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Use of allyl-isothiocyanate and carvacrol to preserve fresh chicken meat during chilling storage

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Abstract: The effect of active compounds (ACs), allyl-isothiocyanate (AITC) and carvacrol (CARV), as natural additives on the quality of fresh chicken meat was evaluated. The meat was treated with 500 and 1000 ppm of ACs, vacuum packaged and stored at 4°C up to 8 days. Physicochemical characteristics, lipid oxidation, microbiological status, sensorial electronic-nose based properties were examined. AITC, particularly 1000 ppm, showed greater activity than CARV and resulted in colour changes, accumulative odour production, triggered reduction in the growth of *Pseudomonas lundensis*, *Staphylococcus aureus*, and *Bacillus cereus* and 3 $\log^{10}$ CFU/g reduction in aerobic mesophilic counts. However, CARV was more active in increasing chroma properties and reducing the growth of *Escherichia coli* O157:H7, *Listeria monocytogenes*, and *Salmonella typhimurium*. Concomitantly, 500 ppm CARV showed greater activity than AITC in controlling lipid oxidation and protecting the colour changes. Therefore, both AITC and CARV possess great potential to extend the shelf life of meat and meat products.

Keywords: active compounds; antimicrobial activity; natural antioxidant; poultry meat; shelf life

Chicken meat is susceptible to quality deterioration by various sources during the preparation, storage and distribution. The consequences of microbial contamination, lipid oxidation (oxidative rancidity) and organoleptic changes (unpleasant flavour, odour and textural characteristics) in meat products can be limited or inhibited using food additives. Several synthetic additives such as butylated-hydroxyanisole and butylated-hydroxytoluene, have been widely used in food preservation. Whereas, the demand for this group of additives has been decreased in recent years and accused due to the growing concern among consumers related to their potential toxicological and carcinogenic effects (Karabagias *et al.* 2011; Šojić *et al*. 2017). However, the use of natural essential oils and their phenolic and non-phenolic active compounds (ACs) are gaining a wide interest as alternatives to synthetic food additives and legalised to be applied in different food systems as flavouring agent and food-preservatives for the prevention of foodborne illness, retardation of deterioration and participate to intensify the healthier manufacture (Dufour *et al*. 2015). Many essential oils and ACs (such as rosemary, thyme, oregano, clove oils, carvacrol, *p*-cyemene, cinnamaldehyde, piperine and eugenol) are documented and considered to be Generally Recognized as Safe and

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approved by the Food and Drug Administration (FDA) and European Union, Council Directive No. 95/2/EC of 1995 regulation on food additives (Sasidharan *et al.* 2010; Šojić *et al.* 2017; Sharma *et al.* 2017). However, some properties may lead to the reduction in the antimicrobial activity of ACs and limit their applications in meat and foods, including poor aqueous solubility, pungent odour and flavour, reaction with constituents of meat (Chacon *et al.* 2006).

Allyl-isothiocyanate (AITC) is a colourless, volatile and aliphatic organosulfur compound (Figure 1). It constitutes almost 90% of the composition of horseradish root (Ward *et al.* 1998). The use of AITC for food preservation is previously approved in Japan (Dufour *et al.* 2015). However, in Europe, the use of AITC as a food additive, flavouring, anti-spoilage agent in food is under revision (EFSA 2010). Carvacrol (CARV) is a major phenolic monoterpenoid constituent found in oregano (*Origanum vulgare*). CARV is highly lipophilic and insoluble in water, the cytotoxic effect of CARV can make it an effective antiseptic and antimicrobial agent (Yadav & Kamble 2009). This study was conducted to investigate the effect of direct application of selected ACs on quality of chicken meat during refrigerated storage.

MATERIAL AND METHODS

Preparation of meat samples. Fresh chicken breast meat 24-hour post-mortem were obtained from a local abattoir. The meat was skin-off minced then homogenized and divided into treatment groups. Groups were mixed with 500 and 1000 ppm of AITC and CARV (dissolved in 5% sunflower oil); while in control, no ACs were added (only sunflower oil). AITC (95%) and CARV (98%) were purchased from SIGMA (Germany.) The samples were then placed in polyethylene bags, and vacuum packaged and stored at 4 ± 0.5°C for up to 8 days. Samples were taken at different time intervals for different analyses on day 1, 3, 6 and 8.

