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Effect of addition of ground vegetable oil seeds on the storage stability of vacuum packaged spent broiler breeder chicken sausages

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ABSTRACT

Spent broiler breeder chicken sausages were developed by incorporating 10% level of ground vegetable oilseeds (poppy, sesame and peanut) as fat replacer separately and were stored at refrigeration temperature (4±1°C) under vacuum packaging. The vacuum packaged spent broiler breeder chicken sausages were analyzed for physico-chemical, microbiological and sensory changes throughout the storage time at regular intervals. Results revealed that the vacuum packaged treatment chicken sausages had significantly ($P < 0.05$) lower FFA, TBARS, tyrosine values and microbial counts than control throughout storage period. Regardless of formulation, coliforms were not detected throughout the storage period in all vacuum packaged sausages. Among treatments, sausages with ground sesame seed (T2) recorded significantly ($P<0.05$) lower microbial counts followed by ground peanut seed (T3) and ground poppy seed added sausages (T1). Scores for all sensory attributes decreased significantly ($P<0.05$) during storage in refrigeration temperatures in all sausages, irrespective of formulations. Regardless of formulation, all the treatments along with control were spoiled after 30 days of refrigeration storage (4±1°C). Combination of vacuum packing and fat replacement with ground vegetable oilseeds as natural antioxidants reduced lipid oxidation and microbial growth in sausages and maintained the sensory quality characteristics during refrigeration for 30 days.
Keywords: Vacuum packaging, Spent hen, Ground vegetable oil seeds, Sausages, Quality.

INTRODUCTION

Consumption of meat from spent broiler breeder hens is limited by its poorer sensory quality, in particular poorer tenderness, compared to meat from broilers (Komiyama *et al.*, 2010). The present study was undertaken keeping in view the necessity for proper utilization of less expensive meat from spent broiler breeder hens to produce cheaper and economically viable nutritious value added sausages and also to open an avenue for gainful utilization of spent broiler breeder hen meat and improve the profitability of poultry industry. In recent years due to the growing consumer demand for healthy products, the fat content of meat formulations has been decreasing in order to develop meat products with an added nutritional value (Bennet *et al.*, and Yang *et al.*, 2016). Reduction in fat in comminuted meat products results in rubbery and dry textured products (Keeton, 1994) and poses difficulties in terms of flavor and texture. Hence, there is a need for using suitable ingredients which are able to replace fat without affecting quality (Buss, 1993). Vegetable oil seeds could have different effects on the quality characteristics of meat products by reducing lipid oxidation to certain extinct without adversely affecting the palatability of the product (Liu *et al.,* 1991 and Paneras & Bloukas, 1994). Poppy seeds contain polyphenols like tannic acid and ellagitannin that act as antioxidants (Saniya *et al.*, 2016). Sesame seeds contain lignans, sesamin, sesamoline and sesamol which have antioxidant activity and are very stable against oxidation deterioration (Ali Asghar *et al.*, 2014). Groundnut seeds are rich in polyphenols, antioxidants, vitamins, minerals and bioactive materials (Arya *et al.*, 2016). Packaging of poultry meat and meat based products has always been challenging because of their perishable nature due to high sensitivity of spoilage and pathogenic organisms (Fontes *et al.,* 2011). Packaging is a method to reduce the contamination of product and to enhance the shelf life. Vacuum packaging can extend the shelf life of food products by reducing the growth of aerobic organisms and inhibiting lipid oxidation, thereby maintaining the keeping quality and acceptability of product for a longer time (Mir and Masoodh, 2017).

The goal of this study was to assess the keeping quality of spent broiler breeder chicken sausages under vacuum packaging at refrigeration by using some of the ground vegetable oilseeds like poppy, sesame and groundnut as partial animal fat substitutes based on physico-chemical, microbiological and sensory properties.

