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Quality characteristics of chicken sausages prepared with addition of beetroot powder stored at refrigerated temperature

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ABSTRACT

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The present study explored preservative potential of beetroot powder (BP) in chicken sausages as natural preservative. Beetroot powder was added at three different levels i.e. T1 (1.5% of BP w/w of meat emulsion), T2 (3.0% of BP w/w of meat emulsion), T3 (4.5% of BP w/w of meat emulsion) in the preparation of chicken sausage and was compared with control (C without BP) chicken sausage which were aerobically packaged. The samples were examined for physico-chemical parameter (pH, cooking yield, emulsion stability), proximate composition, Total phenolic content and 2,2-diphenyl-1-picrylhydrazyl (DPPH) radical scavenging activity. Storage stability of these chicken sausages were also evaluated on the basis of pH, oxidative stability (peroxide value, thiobarbituric acid reactive substances), microbiological analysis (total plate count, psychrophilic counts, coliforms and yeast and mould count) and sensory evaluation for 12 days at refrigeration storage. The results indicated that incorporation of BP significantly improved the cooking yield, emulsion stability, ash content, fibre, DPPH radical scavenging activity and total plate count. During storage restricted fat oxidation, microbial proliferation and better maintained sensorial characteristics were observed in treatments. Therefore, outcomes of the study suggested that beetroot could be used as natural preservative for extension of shelf-life of chicken sausages.

Keywords: Chicken sausage, Beetroot, Antioxidant, Lipid oxidation, Sensory attributes

INTRODUCTION

Food deterioration and spoilage is one of the major global issues and hurdles for the sustainable development. According to United Nations (UN), globally food spoilage or food losses from harvest to retail are about 14%, whereas about 17% of food is wasted thereafter of which 11% is lost at household level, 5% at the food service level and 2% at the retail level (United Nation Environmental Programme, 2021). Shelf-life extension of perishable food items with natural preservatives can be a promising approach for preventing spoilage and food wastage.

Meat is a highly nutritious and perishable food item which accounts for around 7% of total food mass providing 11% of global food energy and 21% of global protein in terms of nutrient availability (Smith *et al*., 2022). Various factors affect the quality and shelf life of meat products during storage. The deterioration of quality of meat products are associated with products safety and purchasing behaviour of consumers. Fat oxidation and microbial proliferation are the principal factors of food products spoilage Verma *et al.* 2023. Therefore, the food processors use preservatives, either natural or synthetic, to prolong the shelf life of meat products as well as to lower microbial growth and lipid oxidation. Additionally, consumers are moving towards natural food preservatives and avoiding synthetic or artificial ones due to health concerns.

Vegetables are sources of myriads of active components that might be used for food processing industry imparting functionalities viz. anti-oxidant, anti-microbial actions etc. Because of its high nitrate content and global availability, Beetroot (*Beta vulgaris L.*) stands out among all vegetable sources. *Beta vulgaris* is high in phenolic acids, vitamins, and antioxidants. Presence of phenolic compounds and betalains in red beet makes it a good source of natural colourants and antioxidants (Ravichandran *et al.*, 2012; Chhikara *et al.*, 2019; Panghal *et al.,* 2017). They also have a chemo-preventive effect against free radicals and oxidative stress (Lechner and Stoner, 2019). Betalains and anthocyanins are two active components found in beetroot. In addition to all of the health benefits, beetroot improves gut health, has oxidative stress inhibitory effects, optimises lipid metabolism, and has a lipid peroxidation effect (De *et al.*, 2021; Babarykin *et al.,* 2019). Thus, the goal of this study is to prolong the storage stability of chicken sausages with addition of beetroot powder at different levels over a 12 days storage period.

MATERIALS AND METHODS

Chicken meat and goat intestine for casing making and other ingredients such as spices, condiment, soya, refined oil, gram dal and packaging material low density

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polyethylene (LDPE) were purchased from local market while freeze-dried beetroot powder (excellent foods) was purchased from online market. Analytical reagents and bacteriological media were obtained from standard firms Hi-media, SRL and CDH.