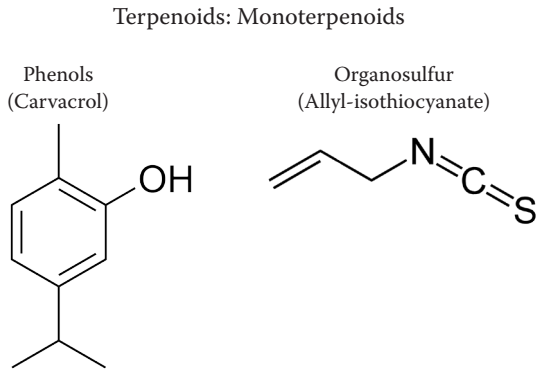

Figure 1. Structure of selected active compounds

Physicochemical properties and determination of TBARS. The pH of meat was determined in triplicate by immersing a pH electrode (Testo 206; Testo-AG, Germany). The colour values were measured using CIELAB (CIE, 1986) scoring system: L^* (lightness), a^* (+a, red; –a, green), and b^* (+b, yellow; –b, blue) by using Konica Minolta CR-400 colourimeter (Konica Minolta Sensing Inc., Japan). Results from L^*, a^* and b^* were recorded as the mean of five measurements and from the measured values relative colourfulness or chroma magnitude (C^*) and hue angle (h^*) were calculated as the following:

$$\text{chroma: } C^* = [(a^*)^2 + (b^*)^2]^{1/2}$$
$$\text{hue angle: } h^* = \tan^{-1}(b^*/a^*) \quad (1)$$

Lipid oxidation was measured by analysing TBARS using the method described by Tarladgis *et al.* (1960), slightly modified as follows. Chicken meat of 4 g was dispensed in mixing glass tubes and homogenized with 15 ml of distilled water. Then 5 ml of 25% trichloroacetic acid (TCA) was added to the mixture and centrifuged at 5000 rpm for 10 min. After the filtration 3.5 ml of this solution was added to 1.5 ml of thiobarbituric acid (TBA) (0.02 M) (TBA 0.6% w/v). The tubes were then kept in a water bath at 100°C for 30 minutes. After cooling, absorbance readings were taken with a Spectrophotometer (U2900-HITACHI Ltd., Japan) at 532 nm against a blank. TBARS were expressed as mg malonaldehyde (MDA equivalent)/1000 g sample.

In vitro anti-microbial activity of ACs (Agar well diffusion assay). The *in vitro* anti-microbial activity of ACs was examined using the method applied by (Fernández-López *et al.* (2005) with minor modifications. ACs prepared as mixture solutions of ACs and sunflower oil in various ratio (v/v) (Table 1). Six bacterial strains, three Gram-positive (*Listeria monocytogenes* CCM 4699, *Staphylococcus aureus* ATCC 6538 and *Bacillus cereus* T1) and three Gram-negative (*Escherichia coli* O157:H7 BO1909, *Salmonella typhimurium* B1310 and *Pseudomonas lundensis* CCP5) were used as target bacteria in antimicrobial tests. Each strain was grown on a plate containing 25 ml sterile Tryptic-Soy agar (TSA, Biokar Diagnostics BK046HA) at 37°C for 24 h (except *Pseudomonas lundensis*, which was incubated at 25°C for 24 hours). The culture was diluted with MRD (Maximum recovery diluent) solution (0.5 g peptone + 4.25 g sodium chloride in 500 ml

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Table 1: Serial dilutions of ACs in sunflower oil used for the microbiological assessment

Dilution ratio (v/v)	ACs/sunflower oil (mg/5 g)
1 : 640	7.81
1 : 320	15.62
1 : 158	31.25
1 : 80	62.5
1 : 40	125
1 : 20	250
1 : 16	312.5
1 : 10	500
1 : 8	625
1 : 5	1000
1 : 4	1250
1 : 2.5	2000
1 : 2	2500
1 : 1.25	4000
1.6 : 1	8000

distilled water) adjusted to the desired concentration of 0.5 optical density (OD) by using a Densitometer (DEN-1B; McFarland, Latvia). Test strains were pour plated with a final cell density of approximately 10^6 CFU/ml, after solidification of the inoculated agar, they were prepared 4 wells per petri dish with diameter of 8 mm which were filled with 100 µl of the appropriate dilution of the ACs. Sterile water was pipetted into the negative control wells. The diameter of the inhibition zone was measured (excluding the 8 mm inner wells) using a Digital Vernier Caliper (Workzone-Caliper, Japan) in millimetres and data were recorded after 24, 48 and 72 h of incubation.

