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Effect of Grape Seed Extract Powder on Shelf Life of Superchilled Chicken Sausage

L. G. Dhagare, K. S. Rathod*, S.R. Badhe and P. S. Patil.

Department of Livestock Products Technology, Nagpur Veterinary College, Nagpur- 440 006 (M.S.), India

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• *Corresponding author.
• *E-mail address:* drkshorrathod79@gmail.com (K. S. Rathod)

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ABSTRACT

The shelf life of chicken sausage was assessed by incorporating 0.25% grape seed extract powder (GSEP) under superchilling storage and compared with chicken sausages incorporated with BHT and Control (without any antioxidant). The moisture, pH, peroxide value in GSEP treated samples increased significantly (P<0.05) throughout storage period TBARS, tyrosine and peroxide levels were marginally lower in GSEP treated chicken sausages than in control and BHT treated products. Over the course of the storage period, the protein, moisture and fat content of all the treated samples dropped gradually. In addition, GSEP treated chicken sausages had the lowest total plate count and psychrophilic count, followed by BHT. The study revealed that with the combined effect of superchilling and incorporation of 0.25% GSEP, the chicken sausage could be stored conveniently under aerobic conditions up to 35 days.

Key words: *Grape seed extract powder, Synthetic antioxidants, Superchilling, Storage study, Quality analysis*

INTRODUCTION

Meat is a good source of essential fat-soluble vitamins and minerals with high bioavailability. Chicken sausage is a popular meat product around the world. In minced meat products, lipid oxidation and microbiological growth are the main causes of deterioration and lower shelf life. Nevertheless, sensory parameters like color, flavour, odour, texture, and even nutritional value of meat is mainly affected by lipid oxidation (Aguirrezabal et al. 2000). Consumption of foods containing considerable levels of polyunsaturated fatty acids has increased the significance and use of antioxidants to prevent oxidation. Antioxidants are used to extend the shelf life, especially lipids and lipid-containing foods. Considering synthetic antioxidants like butylated hydroxyanisole (BHA) and butylated hydroxytolune (BHT) are suspected of being carcinogenic and their use in foods is restricted. As a result, in recent years, the importance of the search for natural antioxidants, especially of plant origin, has greatly increased (Jayaprakasha and Rao, 2000). Due to its antioxidant and antimicrobial properties, Grape Seed Extract Powder can be used as a natural preservative. Thus, it has been explored to substitute synthetic antioxidants, which have toxicological effects on human health.

Food preservation is crucial for the product's safety and stability. Demand of fresh and high quality food is increasing day by day throughout the world (Duun and Rustad, 2007). The shelf life and quality of food products

are highly affected by temperature. Fish and meat are perishable food products that require improved and advanced preservation methods. Chemical, enzymatic, and bacteriological processes cause these foods to deteriorate, resulting in a loss of quality and subsequent spoiling. The process of superchilling, as applied for food preservation, is defined as lowering the temperature of a food product to 1–2^{O}C below its initial freezing point. Food preservation under superchilled condition maintains freshness, quality by suppressing the growth of food spoilage microorganisms. It can reduce the utilization of freezing and thawing in production, increasing yield and lowering energy, labour, and transportation costs (Kaale *et al.* 2011). Therefore, the aim of this study was to determine the shelf life of chicken sausages by incorporating grape seed extract powder and their storage under superchilling temperature

MATERIALS AND METHODS

Fresh clean boneless broiler chicken meat was obtained by slaughtering 6 weeks old poultry birds after trimming all separable body fat tendons, connective tissue as well as skin which was then packaged in LDPE bags and kept under refrigeration temperature (4±1^{O}C) overnight (12 h) and subsequently used for product preparation.

