreased non significantly in treated patties during refrigerated storage. Lower texture score in OE and BE patties might be due to addition of onion and beetroot extract in dried forms. During storage, hardening of the product due to gradual loss of moisture through high density polyethylene packages might be a reason for decrease in texture score. The similar decreasing trend was reported by Sahoo and Anjaneyulu (2010) in aerobically packaged buffalo meat nuggets during refrigerated storage. Yavas and Bilgin (2010) also reported decreased texture score in tofu incorporated chicken meat nuggets respectively stored at refrigeration temperature.

Overall acceptability

Overall acceptability refers to sensory perception of a meat product in totality. Overall acceptability scores of C had no significant difference upto 7th day of storage, thereafter it was decreased significantly (P<0.05) showing significantly (P<0.05) lower overall acceptability than OE and BE. This might be due to higher rate of non-enzymatic browning, fat, protein oxidation and formation of secondary metabolites providing off flavour and taste to the product. Present findings are in close agreement with Elif Aykin-Dincer et al (2020) for beet root extract and powder added sausage. Higher overall acceptability scores of OE and BE could be due to better antioxidant activity of onion and beet root extract powder. Present findings are corroborated with the observations of Almeida et al (2015) for 0.5% jaborcaba peel extract incorporated bologna-type sausages during refrigerated storage. However, OE exhibited higher overall acceptability scores than BE till the end of storage; this might be due to pleasant flavour of onion which was favoured by consumers.

Conclusion

From the study, it is concluded that incorporation of onion and beetroot extract powder in chicken patties inhibits the oxidative changes. All the patties could be stored upto 21st day at refrigeration temperature without affecting quality parameters.

References

- [1] Ahmed IAM, Babiker EE, Al-Juhaimi FY, Bekhit AEDA. Clove polyphenolic compounds improve the microbiological status, lipid stability, and sensory attributes of beef burgers during cold storage. *Antioxidants*. 2022;11(7):1354.
- [2] Al-Ishaq RK, Abotaleb M, Kubatka P, Kajo K, Busselberg D. Flavonoids and their anti-diabetic effects: cellular mechanisms and effects to improve blood sugar levels. *Biomolecules*. 2019;9(9):430.
- [3] Manzoor A, Asif M, Khalid SH, Khan IU, Asghar S. Nanosizing of lavender, basil, and clove essential oils into microemulsions for enhanced antioxidant potential and antibacterial and antibiofilm activities. *American Chemical Society, Omega*. 2023; 8:40600-40612.
- [4] Angor M, Al-Abdullah B. Attributes of low-fat beef burgers made from formulations aimed at enhancing product quality. *Journal of Muscle Foods*. 2010; 21:317-326.
- [5] AOAC. Official methods of analysis. 16th edition. Washington (DC): Association of Official Agricultural Chemists; 1995.
- [6] APHA. Compendium of methods for the microbiological examination of foods. Washington (DC): American Public Health Association; 1992; 105:100-110.
