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Quality characteristics of chicken nuggets incorporated with thyme oil as a natural preservative

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Abstract
The present study was undertaken to evaluate the antimicrobial and antioxidant efficacy of thyme oil on physico-chemical, microbial and sensory attributes of chicken nuggets under refrigerated condition (4±1˚C). Chicken nuggets were formulated with addition of thyme oil at 0.05%, 0.1% & 0.25% along with a control. The fresh nugget samples were analyzed for product & emulsion pH, emulsion stability, cooking yield, shear force value, proximate analysis, calorific value, DPPH scavenging activity, total phenolic content, fatty acid composition and sensory evaluation. Increased level of thyme oil significantly (p<0.05) increased the crude fibre, ether extract, DPPH scavenging activity, total phenolic content, flavor and overall acceptability of the chicken nuggets. Based on the preliminary study, chicken nuggets containing 0.1% of thyme oil was found to be optimum. The optimized nuggets were aerobically packed in LDPE pouches and evaluated for storage stability *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 a 0.1% level of thyme oil added chicken nuggets can be effectively stored upto 28day's under refrigerated condition (4±1˚C).

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

Introduction
India has 851.81% million poultry population (as per 20th L/S Census) with growth rate of 16.81% (DAHD, 2022-2023). Poultry meat is a good source of high quality protein, MUFA, vitamins, especially (B_{12}, Niacin) and minerals such as iron, selenium and zinc. Refrigerated ready to eat foods are become an important new class of products found in supermarket and convenience stores. It is therefore, essential to apply the adequate preservation technologies for meat and meat products to maintain their safety and quality. Now-a-days, various chemical preservative methods has been employed to enhance the shelf life of processed meat products but people prefer to consume safe and healthier foods which is free from chemical residues. Currently, it has been proven that the best alternative method for chemical preservative is the use of naturally extracted plant products for controlling antimicrobial and antioxidant are considered to be a novel and acceptable means of securing safety of refrigerated food stuffs. Spices and essential oils are used by the food industry as natural agents for extending the shelf life of foods.

Thyme *(Thymus vulgaris)* is an evergreen, small bushy herb indigenous to the Mediterranean regions which contains a number of critical compounds such as the phenols: thymol (44-60%) and carvacrol (2.2- 4.2%) (Shetty and Labbe, 1998) [31]. Most commonly the leaves of wild, green and lemon thyme are used as a flavouring agent in meat cooking process. It is often used in stews, soups and in meat stuffing (Solomakos *et al*. 2008) [32]. The essential oil of thyme possesses antimicrobial (Del Nobile *et al*. (2009) [11]; Fratianni *et al*. (2010) [14]; Gouveia *et al*. (2016)) [17], antioxidant Gallucci *et al*. (2009); Kassem *et al*. (2011); Saricoban and Yilmaz (2014) [15, 22, 29] and flavour enhancing properties (Arora *et al*. 1999; Coban and Ozpolat (2012)) [2, 8].

Hence the essential oils of spices have the greatest advantage to cater the demands of consumer as natural preservatives. Keeping these points in view, the present study was undertaken to the evaluate the effect of thyme oil at (0, 0.05, 0.1 & 0.25%) levels 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 (MADO Junior -Model 71382) and stored at (-18±2 ºC) in LDPE pouches as 1kg packs until further use. Commercially available refined oil containing energy (900 Kcal/100 gram), saturated fatty acids (14%) and cholesterol 0% 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 (Thyme) was purchased from (M/s. Akay Flavour and Aromatics Pvt. Limited, Kochi) 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 (Scharfen, model TC11). 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 product was evaluated for pH, emulsion stability, cooking yield, shear force value, proximate analysis, calorific value, DPPH scavenging activity, total phenolic content, and fatty acid composition. The pH of product and emulsion was estimated by using a digital pH meter (Model 361, Systronics, India), as per Trout *et al.*, (1992) [35]. Emulsion stability of batter was estimated following the method described by Baliga and Madaiah (1971) [3]. Weight of raw and cooked chicken nuggets were recorded to calculate the cooking yield (%). Shear force value was determined as per the method described by Berry and Stiffler (1981) [4]. Proximate analysis *viz*., moisture, crude protein, fat, ash content and calorific value of chicken nuggets were estimated as per AOAC (1995) method. DPPH scavenging activity of chicken nuggets was determined (using a BECKMAN DU-640 UV–VIS spectrophotometer) by the procedure of Wu *et al.* (2003) [37] with slight modifications. Total phenolic content were quantified by Folin-Ciocalteau's reagent was measured (using SYSTRONICS *Double beam* UV/Vis Spectrophotometer) and expressed as Gallic acid equivalents Yuan *et al.* (2005) [38]. Fatty acid composition of chicken nuggets was measured (Gas chromatography- Chemito GC 8610, India) by following the procedure.

