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Research paper

Shelf Life of Chicken *Samosa* Incorporated with Custard Apple (*Annona Squamosa*) Peel Powder

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ABSTRACT

Very few studies have been documented regarding the use of natural antioxidants like Custard Apple Peel Powder (CPeP) in meat products over synthetic antioxidants (BHT). Therefore, the current study was aimed to evaluate the effect of CPeP on the shelf life of chicken *Samosa.* The smashed boiled potato (10%) was mixed with minced (6 mm) breast fillets along with an onion (20%), condiments, spices mix, and salt which were then cooked on the preheated pan with continuous stirring till the appearance of golden brown colour and used as filler material for *samosa*. Antioxidants of 1% CPeP and BHT@125 mg/kg were added separately as treatments. About 20g of *samosa* mixture was filled into each dough sheet in a triangular shape and stored under refrigeration (4±1°C) temperature. During the storage period of 12 days the pH, tyrosine, and peroxide value increased significantly (P<0.05) between the storage period and treatment groups with a marginal decrease in TBRAS, tyrosine and peroxide value in CPeP treated chicken *samosa* compared to the control and BHT treated products. The protein, moisture, and fat content of all the treated products decreased gradually over the storage period. However, Total plate and psychrophilic count were lowest in CPeP treated product indicating the replacement of synthetic antioxidant (BHT) by 1% CPeP (natural antioxidant) as a good alternative in meat products.

Keywords: *Chicken Samosa, Custard apple peel powder, Quality analysis, Shelf life, Synthetic antioxidant*

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INTRODUCTION

Poultry meat is the most preferred meat over other meats throughout the country because of its easy availability, low cost, and no religious taboos. Around 72% population of the country is non-vegetarian and regular consumption of meat is increasing continuously over the years (Muthukumar and Naveena 2019). In meat products processing, natural products can be incorporated by using majorities of natural ingredients including antioxidants. Till date, the use of synthetic antioxidants viz Butylated hydroxytoluene (BHT) and butylated hydroxyanisole (BHA) are very common in food processing. However, these antioxidants are implicated to have toxic effects (Banerjee et al. 2012). Due to growing awareness of the ill-effects of free radicals in diet and consciousness about the use of synthetic antioxidants in meat, the natural antioxidant-supplemented foods, have gained a great deal of interest from consumers and the meat industry. Therefore, replacing chemical additives with natural alterative has a good option to reduce the consumption of synthetic additives (Ribeiro et al. 2018).

Plant polyphenols have drawn increasing interest due to their potent antioxidant properties and their marked effect on the prevention of varied oxidative stress-associated diseases. It has been documented that custard apple (*Annona Squamosa*) peel, pulp, leaves, bark, and roots are a reliable source of natural antioxidants and antimicrobial compounds (Abdelbaset et al. 2012; Roy and Ligampeta 2014; Kadam et al. 2018). Peel containing compounds viz., Ammonium acetate, acetic acid, n-Hexadecenoic acid, (-)-Spathulenol, 1-H-Cycloprop(e)azulen-7-ol, and decahydro-1,1,7-trimethyl-4-methylene are the major compounds and possesses antioxidant property whereas phthalic acid contributes to the antimicrobial, antioxidant and anti- fungal properties.

The *samosa* is one of the tasty and delicious popular traditional snacks in India. Although increasing urbanization and change in lifestyle have been witnessed i[1]n the past few years, the liking for traditional meat products still exists among the consumers. Since the demand for ready-to-eat meat products is growing continuously in Indian and overseas markets and very few studies have been documented regarding the effect of Custard Apple Peel Powder on chicken products (Kadam et al. 2018; Koshle et al. 2019), the present study was planned to study the effect of natural antioxidant Custard Apple Peel Powder (CPeP) on the shelf life of chicken Samosa as compared to synthetic-antioxidants (BHT).