Materials and method

The present research was carried out in the Department of Livestock Products Technology, College of Veterinary Science, Tirupati. Spent boiler breeder birds (females) of 72 weeks age were purchased from Chandragiri local market and were slaughtered, deboned and harvested meat was utilized for the present study. All subcutaneous fat and inter muscular fat were removed from the meat and used as the fat source.

All the dry spice ingredients purchased from the local market were cleaned thoroughly and dried in a hot air oven at 50ºC per 60 minutes. The ingredients were ground separately in a blender (Model: Panasonic MX-AC 3005) and sieved through a fine mesh and were stored at room temperature in air tight container for further use. Other non meat ingredients like sugar, salt, garlic, onions and binder were purchased from local supermarket. Onions and garlic were peeled off and made a fine paste in a ratio of 3:1 with help of mixer grinder. Selected oilseeds like poppy, sesame and groundnut seeds were purchased from local super market. Three oilseeds were thoroughly cleaned separately, dry roasted in a pan and made in to paste and were used to incorporate as partial replacer of animal fat in formulation of low fat sausages. The pastes were freshly prepared on the day of incorporation.

Preliminary trials were conducted to select the optimum level of three ground vegetable oilseeds as partial fat replacers in the standardization of low fat spent broiler breeder hen sausages. Both treatments and control chicken sausages were prepared as per the formulations given in table 1 into 4 batches viz, Control (15 % chicken fat), T1 (5% chicken fat+10 % ground poppy seed), T2 (5% chicken fat+10 % ground sesame seed) and T3 (5% chicken fat+10 % ground peanut seed). All the four batches were vacuum packed and kept at refrigeration (4±1° C) temperature for 35 days to determine quality changes of the product at regular intervals of 5 days by physico-chemical, microbiological and sensory parameters.

Analysis

pH of the samples was determined by the procedure of Jay (1964). FFA values were determined based on the procedure of Koniecko (1979). TBARS values were determined based on the procedure of Witte *et al,* (1970). Tyrosine value of stored samples was determined based on the procedure of Strange *et al.* (1977). All the microbiological parameters of standard plate count, psychrophilic plate count, yeast and moulds plate count, coliform plate count, lactobacillus plate count and anaerobic plate counts were determined as per the methods described by APHA (2001). Sensory evaluation of chicken meat sausages thus prepared as per the standardized formulations were oven cooked separately and subjected to sensory evaluation on a 9 point hedonic scale by a semi-trained six member taste panel. The data obtained in the present study was analyzed statistically as per the methods outlined by Snedecor and Cochran (1980).

Table 1. Formulations of chicken sausages fortified with optimum level of ground vegetable oil seeds as fat replacer

Ingredient	Control	Low fat sausages incorporated with vegetable oil seed as fat replacer		
		T1	T2	T3
Chicken meat (%)	85	85	85	85
Chicken fat (%)	15	5	5	5
Ground Poppy seed (%)	0	10	-	-
Ground Sesame seed (%)	-	-	10	
Ground groundnut seed (%)	-	-	-	10
Salt (%)	1.8	1.8	1.8	1.8
Sugar %	1	1	1	1
Polyphosphate(STPP)%	0.3	0.3	0.3	0.3
Ice %	10	10	10	10
Dry Spice mix %	2	2	2	2
Wet Condiment mix*	3	3	3	3
Refined wheat flour	3	3	3	3

*Onion : Garlic paste (3:1)

Results and Discussion

Effect of formulation and storage period (4±1°C) on physico-chemical quality of vacuum packaged spent broiler breeder chicken sausages

The mean ± SE values of physico-chemical quality of vacuum packaged spent broiler breeder chicken sausages as influenced by formulation were presented in Table 2. Treatments differed significantly (P<0.05) from control and highest pH values were observed in the control. It might be due to greater fatty acid content and pH of vegetable oil seeds. These findings are in accordance with Ruma and Praneeta, (2018) in guinea fowl meat sausages.

