APPENDIX A

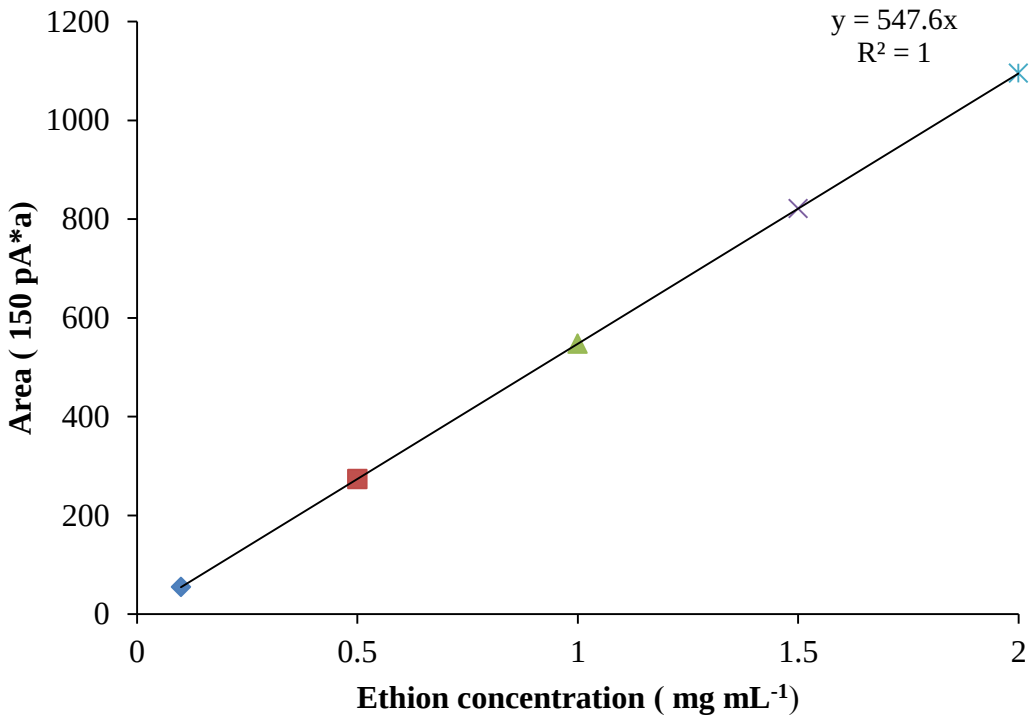

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Figure A1 Linearity between standard ethion concentrations (0.1, 0.5, 1.0, 1.5 and 2.0 mg L^{-1}) and peak area from GC-FPD chromatograph (y = 547.6x; R^2 = 0.9962)