Chicken sausage was prepared as per the method of Biswas *et al.* (2007) with slight modification. Boneless chilled broiler chicken meat cut into small pieces and minced in meat mincer (Stadler Corporation, Mumbai). Salt and the antioxidants to be tasted were added in minced meat and chopped in bowl chopper (Stadler Corporation, Mumbai) for 2 min. with addition of ice flakes (1 min.), vegetable oil (1 min), egg white liquid (2 min.), refined wheat flour, condiment and spice mix (2 min.) so as to obtain specific emulsion. Chicken sausages were prepared by incorporating selected level of grape seed extract powder (0.25%) and BHT (0.125 g/kg) separately to the product along with control (No antioxidant added). Sausage batter was stuffed into 20mm diameter food grade artificial plastic casing using mechanical hand stuffer, linked manually and cooked (Gupta, 990) for 20 min at 80°C with continuous turning to attain an internal temperature of 70±2°C. After removal from water bath, cold showering was done for 10 min, followed by peeling of casing. Prepared chicken sausages weighing approximately 100 g were packaged in well labeled LDPE pouches aseptically and stored at superchilling temperature -2±0.5^{O}C and analyzed at an interval of 7 days until visible slime was detected.

Moisture (%), protein (%), fat (%), pH and Peroxide value of chicken sausages were determined as per the method of AOAC (2012). TBARS value was determined using the extraction method described by Witte *et al.* (1970) with slight modification. Tyrosine value of chicken sausage was estimated by the method described by Strange et al. (1977) with slight modifications. Titratable acidity was performed by the method of Shelef and Jay (1970) with suitable modification. The microbiological qualities of chicken sausages were determined on the basis of total plate count, psychrophilic count and coliform count following the standard method of APHA (1984).

The chicken sausages were subjected for sensory evaluation to assess the appearance, flavor, texture, juiciness, and overall acceptability by semi-trained members from academic staff and students of the department using 8 point descriptive scale (Keeton et al. 1983) and the data obtained during the study was subjected to factorial Complete Randomized Design (Snedecor and Cochran, 1994) using the online software (WASP 2.0) developed by ICAR Goa. The level of significance was determined at 5% using Analysis of Variance (ANOVA).

RESULTS AND DISCUSSION

Proximate Analysis

The moisture content of all the samples of chicken sausages reduced significantly ($P<0.05$) over a storage period of 35 days under superchilling temperature (Table 1). The results are in agreement of Rathod et al. (2017), who recorded a significant reduction in the moisture content of aerobically packaged breast fillets under frozen (-20±1°C) and superchilled (-1.5 to -2.5°C) temperature throughout the storage period of 20 days. These results were also supported by Kanle et al. (2018) who reported a significant decrease in moisture content of aerobically packed superchilled chicken nuggets stored at two different superchilling (- 2 ± 0.5 °C and -0.5±0.5 °C) temperatures.

Table 1. Effect of GSEP on certain proximate analysis of chicken sausages during superchilling storage

Type of product	Storage period (Days)						Treatment (Mean±S.E)
	0	7	14	21	28	35	
	Moisture						
Control No antioxidant	61.62^{a}± 0.144	61.44^{a}± 0.080	60.53^{b}± 0.130	60.34^{bc} ±0.076	60.18^{bc} ±0.064	60.03^{c} ±0.192	60.69^{A}± 0.114

(Table continued)

(Table continued)