Regardless of formulation, the mean pH values were increased significantly (P<0.05) in all vacuum packed sausages up to 15 days and decreased significantly (P<0.05) from 20 to 30 days at refrigeration temperature at 4±1° C. This increase in mean pH up to 15 days of storage might be due to concomitant increase in bacterial load which release metabolites during their metabolism and cause deamination of proteins (Ahmed and Shrivastav, 2007). The reduction in pH after 15 days of refrigeration storage might be due to growth of psychrophilic and lactic acid bacteria which could be attributed to acid formation by microorganisms over storage time (Shelef, 1975). A similar trend was observed by Lesiak *et al.,* (2016) in chicken meat.

All vacuum packed treatments recorded significantly lower FFA, TBARS and tyrosine values than control throughout the storage period. This might be attributed to anti-lipolytic and anti-oxidant effect of vegetable oil seeds (Ali Asghar *et al.*, 2014). Among treatments, sausages with ground sesame seed (T2) were found to have significantly lower FFA, TBARS and tyrosine values. This might be due to the ability of sesame to act as hydrogen donors and they are the primary antioxidants that react with free radicals of sesame seed (Castillo *et al.*, 2018). These results are in conformity with Saniya *et al.*, (2016) in fish nuggets and Biswas *et al.*, (2017) in comminuted chicken products

The mean free fatty acid (percent oleic acid), TBARS and tyrosine values of all vacuum packed sausages were increased significantly (P<0.05) with advancement of storage period irrespective of formulation. This might be due to progressive oxidation of lipids during storage. A similar increase in FFA content during storage has also been reported by Singh *et al.,* (2014) in chicken emulsion and Lonarkar *et al.*, (2021) in chicken samosa.

Effect of formulation and storage period (4±1°C) on microbial quality of vacuum packaged spent broiler breeder chicken sausages

The mean standard plate and anaerobic counts of vacuum packed spent broiler breeder chicken sausages were significantly influenced by the formulation, whereas, psychrophilic, yeast and moulds and lactobacillus counts were not differed significantly by the formulation (Table 3). Vacuum packaged chicken sausages incorporated with ground vegetable oil seeds recorded lower microbial counts than control. Among treatments, sausages with ground sesame seed (T2) recorded significantly (P<0.05) lower microbial counts followed by ground groundnut seed (T3) and ground poppy seed added sausages (T1). This indicates that all three ground vegetable oil seeds are effective in

Table 2: Mean ± SE of physico-chemical quality of vacuum packed low fat chicken sausages as influenced formulation stored at refrigeration temperature (4±1°C).