- [7] Babaoğlu AS, Unal K, Dilek NM, Poçan HB, Karakaya M. Antioxidant and antimicrobial effects of berry pomace extracts on beef patties during refrigerated storage. *Meat Science*. 2022; 187:108765.
- [8] Baqer SH, Al-Shawi SG, Al-Younis ZK. Quercetin, the potential powerful flavonoid for human and food: a review. *Front Biosciences (Elite Journal of Education)*. 2024;16(3):30.
- [9] Bawa A, Vineet J, Thind S. Effect of packaging and storage on the quality of chicken sausages containing soy flour. *Indian Journal of Meat Science Technology*. 1988; 1:79-83.
- [10] Bedrnicek J, Laknerova I, Linhartová Z, Kadlec J, Samková E, Bárta J, Smetana P. Onion waste as a rich source of antioxidants for meat products. *Czech Journal of Food Science*. 2019;37(4):268-275.
- [11] Bhat ZF, Pathak V, Bukhari SAA, Ahmad SR, Bhat H. Quality changes in chevon harrisa during refrigerated storage. *International Journal of Meat Science*. 2011;1:52-61.
- [12] Ceclu L, Nistor O. Red beetroot: composition and health effects—A review. *Journal of Nutrition, Medicine and Diet Care*. 2020;6(1):1-9.
- [13] Chappalwar A, Pathak V, Goswami M, Verma A. Development of functional chicken patties with incorporation of mango peel powder as fat replacer. *Nutrition and Food Science*. 2020;50(6):1063-1073.
- [14] Chen L, Zhu Y, Hu Z, Wu S, Jin C. Beetroot as a functional food with huge health benefits. *Food Science and Nutrition*. 2021;9(11):6406-6420.
- [15] Chhikara N, Kushwaha K, Sharma P, Gat Y, Panghal A. Bioactive compounds of beetroot and utilization in food processing industry: a critical review. *Food Chemistry*. 2019; 272:192-200.
- [16] Dai Z, Han L, Li Z, Gu M, Xiao Z, Lu F. Combination of chitosan, tea polyphenols, and nisin on the bacterial inhibition and quality maintenance of plant-based meat. *Foods*. 2022;11(10):1524.
- [17] de Almeida PL, de Lima SN, Costa LL, de Oliveira CC, Damasceno KA, dos Santos BA, Campagnol PCB. Effect of jabuticaba peel extract on lipid oxidation, microbial stability and sensory properties of Bologna-type sausages during refrigerated storage. *Meat Science*. 2015; 110:9–14.
- [18] Deshpande SP. Development and storage stability of chicken nuggets incorporated with carrot (*Daucus carota* subsp. *sativus*) and radish (*Raphanus raphanistrum*) powder. M.V.Sc. thesis submitted to Maharashtra Animal and Fishery Sciences University, Nagpur; 2022.
- [19] Dey A, Mishra A, Gupta D. A review on the analysis of nutritional composition of beetroot powder. *The Pharma Innovation Journal*. 2023;12(6):665–671.
- [20] Domínguez R, Pateiro M, Gagaoua M, Barba FJ, Zhang W, Lorenzo JM. A comprehensive review on lipid oxidation in meat and meat products. *Antioxidants*. 2019;8(10):429.
- [21] Downs JW, Wills BK. Phenol toxicity. In *StatPearls*. Treasure Island (FL): StatPearls Publishing; 2022.
- [22] Aykın-Dinçer E, Güngör KK, Çağlar E, Erbaş M. The use of beet root extract and extract powder in sausages as natural food colorant. *International Journal of Food Engineering*. 2020.
- [23] Firuzi MR, Niakousari M, Eskandari MH, Keramat M, Gahruei HH, Mousavi Khaneghah A. Incorporation of pomegranate juice concentrate and pomegranate rind powder extract to improve the oxidative stability of