MATERIALS AND METHODS

Boneless breast fillets of chicken meat obtained from the Indian Broiler from the local market of Nagpur were kept at refrigeration temperature (4±1˚C) overnight. On the next day, deboned breast fillets after thawing at room temperature were cut into small pieces and minced through a 6 mm plate in a meat mincer. The boiled potato was smashed and mixed (10%) with minced meat. Other ingredients like an onion (20%), condiments, spices mix, salt, and 1% CPeP were also added into the mixture and mixed thoroughly. This mixture was cooked on the preheated pan on a gas stove with continuous stirring till the appearance of golden brown colour. The mixture was kept at room temperature and used as filler material for samosa. The samosa dough was sheeted and made into semi-circular cuts. About 20g of samosa mixture was filled into each sheet (approximately 15g) and it was given a triangular shape. These raw samosas were deep fat fried in refined sunflower oil at 185˚C till golden brown colour appears (6-7 minutes).

Chicken samosa prepared by incorporating 1.0% of CPeP and BHT (125pp) was compared with the control at a regular interval of 3 days during storage under refrigeration temperature (4±1°C) based

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on the physico-chemical properties (moisture, protein, fat, pH, TBA number, tyrosine value, and peroxide value), microbiological analysis (total plate count, psychrophilic plate count, coliform count, and yeast and mould count) as well as sensory scores. The pH, moisture %, fat% and protein % and peroxide value of chicken samosa were determined as per the method of AOAC (2012). Thiobarbituric acid number and tyrosine value of chicken samosa were determined as per the method suggested by Witte et al. (1970) and Strange et al. (1977) respectively with slight modifications. The microbiological quality of chicken samosa was assessed on the basis of total plate count (TPC), psychrophilic count (PC), as per the procedure of APHA (1984). The sensory evaluations of fried chicken samosa were conducted by semi-trained sensory panellists and the product was evaluated based on various sensory attributes viz., appearance, flavour, texture, juiciness and overall acceptability by using 8 points Hedonic scale (Keeton 1983).

The experiment was repeated thrice and the results were taken in duplicate (n=6). The data generated were subjected to Completely Randomized Design (CRD) using the online software (WASP 2.0) developed by ICAR-CCARI Goa by following the procedure described by Snedecor and Cochran (1994).

RESULTS AND DISCUSSION

Proximate analysis

The results (Table1) indicated that the moisture, protein, and fat in all samples decreased gradually during the entire storage period. However, among the treatments, the variation in moisture, protein, and fat content of chicken *samosa* were non-significant. The moisture and protein content of samples indicated inconsistent deviation during the entire period of storage. In the present study, there was a non-significant effect of antioxidants on the protein content of chicken *samosa*. The fat contents of chicken *samosa* treated with different antioxidants were significantly reduced over a period of 12 days at (4±1°C) refrigerated storage. This trend in the reduction in the moisture, as well as fat content, could be attributed to the method of product preparation and lipolysis of fat. Similar trends were also reported by Phochpor (2014) and Koshle et al. (2019) in chicken nuggets and chicken sticks respectively.

Table 1: Proximate composition (Mean±SE) of aerobically packed chicken *Samosas* during refrigeration (4±1°C) storage (n=6)

Type of product	Storage period (Days)					Treatment mean
	0	3	6	9	12	
			Moisture			
Control	57.89±0.312	56.81±0.392	56.80±0.245	56.09±0.528	56.09±0.626	56.74±0.221
	57.26±0.544	58.13±0.412	56.79±0.225	56.78±0.235	55.84±0.440	56.96±0.213
CPeP	58.52±0.228	57.47±0.251	57.25±0.374	56.93±0.268	55.92±0.493	57.22±0.209
Storage mean	57.89^{a}±0.243	57.47^{ab}±0.234	56.95^{bc}±0.165	56.60^{cd}±0.218	55.95^{d}±0.286	
			Protein			
Control	17.94±0.194	17.06±0.299	16.91±0.368	16.64±0.391	16.19±0.374	16.95±0.175
BHT	17.49±0.243	17.21±0.185	17.06±0.196	16.77±0.417	16.33±0.291	16.97±0.138
CPeP	17.42±0.319	17.35±0.351	17.21±0.185	16.91±0.292	16.48±0.351	17.07±0.142
Storage mean	17.62^{a}±0.149	17.21^{ab}±0.158	17.06^{bc}±0.146	16.78^{bcd}±0.020	16.33^{d}±0.187	
			Fat			
Control	11.15±0.095	11.10±0.099	10.94±0.115	10.63±0.131	10.21±0.267	10.80±0.091
BHT	11.18±0.073	11.08±0.074	10.89±0.104	10.86±0.106	10.23±0.161	10.84±0.076
CPeP	11.16±0.087	11.08±0.078	10.93±0.124	10.65±0.159	10.48±0.127	10.86±0.069
Storage mean	11.16^{a}±0.046	11.09^{ab}±0.046	10.92^{bc}±0.062	10.71^{cd}±0.077	10.31^{e}±0.109	