Preparation of casings

Freshly slaughtered goat small intestine was procured from the local market. Through cleaning of small intestine with clean water was carried out in meat processing lab of Department of Livestock Products Technology (LPT), COVAS, SVPUAT, Meerut. Sliming with 10% saline solution was done for 10 hours to swell out the different layers of intestine. Careful scrapping of small intestine was done to remove all the layers of intestine except sub-mucosa. Further cleaning of casings was done with clean water and stored in saline solution at refrigeration temperature until further usage.

Preparation of sausage

Fresh chicken was purchased from market after that carcass was cleaned, deboned and minced in the meat processing laboratory of Department of LPT, COVAS, SVPUAT, Meerut. The meat was minced twice using (6 mm) plate in a meat mincer. Table salt, sodium nitrite, sodium tripolyphosphate refined vegetable oil, slush ice, chana dal, textured soya, spice mixture, condiment and beetroot powder were incorporated to weighed meat according to formulation (Table 1). Meat emulsion for preparation of chicken sausage was made in Inalsa food processor. Initially, minced meat was blended with table salt, sodium nitrite, sodium tripolyphosphate (STPP) and slush ice for 1.5 min. followed by incorporation of refined vegetable oil and mixed for another 1 min. Later, addition of other ingredients including beet root powder in treatments was followed by blending for further 2 min. After preparation of meat emulsion, it was stuffed into the goat casings using a manual stuffer along-with linking/tying at regular intervals. Prepared sausages were cooked in hot water at 85°C for 25 minutes followed by grilling in an oven at 160°C for 15 minutes. Cooled cooked sausages were packaged in low-density poly ethylene (LDPE) pouch and kept at refrigeration temperature for further analysis.

Table1: Formulation of chicken sausage prepared with incorporation of beetroot powder

Ingredients	C	T1	T2	T3
Minced meat%	68.7	67.2	65.7	64.2
Beetroot powder (%)	-	1.5	3.0	4.5
Condiments (Onion 3: Garlic 2: Ginger 1)	3.0	3.0	3.0	3.0
Soybean (Hydrated) (%)	3.0	3.0	3.0	3.0
Chana dal (%)	3.0	3.0	3.0	3.0
Spices (%)	2.0	2.0	2.0	2.0
Salt (%)	2.0	2.0	2.0	2.0
Sodium tripolyphosphate (%)	0.3	0.3	0.3	0.3
Slush ice (%)	8.0	8.0	8.0	8.0
Oil (%)	10.0	10.0	10.0	10.0
Sodium nitrite (ppm)	120	120	120	120

C: Control chicken sausage without beetroot powder; T1: chicken sausage with 1.5% beetroot powder; T2: chicken sausage with 3.0% beetroot powder; T3: chicken sausage with 4.5% beetroot powder.

Physico-chemical analysis

The cooking yield of samples were estimated by measuring the weight of the raw sausages previously and after cooking and estimated as ratio of cooked weight to raw weight and expressed in percentage. Emulsion stability of sausage emulsion was determined by the method given by Townsend *et al*. (1968). Moisture, protein, fat, fiber and ash percentage of chicken sausages were determined according to the AOAC (1995) procedures. The changes in pH of cooked sausages during storage were measured by digital pH meter following the technique of Troutt *et al*. (1992).

Total phenolic content (µg GAE/100g)

Total phenolic content of chicken sausages was measured using the Folin Ciocalteu method, as Zhang *et al*. (2006) proposed. Sample extract (0.6 mL) and 0.3 mL of 0.2 N Folin-phenol Ciocalteu's reagent were mixed in a test tube. After that, 2.4 mL of a sodium carbonate (20%) solution was added to the mixture, which was then left at room temperature for 10 minutes. Absorbance at 730 nm was measured after filtering the content.