Storage studies: The product was evaluated for physico-chemical prarameters (product pH, FFA content, DPPH scavenging activity TBARS value, Tyrosine value), microbiological and sensory characteristics. The free fatty acid (FFA) content of the chicken nuggets was determined by Koniecko *et al.* (1979). The method was followed for estimation of Thiobarbituric acid reactive substances value. For estimation of Tyrosine value, the method was followed. Total plate count, psychrophillic count, coliform count, and yeast and mould count was enumerated as per the procedure by APHA (1990).

Sensory Evaluation: The sensory evaluation of chicken nuggets was performed by panel of eight semi-trained panel members based on 8 point hedonic scale, wherein 8 denoted "extremely acceptable" and 1 denoted "extremely unacceptable" for sensory attributes *viz*., appearance, flavour, juiciness, texture and overall palatability (Keeton, 1983) [24].

Statistical Analysis: The data generated were analyzed by statistical method of one way analysis of variance and critical difference using the software SPSS package developed as per the procedure of Snedecor and Cochran, (1995) [34] and means were compared by using Duncan's multiple range tests.

Results and Discussion

Physico-chemical parameters

The mean and SE values of various physico-chemical characteristics namely pH (Emulsion & product), emulsion stability, cooking yield, shear force value, proximate analysis, calorific value, DPPH scavenging activity, and total phenolic content of chicken nuggets incorporated with 0, 0.05, 0.1 and 0.25 percent levels of thyme oil are represented in Table 1.

Table 1: Effect of incorporation of thyme oil on physico-chemical parameters and proximate composition of chicken nuggets

Parameter	Thyme oil (%)			
	0	0.05	0.1	0.25
Emulsion pH	6.08±0.04	6.11±0.04	6.13±0.04	6.16±0.04
Product pH	6.17±0.04	6.20±0.04	6.22±0.04	6.26±0.04
Emulsion stability (%)	95.90±0.66	96.19±0.65	96.41±0.62	96.22±0.49
Cooking yield (%)	94.18±0.62	94.22±0.74	94.67±0.75	94.04±0.66
Shear force (kg/cm^2)	0.45±0.03	0.45±0.03	0.44±0.03	0.44±0.03
Moisture (%)	64.14±0.84	64.25±0.62	64.65±0.62	64.35±0.62
Crude Protein (%)	19.22±0.90	19.42±0.93	19.56±0.93	19.36±0.93
Crude Fibre (%)	0.31±0.06^a	0.52±0.04^b	0.55±0.04^b	0.57±0.04^b
Ether Extract (%)	5.12±0.37^a	4.69±0.39^b	4.67±0.39^b	4.72±0.39^b
Total Ash (%)	2.40±0.07	2.41±0.13	2.39±0.13	2.40±0.13
Calorific value (kcal/kg)	1756.83±67.58	1789.33±58.07	1786.33±58.07	1784.33±58.07
DPPH scavenging activity of TO (%)	-	29.78±0.44^a	34.66±1.15^b	36.86±1.13^c
DPPH scavenging activity of TO in product (%)	51.21±1.58^a	55.72±2.4^{ab}	55.67±1.27^{ab}	57.21±1.21^b
Total phenolic content of TO in product (µg/gm)	616.33±5.58^a	743.33±3.84^b	760.33±4.16^c	796.67±5.57^d
Note: Means bearing different superscripts in a row differ significantly ($p<0.05$).				

pH: Inclusion of thyme 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 chicken sausages treated with thyme, clove, cassia and holy basil essential oils (Can, 2012; Sharma *et al.* 2017) [7, 30].