Control-No antioxidant, BHT- 125 ppm CPeP- 1%

Mean ±SE with different superscripts in a row or column differ significantly (P<0.05)

Physicochemical properties

The results (Table 2) indicated that the overall pH of the products was increasing gradually during the entire storage period which might be due to the accumulation of metabolites of bacterial action and deamination of protein by the growth of gram-negative bacterial action (Mokhtar and Youssef 2014 and Biswas et al. 2004). However, there was no significant variation in the pH of the product where antioxidants (BHT & CPeP) were incorporated. The results are supported by Reddy *et al.* (2017a) who recorded a significant increase in pH in chicken meat sausage, incorporated with 2% green tea extract, 2% rosemary extract RT and 0.1% BHA during refrigerated storage.

The TBARS value of all the treatment and control increases consistently during the storage period of 12 days which might be due to auto-oxidation of lipid throughout storage of low-temperature oxygen permeability of packaging material and pro-oxidant nature of added salt (Singh *et al.* 2014; Reddy *et al.* 2017b). The result is in support of Zahid *et al.* (2019) who recorded an increase in TBA value during the storage period of 10 days in fresh beef patties treated with BHT, clove extract as well as ascorbic acid. Das *et al.* (2011), Mokhtar and Youssef (2014), and Goswami *et al.* (2019) also recorded a similar increase in TBARS value upon storage of meat products treated with natural antioxidants. Further, it was documented that the increase in TBARS value in CPeP and BHT treated *samosa* was significantly (P<0.05) lower as compared to the control samples. Although the TBARS value in both CPeP and BHT treated chicken *samosa* are non-significant, the CPeP had a lower TBARS value. This effect of CPeP might be due to presence of different chemical compounds as evident in GC-MS analysis of powder, thus restricting auto-oxidation of fat/lipid in the product during storage. Similar trends in TBARS value during shelf life study were also reported by Kadakadiyavar et al, (2017), Kadam et al. (2018) and Koshle et al. (2019).

Table 2: Physicochemical changes (Mean±SE) in aerobically packed chicken *Samosas* during refrigeration (4±1°C) storage (n=6)

Type of product	Storage period (Days)					Treatment mean
	0	3	6	9	12	
Control	5.91±0.020	5.94±0.028	6.05±0.038	6.29±0.015	6.46±0.008	6.13^{a}0.041±
	5.92±0.022	5.94±0.027	5.99±0.022	6.10±0.0255	6.15±0.016	6.02^{b}0.019±
CPeP	5.89±0.016	5.96±0.039	5.98±0.017	6.04±0.025	6.08±0.029	5.99^{b}0.016±
Storage mean	5.91^{a}±0.010	5.95^{ab}±0.017	6.00^{c}±0.016	6.14^{d}±0.029	6.23^{e}±0.041	
Tyrosine (mg/100g)						
Control	16.07±0.179	17.61±0.192	19.81±0.197	21.44±0.180	23.96±0.293	19.78^{a}0.524±
	16.09±0.127	19.71±0.144	17.21±0.097	19.00±0.121	20.29±0.162	17.88^{b}0.299±
	15.54±0.127	16.11±0.106	16.48±0.129	17.67±0.174	19.12±0.195	16.98^{c}0.245±
Storage mean	15.90^{a}0.102±	16.81^{b}0.171±	17.83^{c}0.355±	19.37^{d}0.388±	21.15^{e}0.511±	
TBARS (mg malanoaldehyde/kg)						
Control	0.32±0.015	0.38±0.026	0.53±0.016	0.58±0.012	0.70±0.007	0.50^{a}0.021±
BHT	0.34±0.020	0.38±0.026	0.42±0.026	0.44±0.020	0.50±0.017	0.41^{b}0.013±
CPeP	0.31±0.017	0.38±0.026	0.40±0.008	0.44±0.004	0.48±0.008	0.40^{b}0.012±
Storage mean	0.32^{a}±0.010	0.39^{b}±0.013	0.45^{c}±0.017	0.48^{cd}±0.018	0.56^{e}±0.025	
Peroxide Value (meq/kg fat)						
Control	0.75±0.019	1.74±0.101	2.24±0.060	3.31±0.143	3.60±0.134	2.33^{a}0.198±
BHT	0.76±0.026	1.31±0.021	1.84±0.200	2.31±0.155	2.76±0.176	1.80^{b}0.143±
CPeP	0.72±0.017	1.24±0.065	1.76±0.153	2.27±0.132	2.50±0.153	1.69^{b}0.131±
Storage mean	0.74^{a}±0.012	1.43^{b}±0.066	1.94^{c}±0.095	2.63^{d}±0.141	2.95^{e}±0.142	

