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APPENDICES

Appendix A Microbial Analysis

Table A1 Aerobic plate count of meat samples during storage time at room temperature

Time (hour)	Aerobic Plate Count (cfu/g)
0	4.881
3	5.079
6	5.505
9	6.447
12	7.114
15	7.230
18	7.491
21	7.914
24	7.944
27	7.763
30	7.845
33	8.447
36	8.380
39	8.431
42	8.531
45	8.518

Appendix B Determination of Total Volatile Basic Nitrogen (TVB-N)

TVB-N value was calculated by the following equation

$$\text{TVB-N (mg/100g)} = \frac{(V_S - V_B) \times (N_{\text{HCl}} \times A_N) \times [W_S \times (M/100) + V_E] \times 100}{W_S}$$

- Where,
- V_S = Titration volume of 0.01 N HCl for sample extract (ml)
 - V_B = Titration volume of 0.01 N HCl for blank (ml)
 - N_{HCl} = Normality of HCl (= 0.01 N \times factor of HCl)
 - A_N = Atomic weight of nitrogen (14.00)
 - W_S = Weight of tissue sample (g)
 - M = Percentage moisture of tissue sample (Assume 80%)
 - V_E = Volume of 4% TCA used in extraction

Table B1 TVB-N values of meat samples during storage time at room temperature

Time (hour)	ml HCl	TVB-N
0	0.055	3.696
3	0.100	6.720
6	0.120	8.064
9	0.200	13.440
12	0.400	26.880
15	0.520	34.944
18	0.580	38.976
21	0.640	43.008
24	1.200	80.640

Appendix C Sensor Response to Meat Spoilage

Table C1 Changes in Hunter color values of 5% w/w PEDOT:PSS, spin-coated at 1000 rpm onto 5%clay nanocomposite films, of meat samples of 100 g during storage time at room temperature

Time (hour)	dL*		da*		db*		dE*	
	Avg	SD	Avg	SD	Avg	SD	Avg	SD
3	-0.09	0.08	0.12	0.03	-0.25	0.10	0.29	0.21
6	-0.10	1.47	0.18	0.04	-0.29	0.20	0.36	1.71
9	-1.28	0.40	0.25	0.08	-0.27	0.14	1.33	0.62
12	-2.45	0.62	0.36	0.15	-0.23	0.34	2.49	1.11
15	-2.89	0.36	0.43	0.10	-0.33	0.22	2.94	0.68
18	-3.97	0.79	0.52	0.09	-0.47	0.85	4.03	1.73
21	-8.65	0.78	1.32	0.06	-1.87	0.32	8.95	1.16
24	-17.28	1.63	2.94	0.02	-3.27	0.41	17.83	2.06
27	-17.89	0.24	2.99	0.04	-3.30	0.16	18.43	0.44
30	-18.79	0.35	3.10	0.12	-3.38	0.15	19.34	0.62
33	-18.82	0.32	3.08	0.14	-3.45	0.18	19.38	0.64
36	-18.99	0.25	3.04	0.10	-3.82	0.14	19.61	0.49
39	-18.64	0.21	3.00	0.02	-3.97	0.20	19.29	0.43
42	-18.76	0.68	2.96	0.06	-4.00	0.10	19.41	0.84
45	-20.26	0.89	3.08	0.07	-4.27	0.43	20.94	1.39

Table C2 Changes in Hunter color values of 5% w/w PEDOT:PSS, spin-coated at 2000 rpm onto 5%clay nanocomposite films, of meat samples of 100 g during storage time at room temperature

Time (hour)	dL*		da*		db*		dE*	
	Avg	SD	Avg	SD	Avg	SD	Avg	SD
3	-0.22	0.11	0.09	0.03	-0.12	0.10	0.27	0.24
6	-0.36	0.50	0.16	0.02	-0.33	0.18	0.52	0.70
9	-0.89	0.24	0.25	0.06	-0.35	0.16	0.99	0.46
12	-1.49	0.56	0.31	0.10	-0.24	0.37	1.55	1.03
15	-1.67	0.04	0.33	0.02	-0.38	0.18	1.74	0.24
18	-3.43	0.15	0.34	0.08	-0.46	0.27	3.48	0.50
21	-7.34	0.09	1.13	0.09	-1.17	0.06	7.51	0.24
24	-14.83	0.08	2.39	0.06	-2.39	0.07	15.22	0.21
27	-15.42	0.20	2.41	0.06	-2.59	0.08	15.82	0.34
30	-16.60	0.89	2.42	0.07	-2.67	0.20	16.99	1.16
33	-16.78	0.30	2.43	0.04	-2.70	0.07	17.17	0.41
36	-17.51	0.37	2.55	0.05	-2.74	0.06	17.91	0.48
39	-17.55	0.22	2.44	0.03	-3.10	0.12	17.99	0.37
42	-17.57	0.59	2.40	0.06	-3.23	0.17	18.03	0.82
45	-19.04	0.71	2.42	0.15	-3.28	0.36	19.48	1.22