DPPH (1, 1-diphenyl-2-picrylhydrazyl)% inhibition

With little modifications, the (DPPH) activities of product samples were determined using the technique given by Kato *et al*. (1988). The 10 mL of ethanol and methanol (1:1) were used to triturate 2.5 g of product sample for 2–3 min. The blended samples were filtered and stored. A test tube was filled with 3.9 ml of the DPPH reagent (250 M), 1 ml of the 0.1 M Tris-HCl buffer (pH 7.4) and 0.1 ml of the sample filtrate. A UV Spectrophotometer was used to measure absorbency at 517 nm.

Lipid oxidation

Lipid stability was estimated by using thiobarbituric acid reactive substances (TBARS) test as given by Witte *et al.* (1970) with suitable modification. The Peroxide value (PV) content was estimated following the method as elaborated by Koniecko (1979).

Microbial analysis

Total plate count (TPC), psychrophilic count, coliform count and yeast and mould count in chicken sausage were measured as per the method given by APHA (1992).

Sensory evaluation

Experienced panel of judges with seven members from College of Veterinary and Animal Sciences, SVPUAT, Meerut, India evaluated the chicken sausages

for appearance and colour, flavour, texture, juiciness and overall acceptability using 9-point hedonic scale, where 9=extremely desirable and 1=extremely undesirable. The sensory evaluation was conducted on all days of evaluation and the whole experiment was replicated thrice (n=21). Before analysis, the chicken sausages were warmed in a microwave oven for 20 sec and then presented to the evaluators in coded form. Tap water was also provided for cleansing the palate during evaluation.

Statistical analysis

Data were analysed using statistical package social science (SPSS) version 22. Means of treatment showing significant difference ($p \leq 0.05$) were subjected to Duncan's multiple range test.

RESULTS AND DISCUSSION

Cooking yield and emulsion stability of chicken meat emulsion added with beetroot powder

The cooking yield of sausages were considerably ($p \leq 0.05$) affected by addition of beetroot powder (Table 2) and increased significantly ($p \leq 0.05$) in treatments. The effect was more prominent ($p \leq 0.05$) in T1 and T2 as increasing the BP content from 3% to 4.5% did not significantly affect the cooking yield. Comparable results were also reported by Zaini *et al*. (2020) for the incorporation of banana peel powder in chicken sausages. The increase in cooking yield among treatments might be attributed to the ability of dietary fibres to prevent moisture migration during cooking. Similarly, Verma *et al*. (2015) and Rani *et al*. (2021) also confirmed that addition of pumpkin pulp and pumpkin seed powder in chicken patties and nuggets considerably improved the cooking yield.

The meat emulsion prepared for sausage making evinced significant ($p \leq 0.05$) differences in their stability (Table 2). Addition of beetroot powder significantly ($p \leq 0.05$) increased the emulsion stability in treatments which increased notably ($p \leq 0.05$) at each level. This increase in emulsion stability could be due to the increase in dietary fibre content of beetroot powder, which retains more water and oil in the product. Kohajdová *et al.* (2018) reported high dietary fibres (65.7%) and good hydration in beetroot powder as incorporation of it significantly increased the water absorption and improved dough stability of baking rolls. Similar results were also reported by Patel *et al.* (2021) for meat nuggets formulated with addition of whey protein concentrate.

Proximate composition of beetroot powder added chicken sausage

Incorporation of beetroot powder significantly ($p \leq 0.05$) affected the proximate composition of chicken sausages (Table 2). The moisture content of T2 and T3 sausages were significantly ($p \leq 0.05$) higher than control which might be attributed to the better hydration and superior water retaining properties of beetroot. However, the incorporation of beetroot reduced the percent protein content of the chicken sausages significantly ($p \leq 0.05$) at higher levels (T2 and T3). This decrease might be due to the low protein content in beetroot and to the fact that meat was replaced by beetroot powder in treatments. Contrarily, Choe *et al*. (2011) observed insignificant effect on protein content of emulsified sausage incorporated with goldenrod leaf and stem powder at 1 and 2% level. Similarly, Jin *et al.* (2014) reported no significant increase in protein content with addition of beetroot powder at 0.5% and 1% in emulsified pork sausage.