Control-No antioxidant, BHT- 125 ppm CPeP- 1%
Mean ±SE with different superscripts in a row or column differ significantly (P<0.05)

The tyrosine value of the control and treated samples were significant during the entire storage period. However, the tyrosine value in the product incorporated with CPeP was significantly lower as compared to control and the product incorporated with BHT. Similar results were recorded by Gadekar et al. (2014) in the restructured goat meat product treated with natural antioxidants. The results are also in agreement with the finding of Koshle et al. (2019) The increase in tyrosine value during storage could be attributed to hydrolytic changes in meat proteins caused by the endogenous enzymes and bacterial proteases (Dainty et al. 1975).

The Peroxide value (PV) for CPeP and BHT treated samples was significantly lower than the control sample during the refrigeration storage period. However, the PV was increased gradually in all treatments during the storage period of 12 days. These findings are in accordance with that of Singh et al. (2014) who reported significantly higher (P<0.05) peroxide values in the control sample on days 5, 7, and 9 as compared to natural preservative (T1= 0.2% clove powder, T2=3% ginger paste and T3 =2% ginger paste) samples. This increase in peroxide value in control samples could be attributed to increased lipid oxidation in the chicken meat mixture. Similar findings were also reported by Koshle et al. (2019) who reported significantly (P<0.05) low PV in chicken sticks treated with CPuE as compared to synthetic antioxidant (BHT).

Microbiological analysis

The microbial analysis (Table 3) indicated that there was a significant increase in total plate count (TPC) during the entire storage period. However, TPC was significantly (P<0.05) lower in CPeP treated chicken *samosa* due to phenolic acid and flavonoid present in CPeP as reported in GC-MS analysis. CPeP was identified with antioxidants, antimicrobial, anticancer, and antifungal properties. Reddy *et al.* (2017a) also observed similar results in the TPC of chicken meat patties treated with natural and synthetic antioxidants. At the end of the storage, the samples treated with CPeP were significantly low in TPC which were supported by the finding of Koshle et al. (2019) who reported similar trend.

Table 3: Microbiological changes (Mean±SE) in aerobically packed chicken *Samosas* during refrigeration (4±1°C) storage (n=6)

Type of product	Storage period (Days) 0	3	6	9	12	Treatment mean
Total plate count (log 10 cfu/g)						
Control	1.43±0.081	3.07±0.061	4.42±0.097	5.48±0.207	6.86±0.135	4.25^{a}±0.353
BHT	1.15±0.091	2.51±0.257	3.63±0.159	4.37±0.246	5.39±0.167	3.41^{b}±0.283
CPeP	0.97±0.039	2.29±0.103	3.11±0.075	3.39±0.179	3.65±0.271	2.68^{b}±0.191
Storage mean	1.18^{a}±0.060	2.62^{b}±0.109	3.72^{bc}±0.145	4.41^{d}±0.236	5.29^{e}±0.335	
Psychrophilic count (log 10 cfu/g)						
Control	Nil	1.39±0.088	3.16±0.078	4.42±0.098	5.42±0.190	2.88^{a}±0.368
	Nil	1.11±0.093	2.39±0.107	3.51±0.132	4.14±0.06	2.23^{b}±0.285
CPeP	Nil	0.94±0.042	2.22±0.053	3.05±0.061	3.21±0.074	1.89^{c}±0.231
Storage mean	Nil	1.15^{a}±0.061	2.60^{b}±0.109	3.66^{c}±0.148	4.26^{d}±0.229	

Control-No antioxidant, BHT- 125 ppm CPeP- 1%

Mean ±SE with different superscripts in a row or column differ significantly (P<0.05)

