J. Meat Sci. 2024, 19(1): 28-38

Research Article

ACS Publisher
www.acspublisher.com

Journal of Meat Science

Year 2024 (June), Volume-19, Issue-1

ISSN 0975-5209 (Print)
ISSN 2581-6616 (Online)

Assessing Impact of Turmeric and Ginger Nanoemulsions Incorporated Carboxy Methyl Cellulose Edible Films on Storage of Refrigerated Chicken Meat Nuggets

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ARTICLE INFO

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Received 18-11-2023; Accepted 18-02-2024
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DOI: 10.48165/jms.2024.19.01.04

ABSTRACT

The study assessed the effectiveness of carboxymethyl cellulose (CMC) based films combined with nano-emulsions of turmeric (NTE) and ginger (NGE) in preserving and extending the shelf life of chicken nuggets when stored at 4°C for a 20-day period. The films contained 6% turmeric nanoemulsion (NTE) and 1% ginger nanoemulsion (NGE). Various parameters including microbial factors (total plate count, yeast and mould count, and psychrotrophic count), physicochemical properties (pH, 2-thiobarbituric acid, and cooking loss), and sensory attributes of the packaged chicken nugget samples were evaluated every 4 days interval. Results indicated that chicken nuggets packaged with CMC films containing nanoemulsions exhibited significantly lower microbial growth, improved physicochemical characteristics, and higher sensory scores compared to the control samples ($P<0.05$)

Key words: carboxy methyl cellulose, turmeric nanoemulsion, ginger nanoemulsion, chicken nuggets

INTRODUCTION

Global consumption of chicken meat is expected to continue rising over the next decade. This growth can be attributed to its cost-effectiveness in production, low fat content, high nutritional value, and unique flavor profile, all without being subject to religious dietary restrictions unlike some other types of meat (Latou *et al.*, 2014). As the chicken meat is having more moisture and protein with high pH which leads to spoilage by microorganisms and lipid peroxidation (Kerry *et al.*, 2006). The main area of concern in poultry industry is the short shelf life of the meat, which can be deciphered by using several novel approaches. One among the novel approach to enhance shelf life and decrease extend of spoilage is active edible packaging.

Active packaging refers to the incorporation of additives into the packaging systems. These constituents delay or stop chemical, microbial, enzymatic and oxidative spoilage, control weight loss, retain colour and integrity of meat based products. Currently, there is a rise in the pursuit for active packaging which involve biodegradable materials. Petro-chemical packaging materials which are widely used in the meat processing industry taken a long time to register. Therefore the development of eco-friendly packaging material comes to the front and there biodegradable packaging material by modulating the barrier attributes, they can prolong the longevity of food and boost its quality and safety (Acevedo-Fani *et al*., 2015).

Cellulose is one of the most abundant polysaccharide present in plants which can be used as efficient biodegradable packaging material.The typical cellulose derivatives, carboxymethyl cellulose (CMC) forms excellent filmswith good gas barrier properties, hydrophilicity and stable internal network structure properties (Almasi *et al.*,2010).

Meat when packed with films having antimicrobial and antioxidant properties added by natural agents are extremely needed nowadays. So, the use of plant extracts, to decrease usage of chemical preservatives as the health concern is increasing meticulously. Ginger and turmeric are dried rhizome of the plant *Zingiber officinale* Rosc and *Curcuma longa L*. respectively which are used in daily basis in Indian household. The extracts of ginger and turmeric have been reported to have strong antimicrobial, antifungal and antioxidant activities in various parts, especially rhizomes (Bellik, Y.,2014, Singh *et al*.,2008).The main chemical compounds of ginger extract are Gingerols, Shogaols, Zingerone, Paradol, camphene, gamma terpinene and terpinen-4-ol (Jelled *et al*., 2015) and in turmeric is curcuminoids (Bojorges *et al*.,2020). Khan *et al*. (2020) packaged chicken meat balls by gelatin composite films enriched with polyphenol loaded nanoemulsions, whereas Cai and Wang, (2021) developed chitosan composite film incorporated with ginger essential oil nano emulsion.

Directly added active ingredients changed the sensory quality, physical characterstics and also lead to toxicity in high concentration. Therefore the size of particles are reduced to nanosize (20–200 nm diameter), hence the technology named as Nanotechnology, other attributes like even distribution of nanoparticles with sustained release in the food ((Nagamallika *et al.,* 2020).

Despite the unique properties of ginger and turmeric, there has been a shortage of research examining their antioxidant and antimicrobial capabilities. As a result, there hasn't been any prior investigation connecting CMC film combined with nanoemulsions of ginger and turmeric extracts to the packaging of chicken meat nuggets. This research project aimed to address this gap and the chicken meat nugget were tested for pH, 2-Thiobarbituric acid value, Per cent cooking loss, total plate count, yeasts and moulds count, psychrotrophic count and sensory properties at an interval of 4 days in the storage period of 20 days.

MATERIALS AND METHOD

Film forming solution was prepared with carboxymethyl cellulose (CMC) at a concentration of 4% (w/v) in distilled water and ultrasonification was done. The extracts of ginger and turmeric were prepared by using the method of Anandh and Lakshmanan, (2014) with some modifications. Nano emulsions of ginger extract (NGE) and turmeric extract (NTE) were prepared by following the method of Foujdar *et al*. (2018). Plasticizer, specifically glycerol was added at 2 % level.

