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Effect of Eugenol (*Eugenia Aromatica*) Treatment and Modified Atmosphere Packaging (MAP) on Storage Stability of Chicken Noodles during Storage at 35±2°C Temperature

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ABSTRACT

The aim of this study was to investigate the effect of eugenol treatment and modified atmospheres (50 % N_2 + 50 % CO_2) packaging (MAP) on the storage stability of chicken noodles stored at 35 ± 2°C for 90 days. A total four treatments were assigned (i) control aerobic (C-AP), (ii) eugenol treated aerobic (ET-AP), (iii) control MAP (C-MAP), and (iv) eugenol and MAP treated (ET-MAP). All samples were evaluated for changes in pH, water activity (a_w), antioxidant activity, Lovibond tintometer colour (*L*, *a**, *b**), texture profiles, sensory attributes, lipid stability and microbial quality. ET-MAP packaging were significantly ($p<0.05$) influenced oxidative stability of noodle samples. ET-AP and ET-MAP treated samples shown to had higher ($p>0.05$) antioxidant activity. The standard plate count (SPC) of noodle samples was higher for both aerobic and MAP controls. ET-MAP samples were exhibited greater antioxidant activity and sensory scores but lower SPC and water activity than other samples.

Keywords: Storage, chicken meat, noodles, eugenol, antioxidant, modified atmosphere packaging

Noodles are becoming choice of foods for persons of all ages because of variety, versatility and mouth feel. Cereals are main raw ingredients in noodle preparation but they are deficient in vitamins and essential amino acids like lysine, tryptophan and threonine. Therefore protein rich ingredients like meat may be incorporated in noodle formulation to combat nutritional deficiency for this category of food products. But incorporation of meat in noodle formulation is not easy as it seems to be because protein gelation differs from that of starch gelation which is used in preparation of noodles. Inclusion of meat in noodles formulation may changes physicochemical properties like colour, flavour and texture. Myoglobin (Mb) oxidation leads to discoloration (Gray *et al*., 1996) while lipid oxidation causes off-notes and flavour and also losses product integrity during storage. Mb oxidations directly influence the consumer acceptability and lipid oxidation products are injurious to health. Many synthetic antioxidants were used to combat oxidation problems of muscle foods, but recent report on health claims of these synthetic chemicals has necessitated research on effective alternatives from natural sources.

The use of natural preservatives to increase the shelf-life of meat products is a promising technology since many herbs, plants, fruits and vegetables extracts have antioxidant (Biswas *et al*., 2012) and antimicrobial activities, and also supply some essential nutrients for health. Eugenol, the active substance, makes up 90 – 95 % of the clove oil was found to be an effective antioxidant in different in-vitro assays like DPPH and $ABTS^+$ activity, superoxide anion scavenging activity, and metal chelating activities (Gulcin *et al.*, 2010). It can be used to minimize the formation of harmful lipid oxidation products, maintaining nutritional quality and prolonging the shelf-life of meat food products. Terpenoids present in clove oil thought to be responsible for inhibitory action against microorganisms by membrane disruption (Lambert, 2001). The use of modified atmosphere packaging (MAP) in combination with other treatments for shelf-life extension of meat

and meat products was extensively reviewed by various scientists. MAP can increase the shelf-life of meat and poultry products by 50 - 400 % and assists in maintaining high quality (Rao and Sachindra, 2002). Aksu and Kaya (2005) reported that shelf-life of Pastrima can be increased up to 150 days by MAP application (50 % CO_2 + 50 % N_2).

However, there is very limited study conducted on the effect of eugenol and/ packaging conditions on the quality of dry and cooked muscle food items in general and chicken noodles in particular during storage. Hence the aim of this study was to evaluate the effect of eugenol treatment and packaging conditions on the quality characteristics of chicken meat noodles stored at 35 ± 2°C.

MATERIALS AND METHODS

Meat samples required for the experiments were obtained from spent layer hen slaughtered in the Department of Livestock Products Technology, College of Veterinary Science, Ludhiana slaughterhouse following scientific slaughtering techniques. The dressed carcases were chilled at 4 ± 1°C for overnight, deboned manually, and then divided into small cubes (5 × 5 × 5 cm^3). The meat cubes were tenderized using marinade containing calcium chloride (0.15 M) and papain (0.25 %) and kept at 4 ± 1°C for 40 hrs. Tenderized meat was washed repeatedly in distilled water, packed in LDPE bags and then frozen at -18 ± 1 °C for subsequent use. The refined saffola oil, refined wheat flour (Maida), spice mix, table salt, tetra sodium pyrophosphate, low density polyethylene (LDPE) were procured from local market. Standard Gallic acid (SRL Chemicals, India), nitro blue tetrazolium (NBT), phenazin methosulphate (PMS), NADH (nicotinamide dinuclotide hydrogen) (S.D.Fine Chemicals, India) Folin-Ciocalteau's reagent (CDH Chemicals, New Delhi, India), 2-2-azinobis-3ethylbenthiazoline-6-sulphonic acid ($ABTS^+$), 1, 1-diphenyl-2-picrylhydrazil (DPPH) and 2-thiobarbituric acid (Sigma-Aldrich, USA) used in the study were of analytical grade.