Table C3 Changes in Hunter color values of 5% w/w PEDOT:PSS, spin-coated at 3000 rpm onto 5%clay nanocomposite films, of meat samples of 100 g during storage time at room temperature

Time (hour)	dL*		da*		db*		dE*	
	Avg	SD	Avg	SD	Avg	SD	Avg	SD
3	-0.02	0.16	0.09	0.03	-0.11	0.10	0.14	0.29
6	0.09	0.95	0.10	0.15	-0.34	0.13	0.37	1.23
9	-0.26	0.28	0.11	0.08	-0.22	0.08	0.36	0.44
12	-0.39	0.23	0.19	0.07	-0.11	0.16	0.45	0.46
15	-0.66	0.24	0.18	0.03	-0.31	0.12	0.75	0.39
18	-1.79	0.36	0.31	0.04	-0.35	0.14	1.86	0.54
21	-6.68	0.22	0.79	0.04	-0.80	0.09	6.77	0.35
24	-12.46	0.08	1.92	0.05	-1.74	0.25	12.73	0.38
27	-12.55	0.10	1.99	0.03	-1.98	0.11	12.86	0.24
30	-12.49	0.20	2.11	0.06	-2.27	0.29	12.87	0.55
33	-12.65	0.12	2.12	0.04	-2.27	0.12	13.03	0.28
36	-13.68	0.19	2.01	0.12	-2.01	0.25	13.98	0.56
39	-14.00	0.15	2.11	0.03	-2.22	0.15	14.33	0.33
42	-14.61	0.95	2.03	0.02	-2.34	0.11	14.94	1.08
45	-15.09	0.25	2.05	0.02	-2.52	0.16	15.44	0.43

Table C4 Changes in Hunter color values of 1% w/w PEDOT:PSS, spin-coated at 1000 rpm onto 5%clay nanocomposite films, of meat samples of 100 g during storage time at room temperature

Time (hour)	dL*		da*		db*		dE*	
	Avg	SD	Avg	SD	Avg	SD	Avg	SD
3	-0.11	0.05	0.08	0.03	-0.02	0.05	0.14	0.13
6	-0.16	0.67	0.14	0.03	-0.01	0.20	0.21	0.90
9	-0.35	0.15	0.11	0.04	-0.02	0.12	0.37	0.31
12	-0.87	0.60	0.25	0.05	-0.13	0.63	0.91	1.28
15	-0.93	0.45	0.24	0.08	-0.09	0.34	0.96	0.87
18	-1.18	1.14	0.35	0.02	-0.04	0.94	1.23	2.10
21	-2.57	0.32	0.78	0.03	-0.29	0.68	2.70	1.03
24	-5.93	0.51	1.23	0.08	-0.68	0.23	6.09	0.82
27	-10.45	0.48	1.64	0.06	-1.48	0.22	10.68	0.76
30	-11.87	0.66	1.71	0.07	-1.76	0.11	12.12	0.84
33	-11.92	0.25	1.64	0.08	-1.87	0.28	12.18	0.61
36	-12.06	0.18	1.58	0.13	-2.09	0.31	12.34	0.62
39	-13.11	0.54	1.62	0.09	-2.04	0.22	13.37	0.85
42	-13.21	1.78	1.53	0.17	-2.06	0.10	13.45	2.05
45	-14.04	0.44	1.63	0.12	-2.14	0.07	14.29	0.63

Table C5 Changes in Hunter color values of 3% w/w PEDOT:PSS, spin-coated at 1000 rpm onto 5%clay nanocomposite films, of meat samples of 100 g during storage time at room temperature

Time (hour)	dL*		da*		db*		dE*	
	Avg	SD	Avg	SD	Avg	SD	Avg	SD
3	-0.26	0.06	0.07	0.02	-0.02	0.24	0.27	0.32
6	-0.67	2.04	0.09	0.06	-0.04	0.55	0.68	2.65
9	-0.88	0.11	0.10	0.03	-0.08	0.22	0.90	0.36
12	-1.02	0.24	0.15	0.10	-0.19	0.32	1.05	0.66
15	-0.99	0.20	0.14	0.06	-0.11	0.25	1.00	0.51
18	-1.25	0.35	0.21	0.37	-0.07	0.61	1.27	1.33
21	-3.23	0.12	0.93	0.04	-0.36	0.32	3.38	0.48
24	-7.21	0.45	2.25	0.02	-1.06	0.23	7.63	0.70
27	-13.87	0.24	2.69	0.03	-1.98	0.20	14.26	0.47
30	-15.95	0.25	2.72	0.04	-2.26	0.09	16.34	0.38
33	-16.40	0.16	2.66	0.03	-2.35	0.08	16.78	0.27
36	-16.31	0.24	2.66	0.06	-2.56	0.22	16.73	0.52
39	-17.05	0.44	2.70	0.02	-2.78	0.06	17.48	0.52
42	-16.80	0.57	2.70	0.02	-2.98	0.16	17.28	0.75
45	-17.94	0.82	2.73	0.07	-3.01	0.29	18.40	1.18

Table C6 Changes in Hunter color values of 5% w/w PEDOT:PSS, spin-coated at 1000 rpm onto 1%clay nanocomposite films, of meat samples of 100 g during storage time at room temperature