Type of product	Storage period (Days)						Treatment (Mean±S.E)
	0	7	14	21	28	35	
	Moisture						
BHT (0.125g/kg) 125ppm	61.24^{a}± 0.098	61.1^{a}± 0.202	60.14^{b}± 0.120	60.03^{b}± 0.224	60.01^{b}± 0.272	59.95^{b}± 0.175	60.41^{B}± 0.116
GSEP 0.25%	61.56^{a}± 0.097	61.38^{ab}± 0.041	61.2^{b}± 0.061	60.6^{d}± 0.086	60.9^{c}± 0.180	61.16^{bc}± 0.080	61.15^{C}± 0.064
Storage (Mean±S.E)	61.47^{a}± 0.074	61.31^{a} ± 0.078	60.6^{b}± 0.125	60.3^{c}± 0.098	60.3^{c}± 0.142	60.38^{bc}± 0.159	
Protein							
Control No antioxidant	25.55^{ab}± 0.111	25.19^{c}± 0.068	25.31bc± 0.073	25.08^{c}± 0.105	25.76^{a}± 0.053	25.68^{a}± 0.147	25.43^{A}± 0.056
BHT 125ppm	26.49^{a}± 0.096	26.33^{a}± 0.206	25.68^{b}± 0.127	25.31^{b}± 0.062	25.37^{b}± 0.105	25.49^{b}± 0.121	25.78^{B}± 0.092
GSEP 0.5%	26.56^{a}± 0.069	26.17^{b}± 0.153	25.72^{c}± 0.116	25.44^{cd}± 0.079	25.26^{d}± 0.035	25.59^{c}± 0.114	25.79^{B}± 0.084
Storage (Mean±S.E)	26.20^{a}± 0.123	25.90^{b}± 0.147	25.57^{c}± 0.073	25.27^{d}± 0.058	25.46^{e}± 0.064	25.59^{e}± 0.072	
Fat							
Control No antioxidant	14.40^{a} ± 0.046	14.16^{b} ±0.080	13.82^{c}± 0.088	13.63^{c}± 0.109	13.68^{c}± 0.067	13.64^{c}± 0.063	13.89^{A}± 0.057
BHT 125ppm	14.39^{a}± 0.073	14.0^{b}± 0.071	13.86^{bc}± 0.119	13.74^{bc}± 0.143	13.69^{bc}± 0.114	13.55^{c}± 0.162	13.87^{A}± 0.064
GSEP 0.25%	14.44^{a}± 0.082	14.29^{ab}± 0.097	14.04^{bc}± 0.096	13.98^{bcd}± 0.142	13.81^{cd}± 0.129	13.65^{d}± 0.166	14.03^{B}± 0.064
Storage (Mean±S.E)	14.41^{a}± 0.037	14.15^{b}± 0.053	13.90^{bd}± 0.060	13.78^{b}± 0.080	13.73^{bd}± 0.059	13.61^{d}± 0.0761	

Mean ± SE with different superscripts in a row (small letter) and a column (capital letter) differ significantly (P<0.05)

At the end of 35 days of storage, all three samples showed a slight decrease in protein content which could be attributed to the activities of endogenous enzymes and microorganisms, although the lower temperature may stifle these responses (Ueng and Chow, 1998). Kanle et al. (2018) also noticed a comparable reduction in protein content of chicken nuggets stored at superchilling temperature. The fat percentage in all the samples also decreased significantly (P<0.05) during the storage period of 35. However, there was no significant (P<0.05) difference in fat content among the products during the storage period. Narkhede (2012) found similar results for the chicken nuggets treated with GSE and dried holy basil powder, with no significant (P<0.05) variations in the fat contents between the treatment groups. Furthermore, lipid oxidation during storage might be responsible for the decrease in fat content of these products. (Gandotra et al. 2012).

Physicochemical Qualities

There was significant (P<0.05) increase in pH of all three products during the entire storage period of 35 days (Table 2) which might be due to the accumulation of metabolites of bacterial action and deamination of proteins by the growth of certain gram-negative bacteria (Mokthar et al. 2014). These results are supported by Kumar and Tanwar (2011) who recorded gradual increase in pH of chicken nuggets during storage. In comparison to other samples, the pH of GSEP was reported to be the lowest. This might be due to lower pH of GSE (4.85), which would lower the pH of the overall product (Narkhede 2012). Similar results were also reported by Shewalkar (2011) and Kokare (2013).