Two nanoemulsions were prepared i.e turmeric extract and ginger extract which were incorporated in nanoCMC solution each at 3, 6 and 10 and 1, 2 and 5 per cent level respectively. The solution was continuously stirred while heating. Seven types of film solutions were prepared viz. solution without addition of nanoemulsion and with nano-CMC alone (C), nanoCMC incorporated with 3 % (T_1), 6% (T_2) and 10 % (T_3)turmeric extract nanoemulsion, and incorporated with 1% (T_4), 2 % (T_5) and 5 % (T_6)ginger extract nanoemulsion and solutions were homogenized in vortex mixer for 2 minutes. Films casting method was used to prepare the films and further these were evaluated for their physical characteristics.

The physical features of films like thickness and grammature were evaluated. The thickness was assessed by using digital micrometer and the grammature was measured by following the procedure stated by Geraldine *et al*., 2008 by taking average of 10 random measurements. The water vapour permeability (WVP) of the films was measured gravimetrically based on ASTM E96-92 method described by Casariego *et al.* (2009). Opacity of the films were evaluated according to the method of Tunc and Duman (2010) by using spectrophotometer The water sorption of edible nanocarboxymethyl cellulose films was evaluated by following the method of Lavorgna *et al*. (2010).

To test the antimicrobial activity of the films modified disc diffusion method was used using MHA plates having cultures of *E.coli* and *S.aureus* with the standard antibiotics i.e. Penicillin G and Streptomycin for *S. aureus* whereas Gentamicin and Chloramphenicol for *E.coli*.

Based on the results of the above parameters, T_2 film from turmeric group and T_4 film from ginger group along with control were analysed for their ultra-structural integrity and were evaluated for their efficiency as active films for storage of chicken nuggets.

FILM MICROSTRUCTURAL ANALYSIS

The FTIR spectra and SEM analysis were done as described by Cai *et al*. (2021). The FTIR spectra of films were performed using Cary 630 FTIR with diamond ATR (Agilent

Technologies, USA) in the wavenumber range from 4000 to 600 cm^{-1} and the resolution was 4 cm^{-1}. The data were analysed by the software provided with the instrument. The microstructure of films was characterized using a scanning electron microscope (Vega 3, SBH, TESCAN Brno S.R.O, CZECH Republic) at an acceleration voltage of 5 kV. The samples were fixed and sputtered with gold under vacuum in order to make the sample conductive. The photographs were taken at 1.32kx magnification.

To prepare chicken meat nuggets, chicken (74.0%), salt (1.8%), fat (5.0%), binder (3.0%), spices (2.2%), condiments (4.0%) and water (10%) were used. Furthermore, nuggets were wrapped around by films.

Quality testing of CMC films on meat nuggets- Physico-chemical characteristics pH

pH of the chicken nuggets were determined by following the method of Trout *et al.* (1992) using deluxe digital pH meter (Deluxe model 101E). 5 grams of representative sample was homogenized with 45 ml of distilled water in a laboratory blender for about one minute. The pH was recorded by immersing the combination glass electrode of digital pH meter in the homogenate. Before the measurement of pH, the pH meter was calibrated with buffer solutions of pH 4 and pH 7 as per user manual instructions to avoid errors.

2-Thiobarbituricacid reactive substances (2-TBARS) value

TBARS values were determined by the method of Tarladgis *et al.* (1960). 10g of sample was blended with 50 ml of distilled water in a blender for 2 minutes. This mixture was transferred to a 500 ml Kjeldahl flask quantitatively. Then the blender was rinsed with 45 ml of distilled water and was transferred quantitatively to the flask to which 5 ml of HCl was added previously. Few glass beads were added to the contents to avoid frothing and bumping. The contents of the flask were heated to 80-100^{0}C with the help of a heating mantle and 50ml of distillate was collected in a stoppered

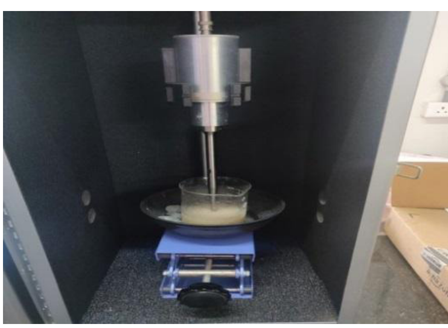

Fig 1: Utrasonication of carboxymethyl cellulose solution

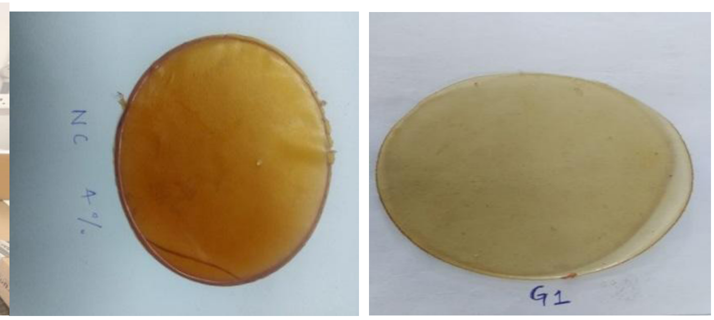

Fig 2: Ginger and Turmeric nano emulsion incorporated films respectively for film studies

Fig 3: steps in wrapping of chicken nuggets in the active packaging film

measuring cylinder. The 5ml of thoroughly mixed distillate was pipetted out in duplicates into 20 ml glass stoppered test tubes to which 5 ml of 0.02 M TBA reagent was added. The contents were mixed well and heated in a boiling water bath for 35 minutes. A blank consisting of 5 ml of distilled water and 5 ml TBA reagent was run simultaneously. After cooling the tubes under running water, optical density (OD) was measured in a spectrophotometer at 532 nm.