Emulsion stability and cooking yield: The emulsion stability of chicken nuggets was numerically higher in 0.1% level of thyme oil treated nuggets and compared to other treatments. However, there was no significant difference between treated nuggets and control. The cooking yield also followed a similar pattern as recorded for emulsion stability. The cooking yield values did not differ between control and thyme oil incorporated chicken nuggets. Among treated chicken nuggets, thyme oil at 0.1% level had a highest numerical value. Similar results were recorded in the emulsion stability and cooking yield between control, pomegranate rind powder, extract and vitamin C incorporated chicken patties (Naveena *et al.* 2008) [26].

Shear force value: Shear force value of treated nuggets decreased numerically with increase in the inclusion levels of thyme oil and not statistically significant. The result was in coincidence to Kanimozhi, (2012) [23] 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 thyme 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) [23]. Incorporation of thyme oil significantly (p<0.05) increased the crude fibre and ether extracts content of the chicken nuggets compared to control whereas total ash content non-significantly (p>0.05) increased.

DPPH scavenging activity: The DPPH scavenging activity of thyme oil was observed to be significantly increasing (p<0.05) with increasing concentrations, highest value being observed in 0.25%. This was in accordance with Mehdizadeh *et al.* (2012) 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 thyme oil increased significantly (p<0.05) which may be increased 4.5 folds more than the control samples. The DPPH scavenging activity of Thyme 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 0.25% revealed significantly higher value than control nuggets which was in accordance with the results of Sharma *et al.* (2017) [30]. 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, which were able to reduce the stable free radical DPPH to non-radical form DPPH-H (Gulcin *et al.* 2012) [16].

Total phenolic content: Total phenolic content of chicken nuggets significantly (p<0.05) increased with increasing level of thyme oil. This result was in concurrent with Rathod (2015) [28] who found that similar result in lemon peel and lemon pulp incorporated chicken nuggets.

Sensory attributes: The mean and SE values of sensory evaluation of chicken nuggets incorporated with 0, 0.05, 0.1 and 0.25 percent levels of thyme oil are represented in Table 2.

Table 2: Effect of incorporation of thyme oil on sensory attributes of chicken nuggets

Sensory attributes	Thyme oil (%)			
	0	**0.05**	**0.10**	**0.25**
Appearance	7.05±0.16	7.11±0.14	7.17±0.15	7.03±0.11
Flavour	6.47±0.20^{a}	6.56±0.18^{ab}	7.09±0.14^{b}	6.62±0.20^{ab}
Juiciness	6.77±0.18	6.99±0.14	7.22±0.17	6.88±0.14
Texture	7.16 ±0.14	7.25±0.13	7.45±0.17	7.02±0.14
Overall acceptability	6.49±0.14^{a}	6.57±0.23^{a}	7.15±0.10^{b}	6.63±0.20^{a}

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

The mean value for appearance did not differ significantly (p>0.05) between treatments and control. However, there was a gradual increase in sensory score of appearance with increase in the level of thyme oil in chicken nuggets. Similar result was in concurrent with Can (2012) [7]. The results were in contrast with Kanimozhi (2012) [23].

Flavour and overall acceptability scores of 0.1% thyme oil treated nuggets were found to be significantly (p<0.05) higher from control nuggets and other treated nuggets. This was in agreement with Kassem *et al.* (2011) [22] who found that nuggets treated with thyme oil of 0.04% and 0.06% showed highest score for odour and overall acceptability. Nuggets incorporated with 0.1% thyme oil had scored the highest flavour and overall acceptability value.