Table 2. Effect of GSEP on certain quality characteristics of chicken sausages during superchilling storage

Type of product	Storage period (Days)						Treatment (Mean±S.E)
	0	7	14	21	28	35	
	pH						
Control No antioxidant	6.09^{f} ± 0.007	6.15^{e}± 0.004	6.21^{d}± 0.004	6.26^{c}± 0.006	6.30^{b}± 0.006	6.35^{a}± 0.016	6.23^{a}± 0.015
BHT 125ppm	6.03^{f}± 0.007	6.13^{e}± 0.010	6.16^{d}± 0.007	6.23^{c}± 0.009	6.25^{b}± 0.009	6.33^{a}± 0.010	6.19^{b}± 0.016
GSEP 0.25%	6.04^{f}± 0.009	6.08^{e}± 0.006	6.14^{d}± 0.007	6.19^{c}± 0.008	6.23^{b}± 0.007	6.28^{a}± 0.006	6.16^{c}± 0.014
Storage (Mean±S.E)	6.05^{a}± 0.007	6.12^{b}± 0.007	6.17^{c}± 0.008	6.23^{d}± 0.008	6.27^{e}± 0.008	6.32^{f}± 0.009	
TBARS (mg malanoaldehyde/kg)							
Control No antioxidant	0.15^{e}± 0.009	0.25^{d}± 0.008	0.36^{c}± 0.014	0.46^{b}± 0.011	0.55^{a}± 0.016	0.46^{b}± 0.013	0.37^{A}± 0.023
BHT 125ppm	0.13^{f}± 0.009	0.17^{e}± 0.008	0.26^{d}± 0.008	0.33^{c}± 0.008	0.36^{b}± 0.010	0.42^{a}± 0.010	0.28^{B}± 0.017
GSEP 0.25%	0.13^{f}± 0.007	0.17^{e}± 0.007	0.24^{d}± 0.011	0.34^{c}± 0.012	0.37^{b}± 0.008	0.45^{a}± 0.006	0.28^{B}± 0.019
Storage (Mean±S.E)	0.14^{a}± 0.005	0.19^{b}± 0.010	0.28^{c}± 0.015	0.38^{d}± 0.014	0.42^{e}± 0.022	0.44^{f}± 0.007	
Tyrosine value (mg/100g)							
Control No antioxidant	16.53d± 0.080	17.18^{c}± 0.110	17.45^{b}± 0.014	18.04^{a}± 0.029	18.17^{a}± 0.012	18.15^{a}± 0.007	17.58^{A}± 0.103
BHT 125ppm	16.37^{d}± 0.003	16.96^{c}± 0.001	17.44^{b}± 0.002	17.46^{b}± 0.002	18.18^{a}± 0.002	18.17^{a}± 0.001	17.43^{B}± 0.025
GSEP 0.25%	16.25^{e}± 0.011	16.64^{d}± 0.015	17.04^{bc}± 0.009	17.08^{bc}± 0.009	17.13^{b}± 0.011	17.32^{a}± 0.011	16.91^{C}± 0.060
Storage (Mean±S.E)	16.38^{a}± 0.037	16.93^{b}± 0.063	17.31^{c}± 0.046	17.52^{d}± 0.096	17.83^{a}± 0.118	17.87^{a}± 0.096	
Peroxide (meq/kg fat)							
Control No antioxidant	0.63^{e}± 0.012	0.81^{d}± 0.012	1.48^{c}± 0.070	2.14^{a}± 0.009	1.98^{b}± 0.012	2.17^{a}± 0.008	1.53^{A}± 0.105
BHT 125ppm	0.60^{f}± 0.009	0.83^{e}± 0.009	1.17^{d}± 0.009	2.3^{a}± 0.010	1.90^{c}± 0.011	2.14^{b}± 0.007	1.49^{B}± 0.110
GSEP 0.25%	0.47^{f}± 0.014	0.76^{e}± 0.009	1.17^{d}± 0.010	1.50^{c}± 0.014	1.87^{b}± 0.012	2.07^{a}± 0.013	1.31^{C}± 0.096
Storage (Mean±S.E)	0.57^{a}± 0.017	0.80^{b}± 0.009	1.27^{c}± 0.041	1.98^{d}± 0.083	1.92^{e}± 0.012	2.13^{f}± 0.010	
Titratable acidity							
Control No antioxidant	0.64^{a}± 0.011	0.54^{b}± 0.005	0.47^{d}± 0.008	0.43^{e}± 0.008	0.55^{bc}± 0.008	0.57^{b}± 0.008	0.53^{A}± 0.011
BHT 125ppm	0.61^{a}± 0.017	0.57^{b}± 0.008	0.53^{c}± 0.015	0.53^{c}± 0.007	0.56^{b}± 0.005	0.53^{c}± 0.007	0.55^{B}± 0.006
GSEP 0.25%	0.57^{b}± 0.008	0.64^{a}± 0.008	0.53^{cd}± 0.008	0.54^{c}± 0.009	0.53^{cd}± 0.008	0.52^{d}± 0.005	0.55^{B}± 0.007
Storage (Mean±S.E)	0.60^{a}± 0.009	0.58^{b}± 0.011	0.51^{c}± 0.008	0.50^{c}± 0.013	0.54^{d}± 0.005	0.54^{d} ±0.006	