Time (hour)	dL*		da*		db*		dE*	
	Avg	SD	Avg	SD	Avg	SD	Avg	SD
3	-0.32	0.10	0.01	0.06	-0.00	0.02	0.32	0.18
6	-0.47	0.24	-0.03	0.15	-0.02	0.07	0.47	0.46
9	-1.45	0.20	0.08	0.08	-0.08	0.04	1.46	0.32
12	-2.24	1.65	0.00	0.11	-0.49	0.48	2.29	2.24
15	-4.57	0.54	0.43	0.10	-0.57	0.38	4.62	1.02
18	-8.39	1.41	1.21	0.12	-0.97	0.47	8.53	2.00
21	-16.59	0.24	2.45	0.12	-3.54	0.22	17.13	0.58
24	-18.99	1.36	3.10	0.14	-4.04	0.21	19.66	1.71
27	-19.01	0.30	3.16	0.15	-4.09	0.18	19.70	0.63
30	-19.11	0.14	3.22	0.12	-4.04	0.27	19.80	0.53
33	-19.25	0.24	3.25	0.07	-4.07	0.22	19.94	0.53
36	-18.14	0.40	3.47	0.05	-3.95	0.18	18.89	0.63
39	-18.56	0.50	3.33	0.04	-4.08	0.20	19.30	0.74
42	-17.93	0.55	3.30	0.05	-4.05	0.24	18.68	0.84
45	-19.43	0.74	3.34	0.04	-4.11	0.24	20.14	1.02

Table C7 Changes in Hunter color values of 5% w/w PEDOT:PSS, spin-coated at 1000 rpm onto 3%clay nanocomposite films, of meat samples of 100 g during storage time at room temperature

Time (hour)	dL*		da*		db*		dE*	
	Avg	SD	Avg	SD	Avg	SD	Avg	SD
3	-0.85	0.08	0.02	0.02	-0.00	0.08	0.85	0.18
6	-0.93	0.46	0.09	0.08	0.05	0.11	0.94	0.65
9	-1.19	0.12	0.21	0.06	-0.02	0.04	1.21	0.22
12	-1.07	0.04	0.22	0.07	-0.17	0.10	1.11	0.21
15	-1.56	0.26	0.37	0.04	-0.25	0.22	1.63	0.52
18	-5.28	0.51	0.81	0.02	-0.71	0.32	5.39	0.85
21	-10.67	0.71	1.54	0.03	-2.53	0.25	11.07	0.99
24	-18.56	1.06	2.96	0.15	-3.90	0.27	19.19	1.48
27	-18.52	0.44	2.94	0.14	-3.66	0.22	19.11	0.80
30	-18.42	0.59	2.78	0.01	-3.72	0.10	18.99	0.70
33	-18.55	0.42	2.88	0.06	-3.68	0.09	19.13	0.57
36	-19.05	0.55	2.89	0.01	-4.04	0.01	19.69	0.57
39	-19.14	0.38	2.87	0.04	-3.90	0.12	19.74	0.54
42	-18.85	0.17	2.86	0.19	-3.70	0.14	19.42	0.50
45	-18.64	0.74	2.98	0.08	-3.92	0.27	19.28	1.09

Table C8 Changes in Hunter color values of 5% w/w PEDOT:PSS, spin-coated at 1000 rpm onto 5%clay nanocomposite films, of meat samples of 25 g during storage time at room temperature

Time (hour)	dL*		da*		db*		dE*	
	Avg	SD	Avg	SD	Avg	SD	Avg	SD
3	-0.01	0.14	0.01	0.02	-0.01	0.05	0.02	0.21
6	-0.02	0.48	0.08	0.04	-0.03	0.10	0.09	0.62
9	-0.06	0.44	0.05	0.04	-0.04	0.08	0.09	0.56
12	-0.22	1.81	0.06	0.08	0.04	0.37	0.23	2.26
15	-0.27	0.24	0.10	0.06	-0.10	0.12	0.31	0.42
18	-0.42	0.31	0.28	0.04	-0.21	0.15	0.55	0.50
21	-0.75	0.32	0.38	0.08	-0.57	0.14	1.02	0.54
24	-3.35	0.58	0.56	0.14	-1.08	0.10	3.57	0.82
27	-4.88	0.34	1.00	0.10	-1.23	0.14	5.13	0.58
30	-6.19	0.72	1.41	0.12	-1.58	0.22	6.55	1.06
33	-7.77	0.50	2.00	0.08	-1.87	0.18	8.21	0.76
36	-8.99	0.57	2.36	0.05	-2.09	0.19	9.53	0.81
39	-10.52	0.20	2.60	0.10	-2.54	0.20	11.13	0.50
42	-12.11	0.21	2.80	0.10	-2.90	0.31	12.77	0.62
45	-17.24	1.21	2.89	0.07	-3.37	0.33	17.81	1.61

Table C9 Changes in Hunter color values of 5% w/w PEDOT:PSS, spin-coated at 1000 rpm onto 5%clay nanocomposite films, of meat samples of 50 g during storage time at room temperature