The texture and juciness scores increased numerically in thyme 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 incorporation of thyme oil had the lowest value for texture and juciness score. Though 0.25% thyme oil treated nuggets recorded numerically higher DPPH value, it was statistically comparable with other treatments. Further, sensory evaluation scores revealed significantly higher values for flavour and overall acceptability for of 0.1% thyme oil treated nuggets than other treated and control nuggets. Hence, based on organoleptic acceptability, incorporation of 0.1% Thyme oil was selected as optimum inclusion level for further studies.

Fatty acid composition: The mean and SE values of fatty acid composition of chicken nuggets incorporated with 0 and 0.1% level of thyme oil are represented in Table 3.

Table 3: Effect of incorporation of thyme oil on fatty acid composition of chicken nuggets

Fatty acids	Thyme oil (%)	
	0	0.1
Myristic	0.38±0.03^{a}	0.61±0.03^{b}
Palmitic	12.37±0.50^{a}	17.32±0.77^{b}
Palmitoleic	1.38±0.12^{a}	1.71±0.07^{b}
Stearic	3.89±0.11^{a}	4.93±0.19^{b}
Oleic	30.89±1.58	28.31±5.14
Linoleic	40.54±3.64^{a}	48.94±3.81^{b}
Linolenic	0.64±0.03^{a}	0.80±0.04^{b}
Arachidonic	0.46±0.03^{a}	0.94±0.06^{b}

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

Thyme oil treated chicken nuggets maintained significantly (p<0.05) higher fatty acid composition values as compared to control. Among the fatty acid of Thyme oil treated chicken nuggets and control, linoleic acid had recorded highest value whereas myristic value had recorded lowest value, respectively.

Storage study: The mean values of various storage parameters of cooked chicken nuggets incorporated with 0 and 0.1 percent level of thyme oil during refrigerated storage (4±1˚C) are presented in table 4, 5 and 6.

pH: pH values of both control and thyme oil treated nuggets increased significantly (p<0.05) as the storage period increases. The pH of thyme oil treated nuggets had recorded lower values throughout storage period as compared to control. This might be due antimicrobial and antioxidant effect of thyme oil.

Free fatty acid (FFA): Free fatty acid increased significantly (p<0.05) from day 0 to day 35 in all chicken nuggets preparations. Thyme 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.

DPPH scavenging activity: The DPPH scavenging activity of thyme oil in the product showed there was significant difference (p<0.05) of control and treated nuggets, whereas treated nuggets were comparable. 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) [16].

Thiobarbituric acid reactive substances (TBARS) value: TBARS value increased significantly (p<0.05) from day 0 to day 35 in all chicken nuggets preparations. 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) [36] which indicates antioxidant activity of thyme oil in the chicken nuggets (Shetty and Labbe, 1988) [31].

Table 4: Effect of incorporation of thyme oil on product physic-chemical parameters of chicken nuggets stored at refrigerated condition (4±1˚C)