S.no	REFRIGERATION STORAGE DAYS							
1.	**pH**							
	Treatments	D ay 0	D ay 5	D ay 10	D ay 15	D ay 20	D ay 25	D ay 30
	Control	6.31 ± 0.005^{a1}	6.35 ± 0.012^{b2}	6.42 ± 0.014^{ab3}	6.44 ± 0.009^{b3}	6.03 ± 0.021^{a4}	5.91 ± 0.021^{a5}	5.80 ± 0.013^{a6}
	T1	6.32 ± 0.005^{a1}	6.36 ± 0.011^{b2}	6.40 ± 0.010^{ab3}	6.42 ± 0.010^{b3}	6.05 ± 0.056^{a4}	5.90 ± 0.004^{a5}	5.82 ± 0.014^{a6}
	T2	6.32 ± 0.009^{a1}	6.35 ± 0.009^{b12}	6.38 ± 0.009^{a23}	6.40 ± 0.014^{b3}	6.22 ± 0.055^{b4}	6.09 ± 0.037^{b5}	5.99 ± 0.029^{b6}
	T3	6.32 ± 0.005^{a1}	6.36 ± 0.007^{b2}	6.40 ± 0.01^{ab3}	6.44 ± 0.018^{b4}	6.21 ± 0.015^{b4}	6.05 ± 0.027^{b5}	5.97 ± 0.024^{b6}
2.	**FFA (% oleic acid)**							
	Control	0.146 ± 0.002^{c1}	0.180 ± 0.001^{e2}	0.207 ± 0.002^{c3}	0.239 ± 0.001^{e4}	0.292 ± 0.002^{d5}	0.383 ± 0.003^{c6}	0.396 ± 0.006^{d7}
	T1	0.130 ± 0.001^{b1}	0.145 ± 0.001^{bcd2}	0.183 ± 0.001^{b3}	0.211 ± 0.001^{c4}	0.280 ± 0.003^{c5}	0.345 ± 0.010^{b6}	0.372 ± 0.003^{c7}
	T2	0.124 ± 0.001^{a1}	0.135 ± 0.004^{a2}	0.168 ± 0.002^{a3}	0.185 ± 0.001^{a4}	0.201 ± 0.001^{a5}	0.261 ± 0.005^{a6}	0.311 ± 0.001^{a7}
	T3	$0.129 \pm 0.001^{a\,b1}$	0.144 ± 0.001^{abc2}	0.180 ± 0.003^{b3}	0.198 ± 0.003^{b4}	0.246 ± 0.005^{b5}	0.331 ± 0.001^{b6}	0.344 ± 0.007^{b7}
3.	**TBARS (mg of malonaldehyde)**							
	Control	0.219 ± 0.001^{b1}	0.303 ± 0.002^{c2}	0.429 ± 0.005^{c3}	0.516 ± 0.002^{c4}	0.631 ± 0.003^{c5}	0.785 ± 0.004^{e6}	0.820 ± 0.001^{d7}
	T1	0.215 ± 0.001^{ab1}	0.244 ± 0.001^{b2}	0.363 ± 0.002^{b3}	0.461 ± 0.003^{b4}	0.571 ± 0.002^{b5}	0.706 ± 0.003^{c6}	0.811 ± 0.002^{c7}
	T2	0.210 ± 0.001^{a1}	0.222 ± 0.002^{a2}	0.301 ± 0.002^{a3}	0.426 ± 0.003^{a4}	0.542 ± 0.004^{a5}	0.622 ± 0.003^{a6}	0.793 ± 0.002^{a7}
	T3	0.216 ± 0.003^{b1}	0.240 ± 0.002^{b2}	0.339 ± 0.005^{b3}	0.455 ± 0.002^{b4}	0.565 ± 0.003^{b5}	0.689 ± 0.003^{b6}	0.803 ± 0.002^{b7}
4.	**TYROSINE (mg)**							
	Control	0.498 ± 0.005^{b1}	0.926 ± 0.018^{ab2}	1.086 ± 0.012^{b3}	1.44 ± 0.019^{b4}	1.616 ± 0.017^{b5}	1.763 ± 0.017^{a6}	2.070 ± 0.018^{a7}
	T1	0.467 ± 0.007^{a1}	0.915 ± 0.012^{a2}	1.021 ± 0.011^{ab3}	1.331 ± 0.014^{a4}	1.505 ± 0.009^{a5}	1.753 ± 0.020^{a6}	2.056 ± 0.019^{a7}
	T2	0.450 ± 0.007^{a1}	0.906 ± 0.013^{a2}	1.008 ± 0.009^{a3}	1.308 ± 0.023^{a4}	1.481 ± 0.013^{a5}	1.71 ± 0.03^{a6}	2.03 ± 0.025^{a7}
	T3	0.466 ± 0.006^{a1}	0.910 ± 0.011^{a2}	1.038 ± 0.020^{ab3}	1.326 ± 0.010^{a4}	1.495 ± 0.022^{a5}	1.747 ± 0.023^{a6}	2.050 ± 0.013^{a7}

Means bearing same numerical superscripts in each column and same alphabetical superscripts in each row do not differ significantly (P<0.05).

Table 3: Mean ± SE of values microbial quality of vacuum packed low fat chicken sausages as influenced formulation stored at refrigeration temperature (4±1°C).