The variations in fat content of sausages were similar to that of protein (Table 2). The fat content decreased significantly ($p \leq 0.05$) with the increasing level of beetroot powder except that at 0.5% level. Park *et al*. (2012) observed that on incorporation of makgeolli fiber the fat content of meat sausages decreased. Similar decrease in fat content was also observed by Verma *et al*. (2016) in chicken meat balls incorporated with cabbage. However, the ash content evinced the significant ($p \leq 0.05$) increase at each level of beetroot incorporation in treatments. Similar trend of increased ash content was observed by Jin *et al*. (2014) in pork sausages added with beetroot powder.

The fibre content escalated significantly ($p \leq 0.05$) with increase in beetroot powder incorporation. Highest ($p \leq 0.05$) fibre content was recorded in T3 which had 4.5% beetroot powder (Table 2). Beetroot powder is a good source of dietary fibres. The freeze-dried red beet contains about 17.2-21.8% total dietary fibre (Nemzer *et al*., 2011). Akin result was also reported by Verma *et al.* (2022) for chicken nuggets prepared with the addition of *nelumbo nucifera* root powder.

Antioxidant Parameters

DPPH (1, 1-diphenyl-2-picrylhydrazyl)% inhibition and Total phenolic content (µg GAE/100g): The DPPH radical percent inhibition is an easy, quick, affordable and widely used technique to assess the antioxidant capacity. Moreover, it efficiently assesses both hydrophilic and hydrophobic (lipophilic) antioxidants. Incorporation of beetroot powder markedly ($p \leq 0.05$) increased the DPPH radical% inhibition in the treatments (Table 2). Among treatments, the DPPH values increased significantly ($p \leq 0.05$) with increase in level of beetroot powder in the sausages. The antioxidant activity of beetroot has been reported in the range of 14.2% to 90.7% (Georgiev *et al*. 2010). The T3 sample showed highest DPPH values. Above results showed that the beetroot can be successfully use in products to provide a great source of natural antioxidant effect.

Plants are rich in phenolic compounds which by the virtue of their hydroxyl groups are endowed with redox properties. These compounds act as free radical scavengers and prevent oxidative deterioration and /or

degeneration. An estimate of total phenolic content indicates the antioxidant potency of a compound. Beetroot powder incorporation recorded appreciable increase in the total phenolic content of the treatments as compared to control (Table 2). Among treatments, the total phenolic content was directly proportional to the level of incorporation. Highest phenolic content was observed in T3 while least total phenolic content was observed in control. Increasing trend in total phenolic content with increase in beetroot powder might be due to presence of polyphenols in the beetroot powder. The level of polyphenols in beetroot may vary from 720 to 1276 mg/kg (Ninfali and Angelino, 2013). Lechner and Stoner (2019) also reported that the chemo-protective effect against free radical compounds and oxidative stress in beetroot is due to the phenolic compounds found in them.

Table 2: Physicochemical properties and antioxidant capacity of chicken sausages incorporated with different levels of beetroot powder

