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Antimicrobial and antioxidant efficacy of cardamom (*Elettaria cardamomum*) on keeping quality of chicken nuggets

M Sutha and G Gawdaman

Abstract
An experiment was conducted to evaluate the antimicrobial and antioxidant efficacy of cardamom oil on physico-chemical, microbial and sensory attributes of chicken nuggets. Chicken nuggets were formulated with addition of cardamom oil at three different levels *viz*., 0.01% - (T_1), 0.05% (T_2), 0.10% (T_3), along with a control (0%). Fresh chicken nugget were analyzed for various physico-chemical (emulsion & product pH, emulsion stability, product yield, shear force value, proximate analysis, DPPH scavenging activity, total phenolic content) and sensory parameters to find the optimum level of incorporation of cardamom oil in the chicken nuggets. Increased level of cardamom oil significantly (p<0.05) increased the DPPH scavenging activity and phenolic content of the chicken nuggets. In order to evaluate the antimicrobial efficacy of cardamom oil, the aerobically packed chicken nuggets were subjected to storage studies *viz*., product pH, free fatty acids, DPPH scavenging activity, thiobarbituric acid reactive substances value, tyrosine value, microbiological and sensory parameters for 35day's at 7day's interval under refrigerated condition. As the storage period progresses the quality attributes gradually and significantly (p<0.05) decreases, but were well within the limits of acceptability. Thus it is concluded that among the three different levels of essential oils used, 0.05% cardamom oil added chicken nuggets was found to be optimum and it can be effectively stored upto 28day's under refrigerated condition (4±1 °*C*) without marked loss in storage quality.

Keywords: Chicken nuggets, cardamom oil, antimicrobial and antioxidant efficacy

Introduction
With the advent in processing and availability of new product, meat consumption, particularly poultry meat consumption has increased many folds all over the world. A large variety of meat products are prepared from broiler meat which includes sausages, patties, nuggets, kebabs and meat balls. Now-a-days, processed meat product are in great demand due to its convenience and with ease of preparation. It invariably undergoes preservation technologies mainly to protect their safety and quality. Addition of preservatives can better protect the microbial and oxidative deterioration of meat product but its residual effect on the consumer health is questionable, so they prefer natural preservatives which is free from chemical residues.
Plant based essential oils or organic extracts and powders are well known to exhibit a wide range of antimicrobial and antioxidant effects (Devatkal *et al.* 2011 and Najeeb *et al.* 2015) [14, 31]. Cardamom (*Elettaria cardamomum*) known as "queen of spices" belongs to the family Zingiberaceae. The basic cardamom aroma is produced by a combination of the major components, 1, 8-cineole (representing 50% or more), with smaller amounts of limonene, α-terpenyl acetate, α-terpineol, borneol, camphor and α-pinene (Lawrence, 1979) [29]. The seeds and essential oil are used as flavouring components in a variety of foods. Cardamom possesses antibacterial, antifungal (Bansod and Rai 2008; Singh *et al.* 2008) [5, 42], anticancer (Sengupta *et al.* 2005) [39], antioxidant (Singh *et al.* 2008; Sultana *et al.* 2010) [42, 46].
Keeping these points in view, the present study was undertaken to evaluate the effect of cardamom oil on physico-chemical, microbial and sensory attributes of chicken nuggets and their storage stability under refrigerated condition (4±1 °C).

Materials and Methods

Procurement of materials for the preparation of chicken Nuggets: Dressed broiler chicken were procured from the retail outlets in vicinity of VCRI, Tirunelveli town, TN. The carcasses were trimmed off the visible adipose and connective tissues and hygienically deboned in the meat processing unit of the department. The deboned meat was minced in a meat mincer and stored at (-18±2 °C) in LDPE pouches until further use. Commercially available refined oil was used in preparation. Condiments paste used contained fresh onion, garlic and ginger in the 1:1:1 ratio. All the spices were purchased from local market of Tirunelveli town. Certified food grade essential oil (Cardamom) was purchased and used.