Where, OD - Optical Density at 532 nm, 7.8- constant

Per cent cooking loss Cooking loss per cent was estimated with the aid of recording the difference between the pre-cooking and post cooking weights of meat and expressed as percentage.

$$Cooking\ loss(\%) = \frac{weight\ of\ sample\ before\ cooking - weight\ of\ sample\ after\ cooking}{weight\ of\ sample\ before\ cooking} \times 100$$

MICROBIAL ANALYSIS

The microbial quality of preparation was evaluated by estimating the Total plate count (TPC), Psychrophilic Bacterial Count (PBC) and Yeast and Mould counts (YMC) following pour plate technique as per standard procedure of ICMSF (1980).

Preparation of serial dilutions

For microbiological analysis, 5 g of representative sample was homogenized with 45 ml of 0.1 per cent sterile peptone water in laboratory blender and tenfold serial dilutions were made from each sample by using 0.1 per cent peptone water as diluent.

Total Plate Count (TPC)

Sterile petri plates were inoculated aseptically with 1ml sample from appropriate dilution in duplicates. 15-20 ml of sterilized and plate count agar (Himedia, Mumbai) at 44-46^{0}C was poured into petri plates gently and the contents were mixed well for even distribution of the sample without air bubbles and plates were allowed for some time to solidify. The plates were then incubated in inverted positions at 37^{0}C for 24 to 48 hrs. Plates having 25-250 colonies were selected and the colonies were counted. The results were expressed as log units per gram of the sample.

Yeast and Mould Count (YMC)

The yeast and mould count of the product was determined by pour plate method using Potato dextrose agar (PDA). Plates inoculated with sample were incubated at 23-25^{0}C for 5-7 days. Colonies were counted and expressed as log units per gram of the sample.

Psychrophilic bacterial count

Psychrophilic bacterial count (PBC) was recorded on pour plates of plate count agar which were incubated at 4^{0}C for 11 days period.

SENSORY EVALUATION

The chicken meat nuggets were analysed for their sensory quality namely for their colour, appearance, flavour, juiciness, tenderness and overall acceptability measured on a 9 point hedonic scale (9 = like extremely to 1 = dislike extremely) with a semitrained taste panel according to the method described by Eke *et al*. (2012) with modifications.

The results were subjected to statistical analysis with SPSS 26.0 (n=6).

RESULTS AND DISCUSSION

In first phase of the study, films were developed and evaluated for their quality and the best films each The T_4film exhibited significantly higher grammature and lower mean water sorption kinetics and it may be attributed to the gelling properties of carboxymethyl cellulose, which leads to higher viscosity in solutions (Ilyas *et al*., 2020). According to Mallika *et al.* (2020), an increased concentration of active ingredients in the film results in reduced water sorption values.from ginger and turmeric group were chosen. In the second phase of the study, the quality of nuggets wrapped in nano CMC film incorporated with nano turmeric and nano ginger extract separately, were studied and the results were presented.

Film characterstics

The thickness of all the films did not show any significant differences (P>0.05), as film thickness is primarily influenced by the solid content in the film-forming solution (Khan *et al.,* 2020).

The mean tensile strength value of T_5 was significantly (P<0.05) higher among all formulations. The interaction between polymer matrix of carboxymethyl cellulose and turmeric and ginger extracts in a nano emulsion forms hydrogen bonds which is likely the reason for increased tensile strength value (Da Silva *et al.*, 2019).

The mean water vapour permeability of the control was significantly (P<0.05) lower than the turmeric nano extract incorporated films, likely due to the hygroscopic nature of turmeric molecules (Gontard *et al.* 1992) but higher than that ginger nano extract incorporated films.

The increased percent elongation at break of T_5 film can be attributed to the flexibility of the raw materials in the film and the plasticizing agent that was added (Mei et al., 2020).

Opacity values were significantly ($P < 0.05$) higher for T_3 films, possibly because of the dispersion of turmeric nanoemulsion particles within the polymeric matrix of the CMC film (Khan *et al.*, 2020).

The higher antioxidant activity values of T_2 and T_3 films were due to the presence of polyphenols (Foujdar *et al.*, 2018).

The feeble antimicrobial activity which was evident through non clear inhibitory zones for *S. aureus* in the agar diffusion test (ABST) indicated the presence of potent active ingredients in low concentration (Foujdar *et al.*, 2018).

FOURIER TRANSFORM INFRARED (FT-IR) SPECTROSCOPY

The FTIR spectra images of control, T_2 andT_4 films are depicted in figure 4, 5 and 6 respectively.