Parameters	C	T1	T2	T3
Cooking yield (%)	89.22±0.13^{a}	90.11±0.27^{b}	91.70±0.21^{c}	91.66±0.22^{c}
Emulsion stability (%)	91.46±0.12^{a}	92.21±0.22^{b}	93.14±0.10^{c}	94.08±0.24^{d}
Moisture (%)	64.95±0.31^{a}	65.77±0.53^{ab}	66.09±0.19^{b}	67.16±0.13^{c}
Protein (%)	15.66±0.56^{c}	15.28±0.38^{bc}	14.81±0.15^{b}	14.27±0.22^{a}
Fat (%)	14.62±0.16^{c}	13.45±0.14^{bc}	13.26±0.17^{b}	12.81±0.15^{a}
Ash (%)	2.82±0.02^{a}	3.04±0.03^{b}	3.12±0.05^{c}	3.24±0.03^{d}
Fiber (%)	0.86±0.19^{a}	1.23±0.11^{b}	1.95±0.18^{c}	2.35±0.17^{d}
DPPH (%)	42.32±0.21^{a}	62.33±0.19^{b}	67.20±0.58^{c}	68.44±0.16^{d}
TPC (µg GAE/g)	14.32±0.57^{a}	21.30±0.37^{b}	25.95±0.17^{c}	28.40±0.44^{d}

Means values having small letters (a, b, c, d…...) treatment wise differ significantly ($P \leq 0.05$) n=6. C: Control chicken sausage without beetroot powder; T1: chicken sausage with 1.5% beetroot powder; T2: chicken sausage with 3.0% beetroot powder; T3: chicken sausage with 4.5% beetroot powder. GAE=gallic acid equivalent

Change in pH, peroxide value and TBARS (mg malonaldehyde/kg) of chicken sausage during storage: Significant differences were observed in pH due to incorporation of beetroot powder in chicken sausages. The pH decreased significantly in treatments than in control which was dependent on the level of incorporation. Highest pH was observed in control and lowest was observed in chicken sausage with 4.5% beetroot powder (Table 3). This difference was evident till the end of storage except variations among T1 and T2 during intermediate days (Day 4 and 8). Similar decrease in pH was also observed by Ozaki *et al.* (2021) in fermented dry sausage incorporated with beetroot powder. Noticeably, during storage the pH of all samples increased significantly, highest being on the 12th day. This increase in pH might be attributed to the biochemical and microbial activities which continue even during refrigeration conditions at a gradual pace.

The peroxide value (PV) of all samples evinced significant ($p \leq 0.05$) differences on the initial day (Table 3). Lowest PV was observed in T3 followed by T2 >T1>C. The higher phenolic content of beetroot might be attributed to the lower PV in treatments. During storage, the PV increased significantly ($p \leq 0.05$) among all groups but remained under the prescribed limits. Best result of peroxide value was observed in T3 having highest concentration of beetroot powder that could be attributed to achievement of threshold by the active compounds present in the beetroot powder in T3. Significantly least ($p \leq 0.05$) PV was observed in T3 and highest in C on day 12 of storage. This contrasting difference in PV between test groups (T1, T2 and T3) and control shows that beetroot powder has active compounds which reduces the rate of lipid oxidation. Ozaki *et al.* (2021) and Turp *et al.* (2016) also reported that the beetroot powder caused a considerable ($p \leq 0.05$) retardation of lipid oxidation in sausages. Similar results were obtained by Duthie *et al.* (2013) with incorporation of 6% of beetroot powder in turkey patties found to have greater number of bioactive compounds (phenolic compounds, carotenes and tocopherols etc.) and oxidation stability.

During storage, TBARS values increased significantly ($p \leq 0.05$) among all groups, highest TBARS values were observed in C and lowest in T3 on day 12 of storage which were under the safe limits (Table 3). T2 and T3 showed non-significant ($p<0.05$) decrease in TBARS values from day 8 to day 12. Appreciable results in groups incorporated with beetroot powder was noticed compared to control due to presence of betalains, which show radical-scavenging activities (Georgiev *et al.*, 2010). Similar results in TBARS values were observed by Mashau *et al.* (2021) who added moringa leaf powder in ground beef and Umaraw *et al.* (2024) for meat balls added with mango seed extract.