	Storage days					
Trea	**0**	**7**	**14**	**21**	**28**	**35**
Product pH						
C	6.20 ±0.03^{A}	6.22 ±0.03^{AB}	6.28 ±0.02^{B}	6.36 ±0.02^{bC}	6.38 ±0.02^{bC}	6.44 ±0.01^{bC}
TO	6.17 ±0.03^{AB}	6.19 ±0.03^{A}	6.24 ±0.02 ^{ABC}	6.28 ±0.02^{aBC}	6.30 ±0.02^{aC}	6.31 ±0.02^{aC}
Free fatty acids (% oleic acid)						
C	0.22±0.03	0.23±0.03	0.24±0.03	0.25±0.03	0.27±0.03	0.29±0.03
TO	0.21±0.03	0.22±0.03	0.23±0.03	0.24±0.03	0.26±0.03	0.27±0.03
DPPH scavenging activity (%)						
C	31.52±1.49^{aC}	31.05±1.08^{aBC}	29.28 ±0.50^{aBC}	28.13±0.56^{aB}	24.73 ±0.48^{aA}	22.24 ±0.5^{aA}
TO	48.82±2.3^{bC}	47.06±2.13^{bBC}	45.57±1.56^{bBC}	42.67±1.12^{bAB}	39.87 ±0.90^{bA}	38.06±0.98^{bA}
TBARS (mg malonaldehye/kg)						
C	0.25±0.04^{bA}	0.39 ±0.07^{bAB}	0.52 ±0.04^{bB}	0.72 ±0.06^{bC}	0.82 ±0.06^{bC}	1.05 ±0.02^{bD}
TO	0.16±0.02^{aA}	0.18 ±0.02^{aA}	0.22 ±0.02^{aAB}	0.23±0.03^{aAB}	0.27 ±0.02^{aB}	0.40 ±0.04^{aC}
Tyrosine value (mg/100gm)						
C	13.15±0.84^{A}	22.04 ±0.93^{bB}	25.22±1.19^{bC}	26.42±1.06^{bC}	27.29±1.10^{bC}	27.70±1.32^{bC}
TO	11.04±0.68^{A}	11.36 ±0.69^{aA}	12.27±0.64^{aB}	13.18±0.91^{aAB}	15.08±0.64^{aB}	17.97±0.69^{aC}

Note: ^{ab} Means bearing different superscript in a column differ significantly (p<0.05) for treatments, ^{AB}Means bearing different superscript in a row differ significantly (p<0.05) for storage days; n= 21 for each treatment

Tyrosine value: Tyrosine value is an indicator of proteolysis in meat and meat products due to bacterial action (Jay, 1996) [20]. 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 0.1% thyme oil had recorded much lower tyrosine value.

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 thyme oil had recorded much lower total plate count.

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) [20].

Table 5: Effect of incorporation of thyme oil on microbiological parameters of chicken nuggets stored at refrigerated temperature (4±1˚C)

Storage days						
Treat	**0**	**7**	**14**	**21**	**28**	**35**
Total plate count (log_{10} cfu/g)						
C	2.82 ± 0.25^{bA}	3.31 ± 0.23^{bAB}	3.58 ± 0.22^{bBC}	3.79 ± 0.19^{bBCD}	4.05 ± 0.13^{bCD}	4.23 ± 0.13^{bD}
TO	2.05 ± 0.05^{aA}	2.19 ± 0.08^{aAB}	2.36 ± 0.10^{aAB}	2.48 ± 0.18^{aAB}	2.64 ± 0.17^{aBC}	2.97 ± 0.20^{aC}
Psychrophilic count (log_{10} cfu/g)						
C	ND	ND	1.39 ± 0.23^{A}	1.64 ± 0.25^{A}	2.12 ± 0.26^{AB}	2.68 ± 0.15^{bB}
TO	ND	ND	1.09 ± 0.20^{B}	1.28 ± 0.24^{B}	1.60 ± 0.28^{B}	2.37 ± 0.10^{aB}
Coliform count (log_{10} cfu/g)						
C	ND	ND	ND	ND	ND	ND
TO	ND	ND	ND	ND	ND	ND
Yeast and Mould count (log_{10} cfu/g)						
C	ND	ND	1.40 ± 0.31^{A}	1.77 ± 0.29^{AB}	2.24 ± 0.23^{BC}	2.64 ± 0.19^{bC}
TO	ND	ND	1.03 ± 0.24^{A}	1.31 ± 0.20^{AB}	1.75 ± 0.20^{AB}	2.01 ± 0.17^{aB}

Note: ^{ab} Means bearing different superscript in a column differ significantly ($p<0.05$) for treatments, ^{AB}Means bearing different superscript in a row differ significantly ($p<0.05$) for storage days; n= 21 for each treatment

Coliform count (log_{10} cfu/g): No coliform count were detected in any of the preparation during the entire storage period. The absence of coliforms in chicken nuggets indicate that the effective heat processing and further post processing contamination is totally avoided.