Initially, the psychrophilic count was not detected in all treatments. However, the psychrophilic counts were observed from day 3 and followed a significantly (P<0.05) increasing trend in all samples of chicken *samosa*. However, the count was significantly (P<0.05) lower in samples treated with CPeP as compared to the control and BHT. These results are supported by earlier findings of Koshle et al. (2019) in chicken sticks treated with Custard apple pulp extract (CPuE) & BHT during refrigerated storage. Similar results were also documented by Goswami *et al.* (2019) who observed a significant (P<0.05) increase in psychrophilic count in chicken nuggets treated with gooseberry pulp powder and gooseberry seed coat powder during the storage period. A significantly low count in the CPeP treated product during the storage could be attributed to the antimicrobial activity of the powder.

Sensory attributes

Results (Table 4) on sensory evaluation of aerobically packaged chicken *samosas* revealed that there was a significant decline (P<0.05) in sensory attributes within the 12 days of the storage period which might be due to pigment and lipid oxidation resulting in non-enzymatic browning between lipid and amino acids (Singh et al., 2014). Similar results were reported by Verma et al. (2013) and Koshle et al. (2019) in sheep meat nuggets incorporated with guava powder and in chicken sticks incorporated with CPuE respectively.

The flavour of CPeP treated product was highly acceptable in comparison to other treatments. However, the flavour scores gradually declined with the duration of storage. These variations could be due to a decrease in the quantum of volatile flavour components and fat oxidation during the storage (Singh et al. 2014). There was a gradual decrease in juiciness in all products up to 12th days but the overall juiciness of the CPeP and BHT products was higher than control. This improvement in the juiciness of the CPeP treated product might be due to the retention of more moisture by chicken *samosa*. Similar results were also reported by Narkhede (2012) in chicken nuggets treated with grape seed extract.

Table 4: Sensory changes (Mean±SE) in aerobically packed chicken Samosas during refrigeration (4±1°C) storage (n=18)

Type of product	Storage period (Days) 0	3	6	9	12	Treatment mean
			Appearance			
Control	7.4±0.077	7.31±0.071	7.06±0.098	6.94±0.113	6.94±0.038	7.13±0.041
BHT	7.34±0.072	7.28±0.100	7.17±0.090	7.08±0.101	7.03±0.049	7.18±0.039
CPeP	7.44±0.104	7.32±0.103	7.26±0.091	7.19±0.091	7.03±0.049	7.24±0.042
Storage mean	7.39^{a}±0.049	7.30^{ab}±0.052	7.16^{bc}±0.054	7.07^{cd}±0.059	7.00^{d}±0.026	
			Flavour			
Control	7.05±0.076	7.08±0.072	6.34±0.090	6.27±0.115	4.86±0.155	6.32^{a}±0.097
BHT	7.20±0.112	7.27±0.100	6.96±0.108	6.75±0.072	6.55±0.098	6.89^{b}±0.053
CPeP	7.52±0.130	7.38±0.127	7.02±0.094	6.91±0.092	6.872±0.114	7.14^{c}±0.053
Storage mean	7.25^{a}±0.067	7.24^{ab}±0.051	6.68^{c}±0.067	6.64^{cd}±0.065	6.09^{e}±0.140	
			Juiciness			
Control	7.00±0.121	6.82±0.136	6.37±0.121	6.25±0.122	4.36±0.184	6.16^{a}±0.116
BHT	7.24±0.098	7.08±0.162	6.78±0.092	6.64±0.132	6.55±0.106	6.86^{b}±0.059
CPeP	7.48±0.082	7.32±0.096	7.11±0.124	7.00±0.106	6.91±0.122	7.16^{c}±0.052
Storage mean	7.24^{a}±0.063	7.07^{a}±0.081	6.75^{b}±0.076	6.63^{bc}±0.080	5.94^{d}±0.174	
			Texture			
Control	7.26±0.059	6.97±0.122	6.70±0.11	6.58±0.151	4.94±0.205	6.50±0.105
BHT	7.24±0.078	6.95±0.117	6.80±0.108	6.61±0.124	6.38±0.165	6.80±0.061
CPeP	7.32±0.078	7.13±0.078	6.88±0.086	6.69±0.122	6.41±0.116	6.89±0.054
Storage mean	7.28^{a}±0.041	7.02^{ab}±0.062	6.80^{bc}±0.059	6.62 ^{c}±0.059	5.91^{d}±0.133	
			Overall palatability			
Control	7.20±0.09	7.08±0.072	6.59±0.083	6.46±0.112	3.47±0.287	6.16^{a}±0.159
BHT	7.49±0.078	7.27±0.092	7.11±0.095	7.02±0.094	6.77±0.092	7.13^{b}±0.047
CPeP	7.44±0.068	7.30±0.108	7.28±0.061	7.12±0.065	6.97±0.102	7.22^{b}±0.040
Storage mean	7.37^{a}±0.048	7.22^{a}±0.053	6.99^{b}±0.061	6.87^{bc}±0.066	5.74^{d}±0.243	