Table 3: Change in pH, peroxide value and TBARS number of storage stability of chicken sausages incorporated with different level of beetroot powder

Groups Days	0 day	4 days	8 days	12 days
		p^H		
C	6.22 ± 0.04^{dA}	6.26 ± 0.03^{cB}	6.43 ± 0.04^{cC}	6.52 ± 0.04^{dD}
T1	6.09 ± 0.02^{cA}	6.25 ± 0.06^{cB}	6.36 ± 0.03^{bC}	6.45 ± 0.07^{cD}
T2	6.04 ± 0.02^{bA}	6.22 ± 0.05^{bB}	6.23 ± 0.08^{aB}	6.36 ± 0.05^{bB}
T3	5.94 ± 0.05^{aA}	6.07 ± 0.02^{aB}	6.24 ± 0.06^{aC}	6.29 ± 0.04^{aD}
		Peroxide value (meq/kg)		
C	3.12 ± 0.05^{dA}	4.34 ± 0.07^{dB}	4.54 ± 0.06^{dC}	5.61 ± 0.06^{dD}
T1	2.73 ± 0.06^{bA}	3.22 ± 0.08^{bB}	3.40 ± 0.02^{bC}	4.05 ± 0.01^{bD}
T2	2.77 ± 0.07^{cA}	3.65 ± 0.04^{cB}	3.93 ± 0.07^{cC}	4.65 ± 0.04^{cD}
T3	2.63 ± 0.04^{aA}	2.85 ± 0.11^{aB}	3.02 ± 0.01^{aC}	3.93 ± 0.08^{aD}
		TBARS number (mg malonaldehyde/ kg)		
C	0.55 ± 0.08^{bA}	0.63 ± 0.04^{cB}	0.68 ± 0.04^{cC}	0.72 ± 0.03^{cD}
T1	0.53 ± 0.05^{aA}	0.59 ± 0.04^{bB}	0.62 ± 0.03^{bC}	0.67 ± 0.04^{bD}
T2	0.54 ± 0.07^{bA}	0.55 ± 0.04^{aA}	0.59 ± 0.04^{aB}	0.63 ± 0.03^{aB}
T3	0.58 ± 0.04^{cA}	0.63 ± 0.03^{cB}	0.71 ± 0.04^{dC}	0.69 ± 0.04^{bC}

Means values having small letters (a, b, c, d…...) treatment wise and capital letters (A, B, C and D) storage wise differ significantly ($p\leq0.05$) n=6; C: Control chicken sausage without beetroot powder; T1: chicken sausage with 1.5% beetroot powder; T2: chicken sausage with 3.0% beetroot powder; T3: chicken sausage with 4.5% beetroot powder.

Microbiological qualities

Total Plate Count: Incorporation of beetroot powder in the chicken sausage significantly improved its microbiological quality (Table 4). On Day 0, significantly lowest TPC were observed in T3 followed by T2, T1 and C which showed that beetroot powder contains ingredients which possess antimicrobial activity. The TPC increased significantly ($p\leq0.05$) among all groups during the storage period. Highest TPC values were observed in C and lowest in T3 on day 12 of storage which were under the prescribed limits. The psychrophilic count was absent up to 4th days of storage and observed at 8th day and count was lower in T3 followed by T2, T1 and control. The incorporation of beetroot can decrease the proliferation of microbes in chicken sausage, which may be associated with bioactive compounds present in beetroot (Gong *et al.* 2022). *E. coli* and yeast and mould growth were not detected in chicken sausage during the storage period.