Preparation of Noodles

Five kilogram of tenderized frozen meat was minced twice through a 6 mm grinding plate and then by 4 mm plate in a meat mincer (Kalsi motors, Ludhiana, India).

Table 1: Formulation of chicken meat noodles

Sl. No.	Name of ingredients	Parts/Percentage
1	Meat	60
2	Refined wheat flour	40
		100*
Other Ingredients*		
3	Sodium tetra polyphosphate (g)	0.3
4	Salt (g)	3
5	Spice mix (g)	1.5
6	Refined oil	4

Meat and refined wheat flour consisting 100 % of formulation, and over and above this various additives were added

After mincing, meat samples were equally divided into two different batches of 2.5 kg each. The first batch designated as control (without eugenol) while the other treatment contained eugenol at 0.1 % level (Burt, 2004) replaced with added refined oil in the formulation. Both the batches of minced meat samples were mixed separately in an Inalsa food blender for 1 min. After complete mixing each sample (dough) was cold extruded (pore size 3 mm) through a hand extruder. The raw noodles were placed on multipored aluminium foil (Aluminium foil is cut into rectangular shape and pores of 2mm size is made with needle for uniform steaming), gelatinized by steaming for 12 min and finally hardened by quick chilling. Moisture content of noodles was reduced by drying in a cabinet dryer at a constant temperature of 60°C for 9 hrs. Samples were packaged under aerobic and MAP conditions viz. control aerobic (C-AP), control MAP (C-MAP), eugenol treated aerobic (ET-AP) and eugenol treated MAP (ET-MAP). All samples were stored in controlled humidity cabinet (Sonar Plus BOD 1062M, F-0.0031900610, Associated Scientific Technologies, New Delhi, India) at ambient temperature (35 ± 2°C, 70 % RH) for 3 months. The samples were drawn at 15 days interval (0, 15^{th}, 30^{th}, 45^{th}, 60^{th}, 75^{th} and 90^{th} day) for evaluation of different physicochemical parameters, microbial quality and sensory attributes.

Analysis of samples

Water activity was determined using potable digital water activity meter (Rotonix HYGRO Palm AW1 Set). The pH

of meat sample was measured with a digital (Elico make, Model: LI 127) pH meter equipped with combined glass electrode (Trout *et al*., 1992) The peroxide value was measured as per procedure described by Koniecko (1979) with suitable modifications. Evaluation of lipid stability was performed by measuring TBARS following the method of Witte *et al*. (1970) with suitable modifications. TBA value was calculated as mg malonaldehyde per kg of sample by multiplying absorbance value with K factor 5.2. The method as described by Koniecko (1979) was followed for quantification of free fatty acid. The $ABTS^{+}$ radical scavenging activity was determined according to method of Shirwaikar *et al*. (2006). The ability to scavenge 1, 1-diphenyl-2picrylhydrazyl (DPPH) radical by added antioxidants in chicken noodles was estimated following the method of Kato *et al*. (1988) with slight modifications. Superoxide radical scavenging activity was based on the reduction of nitro blue tetrazolium (NBT) in the presence of NADH and phenazin methosulphate (PMS) under aerobic condition (Kumar and Chattopadhyay, 2007).

Total phenolics

The polyphenol content was quantified by Folin-Ciocalteau's reagent assay and expressed as Gallic acid equivalents (mg GAE/g) (Yuan *et al*., 2005).

Colour profile analysis

Colour profile was measured using Lovibond Tintometer (Model: RT-300) set at 2º of cool white light (D_{65}) and known as '*L'*, *a** and *b** Values. '*L'* value denotes (brightness 100) or lightness (0), *a** (+ redness/- greenness), *b** (+ yellowness/-blueness) values were recorded on/in a hundreds of chicken noodles kept in a plate.

Texture profile analysis (TPA)

Texture profile analysis (TPA) was conducted using Texture Analyzer (TMS-PRO, Food Technology Corporation, USA as per the procedure outlined by Bourne, 1978).

Microbiological analysis

Conventional methods recommended by American Public Health Association (1984) were used to enumerate microbiological quality of noodle samples.

Sensory evaluation

Samples were evaluated by a six member experienced panel of judges from faculty and postgraduate students of college of veterinary science, Guru Angad Dev Veterinary and Animal Sciences University, Ludhiana, India. A Quantitative Descriptive Analysis was carried out for various sensory attributes such as appearance and colour, texture, flavour, juiciness, after taste and overall acceptability using 8 point scale, where 8=extremely desirable and 1=extremely undesirable (Keeton, 1983).

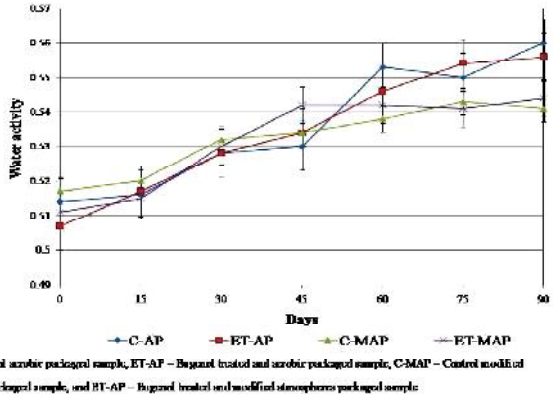

Fig. 1: Effect of eugenol and packaging conditions on the water activity of chicken meat noodles during storage at 35°C

Statistical analysis

Data were analyzed statistically on 'SPSS-16.0' software package as per standard methods of Snedecor & Cochran, (1994). Duplicate samples were drawn for each parameter and the experiment was replicated thrice (n=6). Sensory evaluation was performed by a panel of six member judges three times, so total observations being 18 (n=18). Data were subjected to two way analysis of variance, homogeneity test and Duncan's Multiple Range Test (DMRT) for comparing the means (significance level-0.05) to find the effects between treatment, between storage periods and their interactions.