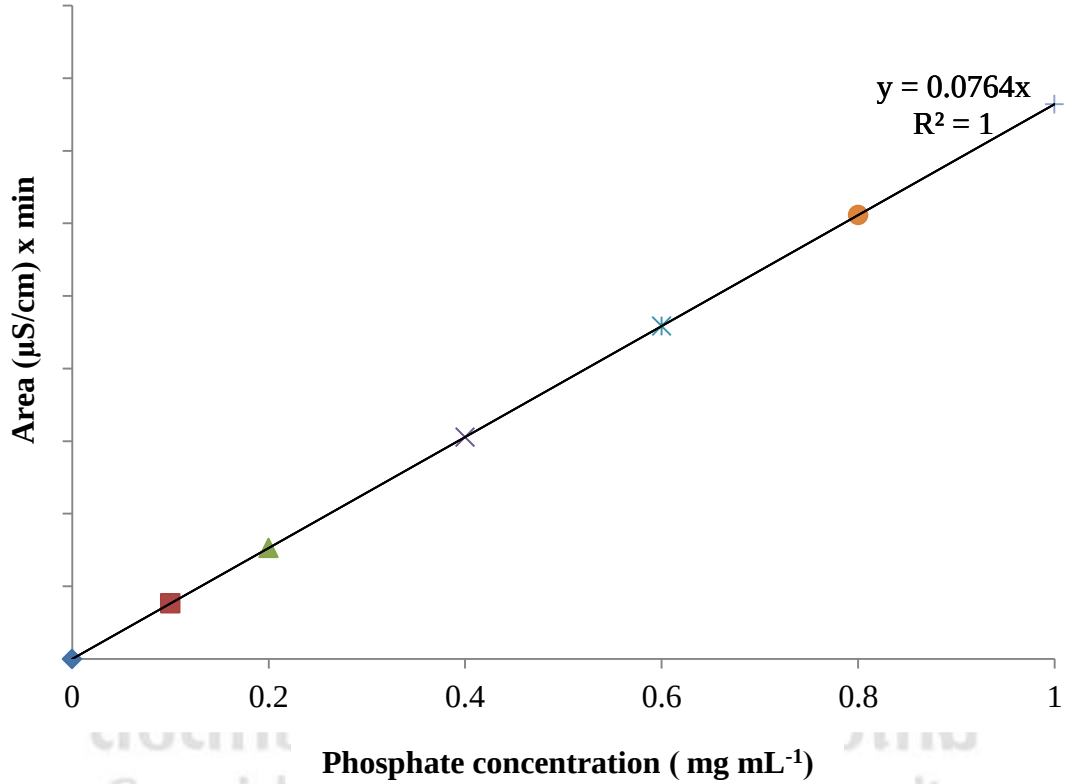

Figure A2 Linearity between standard phosphate concentrations (0.1, 0.2, 0.4, 0.8 and 1.0 mg L^{-1}) and peak area of phosphate ions from IC (y = 0.0764x; R^2 = 0.9978)

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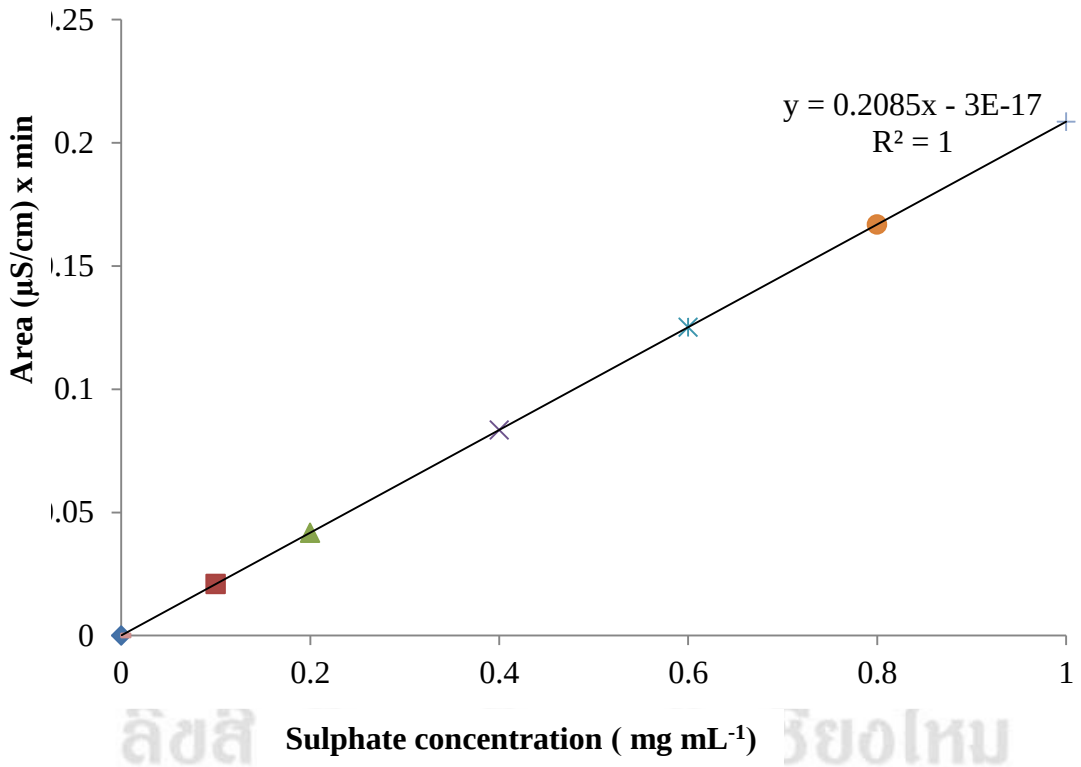