Preparation of chicken nuggets: Based on the preliminary trials, the basic formulation of the chicken nuggets was standardized. For 1kg lean chicken meat, the following ingredients were added at the rate of salt 2%, vegetable oil 5%, dry spices mix 2.5%, wet condiments 2.5%, refined wheat flour 3%, ice flakes 5%. The meat emulsion was prepared by using bowl chopper. Emulsion was filled into parchment paper lined stainless steel moulds and cooked in a steam cooker for 40 minutes till it reaches, the internal temperature (80±2 °*C*). The blocks were allowed to cool at room temperature after removal from pressure cooker and then cut into nuggets of (4×1.5×1.5cm) and packed in polyethylene pouches and stored (4±1 °*C*) for further studies.

Physico-chemical Properties: The pH of emulsion and product was measured by using a digital pH meter as per Trout *et al.* (1992) [47]. Weight of raw and cooked chicken nuggets were recorded to calculate the product yield. Standard procedures were used for determination of emulsion stability (Baliga and Madaiah, 1971) [4], shear force value (Berry and Stiffler, 1981) [6], proximate analysis (AOAC, 1995) [2], DPPH scavenging activity (Wu *et al.* 2003) [49], total phenolic content (Yuan *et al.* 2005) [50].

Storage studies: The product was evaluated for physico-chemical prarameters, microbial and sensory attributes. The free fatty acid (FFA) content of the chicken nuggets was determined by Koniecko *et al.* (1979) [28]. Thiobarbituric acid reactive substances value was measured by the method of Tarladgis *et al.* (1960). Tyrosine value was estimated by modified method of Strange *et al.* (1977) [45]. Total plate count, psychrophillic count, coliform count and yeast and mould count was enumerated as per the procedure by APHA (1984) [3].

Sensory Evaluation: The sensory evaluation of chicken nuggets was performed by panel of eight semi-trained members based on 8 point hedonic scale, wherein 8 denoted "extremely acceptable" and 1 denoted "extremely unacceptable" for sensory attributes *viz*., appearance, flavour, spiciness, juiciness, texture and overall acceptability (Keeton, 1983) [27].

Statistical Analysis: The data generated were subjected to one way-ANOVA and critical difference as per the procedure of Snedecor and Cochran, (1995) [44] and means were compared by using Dunkan's multiple range tests (Dunkan, 1955) [15].

Results and Discussion

Physico-chemical parameters: The mean and SE values of various physico-chemical characteristics namely pH (emulsion & product), emulsion stability, product yield, shear force value, proximate analysis, DPPH scavenging activity and total phenolic content of chicken nuggets incorporated with 0, 0.01, 0.05, 0.10 percent levels of cardamom oil are represented in Table 1.

Table 1: Effect of incorporation of cardamom oil on physico-chemical characteristics and proximate analysis of chicken nuggets

Parameters	Cardamom oil (%)			
	0	0.01	0.05	0.1
Emulsion pH	6.11±0.02	6.13±0.02	6.14±0.02	6.16±0.03
Product pH	6.17±0.03	6.21±0.03	6.24±0.03	6.25±0.03
Emulsion stability (%)	94.17±0.37	94.58±0.41	94.94±0.40	94.54±0.37
Product yield (%)	93.66±0.32	94.02±0.39	94.33±0.41	93.87±0.33
Shear force value (kg/cm^2)	0.55±0.01	0.55±0.02	0.53±0.01	0.53±0.02
Moisture (%)	64.17±0.84	64.54±0.77	64.51±0.94	64.55±0.62
Crude Protein (%)	19.32±0.90	19.67±0.59	19.39±1.02	19.58±0.93
Crude Fibre (%)	0.31±0.06^a	0.49±0.11^b	0.53±0.09^b	0.52±0.04^b
Ether Extract (%)	5.02±0.37	5.09±0.63	5.11±0.51	4.72±0.39
Total Ash (%)	2.36±0.07	2.47±0.36	2.46±0.27	2.39±0.13
DPPH scavenging activity of essential oils	-	21.68±0.93^a	25.02±1.29^b	26.87±1.03^b
DPPH scavenging activity of essential oils in product	25.11±1.27^a	31.52±1.24^b	35.98±1.64^c	38.23±1.28^c
Total phenolic content in product	597.17±6.66^a	611.33±5.64^{ab}	622.00±4.79^b	648.33±5.01^c

Note: Means bearing different superscripts in a row differ significantly ($p<0.05$)

pH: Inclusion of cardamom oil resulted in non-significant ($p>0.05$) increases in pH values of both emulsion and product. Similar results have been reported for pH values in broiler meat patties treated with nutmeg essential oils (Kalaikannan, 2014) [23] and Zakaria *et al.* (2015) [51] who reported that control samples showed low pH when compared to treated samples.