RESULTS AND DISCUSSION

Water activity (a_w)

Results (Fig. 1) showed that a_w of aerobic and modified atmosphere packaged and stored chicken noodles differed

significantly with the progress in storage time. Until 15th day, the a_w in the chicken noodles remained nearly same as that was found during the initial days (0th day), however values increased significantly on the 30th day and afterwards. Amongst all the samples, C-MAP and ET-MAP samples were exhibited slightly lower a_w as compared to C-AP and ET-AP. The increased of a_w in C-AP and ET-AP samples could be due to the ingress of moisture in aerobic packaging conditions by the flour as it constitutes nearly 45 percent of the total noodle formulation.

Similar result of a_w was reported by Paula *et al.* (2010) in Toscana sausages stored in LDPE bags under AP conditions. Contradictory results were also reported by *Kong et al.* (2010) in jerky. According to them at 0 week, ascorbyl palmitate jerky had higher water activity and was decreased after 24 week under MAP.

pH

Packaging condition and storage period had significant ($P < 0.05$) effects on pH values of chicken noodles (Fig. 2). The interaction of the packaging condition × storage period also resulted significant ($P < 0.05$) effect on these values. The pH values were decreased in C-AP and ET-AP samples by the days 60 and 75, while that were decreased in C-MAP and ET-MAP samples on days 30 and 45, respectively. Similar findings were reported by Viuda-Martos *et al.* (2010) when they studied with bologna sausages supplemented with oregano essential oil under different packaging conditions.

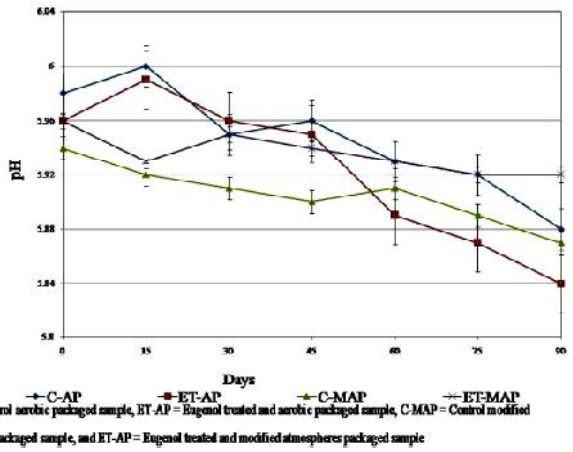

Fig. 2: Effect of eugenol and packaging conditions on the pH of chicken meat noodles during storage at 35°C

In another study, Aksu and Kaya (2005) reported Pastirma (dry sausage) stored under modified atmosphere packaging a reduction in pH was observed during entire storage period. It is also established fact that a decrease in pH was usually attributed to the metabolic activity of the Lactococcus lactis (Jay *et al*., 1962) but have little importance in this study.

Peroxide value

Peroxides are the primary products caused by auto-oxidation. They are formed when polyunsaturated fatty acids react with molecular oxygen, via free radical chain mechanism. Peroxide values at 0th day were the lowest as expected and non-significant difference was found amongst C-AP, ET-AP, C-MAP and ET-MAP chicken noodles (Fig. 3). At the end of the storage, peroxide values were above 2 times higher than those at day 0 for ET-AP and C-MAP samples. The C-AP sample exhibited highest peroxide values (3 times than those at 0th day) and that corresponds to 2 times higher than did the ET-MAP sample ($P<0.05$). Such difference could not be related to their fat content because PVs were expressed on a fat weight basis.

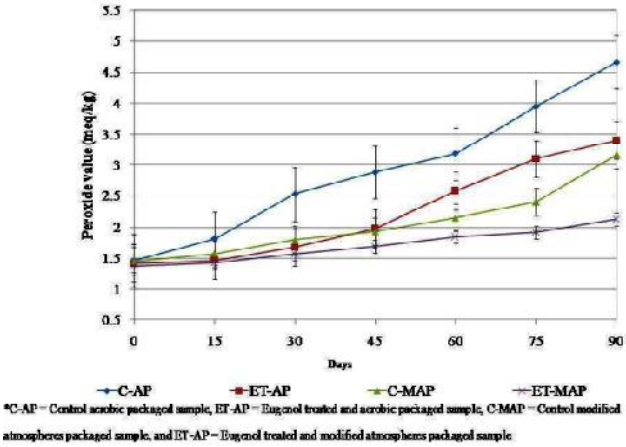

Fig. 3: Effect of eugenol and packaging conditions on the peroxide value of chicken meat noodles during storage at 35°C

The major pro-oxidants in these products could be metal ions (iron/iron compounds) which comes through meats and catalyses the fat in the presence of molecular oxygen and heat. The presence of antioxidant suppressed the chemical reactions, hence lowered PVs in ET-AP sample. The exclusion of reactive oxygen species from the package sample could further reduced the formation of peroxides, and for this, ET-MAP sample showed lowest PVs. However, increase of PVs with the storage time could be attributed to presence of residual oxygen in the package. Similarly,

Kong *et al.* (2010) reported that during 8 week of storage PVs of control jerky were doubled than those found at 0 day while that were lowest for all antioxidant treated samples.