In C, T_2 and T_4 films the peaks at 3263, 3289 and 3267 cm^{-1} corresponds to the hydroxyl stretching vibrations. The stretching peaks in all the three films had shifted towards more intensity indicating strong bond formation. Wavenumbers value shifted slightly from 3263 to 3267 and 3289 cm^{-1} corresponding to increased molecular vibrations.

Sharp peaks of the C, T_2 and T_4 films at 2923, 2928, 2928 cm^{-1} respectively indicate-C-H stretch and the band was sharp.The wavenumbers of the peaks for C, T_2 and T_4 films at 1590, 1577 and 1587 cm^{-1} respectively corresponds to NO_2 stretch. The wavenumbers where shifted towards lower value.

Specific sharp peaks at wavenumbers of 1654 cm^{-1} for T_2 film and 1349 cm^{-1} for T_4 film indicated the presence of C=C (alkene) and in the C group alkenes were absent indicating the presence of turmeric and ginger.

The FTIR results indicated that there was no change in functional groups of the films.

SCANNING ELECTRON MICROSCOPY

The scanning electron microscopic examination revealed that the control films had continuous and smooth surface

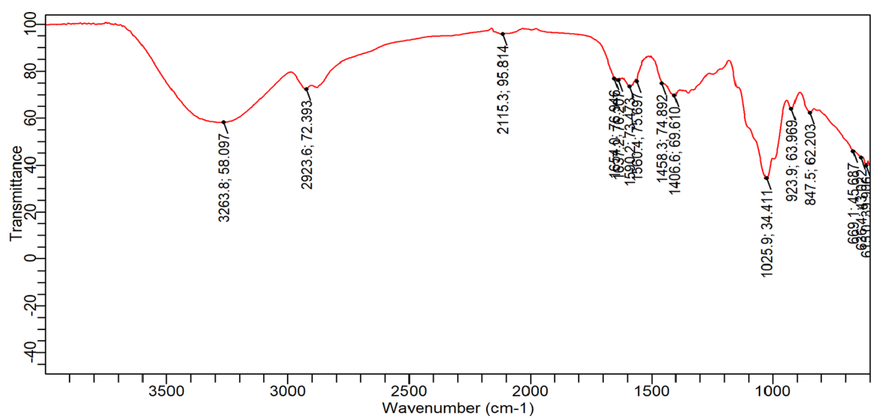

Fig 4: FTIR spectra of control film

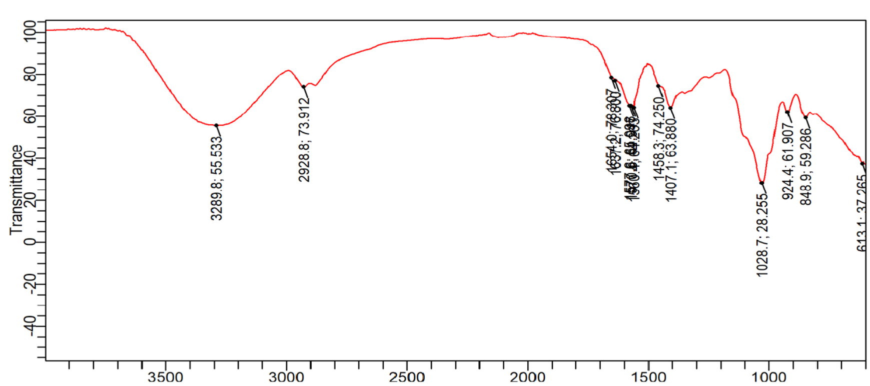

Fig 5: FTIR spectra of T_2film

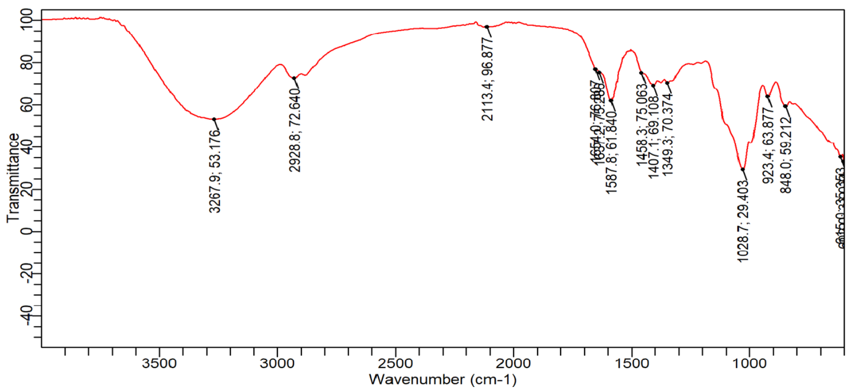

Fig 6: FTIR spectra of T_4film

microstructure with homogenous and dense morphology with no voids. These films surface was evenly distributed (Figure 7).

The ulrastructure of ginger nano extracts incorporated films had increased the roughness of the surface due to incorporation of ginger nanoemulsion. Inhomogeneous structures in the film were present but the matrix was distributed evenly indicating high compatibility between the biopolymer and the incorporated active ingredient. The turmeric nano emulsion incorporated film exhibited homogenously distributed nano turmeric emulsion in the CMC film. The particle shape was homogenous with variations in sizes.