Emulsion stability and product yield: The emulsion stability of chicken nuggets was numerically higher in 0.05% level of cardamom oil treated nuggets and compared to other treatments. However, there was no significant difference between treated nuggets and control. The product yield also followed a similar pattern as recorded for emulsion stability. The product yield values did not differ between control and cardamom oil incorporated chicken nuggets. Among treated chicken nuggets, cardamom oil at 0.05% level had a highest numerical value. Similar results were recorded in the emulsion stability and product yield between control, pomegranate rind powder, extract and vitamin C incorporated chicken patties (Naveena *et al.* 2008) [33].

Shear force value: Shear force value of treated nuggets decreased numerically with increase in the inclusion levels of cardamom oil and not statistically significant. The result was in coincidence to Kanimozhi, (2012) [25] who observed significant decrease in shear force value in rosemary extract incorporated chicken nuggets.

Proximate analysis: There was a slight increase in moisture content of the cardamom oil treated nuggets over control which may be attributed to the increase in emulsion stability, resulted in higher retention of moisture. A similar increase in moisture content was observed in ginger essential oil-added beef patties by Dzudie *et al.* (2004) [17]. Incorporation of cardamom oil significantly ($p<0.05$) increased the crude fibre content of the chicken nuggets compared to control whereas total ash, crude protein and ether extract content non-significantly ($p>0.05$) increased.

DPPH scavenging activity: The DPPH scavenging activity of cardamom oil was observed to be significantly increasing ($p<0.05$) with increasing concentrations. This was in accordance with Mehdizadeh *et al.* (2012) [30] who found that DPPH scavenging assay was used to indicate antioxidant activity of the film and the concentration of essential oil increased, DPPH scavenging activity of cardamom oil increased significantly ($p<0.05$) which may be increased 2.5 folds more than the control samples. The DPPH scavenging activity of cardamom oil in the product showed there was significant difference ($p<0.05$) of control and treated nuggets, whereas treated nuggets were comparable. Among treated nuggets 0.05% revealed significantly higher value than control nuggets which was in accordance with the results of Sharma *et al.* (2017) [40]. Higher DPPH activity in treatment products might be attributed to the presence of various antioxidants such as α-terpinyl acetate, 1,8-cineole α-terpineol and volatile oils in essential oils, which were able to reduce the stable free radical DPPH to non-radical form DPPH-H (Singh *et al.* 2008) [42]. Han *et al.* (2017) [21] reported that the reducing property increases with an increase in the concentration of essential oils.

Total phenolic content: Total phenolic content of chicken nuggets significantly ($p<0.05$) increased with increasing level of cardamom oil. This result was in concurrent with Bhatti *et al.* (2015) [7] who found that similar result phenolic content of cardamom essential oil in product for control, 0.01%, 0.05% and 0.1% were 597.17, 611.33, 622 and 648.33(µg/gm), respectively.

Sensory attributes: The mean and SE values of sensory evaluation of chicken nuggets incorporated with 0, 0.01, 0.05 and 0.1 percent levels of cardamom oil are represented in Table 2.

Table 2: Effect of incorporation of cardamom oil on sensory attributes of chicken nugget

Sensory attributes	Cardamom oil (%)			
	0	0.01	0.05	0.10
Appearance	6.65±0.14	6.60±0.12	6.52±0.15	6.34±0.15
Flavour	6.64±0.16	6.46±0.18	6.42±0.21	6.28± 0.19
Spiciness	6.41±0.14	6.37±0.13	6.32±0.13	6.20±0.13
Texture	6.76±0.16	6.80±0.20	6.60±0.15	6.44±0.16
Juiciness	6.53±0.16	6.47±0.19	6.48±0.13	6.32±0.16
Overall acceptability	6.55±0.15	6.51±0.14	6.46±0.16	6.39±0.17

Note: Means bearing different superscripts in a row differ significantly ($p<0.05$).