TBARS value

The TBARS values ranged from 0.23 – 0.28 mg MDA/kg of sample to 0.56 – 0.85 mg MDA/kg of sample at the end of the storage (Fig. 4). During the initial days (0^{th} day) of storage TBARS values were nearly similar for all samples, however, that showed an upward trends as storage period progress, and reaching statistical differences in C-AP, ET-AP and C-MAP samples ($P < 0.05$) at 30^{th} day and in ET-MAP sample at 45^{th} day. C-AP and ET-MAP exhibits highest and lowest TBARS value respectively at day 30 but variation with respect to ET-MAP was more at 45^{th} day.

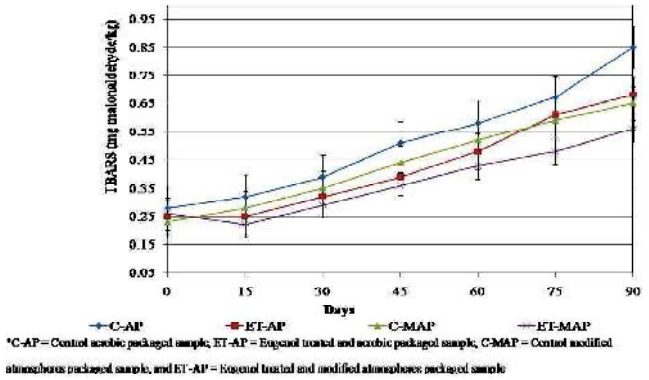

Fig. 4: Effect of eugenol and packaging conditions on the TBARS values of chicken meat noodles during storage at 35°C

These results suggested that lipid oxidation occurred in chicken noodles despite use of effective antioxidant (eugenol, ET-AP), presence of the low percentage of residual oxygen (C-MAP) or combination of these two treatment (ET-MAP). But ET-MAP sample exhibited significantly lower TBARS value on the 45^{th} day and subsequent storage intervals which could be due to additive effect of eugenol treatment and modified atmosphere packaging. The antioxidant activity of oils of spices is general and clove oil (eugenol) in particular is well accepted (Viuda-Martos *et al.,* 2010). This antioxidant activity is related with the capacity of polyphenols to act as metal chelators, free radical scavengers, hydrogen donators of enzymatic systems responsible for initiating oxidation reaction. Furthermore, they can act as substrate of free radicals like superoxide or hydroxyl or intervene in propagation reaction. The increase in TBARS may also be explained by assuming a first process of peroxide accumulation since TBARS are secondary oxidation products that derive from peroxide breakdown. MAP favoured a fast peroxide accumulation and then a fast decomposition of these transient compounds to give rise to secondary products. Hoz *et al*. **(**2004) reported increase of TBARS value in dry sausage treated with α-tocopherol and packaged under modified atmospheres.

Other workers also reported significance increase of TBARS values in salmon jerky snack sticks (Kong *et al*., 2010), Pastirma (Aksu and Kaya, 2005) and variety of sausage products treated with natural antioxidant and packaged under MAP conditions (Viuda-Martos *et al*., 2010).

Free fatty acid contents

Free fatty acid (FFA) content in meat determines the fat status and quality of the product and expressed as percent of oleic acid. On the 15^{th} day, C-AP sample had higher FFA content than all treated samples, and this change was detectable until end of the storage (Fig. 5).

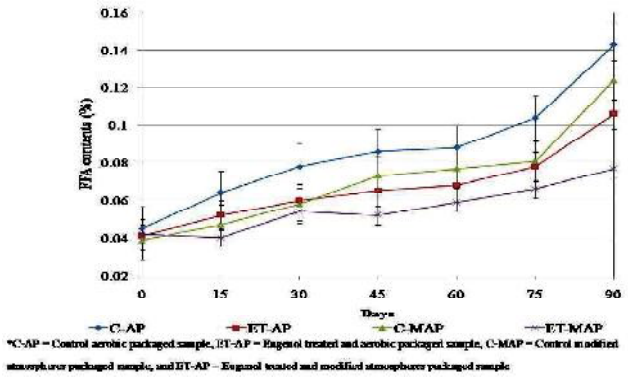

Fig. 5: Effect of eugenol and packaging conditions on the Free fatty acid contents of chicken meat noodles during storage at 35 °C

The significance difference in FFA content was also found in between ET-AP and C-MAP samples at 45^{th} day of storage interval. In general, FFA in all products increased with the increase of storage time. The differences in FFA contents amongst all types of noodles could be due to level of oxidation and decomposition of fat by bacterial multiplication. Modi *et al.* (2007) reported that freshly prepared dehydrated chicken kebab mix had FFA values

of 0.99 %, which gradually ($P < 0.05$) increased to 1.74 % during 6 months of MAP storage.