Yeast and Mould count (log_{10} cfu/g): No Yeast & Mould counts were observed in control and thyme oil treated chicken nuggets upto 7 days of storage. Later during the storage Yeast & Mould count in control were significantly higher than the thyme 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) [9].

Table 6: Effect of incorporation of thyme oil on sensory attributes of chicken nuggets stored at refrigerated temperature (4±1˚C)

Storage days						
Tre	**0**	**7**	**14**	**21**	**28**	**35**
Appearance						
C	6.87 ± 0.18^{C}	6.74 ± 0.16^{BC}	6.43 ± 0.17^{ABC}	6.27 ± 0.15^{AB}	6.03 ± 0.14^{A}	Spoiled
TO	6.95 ± 0.19^{C}	6.88 ± 0.18^{C}	6.52 ± 0.16^{BC}	6.29 ± 0.14^{ABC}	6.13 ± 0.16^{AB}	5.98 ± 0.15^{A}
Flavour						
C	6.85 ± 0.14^{D}	6.69 ± 0.11^{CD}	6.38 ± 0.12^{BC}	6.12 ± 0.10^{AB}	6.00 ± 0.10^{bA}	Spoiled
TO	6.82 ± 0.17^{B}	6.70 ± 0.16^{B}	6.37 ± 0.14^{AB}	6.20 ± 0.13^{A}	6.11 ± 0.16^{aA}	5.99 ± 0.14^{A}
Juiciness						
C	6.75 ± 0.17^{B}	6.58 ± 0.13^{B}	6.41 ± 0.17^{AB}	6.24 ± 0.18^{AB}	6.03 ± 0.18^{A}	Spoiled
TO	6.52±0.18	6.44±0.18	6.38±0.18	6.19±0.17	6.03±0.16	5.96±0.17
Texture						
C	7.01 ± 0.18^{BC}	6.93 ± 0.20^{BC}	6.78 ± 0.20^{BC}	6.38 ± 0.20^{AB}	6.16 ± 0.20^{A}	Spoiled
TO	6.83 ± 0.17^{B}	7.04 ± 0.17^{B}	6.68 ± 0.19^{AB}	6.53 ± 0.25^{AB}	6.37 ± 0.26^{AB}	6.16 ± 0.25^{A}
Overall acceptability						
C	6.78 ± 0.13^{bB}	6.62 ± 0.14^{bB}	6.23 ± 0.14^{bAB}	6.09 ± 0.14^{AB}	5.91 ± 0.17^{A}	Spoiled
TO	6.33 ± 0.22^{aB}	6.33 ± 0.14^{aB}	6.17 ± 0.17^{aAB}	6.13 ± 0.15^{AB}	6.04 ± 0.13^{A}	5.99 ± 0.22^{A}

Note: ab Means bearing different superscript in a column differ significantly ($p<0.05$) for treatments, ABMeans bearing different superscript in a row differ significantly ($p<0.05$) for storage days; n= 21 for each treatment.

In general, 0.1% thyme oil incorporated chicken nuggets had scored higher sensory values than the control. Score for all the sensory attributes significantly (P>0.05) as the day's of storage progress. Perusal of Table 6 revealed that 0.1% level of thyme 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 0.1% thyme oil were acceptable upto 28day's as mean scores for all the sensory attributes varied between 5.96±0.17 and 6.95±0.19 during storage at (4±1˚C).

Conclusion

On the basis of the present findings, it is concluded that the shelf life of 0.1% level thyme oil incorporated chicken nuggets could be extended upto 28 day's under refrigerated conditions without adverse effect on the physic-chemical, microbiological and sensory quality. This novel product development approach not only improve the microbial quality but also reduces the rate and amount of oxidation in the product.

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