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Figure A3 Linearity between standard sulphate concentrations (0.1, 0.2, 0.4, 0.8 and 1.0 mg L^{-1}) and peak area of sulphate ions from IC (y = 0.2085x; R^2 = 0.9999)

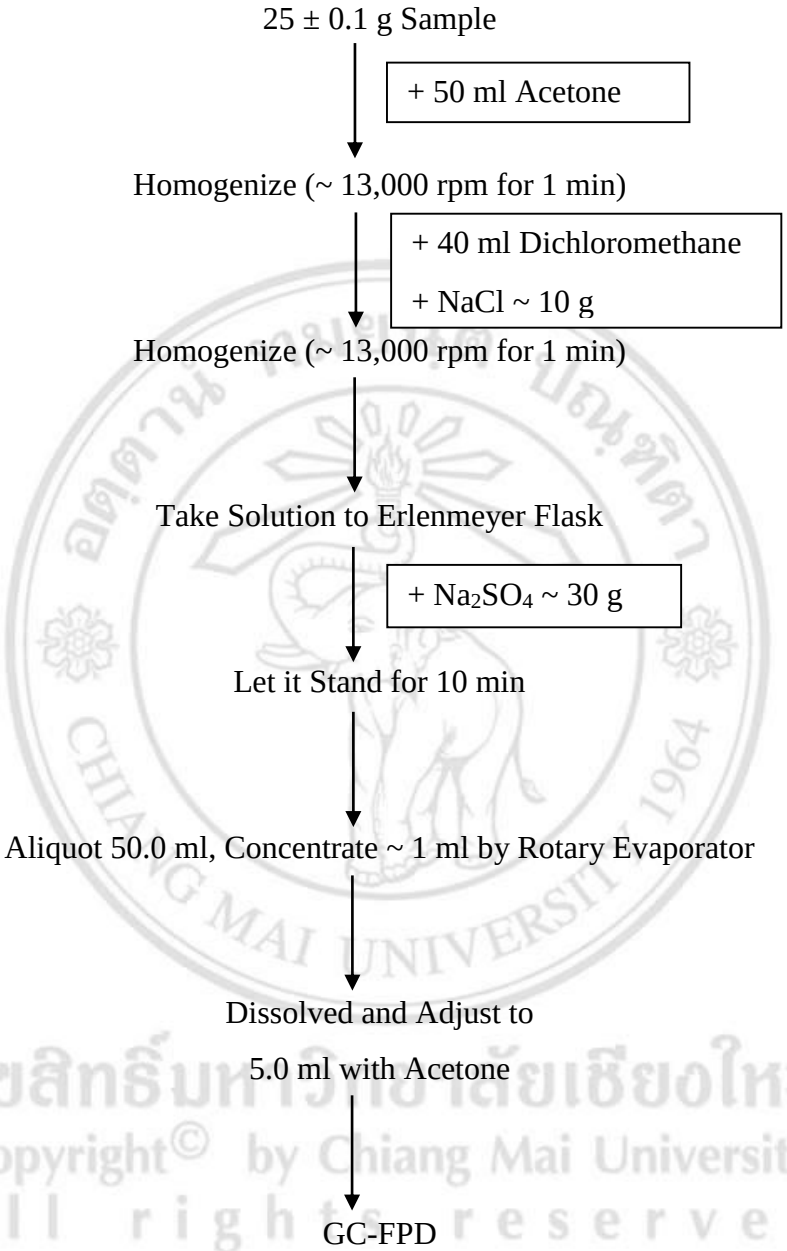

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Figure A 4 The flow chart of the extraction method for GC-FPD analysis based on Steinwandter (1985) and developed by Department of Agriculture (2012)