Antioxidant activity

The antioxidant activities of chicken noodles were determined by $ABTS^+$ assay, DPPH assay, superoxide anion scavenging activity and estimation of total polyphenols (Table 2). The ET-AP and ET-MAP samples were exhibited higher $ABTS^+$ activity than their corresponding controls (C-AP and C-MAP); however as expected the $ABTS^+$ activity was reduced with the progress in storage time, and this could be due to higher storage temperature which encourages increase of chemical reactions and thereby breakdown of antioxidant compounds. The $ABTS^+$ activity of eugenol in meat products was reported (Gulcin *et al.*, 2010). Likewise, DPPH and superoxide anion scavenging activity was decreased with the storage time, in fact, they were differed significantly in ET-AP and ET-MAP samples only after 60th and 45th day of storage, respectively (Table 2). Both the eugenol treated samples showed very good radical-scavenging activity but that was declined very fast at end of the storage. The antioxidant activities of eugenol in chicken and other meat products were studied (Kong *et al.*, 2010). The total polyphenol content was differed among the samples and in between storage interval. During storage, the total polyphenols level fall very rapidly in ET-AP sample than in ET-MAP, and this could be attributed to the degree of oxidation and antioxidative effect of the polyphenols since in air the polyphenol would have reacted more strongly with the free radical produced, leading to their diminution and lower concentration. This idea was lent weight by the data obtained for the oxidation and concentration of polyphenol in the MAP eugenol treated sample. Similarly, decreasing trend of polyphenol content was reported by Viuda-Martos *et al*. (2010) in bologna sausages prepared with oregano essential oil and stored under air and MAP conditions.

Colour profile analysis

Color measurement is very important because brightness and a special white colour are expected in such type of product. However, there is scanty literature available on the correlation between the colour coordinates (*L*, *a** and *b** values) and chicken meat noodles. Results (Fig. 6a, 6b and 6c) indicated that colour parameters measured on the surface of water cooked chicken noodles did not vary significantly amongst the treatments, except redness (*a** value). However, the storage period had a significant effect on *L*, *a** and *b** values. Lightness (*L*) was significantly increased in C-AP sample on the day 60 and in ET-AP and C-MAP samples on the 75th day until end of storage time. Water activity (a_w) is one of the most important factors determining lightness in meat products, and the results obtained for a_w is consistent with the evolution of lightness in this study. Redness (*a** value) decreased significantly (Fig. 6b) during storage ($P > 0.05$), indicating a loss of intensity of red colour which might be due to myoglobin oxidation and slight increase in water activity level.

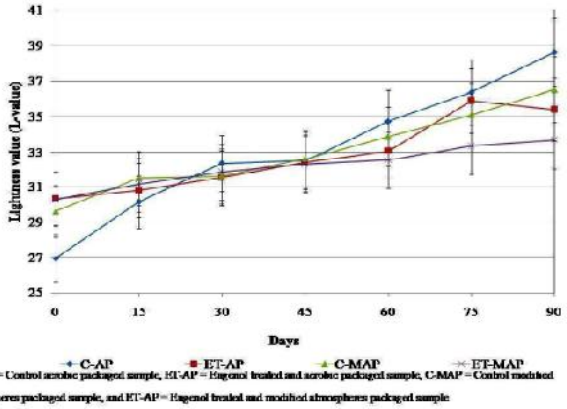

Fig. 6a: Effect of eugenol and packaging conditions on the Lightness value of chicken meat noodles during storage at 35°C

The ET-MAP sample exhibited significantly higher *a** values than C-AP which could be due to antioxidant activity of polypenols present in eugenol (Lu *et al.*, 2011). It has also been observed that MbFe (II) NO is highly unstable in the presence of oxygen so maintaining the lowest levels in oxygen in packs of chicken noodles would keep colour for a longer period. Similar findings reported by Aksu and Kaya (2005) in Pastirma. ccording to them a* value in Pastirma retained better at 10 °C temperature than at 4 °C during 150 days of storage under MAP (50 % CO_2 + 50 % N_2) condition. Yellowness (*b** value) slightly decreases (Fig. 6c) during storage period ($P > 0.05$).

Texture profile analysis

Results of Instron textural value indicated that packaging conditions or use of eugenol in chicken noodles did not affect hardness value; however that was decreased with the progress in storage time and significant difference was observed only after 75 days of storage (Table 3).