Microbiological analysis in meat. Microbiological analysis of meat was carried out through analysing population of aerobic mesophilic counts (AMCs), using the method described by APHA (2001). The results were expressed as (log CFU/g).

Electronic nose analysis. Electronic nose determinations were performed by the method described by Dalmadi *et al.* (2007). NST 3320 instrument (Applied Sensor Technologies, Sweden) was used. Eight-gram meat samples (2 replicates) were filled to special glass vials which were closed by a septum. Signals were recorded and the results were used for statistical analysis. The total cycle time per sample was 430 seconds. Difference of sensor signals between the baseline and the signal value at the end of the sampling time was used for multivariate statistical analysis (canonical discrimination analysis, CDA) as sensor response.

Statistical analysis. Data were analysed using SPSS 23.0 (SPSS Inc., USA). The data were subjected to analysis of variance (ANOVA) and General Linear Model (GLM), then the level of significance was established using Tukey test at ($P < 0.05$).

RESULTS AND DISCUSSION

Physicochemical properties and TBARS. The result from physicochemical properties of chicken meat treated with AITC and CARV are shown in Table 2. Both ACs were active in reducing the pH of meat and significant differences were observed within groups containing ACs and compared to control ($P < 0.05$).

The L^* values of samples treated with AITC were significantly higher than those treated with CARV and of the control group (Table 2). In contrast to AITC the higher concentration of CARV (1000 ppm) reduced the lightness of meat significantly compared to the control ($P < 0.05$). The causes of decreasing in L^* values to a statistically significant level by higher concentration of CARV could be explained by the increased water retention of hygroscopic materials; also, because they may have absorbed free water within the product, thereby decreasing lightness of the meat (Fernández-López *et al.* 2005). The a^* values of control increased gradually in the last day of storage and similar trend with significant rise was observed in meat with CARV. However, AITC, indicated a significant reduction of redness of the meat. The data from b^* values showed that both CARV and AITC had significant effect in increasing the yellowness of the meat compared to control over the storage period. AITC was active in increasing the h^* (hue) values, whereas CARV was more active in increasing C^* of the meat. Mastromatteo *et al.* (2009) evaluated the combined effect of CARV and thymol (0–300 ppm) in non-conventional poultry patties packaged in air and MAP. Similar to the current study they noticed a slight increase in b^* and C^* values at the end of storage, contrariwise they observed an increase in L^* and decreasing a^* values. In accordance to current finding Olaimat *et al.* (2014) coated the chicken breast with AITC, they noticed that 100 µl/g AITC was able to reduce pH value and has potential to give a yellowish colour to the coating at day 11 of storage. An increase in C^* properties and a^* values indicate that CARV has great contribution towards final redness of the meat.

TBARS analysis determines the formation of secondary products of lipid oxidation, i.e. as a result

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Table 2. The influence of different concentrations of AITC and CARV on pH, colour values and TBARS of fresh chicken meat stored for 8 days at 4°C