The mean value of sensory parameters, the scores for appearance, flavour, spiciness, texture, juiciness and overall acceptability did not differ significantly ($p>0.05$) between treatments and control. However, there was a gradual decrease in sensory score with increase in the level of cardamom oil in chicken nuggets. The results were in contrast with Farhad and Reza (2017) [18] who found that the use of chitosan with ethanolic extract of cardamom at 2% level caused a significant increase in the overall acceptance of the samples ($p<0.05$). Busatta *et al.* (2008) [8] stated that the addition of essential oils and extracts triggered an increase in the acceptance of a variety of foods. Kassem *et al.* (2011) [26] reported that addition of essential oil of thyme and jojoba cause an improvement in the sensory properties of beef burgers. From this work, it was found that incorporation of cardamom essential oil did not cause any detrimental effect. If the concentration of cardamom oil is increased the sensory scores may be decreased. When comparison was made among treatment, 0.01%, and 0.05% level of cardamom oil incorporated chicken nuggets obtained more sensory scores than other treatment (0.1%). This result agrees with that obtained by Sasse *et al.* (2009) [38] who reported that many herbs and spices have antioxidant component and improved both colour and flavour stability in meat.

Flavour and overall acceptability scores of 0.05% cardamom oil treated nuggets were found to be non-significantly ($p>0.05$) higher from control nuggets and other treated nuggets. Nuggets incorporated with 0.05% cardamom oil had scored the highest flavour and overall acceptability value. The texture and juciness scores increased numerically in cardamom oil treated nuggets upto 0.1% and then decreased at 0.25%. However, no significant difference ($p>0.05$) was found between the treatments and control. Nuggets treated with 0.25% level of cardamom oil had recorded lowest value for texture and juciness score. Though 0.25% cardamom oil treated nuggets recorded numerically higher DPPH value, it was statistically comparable with other treatments. Further, sensory evaluation revealed significantly higher score values for flavour and overall acceptability of 0.05% cardamom oil treated nuggets than other treated and control nuggets. Hence, based on organoleptic acceptability, incorporation of 0.05% cardamom oil was selected as optimum inclusion level for further studies.

Storage study: The mean values of various storage parameters of cooked chicken nuggets incorporated with 0 and 0.05 percent level of cardamom oil during refrigerated storage (4±1 °*C*) are presented in table 3, 4 and 5.

pH: pH values of both control and cardamom oil treated nuggets increased significantly ($p<0.05$) as the storage period increases. The pH of cardamom oil treated nuggets had recorded lower values throughout storage period as compared to control. This might be due to activation effect of cardamom oil as antimicrobial agent causing protein hydrolysis with appearance of alkyl groups Salem *et al.* (2010) [36]. Galeno *et al.* (2018) [19] stated that when bovine loins treated with nutmeg oil which may increase pH of the beef.

Free fatty acid (FFA): Free fatty acid increased significantly ($p<0.05$) from day 0 to day 35 in all chicken nuggets preparations. FFA content of the products were well below the threshold value i.e. 1.8% (Pearson and Gillet, 1983) [35]. Cardamom oil treated nuggets maintained significantly ($p<0.05$) lower FFA values throughout storage period as

compared to control. The increase in FFA value of chicken nuggets revealed that fat present in the product underwent lower level of hydrolysis and oxidation. Growth of lipolytic microorganisms might be the reason for this significant ($p<0.05$) increase in FFA content of the products during storage (Das *et al.*, 2008) [11].

DPPH scavenging activity: The DPPH scavenging activity of cardamom treated product showed numerically higher DPPH value and there was significant difference ($p<0.05$) between control and treated nugget. Higher DPPH activity in treatment products might be attributed to the presence of various antioxidants such as phenolic acids, phenolic diterpenes, flavonoids, monoterpenes and volatile oils in essential oils (Gulcin *et al.* 2012) [20].