Table 2: Antioxidant activity of chicken noodles stored under aerobic and MAP conditions at 35°C

Treatment [1]	Storage interval (Days)						
	0	15	30	45	60	75	90
	ABTS$^+$ (% inhibition)						
C-AP	47.30±0.62^{dA}	44.08±0.31^{cA}	41.82±0.27^{cA}	39.68±0.30^{bA}	37.75±0.38^{abA}	35.11±0.35^{aA}	34.82±0.21^{aA}
ET-AP	87.75±0.34^{dB}	85.32±0.47^{dB}	84.48±0.58^{cB}	83.47±0.11^{cB}	82.31±0.31^{cB}	80.35±0.17^{bB}	78.10±0.15^{aC}
C-MAP	48.70±0.46^{dA}	45.88±0.50^{cA}	42.13±0.35^{bA}	41.96±052^{bA}	39.77±0.21^{abA}	37.68±0.32^{aA}	36.3±0.35^{aB}
ET-MAP	88.78±0.24^{cB}	86.40±0.16^{bcB}	86.30±0.49^{bcB}	84.77±0.38^{abB}	83.01±0.46^{aB}	82.64±0.13^{aB}	82.94±0.12^{aD}
	DPPH (% inhibition)						
C-AP	13.53±1.27^{fA}	12.05±0.24^{fA}	10.65±0.68^{eA}	8.90±0.23^{dA}	7.55±0.30^{cA}	5.46±0.72^{bA}	3.82±0.32^{aA}
ET-AP	54.27±1.14^{dB}	53.083±1.18^{dB}	50.58±2.21^{cB}	46.27±2.19^{bcB}	43.63±1.23^{bB}	36.90±0.43^{abB}	30.83±1.49^{aB}
C-MAP	14.10±0.86^{dA}	12.97±0.62^{dA}	10.87±0.73^{cA}	9.90±0.39^{bA}	8.27±0.15^{abA}	6.30±0.31^{aA}	4.72±0.19^{aA}
ET-MAP	55.45±1.18^{cB}	54.02±0.94^{cB}	52.32±3.25^{bcB}	47.63±2.29^{bB}	45.20±1.24^{abC}	38.57±2.32^{aC}	35.28±3.25^{aC}
	Superoxide anionic scavenging activity (% inhibition)						
C-AP	27.50±0.85^{gA}	25.33±0.19^{fA}	21.44±0.19^{eA}	16.57±0.43^{dA}	10.82±0.36^{cA}	8.32±0.40^{bA}	5.22±0.34^{aA}
ET-AP	66.53±2.15^{fB}	64.32±0.49^{fB}	60.02±0.06^{eB}	56.64±0.28^{dC}	55.26±0.15^{cC}	53.74±0.12^{bC}	51.22±0.11^{aC}
C-MAP	29.31±0.62^{fA}	25.60±0.33^{eA}	22.51±0.18^{dA}	19.59±0.27^{cB}	14.36±0.50^{bB}	11.55±0.31^{bB}	10.13±0.38^{aB}
ET-MAP	67.88±2.04^{fB}	65.10±0.55^{eCB}	61.74±0.12^{dB}	58.49±0.20^{cD}	56.88±0.60^{bD}	55.28±0.14^{bD}	53.12±0.11^{aD}
	Total phenolics (GAE mg/g)						
C-AP	1.12±0.13^{gA}	0.97±0.08^{fA}	0.88±0.03^{eA}	0.75±0.02^{dA}	0.68±0.01^{cA}	0.54±0.02^{bA}	0.36±0.02^{aA}
ET-AP	4.08±0.13^{gC}	3.68±0.06^{fC}	3.02±0.03^{eC}	2.77±0.03^{dC}	2.54±0.01^{cB}	2.19±0.03^{bC}	1.95±0.02^{aB}
C-MAP	1.19±0.07^{gA}	1.29±0.02^{fB}	1.08±0.02^{eB}	0.86±0.03^{dB}	0.69±0.01^{cA}	0.61±0.01^{bB}	0.41±0.03^{aA}
ET-MAP	4.17±0.11^{gB}	4.01±0.03^{fD}	3.18±0.04^{eD}	3.01±0.02^{dD}	2.75±0.03^{cC}	2.63±0.02^{bD}	2.26±0.03^{aC}

Mean ± S.E. with different superscripts lowercase letters (row wise) and upperercase letters (column wise) differ significantly at $P < 0.05$). C-AP = Control arerobic, ET-AP = Eugenol treated aerobic C-MAP = Control MAP treated ET-MAP = Eugenol and MAP treated GAE-Gallic acid equivalent

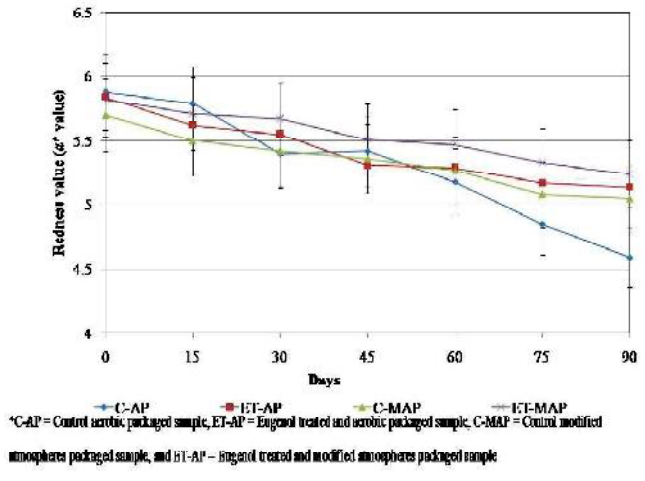

Fig. 6b: Effect of eugenol and packaging conditions on the Redness (a* value) of chicken meat noodles during storage at 35°C