Time (hour)	dL*		da*		db*		dE*	
	Avg	SD	Avg	SD	Avg	SD	Avg	SD
3	-0.33	0.10	0.01	0.02	-0.02	0.24	0.33	0.36
6	-0.50	1.95	0.10	0.12	-0.09	0.67	0.52	2.74
9	-0.55	0.11	0.10	0.04	-0.09	0.22	0.57	0.37
12	-0.62	0.14	0.11	0.09	-0.13	0.24	0.65	0.47
15	-0.93	0.20	0.23	0.08	-0.16	0.16	0.97	0.44
18	-1.71	0.66	0.41	0.04	-0.38	0.14	1.80	0.84
21	-2.44	0.50	0.75	0.08	-0.97	0.14	2.73	0.72
24	-4.83	0.42	1.25	0.08	-1.85	0.13	5.32	0.63
27	-8.86	0.22	2.34	0.06	-2.14	0.10	9.41	0.38
30	-14.72	0.27	2.66	0.04	-2.44	0.19	15.16	0.50
33	-17.17	0.24	2.94	0.03	-2.86	0.15	17.65	0.42
36	-18.26	0.66	2.97	0.05	-3.42	0.23	18.82	0.94
39	-18.09	0.26	2.98	0.08	-3.87	0.32	18.74	0.66
42	-17.73	0.55	2.98	0.05	-3.98	0.04	18.42	0.64
45	-19.15	1.64	2.95	0.07	-3.80	0.81	19.75	2.52

Table C10 Changes in Hunter color values of 5% w/w PEDOT:PSS, spin-coated at 1000 rpm onto 5%clay nanocomposite films, of meat samples of 150 g during storage time at room temperature

Time (hour)	dL*		da*		db*		dE*	
	Avg	SD	Avg	SD	Avg	SD	Avg	SD
3	-0.11	0.15	0.12	0.06	-0.12	0.10	0.21	0.31
6	-0.29	0.25	0.16	0.09	-0.25	0.14	0.42	0.48
9	-1.36	0.22	0.21	0.04	-0.47	0.08	1.45	0.34
12	-3.55	0.45	0.45	0.03	-0.89	0.26	3.69	0.74
15	-5.89	0.28	0.78	0.04	-1.12	0.16	6.04	0.48
18	-10.72	0.71	1.41	0.07	-1.35	0.05	10.90	0.83
21	-16.88	0.82	2.87	0.05	-2.55	0.03	17.31	0.90
24	-19.09	0.37	3.04	0.05	-3.78	0.08	19.70	0.50
27	-19.21	0.58	3.11	0.10	-3.84	0.12	19.84	0.80
30	-19.19	0.89	3.12	0.08	-3.95	0.06	19.84	1.03
33	-19.24	0.25	3.09	0.04	-4.18	0.25	19.93	0.54
36	-18.89	0.35	3.08	0.03	-4.19	0.41	19.60	0.79
39	-19.34	0.16	3.07	0.08	-4.22	0.14	20.03	0.38
42	-19.35	0.19	3.11	0.04	-4.06	0.18	20.02	0.41
45	-20.34	0.18	3.23	0.03	-4.22	0.30	21.03	0.51

Table C11 Changes in Hunter color values of 5% w/w Cu^{2+} , spin-coated at 1000 rpm onto 5%clay nanocomposite films, of meat samples of 100 g during storage time at room temperature

Time (hour)	dL*		da*		db*		dE*	
	Avg	SD	Avg	SD	Avg	SD	Avg	SD
3	-0.47	0.11	1.35	0.09	0.17	0.03	1.44	0.23
6	-1.64	0.13	1.47	0.13	0.27	0.19	2.22	0.45
9	-3.42	1.40	1.05	0.03	5.55	0.21	6.61	1.64
12	-6.31	0.16	0.35	0.13	15.77	0.88	16.99	1.17
15	-11.87	0.07	4.83	0.01	21.00	0.19	24.60	0.27
18	-27.81	3.46	9.43	0.87	33.26	2.33	44.37	6.66
21	-35.71	0.13	14.41	0.01	34.43	0.12	51.66	0.26
24	-40.99	0.04	14.98	0.06	33.56	0.09	55.06	0.19
27	-48.21	0.00	15.10	0.03	33.87	0.04	60.82	0.07
30	-48.67	0.18	14.10	0.18	33.56	0.24	60.99	0.60
33	-48.87	0.16	15.32	0.03	34.16	0.16	61.56	0.35
36	-48.97	0.16	15.17	0.03	33.36	0.16	61.17	0.35
39	-49.10	0.57	14.31	0.10	33.32	0.07	61.04	0.74
42	-50.47	0.12	14.28	0.02	33.77	0.15	62.38	0.29
45	-48.81	0.06	13.91	0.08	33.42	0.05	60.77	0.19

Table C12 Changes in Hunter color values of 5% w/w Cu²⁺, spin-coated at 2000 rpm onto 5%clay nanocomposite films, of meat samples of 100 g during storage time at room temperature