Mean ± SE with different superscripts in a row (small letter) and a column (capital letter) differ significantly (P<0.05)

The TBARS value increased significantly (P<0.05) throughout the storage period of 35 days in all treated samples including control which might be due to auto-oxidation produced by the low-temperature oxygen permeability of packaging material and the pro-oxidant nature of added salt (Singh et al. 2014 and Reddy et al. 2017). However, sausages treated with GSEP had lowest TBARS values than other samples. These findings were also in agreement with Kanle et al. (2018), who observed a significant increase (P<0.05) in TBARS value among samples. Similarly significant increase in TBARS value of chicken nuggets treated with GSE was also reported by Narkhede (2012).

The tyrosine value of the control and treated samples increased significantly (P<0.05) during the entire storage period. The tyrosine value in the GSEP treated sample, on the other side, was significantly (P<0.05) lower than the control and BHT treated sample. This increase in tyrosine value could be attributed to enzymes and bacterial proteases producing hydrolytic changes in meat protein (Sen 1996). However, this increase in tyrosine value in GSEP treated product was under the limit, indicating that the product was far away from spoilage. This increased tyrosine value during storage under superchilled temperature might be due to protein degradation reactions initiated by meat spoilage bacteria and endogenous enzymes (Kanle *et al.* 2018). Similar results were also reported by Rathod et al. (2017) in chicken breast fillets under superchilling storage.

The control sample had significantly (P<0.05) higher peroxide values than GSEP and BHT which could be related to the catalysis of intracellular compounds caused by the breakdown of cell structure by NaCl (Juntachote et al. 2006). In the treated samples (BHT and GSEP), there was a significant (P<0.05) increase in PV from day 28. Nevertheless, GSEP treated samples had significantly (P<0.05) lower PV. Similar results were also reported by Narkhede (2012) in (GSE and DHBP) treated nuggets where in significantly (P<0.05) low PV was recorded as compared to synthetic antioxidants (BHA). Similarly, these results were also supported by Lonarkar et al. (2021), who reported significantly (P<0.05) lower PV in chicken samosa treated with CPuE as compared to synthetic antioxidant (BHT). Moreover, there was a gradual increase in PV in all three samples as storage time progressed.

The titratable acidity of the control and the other two treatments was significantly (P<0.05) higher during initial storage but decreased significantly (P<0.05) towards the end of the storage period which corresponds to rise in their respective pH levels. The results are in support of Singh (2014) who recorded a comparable increase in titratable acidity in raw chicken meat emulsion treated with clove powder, ginger, and garlic paste as a natural preservative.

Microbiological Analysis

The TPC of all three samples were increased gradually throughout the storage period of 35 days. However, when compared to control and BHT treated samples, this rise in TPC was significantly (P<0.05) lower in GSEP treated samples (Table 3). Furthermore, the TPC in all three samples were within the limit for the whole storage time under superchilling conditions. This could be due to the damage caused to bacterial cells due to the development of ice crystals, which prevent bacteria from growing by limiting the amount of water available (Rathod et al. 2017). Kanle et al. (2018) also found similar TPC in chicken nuggets stored under superchilling temperatures.