These images showed that the films were more compact and dense with incorporation of turmeric and ginger extracts nanoemulsions into CMC solution compared with control.

Quality testing of CMC films on meat nuggets

pH measurement

The mean pH value of chicken nuggets wrapped in nano turmeric extract incorporated film were significantly (P<0.05) lower than that of nano ginger extract incorporated film and control. This might be due presence of turmeric in the CMC films to decrease in bacterial activity (Sayadi *et al*., 2021).During refrigerated storage, irrespective of the treatments, the overall pH values of chicken nuggets increased significantly (P<0.05) with increasing storage period.

In confirmation of our results Azarifar *et al*. (2020) demonstrated that raw beef packaged with gelatin-carboxymethyl cellulose based films incorporated with essential oil have a better effect on lowering the pH. Present study was in conflicting with Sayadi *et al.* (2021) in beef coated with zein impregnated with ginger extract and Jahangiri *et al.* (2022) in fresh-salmon fillets coated with chitosan and ginger essential oil nanoemulsion.

2-Thiobarbituric acid reactive substances (2-TBARS) value

2-TBARS value is used to measure the extent of lipid oxidation in the meat products. Lipid oxidation spoils the meat by developing off flavour and rancidity in the food product.

The nuggets wrapped in treatments films had significantly (P<0.05) lower 2-TBARS values when compared to control film wrapped chicken nuggets and were well acceptable up to 16 days of refrigerated storage. The values were still lower for ginger incorporated film than other treatments and were well acceptable throughout the storage period. The 2-TBARS values had increased significantly (P<0.05) from day 0 to day 20 irrespective of the film used. At any point of the storage the T_4 film had recorded significantly (P<0.05) lower 2-TBARS values when compared to others.

The lower values in T_4 film wrapped nuggets could be due to its ability to block oxygen and the antioxidant effect of ginger present in the film through elimination of free radicals (Sayadi *et al.*, 2021). However, the rate of increase in T_4 film wrapped nuggets was at a slower pace.

Similar results were reported by Sayadi *et al.* (2021) who investigated 2-TBARS values in beef sample coated with zein and ginger extract and also by Jahangiri *et al.* (2022) in fresh salmon fillets coated with chitosan and nano emulsion of ginger essential oil. In contrast to this findings, Bojorges *et al.* (2020) in beef loin, pork loin and chicken breast packaged with alginate and turmeric extract and Noori *et al.* (2018) estimated the 2-TBARS values of refrigerated chicken breast fillets coated with sodium caseinate incorporated with ginger nano emulsion and reported no significance (P>0.05) difference between control and treatment on chicken breast throughout the storage period.

Cooking loss

Cooking loss is important factor as it affects the appearance and acceptance of chicken meat. (Noori *et al.* 2018).

There was significant difference (P<0.05) between the per cent cooking loss values of nuggets wrapped in T_4 film and nuggets that were wrapped in T_2 and control films. The mean per cent cooking loss values of chicken meat nuggets wrapped in T_4 film were significantly (P<0.05) lower than the nuggets that were wrapped in T_2 and control films. This might be associated with reduction in rate of evaporation and respiration due to wrapping in films (Mallika *et al.*, 2018). However, the complexes formed between turmeric and CMC might have reduced the interstitial space within the film network and consequently lowered the evaporation.

Table 1: pH and 2-TBARS (Mean ± SE) values of chicken nuggets influenced by different packaging films during refrigerated temperature (4 ± 1°C)

Parameters	Treatments	Days of storage						Overall mean
		Day 0	Day 4	Day 8	Day 12	Day 16	Day 20	
pH	**C**	5.82^{aA} ± 0.17	6.07^{bA} ± 0.16	6.41^{cB} ± 0.11	6.91^{cA} ± 0.07	7.26^{dA} ± 0.07	7.45^{eC} ± 0.02	6.65 ± 0.11
	T_2	6.02^{aA} ± 0.07	6.20^{aA} ± 0.02	6.25^{bA} ± 0.04	6.84^{cC} ± 0.05	7.00^{dC} ± 0.06	7.24^{dA} ± 0.03	6.59 ± 0.08
	T_4	6.03^{aA} ± 0.06	6.23^{bA} ± 0.06	6.66^{bA} ± 0.01	6.73^{cBC} ± 0.03	6.95^{dBC} ± 0.03	7.12^{eB} ± 0.03	6.62 ± 0.07
	Overall mean	**5.96^{NS} ± 0.06**	**6.17* ± 0.06**	**6.44* ± 0.05**	**6.83* ± 0.03**	**7.07* ± 0.05**	**7.27* ± 0.04**	
2-TBARS	**C**	0.41^{aA} ± 0.02	0.86^{bA} ± 0.16	1.38^{cA} ± 0.13	1.59^{cA} ± 0.13	2.12^{dA} ± 0.17	2.6^{eA} ± 0.19	1.49±0.14
	T_2	0.44^{aA} ± 0.02	0.65^{aBC} ± 0.04	1.19^{bB} ± 0.13	1.79^{cB} ± 0.04	1.88^{cB} ± 0.19	2.6^{dA} ± 0.19	1.42 ± 0.13
	T_4	0.41^{aA} ± 0.03	0.51^{aC} ± 0.04	0.83^{bB} ± 0.06	1.03^{cB} ± 0.09	1.18^{cB} ± 0.07	1.63^{dB} ± 0.1	0.93±0.07
	OVERALL MEAN	**0.42^{NS} ±0.01**	**0.67*± 0.06**	**1.13* ± 0.08**	**1.47* ± 0.09**	**1.73* ± 0.13**	**2.28* ± 0.14**	