Time (hour)	dL*		da*		db*		dE*	
	Avg	SD	Avg	SD	Avg	SD	Avg	SD
3	-1.96	0.06	0.50	0.07	0.27	0.04	2.04	0.17
6	-2.74	0.10	0.60	0.03	0.69	0.05	2.89	0.18
9	-4.25	0.05	0.38	0.15	6.59	0.04	7.85	0.24
12	-7.20	0.11	-0.34	0.02	15.31	0.08	16.93	0.21
15	-16.42	0.28	3.96	0.07	22.18	0.24	27.88	0.59
18	-23.78	0.15	5.73	0.12	27.75	0.23	37.00	0.50
21	-36.03	0.16	10.08	0.04	24.76	0.18	44.87	0.38
24	-39.18	0.14	12.83	0.07	26.25	0.18	48.88	0.39
27	-37.50	0.16	12.93	0.07	25.92	0.15	47.39	0.38
30	-39.79	0.41	12.80	0.04	25.00	0.34	48.71	0.79
33	-40.65	0.09	13.35	0.08	24.41	0.10	49.26	0.27
36	-40.25	0.26	12.23	0.14	22.82	0.23	47.86	0.63
39	-41.47	0.92	12.39	0.06	23.83	0.11	49.41	1.09
42	-42.07	0.01	12.33	0.05	22.55	0.05	49.30	0.11
45	-41.25	0.02	12.56	0.06	24.00	0.03	49.35	0.11

Table C13 Changes in Hunter color values of 5% w/w Cu²⁺, spin-coated at 3000 rpm onto 5%clay nanocomposite films, of meat samples of 100 g during storage time at room temperature

Time (hour)	dL*		da*		db*		dE*	
	Avg	SD	Avg	SD	Avg	SD	Avg	SD
3	-0.32	0.03	0.16	0.12	0.08	0.09	0.36	0.24
6	-0.46	0.15	0.37	0.11	0.27	0.10	0.65	0.36
9	0.12	1.04	0.16	0.10	3.53	0.32	3.54	1.46
12	-10.46	0.19	0.33	0.12	18.30	0.14	21.08	0.45
15	-11.92	0.22	1.91	0.10	20.69	0.09	23.96	0.41
18	-22.05	0.22	6.00	0.05	29.24	0.35	37.11	0.62
21	-30.89	0.01	8.73	0.09	29.07	0.08	43.31	0.18
24	-34.10	0.15	7.71	0.04	29.42	0.19	45.69	0.38
27	-33.84	0.70	7.76	0.19	28.82	0.65	45.12	1.54
30	-33.18	1.18	7.51	0.06	29.31	0.18	44.90	1.42
33	-30.92	0.12	7.97	0.02	31.28	0.13	44.70	0.27
36	-29.64	0.59	7.60	0.23	26.67	0.40	40.59	1.22
39	-31.49	0.14	7.58	0.11	27.10	0.18	42.23	0.43
42	-30.68	0.08	6.80	0.03	27.55	0.08	41.79	0.19
45	-30.06	0.08	7.30	0.07	27.79	0.03	41.58	0.18

Table C14 Changes in Hunter color values of 1% w/w Cu²⁺, spin-coated at 1000 rpm onto 5%clay nanocomposite films, of meat samples of 100 g during storage time at room temperature

Time (hour)	dL*		da*		db*		dE*	
	Avg	SD	Avg	SD	Avg	SD	Avg	SD
3	0.53	0.06	1.15	0.03	-0.38	0.34	1.32	0.43
6	1.18	0.50	1.17	0.04	-0.98	0.15	1.93	0.69
9	0.49	1.11	0.89	0.08	1.39	0.10	1.72	1.29
12	-1.62	1.65	0.50	0.15	2.77	0.27	3.25	2.07
15	-5.14	0.31	2.12	0.01	4.49	0.12	7.15	0.44
18	-19.58	1.24	6.16	0.25	22.59	0.87	30.52	2.36
21	-21.70	1.56	6.39	0.56	24.76	1.39	33.54	3.51
24	-22.83	1.59	6.67	0.42	24.11	1.66	33.87	3.67
27	-24.03	1.43	7.56	0.49	25.65	1.99	35.95	3.91
30	-24.01	0.70	7.27	0.08	24.79	0.48	35.27	1.26
33	-24.11	1.06	7.21	0.12	25.42	0.78	35.77	1.96
36	-24.19	2.03	7.3	0.63	26.04	2.33	36.29	4.99
39	-24.70	1.61	7.01	0.49	26.33	0.83	36.78	2.93
42	-24.34	2.88	6.30	0.83	24.23	3.01	34.92	6.72
45	-24.54	2.81	6.56	0.62	22.95	2.02	34.24	5.45

Table C15 Changes in Hunter color values of 3% w/w Cu^{2+} , spin-coated at 1000 rpm onto 5%clay nanocomposite films, of meat samples of 100 g during storage time at room temperature