- frankfurter during refrigerated storage. *LWT*. 2019; 102:237–245.
- [24] Gadekar Y, Sharma B, Shinde A, Verma A, Mendiratta S. Effect of natural antioxidants on the quality of cured, restructured goat meat product during refrigerated storage (4 ± 1 °C). *Small Ruminant Research*. 2014; 119:1–3.
- [25] Habib H, Siddiqi RA, Dar AH, Dar MA, Gul K, Rashid N, Siddiqi US. Quality characteristics of carabeef nuggets as affected by pomegranate rind powder. *Journal of Food Measurement and Characterization*. 2018.
- [26] Haque F, Rahman M, Habib M, Alam M, Monir M, Hossain M. Effect of different levels of orange peel extract on the quality and shelf life of beef muscle during frozen storage. *IOSR Journal of Agriculture and Veterinary Science*. 2020; 13:43–56.
- [27] Hashemi N, Milani E, Koocheki A. Shelf-life extension of chicken fillets using flaxseed mucilage coatings incorporated with bixin-allicin or bixin-orange peel essential oil nanoemulsions. *Food Science & Nutrition*. 2026;14(1):e71428.
- [28] Hossain MB, Lebel J, Birsan R, Rai DK. Enrichment and assessment of the contributions of the major polyphenols to the total antioxidant activity of onion extracts. *Antioxidants*. 2018;7(12):175.
- [29] Ibrahim H, Moawad R, Emam W. Antioxidant effect of pomegranate rind, seed extracts and juice on lipid oxidation and quality properties of cooked beef patties. *Journal of Applied Sciences Research*. 2012;8(8):4023–4032.
- [30] Ibrahim H, Salem M. Effect of adding lemongrass and lime peel extracts on chicken patties quality. *Journal of Applied Sciences Research*. 2013;9(8):5035–5047.
- [31] Jin S, Choi J, Moon S, Jeong J, Kim G. The assessment of red beet as a natural colorant and evaluation of quality properties of emulsified pork sausage containing red beet powder during cold storage. *Korean Journal for Food Science of Animal Resources*. 2014;34(4):472-480.
- [32] Kashyap A, Thind S, Kaur A. Development of chicken meat patties incorporating natural antioxidants. *International Journal Food Science and Technology*. 2012; 2:27-40.
- [33] Kathiravan T, Nadanasabapathi S, Kumar R. Standardization of process condition in batch thermal pasteurization and its effect on antioxidant, pigment and microbial inactivation of ready to drink beetroot (*Beta vulgaris* L.) juice. *International Food Research Journal*. 2014;21(4):1305-1312.
- [34] Kaviani P, Karami B. Study of nutritional value and shelf life of the consolidated burger (grass carp–red meat) during freezing storage at -18 °C. *Research and Innovation in Food Science Technology*. 2024;13(3):117-128.
- [35] Keeton JT. Effect of fat and NaCl/phosphate levels on the chemical and sensory properties of pork patties. *Journal of Food Science*. 1983;48:787-791.
- [36] Kokare P. Development of functional chicken nuggets by incorporation of orange peel and pulp powder. M.V.Sc. thesis submitted to Maharashtra Animal and Fishery Sciences University, Nagpur.2013.
- [37] Koniecko ES. Handbook for meat chemists. Wayne (NJ): Avery Publishing Group Incorporated.; 1979. p.68-69.
- [38] Kumar R, Sharma B, Kumar M, Chidanandaiah, Biswas A. Storage quality and shelf life of vacuum-packaged extended chicken patties. *Journal of Muscle Foods*. 2007;18(3):253-263.
- [39] Kurt S, Ceylan H, Akkoç A. The effects of onion skin powder on the quality of cooked chicken meat patties during refrigerated storage. *Acta Aliment*. 2019; 48:423-430.
- [40] Lesjak M, Beara I, Simin N, Pintač D, Majkic T, Bekvalac K, et al. Antioxidant and anti-inflammatory activities of quercetin and its derivatives. *Journal of Functional Foods*. 2018; 40:68-75.
- [41] Lim YY, Lim TT, Tee JJ. Antioxidant properties of several tropical fruits: a comparative study. *Food Chemistry*. 2007;103(3):1003-1008.
- [42] Lonarkar AG, Rathod KS, Ambadkar RK, Patil PS, Dhagare LG. Shelf life of chicken samosa incorporated with custard apple (*Annona squamosa*) peel powder. *Journal of Meat Science*. 2021;16(1):17-22.
- [43] Lu Y, Zhao R, Wang C, Zhang X, Wang C. Deciphering the non-covalent binding patterns of three whey proteins with rosmarinic acid by multi-spectroscopic and molecular docking approaches. *Food Hydrocolloids*. 2022; 132:107895.
- [44] Makiš A, Čertík M, Klempová T, Semjon B, Marcinčáková D, Jevinová P, et al. Fermented products enriched with polyunsaturated fatty acids in broiler chicken nutrition and fat quality of produced meat. *Applied Sciences*. 2024;14(10):4327.
- [45] Manassis G, Kalogianni AI, Lazou T, Moschovas M, Bossis I, Gelasakis AI. Plant-derived natural antioxidants in meat and meat products. *Antioxidants (Basel)*. 2020;9(12):1215.
- [46] Maqbool H, Safeena MP, Sathish Kumar K, Zynudheen AA, Ninan G, Kumar BM. Beetroot peel extract as a natural preservative for shelf-life extension of Deccan mahseer (*Tor khudree*) steaks during chill storage. 2019.
- [47] Maraie NK, Abdul-Jalil TZ, Alhamdany AT, Janabi HA. Phytochemical study of the Iraqi *Beta vulgaris* leaves and its clinical applications for the treatment of different dermatological diseases. *World Journal of Pharmaceutical and Pharmaceutical Sciences*. 2014; 3:5-19.
- [48] Mirmiran P, Houshialsadat Z, Gaeini Z, Bahadoran Z, Azizi F. Functional properties of beetroot (*Beta vulgaris*)