Control-No antioxidant, BHT- 125 ppm CPeP- 1%

Mean ±SE with different superscripts in a row or column differ significantly (P<0.05)

There was a significant decrease in texture scores in all products during the storage period. However, there were no variations in texture among the product. Similar findings were reported by Koshle et al. (2019) in chicken sticks and Goswami et al. (2019) in chicken nuggets during storage. Reshi *et al.* (2017) also rescored similar findings in the spent hen meat sausages with the incorporation of ginger extract treatment as an antioxidant during the storage.

The Chicken *samosa* without antioxidants was palatable for up to 6 days and therefore on day 9, its palatability was reduced significantly. However, the palatability of the product with BHT and CPeP were optimum up to 12 days of storage. The palatability score for CPeP treated chicken *samosa* was significantly higher than other treated samples. The results are in agreement with that of Koshle et al. (2019) and Kadakadiyavar et al. (2017) who reported similar trends in chicken sticks and chicken nuggets respectively during refrigerated storage**.** Thus the results are indicating the role of CPeP in the extension of the shelf life of chicken *samosa* without affecting the quality.

CONCLUSION

Since the chicken *samosas* prepared by incorporation of CPeP @ 1% demonstrated promising results in proximate composition, physico-chemical properties, oxidative stability, and microbiological profile as compared to synthetic antioxidant (BHT @125mg/kg), custard apple peel powder (CPeP) could be a good alternative to include as a natural ingredient in meat products to extend the shelf life up to 12 days under refrigeration temperature.

REFERENCES

Abdalbasit AM, Abdelwahab SI, Elkheir S, Mohamed Y, Mohd. Fauzi PN, Chuen CS (2012) Antioxidant activity of different parts from Annona-squamosa, and Catunaregam Nilotica methanolic extract. Acta Sci Pol Technol Aliment 11(3) : 249-257.

AOAC (2012) Official Methods of Analysis, 19th edn. Association of Official Analytical Chemists, Gaithersburg, Maryland, USA.

APHA (1984) Compendium of methods for the microbiological examination of food. Speck, M.L. (ed.) American Public Health Association, Washington, W.C.

Banerjee R, Verma AK, Das AK, Rajkumar V, Shewalkar AA, Narkhede HP (2012) Antioxidant Effects of Broccoli Powder Extract in Goat Meat Nuggets. Meat Sci 91(2) : 179-184.

Biswas AK, Keshri RC, Bisht GS (2004) Effect of Enrobing and Antioxidants on Quality Characteristics of Precooked Pork Patties under Chilled and Frozen Storage Conditions. Meat Sci 66(3) : 733-741.

Dainty RH, Shaw BG, De Boer K, Scheps ES (1975) Protein changes caused by bacterial growth on beef. J Applied Bacteriol 1)39) : 73-81.

Das AK, Rajkumar V, Dwivedi DK (2011) Antioxidant effect of curry leaf (Murrayakoenigii) powder on quality of ground and cooked goat meat. Int Food Res J 18 : 563-569.

Gadekar YP, Sharma BD, Shinde AK, Verma AK, Mendiratta SK (2014) Effect of natural antioxidants on the quality of cured, restructured goat meat product during refrigerated storage (4 ± 1°C). Small Rum Res 119 : 1-3.

Goswami M, Prajapati B, Bhoomi S, Shishir N, Shendurse (2019) Shelf life evaluation of chicken meat nuggets incorporated with gooseberry (pulp and seed coat) powder as natural preservatives at refrigerated storage (4±1ºC). Int J Liv Res 9(5) : 53-63.