Meat parameters	Storage time (d)	Active compounds				
		No-AC	AITC-500 ppm	AITC-1000 ppm	CARV-500 ppm	CARV-1000 ppm
pH	1	5.89 ± 0.02 ^{bA}	5.89 ± 0.01 ^{bA}	5.90 ± 0.01 ^{bA}	5.9 ± 0.02 ^{bA}	5.92 ± 0.01 ^{cA}
	3	5.93 ± 0.01 ^{cA}	6.08 ± 0.01 ^{dB}	6.10 ± 0.01 ^{dB}	5.99 ± 0.01 ^{cB}	6.04 ± 0.01 ^{dC}
	6	5.78 ± 0.01 ^{aA}	5.89 ± 0.01 ^{bB}	5.93 ± 0.02 ^{cC}	5.73 ± 0.01 ^{aB}	5.79 ± 0.02 ^{bA}
	8	5.76 ± 0.01 ^{aA}	5.83 ± 0.02 ^{aB}	5.86 ± 0.00 ^{aB}	5.71 ± 0.02 ^{aB}	5.75 ± 0.01 ^{aAB}
*L**	1	49.23 ± 0.29 ^{aA}	49.29 ± 0.76 ^{aA}	49.44 ± 0.55 ^{aA}	48.83 ± 0.74 ^{aA}	48.89 ± 0.67 ^{aA}
	3	51.40 ± 0.29 ^{bA}	52.82 ± 0.54 ^{bB}	54.82 ± 0.54 ^{bC}	49.80 ± 0.60 ^{aB}	49.78 ± 0.32 ^{aB}
	6	53.47 ± 0.38 ^{cA}	56.22 ± 0.47 ^{cB}	58.62 ± 0.84 ^{cC}	51.94 ± 0.50 ^{bB}	52.03 ± 0.78 ^{bB}
	8	52.70 ± 0.42 ^{cA}	56.14 ± 0.38 ^{cB}	58.06 ± 0.57 ^{cC}	51.12 ± 0.93 ^{bB}	51.15 ± 0.90 ^{bB}
a*	1	3.84 ± 0.77 ^{aA}	5.08 ± 0.41 ^{aB}	4.76 ± 0.73 ^{aAB}	4.32 ± 0.18 ^{aA}	4.11 ± 0.39 ^{aA}
	3	4.66 ± 0.62 ^{aA}	5.05 ± 0.33 ^{aA}	4.44 ± 0.13 ^{aA}	4.62 ± 0.24 ^{aA}	4.37 ± 0.16 ^{aA}
	6	4.57 ± 0.18 ^{aAB}	4.86 ± 0.36 ^{aA}	4.40 ± 0.16 ^{aB}	4.68 ± 0.15 ^{abA}	4.39 ± 0.28 ^{aA}
	8	4.25 ± 0.18 ^{aA}	4.98 ± 0.19 ^{aB}	4.20 ± 0.44 ^{aA}	5.22 ± 0.56 ^{bB}	4.26 ± 0.27 ^{aA}
*b**	1	2.60 ± 0.52 ^{aA}	2.41 ± 0.50 ^{aA}	1.87 ± 0.41 ^{aA}	2.24 ± 0.61 ^{aA}	2.40 ± 0.50 ^{abA}
	3	2.34 ± 0.35 ^{aA}	2.38 ± 0.11 ^{aA}	2.03 ± 0.25 ^{aA}	2.43 ± 0.27 ^{abA}	2.19 ± 0.36 ^{abA}
	6	2.58 ± 0.42 ^{aA}	2.39 ± 0.21 ^{aA}	2.12 ± 0.60 ^{aA}	2.23 ± 0.21 ^{aAB}	1.93 ± 0.41 ^{aB}
	8	2.46 ± 0.28 ^{aA}	3.38 ± 0.39 ^{bB}	3.08 ± 0.31 ^{bB}	3.08 ± 0.60 ^{bA}	3.14 ± 0.92 ^{bA}
*C**	1	4.66 ± 0.75 ^{aA}	5.64 ± 0.41 ^{aA}	5.13 ± 0.68 ^{aA}	4.88 ± 0.42 ^{aA}	4.77 ± 0.54 ^{aA}
	3	5.24 ± 0.43 ^{aAB}	5.58 ± 0.31 ^{aA}	4.88 ± 0.20 ^{aB}	5.23 ± -0.22 ^{aA}	4.90 ± 0.23 ^{aA}
	6	5.26 ± 0.31 ^{aA}	5.42 ± 0.36 ^{aA}	4.90 ± 0.38 ^{aA}	5.19 ± 0.12 ^{aAB}	4.81 ± 0.21 ^{aB}
	8	4.92 ± 0.13 ^{aA}	6.03 ± 0.26 ^{aB}	5.23 ± 0.29 ^{aA}	6.06 ± 0.78 ^{bB}	5.32 ± 0.72 ^{aAB}
*h**	1	0.89 ± 0.36 ^{aA}	0.52 ± 0.15 ^{aAB}	0.43 ± 0.14 ^{aB}	0.57 ± 0.16 ^{aA}	0.66 ± 0.13 ^{abA}
	3	0.58 ± 0.18 ^{aA}	0.51 ± 0.04 ^{aA}	0.49 ± 0.06 ^{aA}	0.58 ± 0.10 ^{aA}	0.55 ± 0.11 ^{aA}
	6	0.64 ± 0.13 ^{aA}	0.53 ± 0.06 ^{aA}	0.52 ± 0.15 ^{aA}	0.51 ± 0.07 ^{aA}	0.48 ± 0.14 ^{aA}
	8	0.66 ± 0.13 ^{aA}	0.81 ± 0.13 ^{bA}	0.95 ± 0.29 ^{bA}	0.66 ± 0.09 ^{aA}	0.93 ± 0.32 ^{bA}
TBARS (mg MDA/kg)	1	1.43 ± 0.12 ^{aA}	1.75 ± 0.15 ^{aA}	1.72 ± 0.00 ^{aA}	1.96 ± 0.19 ^{aA}	1.40 ± 0.14 ^{aA}
	8	2.02 ± 0.31 ^{aA}	2.10 ± 0.10 ^{aA}	1.63 ± 0.15 ^{aB}	1.46 ± 0.08 ^{bB}	1.67 ± 0.06 ^{aB}