***Note: Significance**: P<0.05; Means bearing common superscript along the row (small letters) within storage periods and along the column (capital letters) within treatments do not differ significantly. (*) means significant difference between treatments, NS – non significant.*

Table 2: Per cent cooking loss (Mean ± Se) values of chicken nuggets as influenced by different packaging films during refrigerated temperature (4 ± 1°C)

Treatments	DAYS OF STORAGE						Overall mean
	Day 0	Day 4	Day 8	Day 12	Day 16	Day 20	
C	6.61^{aA} ± 0.02	17.28^{aB} ± 2.20	23.21^{bB} ± 1.81	29.10^{cB} ± 1.52	32.11 ± 0.72^{cB}	36.77 ± 1.94^{dB}	24.10 ± 1.79
T_2	6.63^{aA} ± 0.03	9.27^{abA} ± 0.81	11.71^{bA} ± 0.97	12.89^{bA} ± 1.21	19.04^{cA} ± 1.33	27.32^{cA} ± 3.08	14.40 ± 1.30
T_4	6.59^{aA} ± 0.03	6.77^{aA} ± 0.13	9.17^{abA} ± 0.87	10.77^{bA} ± 1.80	20.23^{cA} ± 1.48	23.98^{dA} ± 1.51	12.90 ± 1.22
Overall mean	**6.61^{NS} ± 0.01**	**11.11* ± 1.31**	**15.09* ± 1.62**	**17.19* ± 2.19**	**23.79* ± 1.58**	**29.35* ± 1.8**	

***Note:Significance**: P<0.05; Means bearing common superscript along the row (small letters) within storage periods and along the column (capital letters) within treatments do not differ significantly. (*) means significant difference between treatments, NS – non significant.*

The cooking loss was increased with increasing storage periods but at any point of storage period T_4 film wrapped nuggets had lower cooking losses when compared to the nuggets wrapped in T_2 and control films.

These results are consistent with the findings of Noori *et al*. (2018) in chicken breast fillets coated with sodium caseinate incorporated with ginger nano emulsion and they reported that ginger oil nano emulsion coated samples are resistant against mass transport due to the partial hydrophobicity of the surface of fillets and also correlated with Kucukozet and Uslu (2018) coated chicken thigh by sodium caseinate and starch solution.

Microbial analysis

Total Plate Count (TPC)

The mean total plate count values of chicken meat nuggets wrapped in treatments film were significantly (P<0.05) lower than the nuggets that were wrapped in control film. This might be due to the antimicrobial capacity of turmeric and ginger that could be related to the polyphenols present in them (Foujdar *et al*., 2018).

During storage period the total plate counts increased with increasing storage period. However lower counts were noticed in nuggets wrapped in T_2 and T_4 films than nuggets wrapped in control film. Unacceptable TPC values were found in control treated nuggets on day 20 under refrigerated storage temperature whereas the values were well within limits for T_2 and T_4 films wrapped nuggets even towards the end days of refrigerated period. This could be due to the slow release of turmeric and ginger nano emulsion resulting in strong antimicrobial activity. The strong antimicrobial properties of ginger were related to more than 400 different compounds, including: zingerone, gingerols, shogaols and sesquiterpenoids and turmeric is related to the curcuminoids (Sayadi *et al*., 2021, Foujdar *et al*., 2018).

The results were well in agreement with Sayadi *et al*. (2021) who examined beef coated with zein enriched with ginger extract and also related to Abdou *et al.* (2018) in refrigerated chicken fillets coated with curcumin loaded nano emulsions and pectin.

Yeast and Mould Count (YMC)

The mean yeast and mould count values of chicken meat nuggets wrapped in T_4 film were significantly (P<0.05) lower than the nuggets that were wrapped in T_2 and control films.

Table 3: Mean ± SE values of Total plate count and Yeast and mould count (log CFU/g) of chicken nuggets influenced by different packaging films during refrigerated temperature (4 ± 1°C)