APPENDIX B

Table A1 Standard ethion (1 mg L^{-1}) degradation when treated with TiO_2 Photocatalysis for 60 min

Concentrations of TiO_2 (mg mL^{-1})	**Ethion degradation (%)**					
	Exposure time to the photocatalysis (min)					
	0	**15**	**30**	**45**	**60**	**Average**
5	0.00	36.43	55.71	50.00	78.57	44.14E
10	0.00	43.14	64.29	86.43	82.57	55.29D
20	0.00	57.14	71.43	86.43	89.00	60.80C
40	0.00	68.57	76.86	86.43	92.57	64.89B
60	0.00	76.43	88.57	83.57	82.57	66.23A
Average	0.00e	56.34d	71.37c	78.57b	85.06a	
F	Conc ** ; Time ** ; Conc x Time - ns					
%CV	0.11					

The same letter in the column do not differ significantly at $p = 0.05$ using the least significant difference test.

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Table A2 Iodine liberation during TiO_2 photocatalysis at different concentrations of TiO_2 for 60 min

Concentrations Of TiO_2 (mg mL^{-1})	Iodine production (Absorbance 354 nm)				
	0 min	**15 min**	**30 min**	**45 min**	**60 min**
0	0±0.00a	0 ± 0.00d	0±0.00d	0 ± 0.00e	0 ± 0.00d
15	0±0.00a	0.30±0.00c	0.33±0.00c	0.33±0.00d	0.31±0.00c
30	0±0.00a	0.60±0.00b	0.43±0.00b	0.53± 0.00c	0.60± 0.00b
45	0±0.00a	1.23±0.00a	1.23±0.00a	1.32±0.00b	1.13±0.00a
60	0±0.00a	1.51±0.00a	1.83±0.00a	2.00±0.00a	1.88± 0.00a

Mean ± SD within the same column followed by the same letter do not differ significantly at p=0.05 using the least significant difference test

Table A3 Percent of standard ethion (1 mg L^{-1}) degradation during TiO_2 photocatalysis at different concentrations of TiO_2 for 60 min

Concentrations of TiO_2 (mg mL^{-1})	Ethion degration (%)				
	0 min	**15 min**	**30 min**	**45 min**	**60 min**
0	0±0.00a	1.0±0.20e	2.0±0.19d	2.0±0.26e	3.0±0.17e
15	0±0.00a	9.9±0.26c	60.4±0.52a	62.6±0.26c	64.8±0.26c
30	0±0.00a	4.4±0.17d	49.5±0.30b	48.4±0.26d	61.5±0.20d
45	0±0.00a	19.8±0.30b	60.4±0.26a	69.2±0.26b	71.4±0.20b
60	0±0.00a	29.7±0.26a	39.6±0.30c	75.8±0.36a	85.7±0.20a

Mean ± SD within the same column followed by the same letter do not differ significantly at *p*=0.05 using the least significant difference test

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Table A4 Iodine production corresponding to the ethion degradation percentage during TiO_2 photocatalysis at different concentrations of TiO_2 for 60 min

Concentrations of TiO_2 (mg mL^{-1})	Iodine production	Ethion degration
0	0.00±0.00e	3.00±0.14e
15	0.52±0.01d	64.8±0.20d
30	0.98±0.02c	61.5±0.25c
45	1.86±0.03b	71.4±0.25b
60	3.11±0.06a	85.7±0.25a

Mean ± SD within the same column followed by the same letter do not differ significantly at p=0.05 using the least significant difference test

Table A5 Ethion concentration changes at different concentrations of TiO_2 during TiO_2 photocatalysis for 60 min