*L**, *a**, *b**, *C**, *h** – colour values; ^{a,b,c}means in the same column with different superscript are significantly different regarding the days of storage; ^{A,B,C}means in the same row with different superscript are significantly different regarding the concentrations of ACs ($P < 0.05$)

of unsaturated fatty acid oxidation, mainly MDA, which may contribute to the off-flavour in stored meat products (Šojić *et al*. 2017). In the current study at the end of storage, meat containing CARV and 1000 ppm AITC showed significantly lower TBARS values ($P < 0.05$) (Table 2). It has been reported that 1–2 mg MDA/kg meat could be considered as threshold limit value for rancidity in meat (Tarladgis *et al*. 1960). Results from the present study are particularly meaningful because ACs, mainly CARV had a clear protective effect against lipid oxidation by keeping TBARS lower than 2 mg MDA/kg. This fact could be attributed to strong antioxidant activity of CARV that interferes with free radical propagation process and it can react with lipid and hydroxyl radicals to convert them into stable products (Sharma *et al*. 2017).

Evaluation of in-vitro antimicrobial activity of ACs. The result from AITC compared to control showed complete inhibition (CI) of *Pseudomonas lundensis*, *Staphylococcus aureus* and *Bacillus cereus* with partial inhibition of *Escherichia coli*, *Listeria monocytogenes* and no inhibition of *Salmonella typhimurium*. CARV did not show CI of any of the studied strains, however, partial inhibition of *Escherichia coli*, *Listeria monocytogenes*, *Salmonella typhimurium* and *Bacillus cereus* was observed, and no inhibition noticed for *Pseudomonas lundensis* and *Staphylococcus aureus* (Table 3). Current findings agreed with the

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Table 3. *In vitro* antibacterial activity estimated by inhibition zone of AITC and CARV