Thiobarbituric acid reactive substances (TBARS) value: TBARS value increased significantly ($p<0.05$) from day 0 to day 35 in all chicken nuggets preparations. This might be attributed to lipid hydrolysis, oxidative rancidity and secondary product formation at refrigeration temperature. Unsaturated fatty acids might have undergone a process of oxidative changes causing increase of TBARS value. TBARS concentration in all the chicken nuggets (control and treatment) during entire storage study were well below the threshold level of lipid oxidation (1-2mg malonaldehyde/kg) suggested by Watts (1962) [48] which indicates antioxidant activity of cardamom oil in the chicken nuggets (Shetty and Labbe, 1988) [41]. Increasing cardamom essential oil level decreased the TBARS value, such findings may be attributed to the high antioxidant effect of cardamom essential oils, which is related to the scavenger nature of its flavonoids and phenolic content (Kassem *et al.* 2011) [26].

Tyrosine value: Tyrosine value is an indicator of proteolysis in meat and meat products due to bacterial action (Jay, 1996) [22]. In the present study there was almost significantly ($p<0.05$) linear increase in tyrosine value noticed in both control and treatment. When comparison made between control and treatment, product treated with 0.05% cardamom oil had recorded much lower tyrosine value.

Table- 3: Effect of incorporation of cardamom oil on product physico-chemical parameters of chicken nuggets stored at refrigerated condition (4±1 °C)

Treat	Storage days					
	0	**7**	**14**	**21**	**28**	**35**
Product pH						
C	6.21 ±0.03^{A}	6.23 ±0.03^{AB}	6.27 ±0.02^{B}	6.35 ±0.02^{bC}	6.38 ±0.02^{bC}	6.45 ±0.01^{bC}
CO	6.16 ±0.03^{AB}	6.18 ±0.03^{A}	6.23 ±0.02^{ABC}	6.27 ±0.02^{aBC}	6.30 ±0.02^{aC}	6.33 ±0.02^{aC}
Free fatty acids (% oleic acid)						
C	0.23±0.03	0.24±0.03	0.25±0.03	0.27±0.03	0.29±0.03	0.30±0.03
CO	0.21±0.03	0.22±0.03	0.23±0.03	0.25±0.03	0.27±0.03	0.29±0.03
DPPH scavenging activity (%)						
C	31.42±1.49^{aC}	31.05±1.08^{aBC}	29.74 ±0.50^{aBC}	28.13±0.56^{aB}	23.53 ±0.48^{aA}	22.14 ±0.5^{aA}
CO	48.82±2.3^{bC}	47.06±2.16^{bBC}	45.57±1.54^{bBC}	42.67±1.14^{bAB}	39.87 ±0.91^{bA}	38.09±0.98^{bA}
TBARS (mg malonaldehye/kg)						
C	0.27±0.04^{bA}	0.40 ±0.07^{bAB}	0.51 ±0.04^{bB}	0.73 ±0.06^{bC}	0.85 ±0.06^{bC}	1.01 ±0.02^{bD}
CO	0.15±0.02^{aA}	0.19 ±0.02^{aA}	0.22 ±0.02^{aAB}	0.24±0.03^{aAB}	0.28 ±0.02^{aB}	0.39 ±0.04^{aC}
Tyrosine value (mg/100gm)						
C	13.13±0.84^{A}	23.05 ±0.93^{bB}	25.24±1.19^{bC}	26.45±1.06^{bC}	27.30±1.10^{bC}	27.82±1.32^{bC}
CO	11.06±0.68^{A}	11.31 ±0.69^{aA}	12.24±0.64^{aB}	13.16±0.91^{aAB}	15.09±0.64^{aB}	18.87±0.69^{aC}

Note: Note: Means bearing different upper case letter superscripts in a row and lower case letter superscripts in a column differ significantly ($p<0.05$).

Total plate count (log_{10} cfu/g): The mean value of total plate count increased significantly ($p<0.05$) as the storage day's progressive (in both control and treatment) but well within the acceptable threshold limit. When comparison made between control and treatment, product treated with cardamom oil had recorded much lower total plate count. The lower microbial counts in treated samples might be due to presence of antimicrobial compounds such as 1,8-cineole (20-60 percent) and α-terpinyl acetate (20-53 percent) in cardamom (Nanasombat *et al.* 2005) [32]. Similar load of SPC (log 3.47-4.4/gm) in low fat chicken nuggets during storage study (4±1 °*C*) for 20 days was reported by Cholan (2008) [10].