S.no.	Treatments	Day 0	Day 5	Day 10	Day 15	Day 20	Day 25	Day 30
				Refrigeration storage days				
1.				**Standard plate count (cfu/g)**				
	Control	2.95 ± 0.004^{d1}	3.03 ± 0.007^{a2}	3.60 ± 0.022^{b3}	4.25 ± 0.033^{b4}	4.68 ± 0.007^{c5}	5.43 ± 0.01^{ab6}	5.80 ± 0.008^{b7}
	T1	2.85 ± 0.017^{c1}	2.98 ± 0.003^{a2}	3.51 ± 0.01^{b3}	4.20 ± 0.02^{b4}	4.58 ± 0.009^{b5}	5.43 ± 0.014^{b6}	5.80 ± 0.008^{b7}
	T2	2.74 ± 0.010^{a1}	2.91 ± 0.005^{a2}	3.40 ± 0.018^{a3}	4.08 ± 0.02^{a4}	4.50 ± 0.01^{a5}	5.39 ± 0.01^{a6}	5.72 ± 0.01^{a7}
	T3	2.81 ± 0.01^{b1}	2.97 ± 0.006^{a2}	3.51 ± 0.01^{b3}	4.24 ± 0.02^{b4}	4.56 ± 0.01^{b5}	5.43 ± 0.01^{ab6}	5.79 ± 0.008^{b7}
2.				**Psychrophilic plate counts (cfu/g)**				
	Control	ND	ND	ND	1.33 ± 0.075^{a1}	1.71 ± 0.04^{a2}	1.94 ± 0.03^{a3}	2.34 ± 0.02^{b4}
	T1	ND	ND	ND	1.30 ± 0.07^{a1}	1.60 ± 0.03^{a2}	1.90 ± 0.03^{a3}	2.27 ± 0.04^{ab4}
	T2	ND	ND	ND	1.22 ± 0.07^{a1}	1.58 ± 0.03^{a2}	1.87 ± 0.05^{a3}	2.18 ± 0.07^{a4}
	T3	ND	ND	ND	1.27 ± 0.09^{a1}	1.63 ± 0.06^{a2}	1.92 ± 0.02^{a3}	2.25 ± 0.04^{ab4}
3.				**Yeast moulds plate count (cfu/g)**				
	Control	ND	ND	ND	0.89 ± 0.18^{a1}	1.80 ± 0.06^{c2}	2.17 ± 0.02^{c3}	2.26 ± 0.01^{b4}
	T1	ND	ND	ND	0.85 ± 0.17^{a1}	1.03 ± 0.01^{a1}	1.83 ± 0.03^{a2}	2.04 ± 0.02^{a2}
	T2	ND	ND	ND	0.84 ± 0.16^{a1}	1.61 ± 0.08^{b2}	1.97 ± 0.02^{b3}	2.08 ± 0.03^{a3}
	T3	ND	ND	ND	0.90 ± 0.18^{a1}	1.60 ± 0.03^{b2}	1.88 ± 0.03^{ab23}	2.02 ± 0.01^{a3}
4.				**Lactobacillus plate count (cfu/g)**				
	Control	1.71 ± 0.03^{a1}	1.64 ± 0.02^{a1}	1.62 ± 0.04^{a1}	1.77 ± 0.04^{a1}	2.11 ± 0.08^{a2}	2.89 ± 0.04^{b3}	3.41 ± 0.07^{ab4}
	T1	1.73 ± 0.05^{a1}	1.58 ± 0.07^{a1}	1.65 ± 0.04^{a1}	1.72 ± 0.04^{a1}	2.20 ± 0.07^{a2}	2.72 ± 0.09^{ab3}	3.34 ± 0.09^{ab4}
	T2	1.70 ± 0.05^{a1}	1.63 ± 0.04^{a1}	1.62 ± 0.04^{a1}	1.67 ± 0.05^{a1}	2.21 ± 0.05^{a2}	2.52 ± 0.14^{a3}	3.20 ± 0.09^{a4}
	T3	1.71 ± 0.04^{a1}	1.61 ± 0.05^{a1}	1.64 ± 0.06^{a1}	1.69 ± 0.05^{a1}	2.16 ± 0.16^{a2}	2.63 ± 0.10^{ab3}	3.49 ± 0.006^{b4}
5.				**Anaerobic plate count (cfu/g)**				
	Control	1.41 ± 0.06^{b1}	1.74 ± 0.04^{c2}	2.08 ± 0.02^{b3}	2.32 ± 0.01^{b4}	2.74 ± 0.01^{b5}	2.95 ± 0.004^{b6}	3.58 ± 0.01^{b7}
	T1	1.27 ± 0.06^{b1}	1.59 ± 0.05^{bc2}	2.06 ± 0.03^{b3}	2.26 ± 0.03^{ab4}	2.77 ± 0.03^{b5}	2.87 ± 0.03^{b6}	3.49 ± 0.04^{b7}
	T2	1.08 ± 0.03^{a1}	1.30 ± 0.04^{a2}	1.72 ± 0.05^{a3}	2.17 ± 0.04^{a4}	2.41 ± 0.02^{a5}	2.61 ± 0.04^{a6}	3.02 ± 0.007^{a7}
	T3	1.33 ± 0.05^{b1}	1.49 ± 0.05^{b1}	1.76 ± 0.08^{a2}	2.54 ± 0.03^{c3}	2.85 ± 0.01^{c4}	2.90 ± 0.01^{b4}	3.43 ± 0.08^{b5}