Table 3. Effect of GSEP on microbiological profile of chicken sausages during superchilling storage

Type of product	Storage period (Days)						Treatment (Mean ± S.E)
	0	7	14	21	28	35	
	Total Plate Count (log10cfu/g)						
Control No antioxidant	0.52^{e}± 0.010	2.01^{d}± 0.062	2.63^{c}± 0.019	3.17^{b}± 0.017	3.85^{a}± 0.019	4.04^{a}± 0.21	2.70^{A}± 0.20
BHT 125ppm	0.53^{f}± 0.021	1.24^{e}± 0.017	2.5^{d}± 0.018	2.95c± 0.021	3.48^{b}± 0.10	3.68^{a}± 0.018	2.40^{B}± 0.195
GSEP 0.25%	0.46^{f}± 0.024	1.22^{e}± 0.016	1.94^{d}± 0.041	2.49^{c}± 0.017	2.94^{b}± 0.017	3.15^{a}± 0.017	2.03^{C}± 0.160
Storage (Mean ± S.E)	0.50^{f}± 0.013	1.49^{e}± 0.091	2.35^{d}± 0.074	2.87^{c}± 0.069	3.42^{b}± 0.096	3.62^{a}± 0.11	

(Table continued)

(Table continued)

Type of product	Storage period (Days)						Treatment (Mean ± S.E)
	0	7	14	21	28	35	
	Total Plate Count (log10cfu/g)						
Psychrophilic Count (log10cfu/g)							
Control No antioxidant	ND	ND	ND	ND	1.38^{b}± 0.051	3.17^{a}±0.022	0.76^{A}± 0.20
BHT 125ppm	ND	ND	ND	ND	1.11^{b}± 0.017	2.37^{a}± 0.013	0.58^{B}± 0.012
GSEP 0.25%	ND	ND	ND	ND	0.95^{b}± 0.021	2.22^{a}± 0.012	0.53^{C}± 0.14
Storage (Mean ± S. E)	ND	ND	ND	ND	1.15^{b}± 0.04	2.58^{a}± 0.10	

Mean ± SE with different superscripts in a row (small letter) and a column (capital letter) differ significantly (P<0.05)

The TPC in chicken sausages incorporated with GSEP was significantly (P<0.05) lower than other two treated products which could be attributable to phenolic acids and flavonoids present in GSEP (Narkhede 2012). Under superchilling conditions, there was no growth of psychrophilic organisms from day 0 to day 21. After that, until the end of the storage study, a significant (P<0.05) increase in PPC was seen in all products. However, the count was significantly (P<0.05) lower in GSEP-treated samples than in control and BHT-treated samples. This might be due to the increased enzymatic activity of psychrotrophs at -1.5 to -2.5^{O}C temperature leading to the quality deterioration. Kanle et al. (2018) also recorded a similar trend of increase in the PPC of chicken nuggets during storage under superchilling temperature. E. *coli* organisms were not detected in the chicken sausages in all three treated samples as well as control samples throughout the storage period. These organisms are indicators of faecal contamination and the absence of these bacteria suggested that the chicken sausages were not contaminated during the post-processing stage. Similar observations were also reported by Koshle et al. (2019) and Lonarkar (2021).

Sensory qualities

The appearance scores of chicken sausages treated with GSEP were significantly (P<0.05) higher than other two samples during the storage study (Table 4). However, as storage progressed, appearance scores of all samples decreased significantly (P<0.05) which might be due to production of free radicals in lipid oxidation resulting in non-enzymatic browning (Singh et al. 2014). However, the products treated with BHT and GSEP were well accepted at day 35. The results were well supported by the findings of Lonarkar (2021) Koshle et al. (2019) who reported similar results in chicken samosa and chicken sticks incorporated with custard apple pulp extract respectively.