Bacterial strains		Active compounds									
		AITC					CARV				
		No AC	**1 : 10 (v/v)**	**1 : 20 (v/v)**	**1 : 40 (v/v)**	**1 : 80 (v/v)**	**No AC**	**1 : 10 (v/v)**	**1 : 20 (v/v)**	**1 : 40 (v/v)**	**1 : 80 (v/v)**
Pseudomonas lundensis CCP5	24 h	NI	CI	CI	CI	CI	NI	NI	NI	NI	NI
	48 h	NI	CI	CI	CI	CI	NI	NI	NI	NI	NI
	72 h	NI	CI	CI	CI	CI	NI	NI	NI	NI	NI
	*	**No AC**	**1 : 80**	**1 : 158**	**1 : 320**	**1 : 640**	**No AC**	**1 : 2**	**1 : 4**	**1 : 8**	**1 : 16**
Escherichia coli O157:H7 BO1909	24 h	NI	2.98 ± 1.26	1.36 ± 0.50	NI	NI	NI	3.88 ± 0.54	2.42 ± 0.40	NI	NI
	48 h	NI	1.59 ± 1.57	0.55 ± 0.96	NI	NI	NI	4.03 ± 0.64	2.23 ± 0.20	NI	NI
	72 h	NI	1.39 ± 1.42	0.48 ± 0.83	NI	NI	NI	3.83 ± 0.41	2.39 ± 0.29	NI	NI
		No AC	**1.6 : 1**	**1 : 1.25**	**1 : 2.5**	**1 : 5**	**No AC**	**1 : 10**	**1 : 20**	**1 : 40**	**1 : 80**
Staphylococcus aureus ATCC 6538	24 h	NI	CI	CI	CI	CI	NI	NI	NI	NI	NI
	48 h	NI	CI	CI	CI	CI	NI	NI	NI	NI	NI
	72 h	NI	CI	CI	CI	CI	NI	NI	NI	NI	NI
	*	**No AC**	**1 : 80**	**1 : 158**	**1 : 320**	**1 : 640**	**No AC**	**1 : 2**	**1 : 4**	**1 : 8**	**1 : 16**
Listeria monocytogenes CCM 4699	24 h	NI	3.05 ± 2.18	1.91 ± 1.01	1.09 ± 0.16	NI	NI	3.87 ± 0.48	2.16 ± 0.13	NI	NI
	48 h	NI	1.78 ± 0.74	NI	NI	NI	NI	3.69 ± 0.39	2.13 ± 0.10	NI	NI
	72 h	NI	1.75 ± 0.30	NI	NI	NI	NI	3.66 ± 0.18	2.14 ± 0.10	NI	NI
	*	**No AC**	**1 : 80**	**1 : 158**	**1 : 320**	**1 : 640**	**No AC**	**1 : 2**	**1 : 4**	**1:8**	**1 : 16**
Salmonella Typhimurium B1310	24 h	NI	NI	NI	NI	NI	NI	3.39 ± 0.62	2.00 ± 0.53	NI	NI
	48 h	NI	NI	NI	NI	NI	NI	3.10 ± 0.54	1.69 ± 0.51	NI	NI
	72 h	NI	NI	NI	NI	NI	NI	3.10 ± 0.29	1.97 ± 0.10	NI	NI
		No AC	**1.6 : 1**	**1 : 1.25**	**1 : 2.5**	**1 : 5**	**No AC**	**1 : 10**	**1 : 20**	**1 : 40**	**1 : 80**
Bacillus cereus T1	24 h	NI	CI	CI	CI	CI	NI	0.50 ± 0.17	NI	NI	NI
	48 h	NI	CI	CI	CI	CI	NI	0.69 ± 0.60	NI	NI	NI
	72 h	NI	CI	CI	CI	CI	NI	0.36 ± 0.62	NI	NI	NI

AITC – allyl-isothiocyanate; CARV – carvacrol; *thickness of inhibition zone was calculated in mm ± s.d.; NI – no inhibition, CI – complete inhibition

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results by Guarda *et al.* (2011) who coated films with microcapsules containing 10% of CARV and thymol and observed 9.0 ± 0.8 mm zone of inhibition in *Escherichia coli*. While their findings do not agree to ours regarding the *Staphylococcus aureus* as it was observed 11.3 ± 1.3 mm zone of inhibition. Ward *et al.* (1998) used a volatile distillate extract from fresh horseradish root contained about 90% AITC in cooked beef. They noted that the growth of *Staphylococcus aureus*, *Escherichia coli*, *Salmonella typhimurium* and *Listeria monocytogenes* on agar was completely inhibited for 7 days in aerobic storage at 12°C. The selected ACs in this study showed the growth inhibition of both food pathogenic and food spoilage bacteria.