Means bearing same numerical superscripts in each column and same alphabetical superscripts in each row do not differ significantly (P<0.05).

delaying the microbial growth during the storage period and among them sesame seed was proved to be a preferred preservative ingredient. This might be attributed to superior antimicrobial effect of sesame seeds over groundnut and poppy seeds. Similar observations were reported by Reddy *et al*., (2013) in restructured mutton slices, Kumari (2013) in chicken cutlets, Naveena *et al.,* (2016) in chicken sausages and Amaral *et al*., (2015) in low fat pork sausages and Bhaskar *et al.,* (2017) in chicken *samosa*.

Regardless of formulation, psychrophilic and yeast and mould counts could not be detected up to 10 days of refrigerated storage in any of the sausages. This might be due requirement of more than a week of incubation period for psychrophillic bacteria and most yeast and moulds. Similar findings were noticed by Kumar *et al*., (2011) in chicken sausages and Saniya *et al*., (2016) in fish nuggets. Coliforms were not detected throughout the storage period in all vacuum packaged sausages irrespective of formulations. This might be due to strict hygienic condition and correct method followed during preparing and processing of sausages. The higher lactobacillus counts in treatments might be because of more moisture coupled with more readily utilizable carbohydrate by the lactic acid bacteria (Kumar *et al*., 2011). The increase in lactic acid bacteria might be due to competition for nutrients and also to pH reduction by the organic acids produced over storage time (Shelef, 1975). The results were in agreement with Al-Jasser, (2012) in chicken meat products and Zargar *et al*. (2014) in chicken meat balls.

The counts for all microbial parameters were influenced by storage period and increased significantly (P<0.05) as storage period advances, irrespective of the formulation. This might be due to the permissive temperature and relative availability of moisture and nutrients for the growth of microorganisms and associated cross contamination (James *et al*. 2014). A similar trend was reported by Rufina *et al*. (2016) in vacuum packaged chicken and Azita *et al*. (2019) in emulsion type sausages.