Table 4: Change in microbial quality of chicken sausages incorporated with different level of beetroot powder

Groups Days	0 day	4 days	8 days	12 days
		Total plate counts (cfu/gm)		
C	2.37 ± 0.08^{dA}	3.34 ± 0.12^{dB}	3.40 ± 0.17^{dC}	4.64 ± 0.16^{dD}
T1	2.11 ± 0.18^{cA}	2.23 ± 0.19^{bB}	2.96 ± 0.18^{cC}	3.88 ± 0.09^{cD}
T2	1.99 ± 0.11^{bA}	2.64 ± 0.13^{cB}	2.76 ± 0.12^{bC}	3.82 ± 0.11^{bD}
T3	1.72 ± 0.14^{aA}	1.95 ± 0.17^{aB}	2.35 ± 0.15^{aC}	3.59 ± 0.14^{aD}
		Psychrophilic counts (cfu/gm)		
C	ND	ND	1.58 ± 0.12^{bA}	2.26 ± 0.15^{bB}
T1	ND	ND	1.36 ± 0.09^{abA}	2.06 ± 0.11^{aB}
T2	ND	ND	$1.21\pm.011^{aA}$	1.98 ± 0.08^{aB}
T3	ND	ND	1.18 ± 0.15^{aA}	1.86 ± 0.14^{aB}
		Coliform counts (cfu/gm)		
C	ND	ND	ND	ND
T1	ND	ND	ND	ND
T2	ND	ND	ND	ND
T3	ND	ND	ND	ND
		Yeast and Moulds (cfu/gm)		
C	ND	ND	ND	ND
T1	ND	ND	ND	ND
T2	ND	ND	ND	ND
T3	ND	ND	ND	ND

Means values having small letters (a, b, c, d…...) treatment wise and capital letters (A, B, C and D) storage wise differ significantly ($p<0.05$) n=6; C: Control chicken sausage without beetroot powder; T1: chicken sausage with 1.5% beetroot powder; T2: chicken sausage with 3.0% beetroot powder; T3: chicken sausage with 4.5% beetroot powder. ND: Not detected

Change in sensory attributes of beetroot added chicken sausage

All attributes of the sensory analysis varied significantly ($p \leq 0.05$) among the groups and it was also noticed that every parameter decreased significantly ($p \leq 0.05$) during storage (Table 5). Overall, from day 0 to day 12 the sensory score for colour and appearance reduced but were in acceptable range during the whole storage period. Hwang *et al.* (2017) reported that with increase in the level of fermented beetroot extract overall acceptability scores for pork sausages reduced. Sucu and Turp (2018) also observed increased visual colour and overall acceptability scores incorporation of beetroot powder in Turkish fermented beef sausage as compared to control. Jin *et al*. (2014) reported that incorporation of beetroot powder increases the colour score of the sausages formed. In present study T3 showed lower colour and appearance score which might be attributed due to production of intense red colour in the product with incorporation of 4.5% level of beetroot powder which makes chicken sausages less appealing and also made the product look dry. Flavour attributes of all samples decreased during storage which might be due to the oxidation of fat and protein by microbial proliferation leading to generation of off-flavour compounds (Umaraw *et al.,* 2020). Singh *et al.* (2021) also observed significant ($p \leq 0.05$) decrease in juiciness and texture scores of chicken sausage during storage which might be due to alteration in the matrix of sausage during storage. On day 0, control received highest acceptability followed by treatments. But with storage the changes in other sensory attributes significantly influenced the overall acceptability of products. By the end of storage (day 12) only T2 received scores above 7 rest all samples were rated below 7 indicating the changes in sensory attributes during storage.

Table 5: Sensory evaluation values of chicken sausages incorporated with different level of beetroot powder