Psychrophilic count (log_{10} cfu/g): Psychrophilic counts were not observed on day 0 and day 7 in any of the chicken nugget preparation. Detectable psychrophilic counts were appeared on day 14 onwards and significantly ($p<0.05$) linear increase in counts noticed in both control and treatment. This might be attributed to the fact that bacteria generally need some lag phase before active multiplication is initiated (Jay, 1996) [22]. The reduction in psychrophilic count correlated to active ingredients in cardamom phenolic compounds, flavonoids and aromatic acids.

Coliform count (log_{10} cfu/g): No coliform count were detected in any of the preparations on any interval of storage period. The absence of coliforms in chicken nuggets indicate that the effective heat processing and further post processing contamination is totally avoided whereas, the presence of high concentration of coliforms in food is indicative of failures during processing, heat treatment or inadequate hygiene (Bhat *et al.* 2015) [7].

Table 4: Effect of incorporation of cardamom oil on microbiological parameters of chicken nuggets stored under refrigerated condition (4±1 °*C*).

Treat	Storage days					
	0	**7**	**14**	**21**	**28**	**35**
Total plate count (log_{10} cfu/g)						
C	2.71 ± 0.25^{bA}	3.11 ± 0.23^{bAB}	3.38 ± 0.22^{bBC}	3.63 ± 0.19^{bBCD}	4.01 ± 0.13^{bCD}	4.35 ± 0.13^{bD}
CO	2.03 ± 0.05^{aA}	2.17 ± 0.08^{aAB}	2.16 ± 0.10^{aAB}	2.28 ± 0.18^{aAB}	2.62 ± 0.17^{aBC}	2.95 ± 0.20^{aC}
Psychrophilic count (log_{10} cfu/g)						
C	ND	ND	1.40 ± 0.23^{A}	1.54 ± 0.25^{A}	2.13 ± 0.26^{AB}	2.78 ± 0.15^{bB}
CO	ND	ND	1.07 ± 0.20^{B}	1.10 ± 0.24^{B}	1.50 ± 0.28^{B}	2.34 ± 0.10^{aB}
Coliform count (log_{10} cfu/g)						
C	ND	ND	ND	ND	ND	ND
CO	ND	ND	ND	ND	ND	ND
Yeast and Mould count (log_{10} cfu/g)						
C	ND	ND	1.30 ± 0.31^{A}	1.57 ± 0.29^{AB}	2.14 ± 0.23^{BC}	2.34 ± 0.19^{bC}
CO	ND	ND	1.03 ± 0.24^{A}	1.31 ± 0.20^{AB}	1.65 ± 0.20^{AB}	2.08 ± 0.17^{aB}

Note: Note: Means bearing different upper case letter superscripts in a row and lower case letter superscripts in a column differ significantly ($p<0.05$).

Yeast and Mould count (log_{10} cfu/g): No Yeast & Mould counts were observed in control and cardamom oil treated chicken nuggets upto 7 days of storage. Later during the storage Yeast & Mould count in control were significantly higher than the cardamom oil treated nuggets which might be due to the increased chemical and enzymatic activity which breakdown fat, protein and carbohydrate of meat product resulting in slime formation Dave *et al.* (2011) [12]. Significant ($p<0.05$) differences were observed between 0.05% cardamom oil treated and control samples on all the day's of storage. Kandasamy *et al.* (2011) [24] found that the antimicrobial effect of cardamom was highly active against *Aspergillus niger*. Aneja *et al.* (2009) [1] reported that cardamom extracts were effective against oral pathogenic bacteria like *Streptococcus mutans* and *Candida albicans*.

Table 5: Effect of incorporation of cardamom oil on sensory attributes of chicken nuggets stored under refrigerated condition (4±1 °*C*).