Effect of formulation and storage period (4±1°C) on sensory quality of vacuum packaged spent broiler breeder low fat chicken sausages

The mean ± SE values of sensory parameters of vacuum packaged spent broiler breeder chicken sausages as influenced by formulation are presented in Table 4. The mean scores of appearance, juiciness, tenderness were not significantly affected by the incorporation of ground vegetable oil seeds as fat replacer in sausages whereas and flavour and overall acceptability mean scores were affected significantly. All the three treatments had higher scores for all sensory parameters and they were comparable with the control. Higher scores for treatments indicated that the fiber from ground vegetable oil seeds retained the appropriate amount of moisture and fat to assure a juicy product (Selani *et al*., 2016). Among treatments, chicken sausages with sesame seed paste (T2) scored significantly (P<0.05) higher flavour scores than others. This might be due to acceptable nutty flavour of sesame seeds. This was in agreement with Naveen, (2015) in novel chicken sausages Goswami *et al.,* (2018) in low fat cara beef cookies.

The mean sensory scores for all sensory parameters were significantly (P<0.05) influenced by the storage period and were decreased as storage period progresses irrespective of the packaging and formulation. The decrease in sensory scores of vacuum packaged sausages with advancement of storage period might be due to pigment and lipid oxidation, increased TBA values of samples (Tarladgis *et al*., 1960) and increased microbial load (Bhat *et al*., 2011). Similar trend was reported by Naveen *et al*., (2016) in duck sausages, Prathyusha *et al.,* (2016) in chicken nuggets, Reshi *et al*., (2017) in spent hen chicken sausages and Heena *et al*., (2021) in low fat Goshtaba.

CONCLUSION

The ground vegetable oil seeds added antioxidant and antimicrobial properties to the spent broiler breeder chicken sausages as evidenced by from significantly lower values for almost all the microbial and oxidation parameters than control. Thus, chicken sausages of good acceptability and better storage stability could be prepared by incorporating ground vegetable oilseeds. This study indicated that combinations of natural antioxidants and vacuum packaging were significantly effective in extension of product shelf-life to 30 days under refrigerated storage.

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Table 4: Mean ± SE of sensory quality of vacuum packed low fat chicken sausages as influenced formulation stored at refrigeration temperature (4±1°C).