- in management of cardio-metabolic diseases. *Nutrition and Metabolism (Lond)*. 2020; 17:3.
- [49] Mohamed H, Mansour H. Incorporating essential oils of marjoram and rosemary in beef patties manufactured with mechanically deboned poultry meat to improve lipid stability and sensory attributes. *LWT Food Science and Technology*. 2012;45(1):79-87.
- [50] Nagre S, Chappalwar A, Rindhe S, Londhe S, Nikam M. Development of chicken patties incorporated with onion (*Allium cepa*) and beetroot (*Beta vulgaris*) extract powder. *Journal of Meat Science*. 2023;18(1):67-74.
- [51] Patošz N, Sawicki T, Wiczowski W. Profile of phenolic acids and flavonoids of red beet and its fermentation products and the effect of long-term consumption of fermented beetroot juice on phenolics in human plasma and urine. *Polish Journal of Food and Nutrition Sciences*. 2020;70(1):55-65.
- [52] Nauman K, Jaspal MH, Asghar B, Manzoor A, Akhtar KH, Ali U, et al. Effect of different packaging atmosphere on microbiological shelf life, physicochemical attributes, and sensory characteristics of chilled poultry fillets. *Food Science Animal Resources*. 2022;42(1):153-174.
- [53] Pachpor V. Quality assessment of chicken nuggets incorporated with guava fruit extract as antioxidants. M.V.Sc. thesis submitted to Maharashtra Animal and Fishery Sciences University, Nagpur. 2014.
- [54] Porto M, Okina V, Pimentel T, Prudencio S. Physicochemical stability, antioxidant activity and acceptance of beet and orange mixed juice during refrigerated storage. *Beverages*. 2017;3(3):36.
- [55] Rahman S. Food preservation by freezing. In: *Handbook of food preservation*. New York: Marcel Dekker; 1999.
- [56] Rajkumar V, Verma A, Patra G, Pradhan S, Biswas S, Chauhan P, et al. Quality and acceptability of meat nuggets with fresh Aloe vera gel. *Asian-Australasian Journal of Animal Sciences*. 2016;29(5):702-708.
- [57] Ranawana V, Moynihan E, Campbell F, Duthie G, Raikos V. Beetroot improves oxidative stability and functional properties of processed foods: singular and combined effects with chocolate. *Journal of Food Science and Technology*. 2018; 55.10.1007/s13197-018-3157-3
- [58] Rathour M, Malav OP, Kumar P, Chatli MK, Mehta N. Storage stability of chevon rolls incorporated with ethanolic extracts of Aloe vera and cinnamon bark at refrigeration temperature (4 ± 1 °C). *Journal of Animal Research*. 2017;7:183-190.
- [59] Reddy M, Kumar M, Reddy G, Krishnaiah N, Reddy N, Reddy D. Storage stability of vacuum-packaged turkey meat sausages incorporated with carrot and radish paste during refrigerated storage. *International Journal of Chemical Studies*. 2020; 8(4):1054-1058.
- [60] Ribeiro M, Singh S, Guestrin C. Anchors: high-precision model-agnostic explanations. *Proc AAAI Conference on Artificial Intelligence*. 2018;32(1).
- [61] Sadeghian M, Mardani N, Jahadi M, Keighobadi K. Antioxidant and antimicrobial activities of aqueous extract of yellow and white sweet Spanish onion (*Allium cepa* L.). *Nutrition and Food Sciences Research*. 2020;7(4):33-39.
- [62] Sahoo J, Anjaneyulu ASR. Effects of natural antioxidants and vacuum packaging on the quality of buffalo meat nuggets during refrigerated storage. *Meat Science*. 1997; 47:223-230.
- [63] Sarvinehbaghi MB, Ahmadi M, Shiran M, Azizkhani M. Antioxidant and antimicrobial activity of red onion extract nanoencapsulated in native seed gum coating and its effect on shelf life of beef fillet. *Journal of Food Measurement and Characterization*. 2021;15(5):4771-4780.
- [64] Sharma P, Yadav S. Effect of incorporation of pomegranate peel and bagasse powder and their extracts on quality characteristics of chicken meat patties. *Food Science of Animal Resources*. 2020;40(3):388-400.
- [65] Shelef LA, Jay JM. Use of a titrimetric method to assess the bacterial spoilage of fresh beef. *Applied Microbiology*. 1970;19(6):902-905.
- [66] Singh B, Hathan BS. Chemical composition, functional properties and processing of beetroot: a review. *International Journal of Scientific Engineering Research*. 2014;5(1):679-684.
- [67] Singh P, Kumar S, Bhat ZF, Kumar P. Effect of clove oil on the storage quality of aerobically packaged fibre-enriched chevon cutlets. *Journal of Meat Science*. 2014;10(1):36-43.
- [68] Singh P, Sahoo J, Chatli MK, Biswas A. Shelf-life evaluation of raw chicken meat emulsion incorporated with clove powder, ginger and garlic paste at refrigerated storage (4 ± 1 °C). *International Food Research Journal*. 2014; 21(4):1363-1369.
- [69] Singh RP, Chidambara Murthy KN, Jayaprakasha GK. Studies on the antioxidant activity of pomegranate peel and seed extracts using in vitro models. *Journal of Agriculture Food Chemistry*. 2002;50(1):81-86.
- [70] Singleton VL, Rossi JA. Colorimetry of total phenolics with phosphomolybdic-phosphotungstic acid reagents. *American Journal of Enology and Viticulture*. 1965;16(3):144-158.
- [71] Snedecor GW, Cochran WG. *Statistical methods*. 8th ed. Ames (IA): Iowa State University Press, Amer, Iowa, USA. 1989.
- [72] Terao J. Potential role of quercetin glycosides as anti-atherosclerotic food-derived factors for human health. *Antioxidants*. 2023;12(2):258.