Table 4. Effect of GSEP on sensory attribute of chicken sausages during superchilling storage

Type of product	Storage period (Days)						Treatment (Mean±S.E)
	0	7	14	21	28	35	
	Appearance						
Control No antioxidant	7.45^{a}± 0.09	7.40^{a}± 0.08	7.09^{bc}± 0.09	7.15^{b}± 0.10	6.82^{d}± 0.10	6.90^{cd}± 0.08	7.13± 0.041
BHT 125ppm	7.46^{a}± 0.08	7.33^{ab}± 0.08	7.08^{cd}± 0.08	7.24^{bc}± 0.07	7.05^{cd}± 0.08	7.02^{d}± 0.09	7.20± 0.034
GSEP 0.25%	7.37^{a}± 0.07	7.35^{ab}± 0.08	7.16^{bc}± 0.07	7.21^{bc}± 0.07	7.19^{c}± 0.08	7.10^{c}± 0.08	7.23± 0.032
Storage (Mean±S.E)	7.44^{a}± 0.041	7.36^{a}± 0.048	7.11^{bc}± 0.052	7.20^{b}± 0.053	7.05^{c}± 0.063	7.03^{c}± 0.055	

(Table continued)

(Table continued)

Type of product	Storage period (Days)						Treatment (Mean±S.E)
	0	7	14	21	28	35	
	Appearance						
Flavour							
Control No antioxidant	7.64^{a}± 0.088	7.5^{ab}± 0.090	7.33^{bc}± 0.057	7.19^{cd}± 0.071	7.14^{cd}± 0.078	7.08^{d}± 0.101	7.23^{A}± 0.038
BHT 125ppm	7.64^{a}± 0.078	7.5^{ab}± 0.090	7.33^{bc}± 0.070	7.22^{c}± 0.060	7.22^{c}± 0.072	7.14^{c}± 0.088	7.34^{B}± 0.035
GSEP 0.25%	7.72^{a}± 0.072	7.55^{ab}± 0.098	7.36^{bc}± 0.067	7.28^{c}± 0.060	7.25^{c}± 0.060	7.17^{c}± 0.080	7.39^{B}± 0.035
Storage (Mean±S.E)	7.67^{a}± 0.045	7.52^{b}± 0.052	7.34^{d}± 0.036	7.23^{cd}± 0.037	7.20^{c}± 0.040	7.13^{c} ±0.051	
Juiciness							
Control No antioxidant	7.56^{a}± 0.098	7.44^{ab}± 0.079	7.30^{bc}± 0.059	7.25^{bc}± 0.083	7.08^{cd}± 0.092	6.94^{d}± 0.106	7.26± 0.040
BHT 125ppm	7.42^{a}± 0.092	7.31^{ab}± 0.071	7.25^{ab}± 0.073	7.25^{ab}± 0.073	7.14^{bc}± 0.088	6.97^{c}± 0.094	7.22± 0.035
GSEP 0.25%	7.33^{a}± 0.090	7.30^{ab}± 0.082	7.28^{ab}± 0.060	7.22^{ab}± 0.060	7.17^{ab}± 0.090	7^{c}± 0.099	7.21± 0.034
Storage (Mean±S.E)	7.43^{a}± 0.054	7.35^{ab}± 0.045	7.28^{bc}± 0.036	7.24^{bcd}± 0.041	7.13^{d}± 0.051	6.97^{e} 0.057	
Texture							
Control No antioxidant	7.64^{a}± 0.088	7.56^{ab}± 0.089	7.36^{bc}± 0.078	7.25^{cd}± 0.060	7.08^{de}± 0.083	6.94^{e}± 0.089	7.23^{A}± 0.040
BHT 125ppm	7.55^{a}± 0.098	7.44^{ab}± 0.089	7.33^{abc}± 0.070	7.28^{bc}± 0.060	7.14^{cd}± 0.088	7^{d}± 0.090	7.29^{AB}± 0.038
GSEP 0.25%	7.52^{a}± 0.085	7.5^{a}± 0.090	7.39^{ab}± 0.086	7.25^{bc}± 0.060	7.17^{bc}± 0.080	7.08^{c}± 0.083	7.32^{B}± 0.036
Storage (Mean±S.E)	7.57^{a}± 0.052	7.5^{a}± 0.051	7.36^{b}± 0.044	7.26^{bc}± 0.034	7.13^{cd}± 0.048	7.01^{d}± 0.050	
Overall palatability							
Control No antioxidant	7.47^{a}± 0.094	7.42^{a}± 0.083	7.33^{ab}± 0.057	7.28^{ab}± 0.083	7.14^{b}± 0.078	6.89^{c}± 0.086	7.32^{A}± 0.037
BHT 125ppm	7.5^{a}± 0.090	7.44^{ab}± 0.079	7.33^{ab}± 0.070	7.25^{bc}± 0.060	7.11^{c}± 0.086	6.80^{d}± 0.082	7.24^{B}± 0.038
GSEP 0.25%	`7.42^{a}± 0.093	7.36^{a}± 0.078	7.31^{a}± 0.071	7.22^{ab}± 0.060	7.05^{b}± 0.089	6.83^{c}± 0.080	7.19^{B}± 0.037
Storage (Mean±S.E)	7.46^{a}± 0.052	7.40^{ab}± 0.045	7.32^{bc}± 0.037	7.25^{c}± 0.039	7.10^{d}± 0.048	6.84^{e}± 0.047	