Kadakadiyavar PV, Ambadkar RK, Rathod KS 2017. Assessment of quality of chicken nuggets treated with mango peel extract. J Meat Sci 12(1) : 27–32.

Kadam BR, Ambadkar RK, Rathod KS (2018) Effect of custard apple (Annona squamosa) peel extract on shelf life of chicken breast fillets. J Environ Bio-Sci 32(1) : 9-14.

Keeton JT (1983) Effect of fat and NaCl/phosphate levels on the chemical and properties of pork patties. J Food Sci 48 : 878-881.

Koshle M, Ambadkar RK and Rathod KS (2019) Standardization of Chicken Sticks Incorporated with Custard Apple (Annona Squamosa L.) Pulp Extract. J Meat Sci Technol 7(4) : 45-49.

Mokhtar SM, Youssef KM (2014) Antioxidant effect of some plant extracts as compared with BHA/BHT on lipid oxidation and some quality properties of fresh beef burgers stored at 4°C. J Food Sci 2 : 19-29.

Muthukumar M, Naveena BM (2019) Entrepreneurship opportunity in meat sector. Lead Paper presented in: International symposium and 9th conference of Indian Meat Science Association on November 6th -8th, 2019.

Narkhede HP (2012) Incorporation of grape seed extract and dried holy basil powder as natural antioxidants to develop functional chicken nuggets, M.V.Sc thesis submitted to MAFSU, Nagpur.

Pachpor VR (2014) 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.

Reddy DM, Vani S, Naveen Z, Eswara Rao B (2017a) Comparative effect of natural and synthetic anioxidants on microbiological quality of chicken meat patties during refrigeration storage. Int J Sci Environ Technol 6(1) : 443 – 448.

Reddy DM, Babu AJ, Rao BE, Moorthy PRS, Vani S (2017b) Studies on the Comparative Effect of Rosemary, Green Tea Extracts and Butylated Hydroxy Anisole on the Keeping Quality of Chicken Meat Sausages during Refrigeration Storage. Int J Curr Microbiol Appl Sci 6(3) : 2144-2151.

Reshi MU, Bhat RA, Dobi MR, Pirzada R, Beigh SA, Ahad WA, Ulfirdos W, Malik AH (2017) Enhancement of Shelf Life of Spent Hen Meat Sausages with Incorporation of Ginger Extract. Int J Curr Microbiol Appl Sci 6(11) : 1124-1130.

Ribeiro JS, Santos MJMC, Silva LKR, Pereira LCL, Santos da Silva IA, Lannes SC, Da Silva MV (2018) Natural Antioxidants Used in Meat Products: A Brief Review. Meat Sci 148 : 181-188.

Roy S, Lingampeta P (2014) Solid wastes of fruits peels as source of low cost broad spectrum natural antimicrobial compounds-furanone, furfural and benezenetriol. Int J Res Eng Technol 7)3) : 273-279.

Singh P, Sahoo J, Chatli MK, Biswas AK (2014) Shelf life evaluation of raw chicken meat emulsion incorporated with clove powder, ginger and garlic paste as natural preservatives at refrigerated storage (4±1° C). Int Food Res J 21(4) : 1363.

Snedecor GW, Cochran WG (1994) Statistical methods, 8thedition. Iowa State University Press, Amer., Iowa, USA.

Strange ED, Benedict RC, Smith JL, Swift CE (1977) Evaluation of Rapid Tests for Monitoring Alterations in Meat Quality during Storage. J Food Protec 40(12) : 843-847.

Verma AK, Rajkumar V, Banerjee R, Biswas S, Das AK (2013) Guava (Psidium Guajava L.) Powder as an Antioxidant Dietary Fibre in Sheep Meat Nuggets. Asian-Austra J Ani Sci 26(6) : 26-113

Witte VC, Krause GF, Bailey ME (1970) A New Extraction Method for Determining 2- Thiobarbituric Acid Values of Pork and Beef during Storage. J Food Sci 35(5) : 582-585.

Zahid MA, Seo J, Parvin R, Ko J, Yang H (2019) Comparison of Butylated Hydroxytoluene, Ascorbic Acid, and Clove Extract as Antioxidants in Fresh Beef Patties at Refrigerated Storage. Food Sci Ani Resources 39(5) : 768-779.