S.No.	Refrigeration Storage days							
1.	**Appearance**							
	Treatments	D ay 0	D ay 5	D ay 10	D ay 15	D ay 20	D ay 25	D ay 30
	Control	7.62±0.14 ^{a1}	7.48±0.11 ^{ab1}	7.00±0.12 ^{b2}	6.86±0.15 ^{b2}	6.11±0.15 ^{a3}	6.05±0.13 ^{a3}	5.86±0.13 ^{a3}
	T1	7.81±0.12 ^{a1}	7.57±0.11 ^{ab1}	7.13±0.11 ^{b2}	6.98±0.14 ^{b2}	6.19±0.15 ^{a3}	6.07±0.11 ^{a3}	5.92±0.12 ^{a3}
	T2	7.95±0.12 ^{a1}	7.59±0.12 ^{b2}	7.14±0.12 ^{b3}	6.98±0.11 ^{b3}	6.27±0.15 ^{a4}	6.15±0.12 ^{a4}	5.94±0.11 ^{a4}
	T3	7.77±0.09 ^{a1}	7.56±0.11 ^{ab1}	7.10±0.07 ^{b2}	6.94±0.11 ^{b2}	6.29±0.09 ^{a3}	6.11±0.09 ^{a3}	5.98±0.14 ^{a3}
2.	**Flavour**							
	Control	7.54±0.11 ^{a1}	7.26±0.11 ^{a1}	6.65±0.15 ^{b2}	6.37±0.12 ^{b23}	6.12±0.16 ^{a3}	6.02±0.12 ^{a3}	5.49±0.17 ^{a4}
	T1	7.73±0.12 ^{ab1}	7.31±0.15 ^{a2}	6.62±0.12 ^{b3}	6.41±0.13 ^{b34}	6.27±0.14 ^{a34}	6.02±0.13 ^{a4}	5.51±0.09 ^{a5}
	T2	7.88±0.12 ^{ab1}	7.38±0.13 ^{a2}	6.80±0.11 ^{b3}	6.44±0.12 ^{b4}	6.31±0.11 ^{a4}	6.09±0.10 ^{a4}	5.59±0.11 ^{a5}
	T3	7.65±0.09 ^{ab1}	7.33±0.14 ^{a2}	6.65±0.12 ^{b3}	6.43±0.10 ^{b34}	6.29±0.18 ^{a45}	6.04±0.09 ^{a5}	5.58±0.08 ^{a6}
3.	**Juiciness**							
	Control	7.52±0.11 ^{a1}	7.30±0.11 ^{a1}	6.65±0.10 ^{bc2}	6.48±0.11 ^{bc23}	6.20±0.14 ^{a34}	6.04±0.15 ^{a45}	5.70±0.10 ^{a5}
	T1	7.61±0.09 ^{a1}	7.31±0.12 ^{a1}	6.81±0.11 ^{bc2}	6.61±0.13 ^{c2}	6.25±0.14 ^{a3}	6.00±0.13 ^{a34}	5.74±0.11 ^{a4}
	T2	7.76±0.12 ^{a1}	7.40±0.12 ^{a2}	6.93±0.09 ^{c3}	6.65±0.0.14 ^{c3}	6.29±0.13 ^{a4}	6.10±0.13 ^{a45}	5.83±0.12 ^{a5}
	T3	7.66±0.10 ^{a1}	7.37±0.10 ^{a1}	6.87±0.12 ^{bc2}	6.40±0.16 ^{bc3}	6.26±0.12 ^{a3}	6.06±0.09 ^{a34}	5.76±0.10 ^{a4}
4.	**Tenderness**							
	Control	7.66±0.13 ^{a1}	7.36±0.12 ^{a1}	6.65±0.11 ^{a2}	6.37±0.12 ^{abc23}	6.25±0.13 ^{a3}	6.02±0.12 ^{a3}	5.54±0.10 ^{a4}
	T1	7.90±0.12 ^{a1}	7.51±0.12 ^{a2}	6.75±0.11 ^{a3}	6.54±0.13 ^{bc3}	6.19±0.12 ^{a4}	6.04±0.11 ^{a4}	5.68±0.10 ^{a5}
	T2	7.95±0.11 ^{a1}	7.52±0.09 ^{a2}	6.87±0.12 ^{a3}	6.63±0.11 ^{c3}	6.22±0.11 ^{a4}	6.05±0.12 ^{a4}	5.69±0.10 ^{a5}
	T3	7.79±0.09 ^{a1}	7.41±0.14 ^{a2}	6.69±0.12 ^{a3}	6.51±0.14 ^{bc3}	6.16±0.12 ^{a4}	6.04±0.10 ^{a4}	5.66±0.10 ^{a5}
5.	**Overall acceptability**							
	Control	7.67±0.10 ^{a1}	7.33±0.11 ^{a1}	6.63±0.15 ^{ab2}	6.43±0.22 ^{bc23}	6.04±0.11 ^{a34}	5.78±0.09 ^{a45}	5.56±0.09 ^{a5}
	T1	7.86±0.12 ^{b1}	7.36±0.09 ^{a2}	6.61±0.10 ^{a3}	6.45±0.10 ^{c3}	6.11±0.11 ^{a4}	5.85±0.11 ^{a45}	5.58±0.09 ^{a5}
	T2	7.93±0.12 ^{b1}	7.66±0.11 ^{a1}	6.70±0.12 ^{a2}	6.52±0.09 ^{c2}	6.13±0.11 ^{a3}	5.98±0.11 ^{a3}	5.61±0.10 ^{a4}
	T3	7.90±0.08 ^{b1}	7.63±0.12 ^{a1}	6.68±0.09 ^{a2}	6.48±0.10 ^{c2}	6.12±0.12 ^{a3}	5.94±0.10 ^{a3}	5.60±0.08 ^{a4}

Means bearing same numerical superscripts in each column and same alphabetical superscripts in each row do not differ significantly (P<0.05).

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