Parameters	Treatments	Days of storage						Overall mean
		Day 0	Day 4	Day 8	Day 12	Day 16	Day 20	
Total plate count	**C**	3.09^{aA} ± 0.03	4.16^{bC} ± 0.02	4.35^{cB} ± 0.01	5.15^{dB} ± 0.03	5.68^{eB} ± 0.09	6.26^{aB} ± 0.05	4.78± 0.18
	T_2	3.12^{aA} ± 0.03	3.23^{bA} ± 0.02	3.48^{cB} ± 0.05	4.34^{dA} ± 0.20	4.37^{dB} ± 0.08	5.22^{eA} ± 0.06	3.96± 0.13
	T_4	3.14^{aA} ± 0.03	3.36^{abB} ± 0.001	3.70^{bA} ± 0.11	4.16^{cA} ± 0.02	4.25^{cA} ± 0.03	5.26^{dA} ± 0.06	3.98± 0.12
	Overall mean	**3.11^{NS} ± 0.02**	**3.58* ± 0.1**	**3.84* ± 0.1**	**4.55* ± 0.12**	**4.77* ± 0.16**	**5.58* ± 0.12**	
Yeast and mould count	**C**	0.73^{aA} ± 0.02	1.61^{bA} ± 0.21	2.31^{cB} ± 0.04	3.84^{dB} ± 0.1	4.65^{eA} ± 0.15	5.48^{fA} ± 0.04	3.10 ± 0.29
	T_2	0.70^{aA} ± 0.02	1.45^{bA} ± 0.25	1.78^{bcA} ± 0.13	1.99^{cA} ± 0.1	2.97^{dB} ± 0.06	3.51^{eB} ± 0.1	2.07 ± 0.17
	T_4	0.72^{aA} ± 0.02	1.36^{bA} ± 0.04	1.65^{bcA} ± 0.04	1.77^{cA} ± 0.16	1.87^{cC} ± 0.18	2.99^{cC} ± 0.06	1.73 ± 0.12
	Overall mean	**0.72^{NS} ± 0.01**	**1.47* ± 0.11**	**1.91* ± 0.08**	**2.53* ± 0.23**	**3.16* ± 0.29**	**3.99* ± 0.26**	

Note:Significance: *P<0.05; Means bearing common superscript along the row (small letters) within storage periods and along the column (capital letters) within treatments do not differ significantly. (*) means significant difference between treatments, NS – non significant.*

The results were well in agreement with Sayadi *et al.* (2021) in beef sample who coated with zein and ginger extract andwithNoori *et al.* (2018) in chicken breast fillets coated with sodium caseinate enriched with ginger nano emulsion and they stated that bioactive compounds formulated as nano emulsion enhanced the transport mechanisms through the cell membrane of the target microorganisms. In fact, the larger surface area and higher affinity of nano-droplets with bacteria cells, yields a quantum-size effect and increases the antimicrobial activity.

SENSORY EVALUATION

The higher mean colour, flavour, tenderness and overall acceptability values of chicken meat nuggets wrapped in T_4 film might be due to inhibition of chemical and microbial reactions in ginger film wrapped nuggets (Sayadi *et al.*, 2021). Similar results were obtained by Noori *et al.* (2018) with ginger nano emulsion coated chicken fillets and stated that the fillets were more acceptable due to pleasant odour and shiny surface.

The sensory scores were decreased with increasing storage periods but at any point of storage treatment films wrapped nuggets had significantly (P<0.05) higher sensory scores when compared to those wrapped in control films. However, the rate of decrease in sensory scores in treatments films wrapped nuggets was slower. This might be due to antimicrobial effect, anti-oxidant effect of tur-

Table 4: Mean ± SE values of Colour, Flavour, tenderness and juiciness of chicken nuggets influenced by different packaging films during refrigerated temperature (4 ± 1°C)