Time (hour)	dL*		da*		db*		dE*	
	Avg	SD	Avg	SD	Avg	SD	Avg	SD
3	-0.15	0.08	0.53	0.05	0.47	0.04	0.73	0.17
6	-0.25	0.23	0.81	0.11	-1.01	0.08	1.32	0.42
9	-0.69	0.41	0.98	0.06	4.90	0.13	5.05	0.60
12	-1.25	0.73	1.31	0.10	4.25	0.17	4.62	1.00
15	-13.70	0.18	3.08	0.03	21.15	0.09	25.39	0.30
18	-24.51	1.38	8.92	0.85	31.07	2.18	40.57	4.41
21	-28.25	0.55	10.03	0.19	29.42	0.87	42.00	1.61
24	-31.83	0.11	12.22	0.18	29.44	1.11	45.05	1.40
27	-36.81	0.27	12.39	0.18	30.05	0.50	49.11	0.95
30	-37.39	0.34	12.13	0.17	30.90	0.56	50.00	1.07
33	-37.10	0.44	11.88	0.09	29.03	0.77	48.58	1.30
36	-39.15	0.52	11.42	0.16	28.95	0.28	50.01	0.96
39	-39.86	0.31	10.18	0.05	29.30	0.22	50.51	0.58
42	-41.68	0.93	10.47	0.34	28.96	0.58	51.82	1.85
45	-43.20	0.23	10.64	0.39	29.32	0.27	53.28	0.89

Table C16 Changes in Hunter color values of 10% w/w Cu²⁺, spin-coated at 1000 rpm onto 5%clay nanocomposite films, of meat samples of 100 g during storage time at room temperature

Time (hour)	dL*		da*		db*		dE*	
	Avg	SD	Avg	SD	Avg	SD	Avg	SD
3	-0.33	0.14	2.58	0.03	0.25	0.06	2.61	0.23
6	-1.67	0.90	3.15	0.01	-0.75	0.31	3.64	1.22
9	-1.87	0.14	2.93	0.10	1.59	0.06	3.82	0.30
12	-2.26	0.23	3.08	0.11	5.81	0.22	6.96	0.56
15	-12.53	2.10	3.76	0.48	22.73	1.14	26.23	3.72
18	-28.70	0.16	8.08	0.16	38.13	0.89	48.40	1.21
21	-37.86	0.62	12.94	0.17	38.77	1.68	55.71	2.47
24	-44.42	0.70	15.98	0.34	37.84	0.36	60.50	1.40
27	-49.55	1.68	16.07	0.86	37.99	0.99	64.47	3.53
30	-50.58	0.22	16.03	0.09	37.49	0.37	64.97	0.68
33	-49.94	0.28	16.31	0.20	36.88	0.35	64.19	0.83
36	-50.01	0.15	15.24	0.17	36.96	0.43	64.03	0.75
39	-50.07	1.00	15.39	0.21	35.27	0.34	63.15	1.55
42	-50.47	0.27	15.29	0.08	35.40	0.22	63.52	0.57
45	-50.57	0.58	15.06	0.30	35.55	0.43	63.62	1.31

Table C17 Changes in Hunter color values of 5% w/w Cu²⁺, spin-coated at 1000 rpm onto 1%clay nanocomposite films, of meat samples of 100 g during storage time at room temperature

Time (hour)	dL*		da*		db*		dE*	
	Avg	SD	Avg	SD	Avg	SD	Avg	SD
3	-2.21	0.35	1.31	0.08	1.83	0.03	3.16	0.46
6	-2.95	0.52	1.41	0.07	4.18	0.06	5.31	0.65
9	-6.76	1.32	1.64	0.08	14.19	1.35	15.81	2.75
12	-19.73	1.28	4.45	0.16	21.80	0.61	29.74	2.05
15	-37.96	3.42	8.22	0.54	32.20	1.15	50.45	5.11
18	-44.10	1.32	12.56	0.12	33.69	0.25	56.90	1.69
21	-49.31	1.69	14.56	0.18	34.44	0.74	61.88	2.61
24	-49.33	0.59	14.33	0.60	34.64	0.89	61.96	2.08
27	-49.85	1.38	14.92	0.13	34.47	0.23	62.42	1.74
30	-49.98	1.11	14.50	0.08	33.79	0.25	62.05	1.44
33	-49.29	1.40	14.61	0.14	33.81	0.73	61.53	2.27
36	-50.31	1.20	14.77	0.48	34.47	0.71	62.75	2.39
39	-49.40	1.30	14.88	0.41	33.90	0.68	61.73	2.39
42	-50.30	2.32	14.35	0.45	33.99	1.32	62.38	4.09
45	-49.41	1.50	14.33	0.38	34.11	0.72	61.73	2.60

Table C18 Changes in Hunter color values of 5% w/w Cu²⁺, spin-coated at 1000 rpm onto 3%clay nanocomposite films, of meat samples of 100 g during storage time at room temperature