Groups Days	0 day	4 days	8 days	12 days
		Colour and Appearance		
C	8.17 ± 0.08^{aD}	7.86 ± 0.07^{aC}	7.23 ± 0.07^{aB}	6.81 ± 0.07^{aA}
T1	8.51 ± 0.11^{bD}	8.19 ± 0.08^{bC}	7.75 ± 0.11^{bB}	7.31 ± 0.18^{bA}
T2	8.52 ± 0.15^{bC}	8.33 ± 0.13^{cBC}	8.24 ± 0.07^{cB}	7.60 ± 0.12^{cA}
T3	8.19 ± 0.12^{aC}	7.90 ± 0.18^{aB}	7.73 ± 0.09^{bB}	7.51 ± 0.14^{cA}
		Flavour		
C	8.50 ± 0.14^{cD}	8.15 ± 0.08^{bC}	7.29 ± 0.16^{aB}	6.71 ± 0.16^{aA}
T1	8.41 ± 0.08^{cD}	8.21 ± 0.10^{bcC}	7.63 ± 0.15^{bB}	7.29 ± 0.10^{cA}
T2	8.25 ± 0.09^{bC}	8.30 ± 0.10^{cC}	8.00 ± 0.12^{cB}	7.49 ± 0.18^{dA}
T3	8.07 ± 0.07^{aC}	7.76 ± 0.09^{aB}	7.61 ± 0.13^{bB}	7.16 ± 0.15^{bA}
		Texture		
C	8.42 ± 0.15^{cD}	8.29 ± 0.16^{cC}	7.19 ± 0.10^{aB}	6.79 ± 0.09^{bA}
T1	8.30 ± 0.10^{bD}	7.79 ± 0.09^{bC}	7.31 ± 0.10^{bB}	6.77 ± 0.09^{bA}
T2	8.50 ± 0.09^{dD}	8.25 ± 0.09^{cC}	7.86 ± 0.12^{cB}	7.50 ± 0.09^{cA}
T3	7.86 ± 0.11^{aD}	7.51 ± 0.09^{aC}	7.14 ± 0.14^{aB}	6.38 ± 0.20^{aA}
		Juiciness		
C	8.25 ± 0.07^{bD}	8.15 ± 0.08^{bC}	7.93 ± 0.13^{cB}	6.15 ± 0.08^{aA}
T1	8.29 ± 0.09^{bC}	8.14 ± 0.08^{bC}	7.70 ± 0.12^{bB}	7.25 ± 0.09^{cA}
T2	8.51 ± 0.18^{cC}	8.27 ± 0.09^{cB}	8.25 ± 0.09^{dB}	7.48 ± 0.13^{dA}
T3	7.98 ± 0.18^{aC}	7.60 ± 0.19^{aB}	7.50 ± 0.18^{aB}	6.65 ± 0.12^{bA}
		Overall Acceptability		
C	8.50 ± 0.09^{cD}	7.24 ± 0.09^{bC}	7.05 ± 0.09^{aB}	6.79 ± 0.12^{aA}
T1	7.51 ± 0.15^{bC}	7.21 ± 0.09^{bB}	7.11 ± 0.09^{aAB}	6.99 ± 0.11^{bA}
T2	7.64 ± 0.13^{bC}	7.49 ± 0.12^{cB}	7.29 ± 0.14^{bA}	7.21 ± 0.10^{cA}
T3	7.25 ± 0.09^{aC}	7.18 ± 0.10^{aBC}	7.02 ± 0.12^{aB}	6.85 ± 0.09^{aA}

Means values having small letters (a, b, c, d…...) treatment wise and capital letters (A, B, C and D) storage wise differ significantly ($p \leq 0.05$) n=21; C: Control chicken sausage without beetroot powder; T1: chicken sausage with 1.5% beetroot powder; T2: chicken sausage with 3.0% beetroot powder; T3: chicken sausage with 4.5% beetroot powder.

CONCLUSION

The incorporation of beetroot powder in chicken sausages significantly improved the emulsion stability of the sausage batter resulting in increased cooking yield of the product. Although the replacement of chicken meat with beetroot powder decreased the protein and fat content of sausages, the moisture, ash and dietary fibres increased appreciably along with the DPPH and total phenolic content. The high DPPH and TPC of products augmented the storage stability of the chicken sausages as evinced from the restricted increase in deteriorative changes such as peroxide value and TBARS numbers. Moreover, the microbial proliferation was lower in treatments and the sensory characteristics were also better maintained. Among treatments, microbial quality and lipid oxidation were slightly better maintained in T3 however, T2 evinced better overall acceptability during storage.

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