The product's flavour score was significantly (P<0.05) higher in GSEP-treated samples and was very well acceptable when compared to other products. At the end of the storage, all samples had a significant (P<0.05) decrease in flavour scores. These results are supported by Narkhede (2012) and Manjhi (2013) who recorded a reduction in flavour score in GSE-treated chicken products. They also reported preservative effect of GSE in chicken products, preventing microbiological spoilage, lipid oxidation, and the development of rancid flavour. GSE's phenolic chemicals and flavonoids may be responsible for these effects (Jayaprakasha et al. 2001 and Shi et al. 2003). The difference in flavour score in chicken sausages with storage could be related to fat oxidation and a decrease in volatile

flavour components (Singh et al. 2014). The juiciness of all products decreased gradually throughout the storage study. The overall juiciness of the BHT and GSEP-treated products, however, was lower than that of the control. These findings contradict with findings of Kanle et al. (2018), who reported higher juiciness in chicken nuggets stored under superchilled temperatures than chilled samples. Narkhede (2012) also recorded increased juiciness in chicken nuggets treated with GSE after 25 days under refrigeration storage. Similarly, texture scores of all three samples decreased significantly ($P<0.05$) throughout the storage study. Kanle et al. (2018) reported rubbery texture in chicken nuggets stored under superchilling temperature. Additionally, the lower textural score at the end of storage could be attributable to moisture loss and changes in protein and fat properties throughout storage (Manjhi 2013).

The overall palatability of chicken sausages treated with GSEP was significantly higher ($P<0.05$) than BHT-treated samples and control. However, a few panellists noticed moderate irritation after consuming GSEP-treated samples for a few minutes, which might be as one of the negative effects of grape seed extract powder (Nordqvist, 2018). These lower scores over the storage period, as shown in the table, could be the result of the cumulative effect of other sensory scores. The findings are consistent with those of Koshleet *et al*. (2019), who observed a similar tendency in chicken sticks after refrigeration.

All samples were acceptable to the sensory panelists on day 35 despite of gradual decrease in all sensory scores during the storage period of 35 days.

CONCLUSION

The findings of the study indicated that, incorporation of 0.25 % grape seed extract powder (a natural antioxidant) in chicken sausages and their storage under superchilling (-2±0.5°C) temperature had promising synergistic effect in keeping the products freshness up to 35 days indicating a good alternative to replace synthetic antioxidants in meat food products.

COMPETING INTERESTS

The authors do not have any competing interests among themselves or others related to this research work.

ETHICS STATEMENT

Not applicable

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