Time (hour)	dL*		da*		db*		dE*	
	Avg	SD	Avg	SD	Avg	SD	Avg	SD
3	-1.78	0.09	1.54	0.05	2.45	0.18	3.40	0.32
6	-2.36	0.13	1.70	0.05	4.50	0.28	5.36	0.46
9	-2.75	1.37	2.05	0.08	8.70	0.20	9.36	1.65
12	-10.28	1.02	3.35	0.45	19.06	1.48	21.92	2.95
15	-15.52	1.33	6.60	0.37	28.08	1.67	32.76	3.37
18	-33.07	0.43	10.54	0.28	32.47	0.84	47.53	1.55
21	-39.86	1.73	13.85	0.26	34.04	0.63	54.23	2.62
24	-46.75	0.49	14.37	0.12	34.13	0.21	59.64	0.82
27	-47.77	0.26	14.61	0.19	33.44	0.78	60.11	1.23
30	-48.43	1.18	14.54	0.07	34.21	0.80	61.05	2.05
33	-49.25	0.27	15.15	0.39	33.66	0.69	61.55	1.35
36	-49.58	0.38	15.01	0.02	34.36	0.08	62.16	0.48
39	-50.05	0.25	14.98	0.03	33.79	0.07	62.22	0.35
42	-49.61	0.16	14.44	0.26	33.84	0.92	61.76	1.34
45	-49.73	0.15	15.00	0.22	33.92	0.65	62.04	1.02

Table C19 Changes in Hunter color values of 5% w/w Cu²⁺, spin-coated at 1000 rpm onto 5%clay nanocomposite films, of meat samples of 25 g during storage time at room temperature

Time (hour)	dL*		da*		db*		dE*	
	Avg	SD	Avg	SD	Avg	SD	Avg	SD
3	-0.91	0.12	0.67	0.03	0.84	0.07	1.41	0.22
6	-1.28	0.44	0.91	0.05	1.43	0.07	2.13	0.56
9	-1.94	0.38	1.18	0.09	2.10	0.19	3.09	0.66
12	-2.99	0.32	1.35	0.01	9.72	0.24	10.26	0.57
15	-3.08	0.73	1.58	0.19	14.75	1.66	15.15	2.58
18	-8.85	0.79	1.92	0.17	17.03	0.67	19.29	1.63
21	-22.17	0.95	10.61	0.38	25.01	0.89	35.07	2.22
24	-30.40	1.41	12.63	0.38	30.29	0.75	44.74	2.54
27	-37.11	1.35	13.76	0.16	31.07	0.58	50.32	2.09
30	-44.31	0.81	13.70	0.21	31.54	0.19	56.09	1.21
33	-44.42	0.73	14.59	0.42	32.75	0.56	57.09	1.71
36	-46.46	0.75	14.38	0.41	31.76	0.23	58.09	1.39
39	-48.13	0.62	14.45	0.40	31.84	0.25	59.49	1.27
42	-48.77	0.87	14.63	0.35	31.73	0.32	60.00	1.54
45	-48.47	0.75	14.34	0.34	32.18	0.22	59.92	1.31

Table C20 Changes in Hunter color values of 5% w/w Cu²⁺, spin-coated at 1000 rpm onto 5%clay nanocomposite films, of meat samples of 50 g during storage time at room temperature

Time (hour)	dL*		da*		db*		dE*	
	Avg	SD	Avg	SD	Avg	SD	Avg	SD
3	-0.71	0.03	0.72	0.12	0.84	0.05	1.31	0.20
6	-1.39	0.04	1.40	0.12	1.32	0.07	2.37	0.23
9	-3.83	1.12	1.30	0.32	3.19	1.25	5.15	2.69
12	-4.48	0.65	1.45	0.28	12.59	0.29	13.44	1.22
15	-7.16	1.44	2.32	0.19	18.31	0.17	19.80	1.80
18	-17.82	1.35	6.35	0.30	27.59	0.51	33.46	2.16
21	-29.39	0.04	12.37	0.31	32.03	1.00	45.20	1.35
24	-32.51	0.26	13.84	0.06	32.49	0.35	48.00	0.67
27	-42.27	2.00	14.28	0.57	32.42	2.15	55.15	4.72
30	-46.27	0.23	13.82	0.21	32.64	0.77	58.29	1.21
33	-47.52	1.70	14.44	0.13	32.84	0.44	59.54	2.27
36	-48.44	2.13	14.71	0.50	31.90	2.20	59.84	4.83
39	-49.43	0.40	15.07	0.15	32.73	0.36	61.17	0.91
42	-48.96	0.67	14.31	1.11	32.76	3.85	60.62	5.63
45	-49.81	0.50	15.14	0.20	32.39	1.40	61.31	2.10

Table C21 Changes in Hunter color values of 5% w/w Cu²⁺, spin-coated at 1000 rpm onto 5%clay nanocomposite films, of meat samples of 150 g during storage time at room temperature