Microbiological characteristics. Figure 2 shows that the total AMCs increased from 3.96 to 6.59 $\log^{10}$ CFU/g in control at the end of storage ($P < 0.05$). Similar increase was observed with CARV 1000, however, the ATIC 1000 ppm was more active in reducing the AMCs about (3 logs). In accordance to our findings, Olaimat *et al.* (2014) noted that aerobic bacterial numbers in chicken breast treated with 25 to 100 µl/g AITC were reduced by 1.72 to 3.75 $\log^{10}$ CFU/g during 21 days of storage at 4°C. Additionally, Mastromatteo *et al.* (2009) found the final cell load of total viable count for poultry patties stored at 0–3°C was decreased about 1–1.5 $\log^{10}$ CFU/g with 150 ppm CARV. Moreover, it has been reported that total viable count of 7 $\log^{10}$ CFU/g, considered as the upper microbiological limit for acceptable quality meat (Karabagias *et al.* 2011). Such high populations of bacteria were not recorded in the present study.

Electronic nose. The E-nose was able to show proper distinguish between untreated and treated meat based on the type of AC and storage time (Figure 3). Additionally, overlapping between CARV and control groups were noticed, while AITC yield the biggest mean differences compared to control and CARV. Moreover, high concentration of both ACs (1000 ppm) showed clear separations compared to other groups (Figure 3C). In this study, it was noted that both ACs and clearly AITC produced spicy smell in chicken meat, this odour was perceived abundantly just after opening the packages, which might be pleasing for some foods such as meat. However, very low quantity of AITC can be applied to foods due to its potential to produce strong aroma that can modify odour properties of meat (Figures 3A and 3B). Olaimat *et al.* (2014) also noted that slight odour was detected through informal sensory analysis by using AITC in coatings at 50 µl/g. Chacon *et al.* (2006) 60.67% pork, and 17.59% pork fat used 500 ppm AITC in dry fermented sausages and resulted in an acceptable level of spiciness although slightly spicy by panellists. Mastromatteo *et al.* (2009) also observed that the application of CARV in poultry patties had a distinctive but pleasant flavour and showed no modification for off-odour perception during the storage period. Concomitantly, reduced AMCs were noticed with AITC 1000 indicating that the E-nose can distinguish the meat as either fresh or spoiled (Edita *et al.* 2018).

CONCLUSION

AITC particularly 1000 ppm of AITC showed considerably higher effect compared to CARV in increasing L^*, b^* and h^*, decreasing a^* values, and caused reduction in the population of AMCs and the growth reduction of *Pseudomonas lundensis*, *Staphylococcus aureus* and *Bacillus cereus*. However, CARV were more active in reducing the growth of *Escherichia coli*, *Listeria monocytogenes* and *Salmonella typhimurium*. Additionally, 500 ppm CARV showed

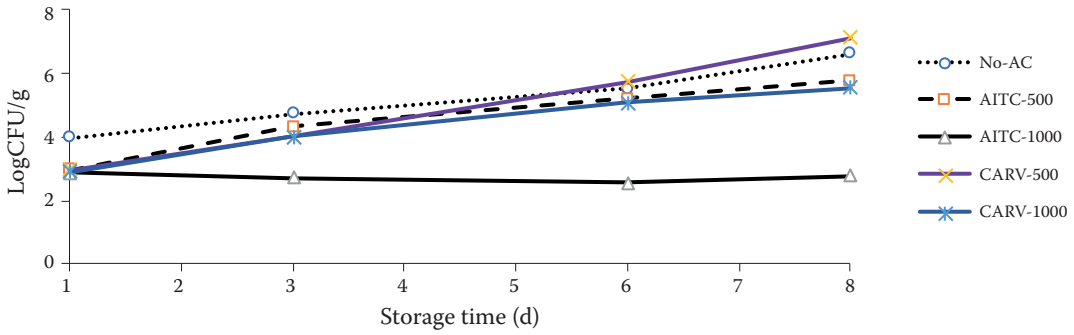

Figure 2. Effect of different concentrations of AITC and CARV on aerobic mesophilic counts of chicken meat stored for 8 days at 4°C