Parameters	Treatments	Days of storage						Overall mean
		Day 0	Day 4	Day 8	Day 12	Day 16	Day 20	
Colour	C	8.59^{dA} ± 0.1	7.54^{cA} ± 0.13	7.04^{cA} ± 0.25	7.21^{cA} ± 0.21	5.11^{bA} ± 0.12	4.10^{aAB} ± 0.14	6.29 ± 0.23
	T_2	8.60^{cA} ± 0.1	7.55^{bA} ± 0.16	7.38^{bA} ± 0.24	7.38^{bA} ± 0.29	5.50^{aB} ± 0.42	5.30^{aBC} ± 0.25	6.95 ± 0.22
	T_4	8.44^{dA} ± 0.1	6.42^{cA} ± 0.55	6.15^{cA} ± 0.35	5.58^{cA} ± 0.4	5.96^{bB} ± 0.4	5.20^{aA} ± 0.4	6.60 ± 0.26
	Overall mean	**8.60^{NS} ± 0.05**	**7.54^{*} ± 0.08**	**7.31^{*} ± 0.13**	**7.26^{*} ± 0.15**	**5.59^{*} ± 0.18**	**4.79^{*} ± 0.25**	
Flavour	C	8.42^{dA} ± 0.11	7.78^{cB} ± 0.16	5.17^{bA} ± 0.22	4.81^{bA} ± 0.18	4.86^{bA} ± 0.32	4.13^{aA} ± 0.20	**5.86 ± 0.29**
	T_2	8.34^{cA} ± 0.10	7.77^{bcB} ± 0.33	7.10^{abC} ± 0.30	7.00^{abB} ± 0.34	6.59^{aB} ± 0.42	6.22^{aC} ± 0.28	**7.17 ± 0.17**
	T_4	8.44^{dA} ± 0.10	6.42^{cA} ± 0.55	6.15^{cB} ± 0.35	5.96^{cA} ± 0.40	5.58^{bAB} ± 0.40	5.20^{aB} ± 0.40	**6.29 ± 0.23**
	Overall mean	**8.40^{NS} ± 0.05**	**7.32^{*} ± 0.26**	**6.02^{*} ± 0.28**	**6.04^{*} ± 0.25**	**5.68^{*} ± 0.27**	**5.18^{*} ± 0.26**	
Tenderness	C	8.40^{eA} ± 0.08	7.38^{dA} ± 0.12	6.33^{cA} ± 0.36	6.03^{cA} ± 0.23	4.79^{bA} ± 0.16	3.39^{aA} ± 0.21	**6.05 ± 0.29**
	T_2	8.33^{cA} ± 0.09	8.21^{cB} ± 0.19	7.25^{bB} ± 0.14	6.88^{bB} ± 0.06	5.62^{aA} ± 0.13	5.24^{aB} ± 0.3	**6.92 ± 0.21**
	T_4	8.36^{dA} ± 0.09	7.91^{dB} ± 0.12	6.74^{cBC} ± 0.14	6.70^{cB} ± 0.11	4.80^{bA} ± 0.69	3.77^{aC} ± 0.32	**6.38 ± 0.30**
	Overall mean	**8.36^{NS} ± 0.05**	**7.83^{*} ± 0.11**	**6.77^{*} ± 0.16**	**6.54^{*} ± 0.12**	**5.07^{*} ± 0.25**	**4.13^{*} ± 0.25**	
Juiciness	C	8.00^{cA} ± 0.35	7.18^{cA} ± 0.49	6.01^{bA} ± 0.13	6.15^{bA} ± 0.22	4.14^{aA} ± 0.37	3.32^{aA} ± 0.17	**5.80 ± 0.3**
	T_2	8.22^{eA} ± 0.34	7.59^{deA} ± 0.46	6.41^{cB} ± 0.16	6.78^{cdAB} ± 0.26	4.88^{bAB} ± 0.27	3.80^{aAB} ± 0.35	**6.28 ± 0.28**
	T_4	7.84^{dA} ± 0.28	7.75^{cdA} ± 0.15	7.48^{cdAB} ±0.18	7.14^{cB} ± 0.23	5.22^{bB} ± 0.19	4.22^{aB} ± 0.19	**6.61 ± 0.25**
	Overall mean	8.02^{NS} ± 0.18	7.51^{*} ± 0.22	6.63^{*} ± 0.17	6.69^{*} ± 0.16	4.70^{*} ± 0.19	3.78^{*} ± 0.16	

***Note: Significance**: P<0.05; Means bearing common superscript along the row (small letters) within storage periods and along the column (capital letters) within treatments do not differ significantly. (*) means significant difference between treatments, NS – non significant*

Table 5: Mean ± SE values of overall acceptability (mean ± se) values of chicken nuggets as influenced by different packaging films during refrigerated temperature (4 ± 1°c)

TREATMENTS	DAYS OF STORAGE						OVERALL MEAN
	DAY 0	DAY 4	DAY 8	DAY 12	DAY 16	DAY 20	
C	$8.43^{eA} \pm 0.09$	$6.83^{dB} \pm 0.4$	$6.16^{cdA} \pm 0.36$	$5.56^{cA} \pm 0.19$	$4.69^{bA} \pm 0.28$	$3.20^{aA} \pm 0.21$	**5.81 ± 0.3**
T_2	$8.36^{eA} \pm 0.11$	$7.80^{eA} \pm 0.23$	$7.00^{dB} \pm 0.30$	$6.02^{cB} \pm 0.27$	$4.69^{bA} \pm 0.22$	$3.87^{aB} \pm 0.26$	**6.29 ± 0.29**
T_4	$8.51^{dA} \pm 0.12$	$6.80^{cAB} \pm 0.41$	$6.05^{bcA} \pm 0.49$	$5.06^{abC} \pm 0.42$	$4.93^{aB} \pm 0.22$	$4.06^{aC} \pm 0.28$	**5.90 ± 0.28**
OVERALL MEAN	**$8.43^{NS} \pm 0.06$**	**7.14* ± 0.21**	**6.40* ± 0.23**	**5.55* ± 0.18**	**4.70*± 0.14**	**3.71* ± 0.15**	

***Note: Significance**: P<0.05; Means bearing common superscript along the row (small letters) within storage periods and along the column (capital letters) within treatments do not differ significantly. (*) means significant difference between treatments, NS – non significant*

meric and ginger in the CMC film, couples with barrier properties of film.

The results were well in agreement with those of Sayadi *et al.* (2021) on beef sample coated with zein and ginger extract, Noori *et al.* (2018) in chicken breast fillets coated with sodium caseinate incorporated with ginger nano emulsion and also correlated with Abdou *et al.* (2018) for refrigerated chicken fillets wrapped with curcumin loaded nanoemulsions and pectin coatings.

CONCLUSION

The chicken meat nuggets that were packaged in turmeric and ginger nanoemulsions incorporated carboxy methyl cellulose edible films had recorded significantly (P <0.05) lower 2-TBARS values, microbial counts and higher sensory scores than the nuggets wrapped in control package. The results showed that meat can be preserved and shelf life can be extended by novel active packaging of nano carboxymethyl cellulose films incorporated with turmeric and ginger nanoemulsion. Further, this can be a cost effective sustainable alternative packaging in the future.

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