Time (hour)	dL*		da*		db*		dE*	
	Avg	SD	Avg	SD	Avg	SD	Avg	SD
3	-0.64	0.06	1.83	0.09	1.18	0.12	2.27	0.27
6	0.31	0.67	1.623	0.11	1.63	0.15	2.33	0.93
9	-5.11	0.57	2.14	0.16	12.79	0.84	13.94	1.57
12	-10.28	0.64	3.89	0.11	21.36	0.21	24.03	0.96
15	-16.80	2.49	6.17	0.30	29.68	1.06	34.66	3.85
18	-32.84	0.65	10.92	0.16	33.71	0.29	48.31	1.10
21	-42.58	1.20	14.88	0.35	33.84	0.32	56.39	1.87
24	-47.45	0.48	14.38	0.05	33.27	0.43	59.71	0.96
27	-49.56	1.30	14.63	0.30	33.36	0.58	61.51	2.18
30	-50.53	0.80	14.82	0.33	33.11	0.13	62.20	1.26
33	-49.17	0.37	14.03	0.34	33.79	0.33	61.29	1.04
36	-48.65	0.55	14.68	0.14	33.33	0.43	60.77	1.12
39	-48.54	0.24	14.53	0.11	33.05	0.32	60.50	0.67
42	-48.97	0.22	14.25	0.13	33.77	0.63	61.17	0.98
45	-49.58	0.18	14.60	0.08	33.84	0.23	61.78	0.49

Appendix D Electrical Conductivity of Sensor to Meat Spoilage

Table D1 Electrical conductivity of 5% w/w PEDOT:PSS, spin-coated at 1000 rpm onto 5%clay nanocomposite films, of meat samples of 150 g

Time (hour)	Avg	SD
0	7.03E-08	6.71E-10
3	6.90E-08	9.71E-10
6	6.56E-08	3.51E-09
9	4.51E-08	5.71E-09
12	1.11E-08	2.71E-09
15	9.09E-09	1.75E-09
18	1.21E-08	2.44E-09
21	8.97E-09	6.60E-10
24	1.45E-08	5.78E-09
27	8.72E-09	1.34E-09
30	2.90E-09	8.08E-10
33	3.86E-09	3.18E-10
36	1.82E-09	1.27E-09
39	8.57E-10	7.27E-10
42	6.60E-10	2.35E-09
45	1.54E-10	8.35E-10

Table D2 Electrical conductivity of 5% w/w Cu^{2+} , spin-coated at 1000 rpm onto 5%clay nanocomposite films, of meat samples of 150 g

Time (hour)	Avg	SD
0	7.03E-08	6.71E-10
3	6.90E-08	9.71E-10
6	6.56E-08	3.51E-09
9	4.51E-08	5.71E-09
12	1.11E-08	2.71E-09
15	9.09E-09	1.75E-09
18	1.21E-08	2.44E-09
21	8.97E-09	6.60E-10
24	1.45E-08	5.78E-09
27	8.72E-09	1.34E-09
30	2.90E-09	8.08E-10
33	3.86E-09	3.18E-10
36	1.82E-09	1.27E-09
39	8.57E-10	7.27E-10
42	6.60E-10	2.35E-09
45	1.54E-10	8.35E-10

Appendix E Bentonite Clay, Max-Gel® GRADE SAC

Table E1 Absorbance at 818 nm of the standard aqueous Cu²⁺ solution.

Std. Cu ²⁺ solution (ppm)	Avg	SD
1	0.163	0.015
5	0.381	0.068
10	0.656	0.024
20	1.156	0.051
40	2.213	2.213

Appendix F Poly(vinyl acetate) Emulsion, Adhesive Latex TOA NO.LA-22S

Table F1 Physical properties of Poly(vinyl acetate) Emulsion

Physical Properties	
Appearance	Clear viscous emulsion
Solid content, %	22 - 25
Viscosity, LVT#4@12.30 °c, cps	25,000 – 40,000
pH (30°C)	4.0 – 5.5
Pound per gallon	8.6 -8.8
Appearance of film	Hazy

Appendix G Bentonite Clay, Max-Gel® GRADE SAC

Table G1 Typical chemical analysis of bentonite on dry basis at 105 °C

Element	Percentage
SiO ₂	65-70
Al ₂ O ₃	13-17
Fe ₂ O ₃	1.0-2.0
Na ₂ O	1.5-2.5
LOI	10-12
MgO	2.0-3.0
CaO	1.5-2.5
K ₂ O	0.4-0.8
TiO ₂	0.2-0.3

Table G2 Physical properties of bentonite

Physical Properties	
Moisture content, %	8-12
5% suspension, pH	9.5-11.0
Swelling index, ml per 2 g of clay	15
Viscosity dial reading at 600 rpm	12-20
Dry particle size (pass 200 meshes), %	80 min
Wet particle size (pass 325 meshes),	98 min
Specific gravity	2.3-2.4
CEC, meq/100g of clay	50

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Presentations:

1. Ruangrit, N., Magaraphan, R., Manuspiya, H., and Nithitanakul, M. (2007, December 4-7) Polypropylene/Clay Nanocomposite Intelligent Packaging Based on PEDOT:PSS Sensor. Poster presented at The 10th Poymer Pacific Conference, Kobe, Japan.
2. Ruangrit, N., Magaraphan, R., Manuspiya, H., and Nithitanakul, M. (2008, April 23) Polypropylene/Organoclay Nanocomposite Intelligent Packaging. Poster presented at PPC Annual Research Presentation 2008, Chulalongkorn University, Bangkok, Thailand.