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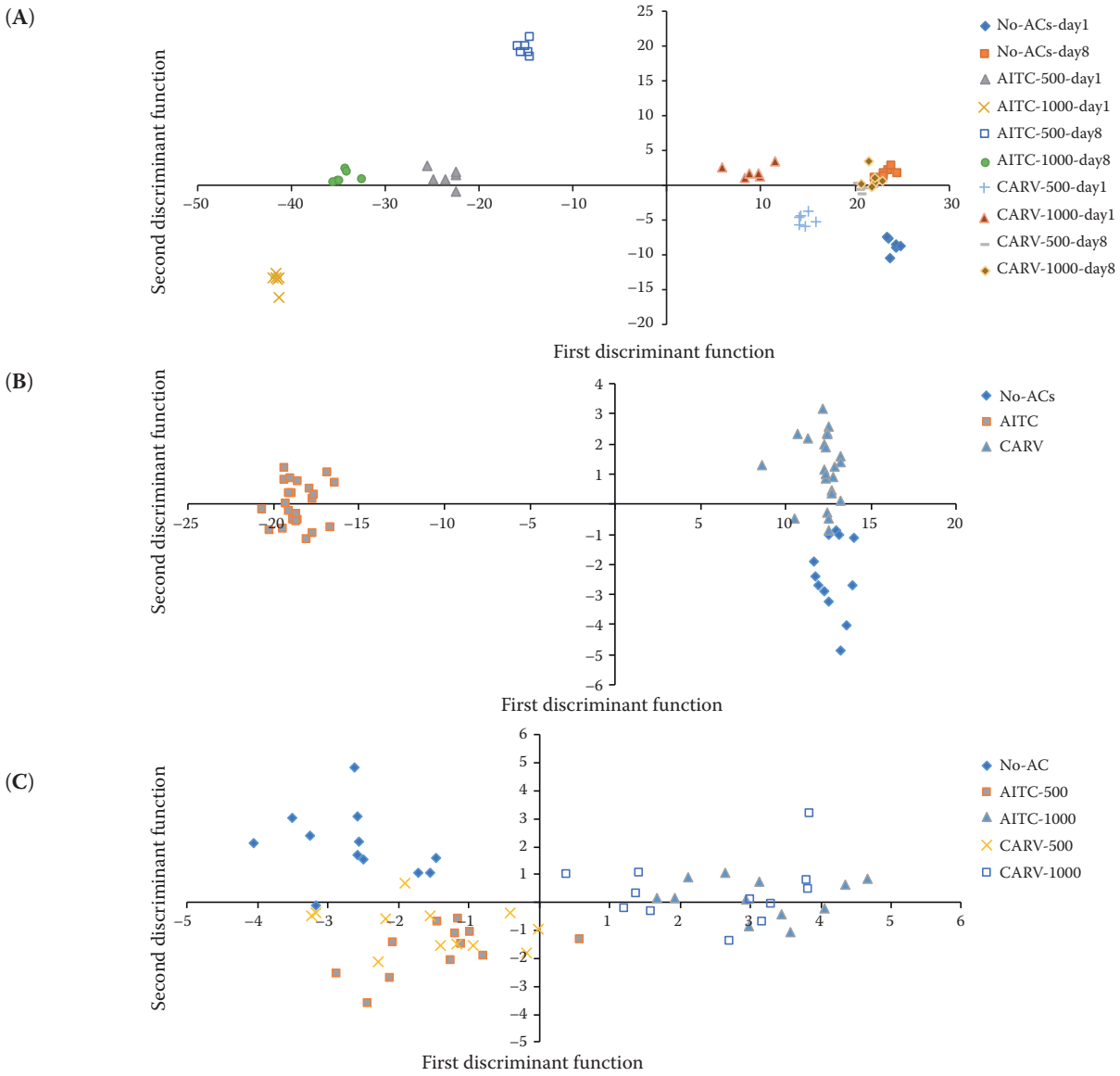

Figure 3. Effect of different concentrations of AITC and CARV on smell detected by electronic nose of chicken meat stored for 8 days at 4°C

Canonical discriminant analysis score plot of: (**A**) – storage days and concentration of ACs, (**B**) – ACs, and (**C**) – concentration of ACs

greater activity than AITC in reducing TBARS values with a smaller flavour impact. The current findings highlight the efficacy of CARV and AITC with their great potential to preserve the quality characteristics of the chicken meat.

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