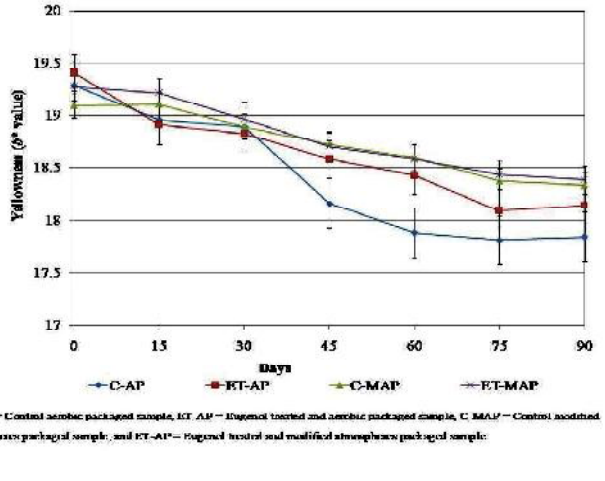

Fig. 6c: Effect of eugenol and packaging conditions on the Yellowness (b* value) of chicken meat noodles during storage at 35°C

Table 3: Texture profiles (Allo-Kramer Shear) of chicken noodles stored under aerobic and MAP conditions at 35 °C

Treatment [1]	Storage interval (Days)						
	0	15	30	45	60	75	90
	Hardness (N)						
C-AP	119.90±4.29	117.34±2.41	116.35±1.55	114.22±0.99	111.85±1.83^{b}	108.93±1.40	102.99±0.76
ET-AP	114.23±3.96	112.47±1.32	110.50±1.43	109.27±1.74	107.03±0.67^{ab}	104.52±1.50	100.65±1.74
C-MAP	119.46±2.56	118.43±1.34	114.85±1.48	114.12±2.04	110.98±0.74^{ab}	109.87±1.66	98.48±1.43
ET-MAP	118.88±3.70	116.70±1.65	113.37±2.49	115.62±1.30	112.55±1.56^{ab}	107.72±1.41	104.20±2.54
	Stringiness (mm)						
C-AP	40.20±1.17	40.04±1.45	38.70±1.28	35.63±1.37	34.01±0.61^{ab}	33.12±1.33	31.50±1.20
ET-AP	42.34±1.19	40.40±1.36	39.10±1.27	37.93±1.39	36.27±1.35^{ab}	34.27±0.55	32.52±0.63
C-MAP	42.00±1.54	40.95±1.37	38.82±1.29	36.71±0.50	34.80±1.32^{a}	33.30±1.37	32.80±1.39
ET-MAP	42.56±1.47	41.13±1.10	39.26±1.22	37.16±0.65	36.50±1.51^{a}	34.53±0.58	33.11±1.41
	Adhesiveness (mJ)						
C-AP	448.17±6.60^{A}	444.74±5.37^{abA}	460.44±3.32^{abB}	474.00±2.66^{abB}	482.49±4.03^{bB}	486.05±3.11^{A}	494.09±4.53^{A}
ET-AP	429.83±5.60^{A}	432.89±3.65^{aA}	441.48±2.15^{abAB}	458.54±2.14^{bAB}	467.93±2.27^{bAB}	476.43±2.86^{A}	479.63±2.62^{A}
C-MAP	433.60±7.83^{A}	437.92±4.45^{aA}	449.10±3.22^{abAB}	461.44±4.31^{abAB}	474.77±3.67^{bB}	480.16±3.26^{A}	487.29±3.72^{A}
ET-MAP	428.93±3.10	427.18±6.18^{a}	436.06±4.17^{a}	445.78±3.27^{ab}	453.84±2.55^{ab}	473.52±4.22	485.25±2.17
	Adhesive Force (N)						
C-AP	2.97±0.19^{A}	3.35±0.24^{A}	3.40±0.15^{A}	3.38±0.13^{B}	3.48±0.08^{abB}	3.57±0.14^{abB}	3.68±0.10^{A}
ET-AP	3.32±0.33^{A}	3.27±0.13^{A}	3.28±0.11^{AB}	3.42±0.16^{B}	3.35±0.04^{aAB}	3.40±0.05^{abA}	3.49±0.17^{A}
C-MAP	3.18±0.14^{A}	3.25±0.22^{A}	3.35±0.14^{AB}	3.42±0.13^{B}	3.45±0.11^{abB}	3.50±0.06^{abB}	3.58±0.08^{A}
ET-MAP	3.07±0.23	3.15±0.14	3.18±0.09	3.22±0.10	3.28±0.12^{a}	3.38±0.10^{ab}	3.52±0.14

Mean ± S.E. with different superscripts lowercase letters (row wise) and upperercase letters (column wise) differ significantly at $P < 0.05$). C-AP = Control arerobic, ET-AP = Eugenol treated aerobic C-MAP = Control MAP treated ET-MAP = Eugenol and MAP treated

The stringiness and adhesiveness values were respectively decreased and increased after day 30 and 45 of the storage interval. The adhesive force followed same trend that showed by other textural parameter. As storage time progress hardness of noodles was decreased. This could be attributed to increase of moisture content by the chicken noodles which lead to increased in water absorption index but decreased in water solubility index. The decreased in solubility index resulted in increased in hardness of noodles due to loss in degree of gelatinization on cooking. The stringiness, adhesiveness and adhesive force are secondary parameters, so when hardness value increased or decreased, this parameter also changed accordingly.