- [73] Troutt ES, Hunt MC, Johnson DE, Clans JW, Castner CL, Kropf DH. Characteristics of low-fat ground beef containing texture-modifying ingredients. *Journal of Food Science*. 1992;57(1):19-24.
- [74] Verma SP, Sahoo J. Improvement in the quality of ground chevon during refrigerated storage by tocopherol acetate preblending. *Meat Science*. 2000;56(4):403-413.
- [75] Wang B, Pham LB, Adhikari B. Complexation and conjugation between phenolic compounds and proteins: mechanisms, characterisation and applications as novel encapsulants. *Sustainable Food Technology*. 2024;2(5):1206-1227.
- [76] Wani S, Majeed D. Evaluation of quality attributes and storage stability of pickle prepared from chicken gizzard. *Journal of Meat Science and Technology*. 2014;2(4):85-89.
- [77] Witte VC, Krause GF, Bailey ME. An extraction method for determining thiobarbituric acid values of pork and beef during storage. *Journal of Food Science*. 1970; 35:582-585.
- [78] Wu Y, Wang W, Zhao Y, et al. Effects of different phenolic compounds on the oxidative stability of myofibrillar proteins after in vitro metal-catalyzed oxidation. *Food Science of Animal Products*. 2025;3(3):9240123.
- [79] Yaqoob Z, Arshad M, Khan MK, Imran M, Ahmad M, Ahmad S, et al. Ultrasound-assisted extraction of guava and papaya leaves for the development of functional shrimp patties. *Food Science and Nutrition*. 2020;8(7):3923-3935.
- [80] Yavas E, Bilgin B. Effect of calcium lactate, sodium diacetate and sodium chloride mixture on the microbiological, chemical and sensory properties of chicken nuggets stored in refrigeration and under modified atmospheres. *International Journal of Poultry Science*. 2010;9(1):66-71.
- [81] Zahid MA, Choi JY, Seo JK, Parvin R, Ko J, Yang HS. Effects of clove extract on oxidative stability and sensory attributes in cooked beef patties at refrigerated storage. *Meat Science*. 2020; 161:107972.
- [82] Zargar F, Kumar S, Bhat ZF, Kumar P. Effect of pumpkin on the quality characteristics and storage quality of aerobically packaged chicken sausages. *Springer Plus*. 2014; 3:39.
- [83] Zhang H, Wu J, Guo X. Effects of antimicrobial and antioxidant activities of spice extracts on raw chicken meat quality. *Food Science and Human Wellness*. 2016;5(1):39-48.
- [84] Zhu L, Myhill LJ, Andersen-Civil AIS, Thamsborg SM, Blanchard A, Williams AR. Garlic-derived organosulfur compounds regulate metabolic and immune pathways in macrophages and attenuate intestinal inflammation in mice. *Molecular Nutrition and Food Research*. 2022.

© 2026, by the Authors. The articles published from this journal are distributed to the public under “**Creative Commons Attribution License**” (<http://creativecommons.org/licenses/by/3.0/>). Therefore, upon proper citation of the original work, all the articles can be used without any restriction or can be distributed in any medium in any form.

Publication History	
Received	30.01.2026
Revised	21.03.2026
Accepted	21.03.2026
Online	03.04.2026