Treat	Storage days					
	0	**7**	**14**	**21**	**28**	**35**
Appearance						
C	6.78 ± 0.18^{C}	6.73 ± 0.16^{BC}	6.41 ± 0.17^{ABC}	6.25 ± 0.15^{AB}	6.03 ± 0.14^{A}	Spoiled
CO	6.97 ± 0.19^{C}	6.87 ± 0.18^{C}	6.54 ± 0.16^{BC}	6.27 ± 0.14^{ABC}	6.11 ± 0.16^{AB}	5.95 ± 0.15^{A}
Flavour						
C	6.79 ± 0.14^{D}	6.65 ± 0.11^{CD}	6.36 ± 0.12^{BC}	6.11 ± 0.10^{AB}	6.02 ± 0.10^{bA}	Spoiled
CO	6.82 ± 0.17^{B}	6.73 ± 0.16^{B}	6.39 ± 0.14^{AB}	6.29 ± 0.13^{A}	6.12 ± 0.16^{aA}	5.91 ± 0.14^{A}
Juiciness						
C	6.79 ± 0.17^{B}	6.59 ± 0.13^{B}	6.43 ± 0.17^{AB}	6.27 ± 0.18^{AB}	6.03 ± 0.18^{A}	Spoiled
CO	6.54±0.18	6.45±0.18	6.35±0.18	6.16±0.17	6.07±0.16	5.92±0.17
Texture						
C	7.01 ± 0.18^{BC}	6.91 ± 0.20^{BC}	6.72 ± 0.20^{BC}	6.33 ± 0.20^{AB}	6.12 ± 0.20^{A}	Spoiled
CO	7.06 ± 0.17^{B}	7.14 ± 0.17^{B}	6.76 ± 0.19^{AB}	6.53 ± 0.25^{AB}	6.34 ± 0.26^{AB}	6.11 ± 0.25^{A}
Overall acceptability						
C	6.68 ± 0.13^{bB}	6.59 ± 0.14^{bB}	6.21 ± 0.14^{bAB}	6.08 ± 0.14^{AB}	5.91 ± 0.17^{A}	Spoiled
CO	6.34 ± 0.22^{aB}	6.28 ± 0.14^{aB}	6.17 ± 0.17^{aAB}	6.11 ± 0.15^{AB}	6.01 ± 0.13^{A}	5.93 ± 0.22^{A}

Note: Note: Means bearing different upper case letter superscripts in a row and lower case letter superscripts in a column differ significantly ($p<0.05$).

A decreasing trend in the scores of appearance, flavour, juiciness, texture and overall acceptability was observed both in control and optimized nuggets at the progressive storage intervals. Decrease in appearance scores with advancement of storage days might be attributed to oxidative fading, moisture loss and non-enzymatic browning from reaction between lipid oxidation products and aminoacids (Chandralekha *et al.* 2012) [9]. Decrease in flavour scores might be correlated with the increase in TBA value in the meat products stored under aerobic conditions. The decline in flavour score in all products could be attributed to fat loss as fat content of meat product has greater role in development of flavour (Pearson and Gillet, 1997) [34]. Evaporative loss of moisture from the product during refrigerated storage could be the reason for lower juiciness scores during refrigerated storage in low density polyethylene. Decline in textural scores might be attributed to proteolytic and disulphide bond changes taking place with progress of storage period (Santamaria *et al.*, 1992) [37].

In general, 0.05% cardamom oil incorporated chicken nuggets had scored higher sensory values than the control. Score for all the sensory attributes significantly ($p<0.05$) differ as the day's of storage progress. Perusal of Table 5 revealed that 0.05% level of cardamom oil incorporation had improved the sensory attributes *viz*., appearance, flavor, juciness, texture and overall palatability of chicken nuggets. Results on storage studies showed that chicken nuggets containing 0.05% cardamom oil were acceptable upto 28 day's as mean scores for all the sensory attributes varied between 6.01±0.13 and 7.14±0.17 during storage at (4±1 °*C*).

Conclusion

On the basis of the present findings, it is concluded that the shelf life of 0.05% level cardamom oil incorporated chicken

nuggets could be extended upto 28 day's under refrigerated conditions without adverse effect on the physic-chemical, microbiological and sensory attributes. This novel product development approach not only improve the microbial quality but also reduces the rate and amount of oxidation in the product. Cardamom essential oil is rich in antioxidant and antimicrobial components that efficiently highlight its role as a natural preservative material in meat and meat product.

Conflict of Interest
Not available

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Not available

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