Microbiological quality

Results showed that during initial days of storage, packaging conditions did not affect microbiological quality of chicken noodles; however, on the 15th day, both C-AP and C-MAP samples had higher ($P < 0.05$) standard plate count (SPC) than ET-AP and ET-MAP samples (Fig. 7).

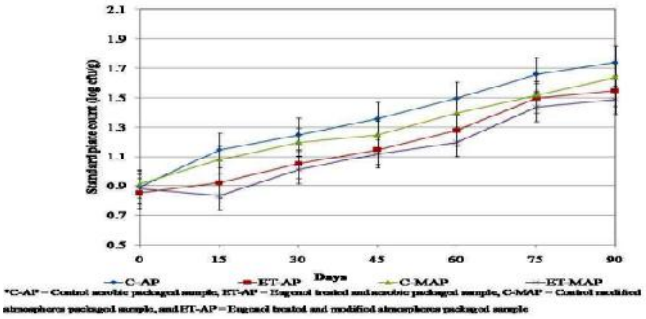

Fig. 7: Effect of eugenol and packaging conditions on the standard plate count (SPC) of chicken meat noodles during storage at 35°C

However, SPC increased in all samples with the increase of storage period regardless the packaging conditions.

The higher SPC in C-AP samples could be attributed to the availability of O_2 that required for the growth of maximum numbers of bacteria. Though it is well known that elevated levels of carbon dioxide inhibit microbial growth, but higher SPC count confirms that concentration of CO_2 used in MAP was not sufficient to inhibit the growth of aerobic mesophilic bacteria. Similar findings also reported by Aksu and Kaya (2005) in sliced Pastirma when stored under MAP conditions (50 % CO_2 + 50 % N_2). In general, SPC were in the range of 1.49 – 1.74 log cfu/g during 90 days of storage in all samples which were very less than the recommended acceptable limits of 7.0 log cfu/g meat sample. Lower SPC in ET-MAP sample could be attributed to bacteriostatic effect of eugenol and modified atmospheres. Antibacterial effects of eugenol in meat systems are well documented (Burt, 2004). Total Coliforms, *Staphylococcus* spp. count (SC), *Lactobacillus* spp. count and Yeast and mold (YMC) were not detected at any storage interval up to 90 days of storage.

Sensory attributes

Results of sensory evaluation indicated that during initial days of storage, eugenol treatment and packaging conditions significantly affected sensory scores for all parameters, except texture. ET-AP and ET-MAP samples had better colour stability due to antioxidant effect of eugenol and MAP conditions (Fig. 8). The effects of eugenol and packaging conditions on colour stability in meat products are well documented (Gulcin *et al*., 2010). The appearance and colour scores were declined in all samples over storage time, and this could be attributed to non-enzymatic browning reaction between lipid oxidation products and amino acids. But even at the end of the storage (on the 90th day) panel members were rated all the products rated ‘very good’ to ‘good’. Flavour scores were also showed similar trend to that of appearance and colour scores. ET-MAP sample exhibited highest flavour scores while that were least for C-AP and C-MAP samples. The textural scores were followed with the finding of a_w. As a_w increased, the textural scores decreased significantly. Meat flavour intensity was significantly differed amongst the treatments at initial day (0th day) and at the end of the storage. This could be attributed to intense smell of flavonoids present in eugenol. Eugenol, however did not affect after taste which varied in the products on the 15th day and afterwards throughout the storage period. ET-MAP sample had highest after taste score than all other samples. The overall acceptability of all samples followed the same pattern that observed for other sensory attributes. However, slightly higher overall acceptability scores were observed in ET-MAP sample which could be attributed to the higher flavour and textural scores. The overall acceptability scores were rated ‘very good’ to ‘good’ in all samples at the end of the storage.

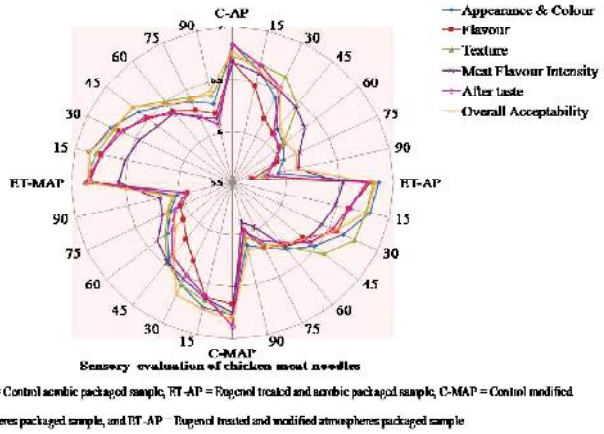

Fig. 8: Effect of eugenol and packaging conditions on the sensory quality of chicken meat noodles during storage at 35°C

CONCLUSION

Lipid oxidation, antioxidant, sensory and microbiological data obtained in the study indicate that the combined eugenol and modified atmosphere packaging treatment exhibited a strongly additive interaction which can be successfully used for extending shelf-life of chicken noodles. This also confirms the potential activity of eugenol and different packaging strategy for improving shelf-life of chicken meat products.

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