Concentrations	Ethion concentration (mg mL^{-1})				
Tio_2 of (mg mL^{-1})	0 min	15 min	30 min	45 min	60 min
0	1±0.00a	0.99±0.01a	0.98±0.02a	0.98±0.02a	0.97±0.03a
15	1±0.00a	0.90±0.04a	0.39±0.04d	0.37±0.07c	0.35±0.06b
30	1±0.00a	0.95±0.03a	0.50±0.02c	0.51±0.01b	0.38±0.02b
45	1±0.00a	0.80±0.02b	0.39±0.02d	0.30±0.02d	0.28±0.03c
60	1±0.00a	0.70±0.02c	0.60±0.02b	0.24±0.02e	0.14±0.02d

Mean ± SD within the same column followed by the same letter do not differ significantly at p=0.05 using the least significant difference test

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Table A6 pH value of standard ethion solution during TiO_2 photocatalysis at different concentrations of TiO_2 for 60 min

Concentrations TiO_2 of (mg mL^{-1})	pH value				
	0 **min**	15 **min**	30 **min**	45 **min**	60 **min**
0	7.73a	7.71a	7.36a	7.26a	7.09a
15	7.09a	7.04a	6.99a	6.97a	6.98a
30	7.20a	7.35a	7.13a	7.04a	7.01a
45	7.64a	7.32a	7.06a	6.94a	6.98a
60	7.77a	7.30a	7.09a	6.97a	6.94a

Mean ± SD within the same column followed by the same letter do not differ significantly at p=0.05 using the least significant difference test

Table A7 Temperature of standard ethion solution during TiO_2 photocatalysis at different concentrations of TiO_2 for 60 min

Concentrations Of TiO_2 (mg mL^{-1})	Temperature				
	0 min	**15 min**	**30 min**	**45 min**	**60 min**
0	0±0.00b	0±0.00b	0±0.00b	0±0.00b	0±0.00c
15	26.9±0.30a	25.6±0.02a	25.8±0.0a	26.5±0.02a	27.5±0.02b
30	26.9±0.28a	25.3±0.03a	26±0.26a	26.5±0.17a	28.1±0.30a
45	26.9±0.36a	25.7±0.26a	25.9±0.30a	26.5±0.36a	27.6±0.17ba
60	26.9±0.20a	25.9±0.26a	26.4±0.26a	26.8±0.26a	27.7±0.26ba

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Table A8 Oxidation-reduction potential (ORP) of ethion solution during TiO_2 photocatalysis at different concentrations of TiO_2 for 60 min

Concentrations Of TiO_2 (mg mL^{-1})	ORP value (mV)				
	0 min	15 min	30 min	45 min	60 min
0	-23±0.04b	-24±0.03e	-23±0.03e	-22±0.02e	-21±0.02e
15	0±0.00a	25.3±0.03d	44.7±0.03d	41.2±0.02d	55.0±0.04d
30	0±0.00a	55.2±0.02c	63.8±0.02c	75.2±0.02c	86.2±0.02c
45	0±0.00a	79.5±0.04b	86.5±0.06b	102.2±0.03b	111.9±0.03b
60	0±0.00a	114.9±0.02a	125.9±0.02a	142.6±0.02a	159.8±0.03a

Mean ± SD within the same column followed by the same letter do not differ significantly at p=0.05 using the least significant difference test

Table A9 Sulphate concentration of ethion solution during TiO_2 photocatalysis at different concentrations of TiO_2 for 60 min

Concentrations of TiO_2 (mg mL^{-1})	Control	Sulphate concentration (ppm)
0	0.00±0.00a	0.00±0.00d
15	0.00±0.00a	0.26±0.00c
30	0.00±0.00a	0.30±0.00a
45	0.00±0.00a	0.28±0.00b
60	0.00±0.00a	0.28±0.00b

Mean ± SD within the same column followed by the same letter do not differ significantly at p=0.05 using the least significant difference test

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Table A10 Phosphate concentration of ethion solution during TiO_2 photocatalysis at different concentrations of TiO_2 for 60 min

Concentrations of TiO_2(mg mL^{-1})	Control	Phosphate concentration (ppm)
0	0±0.00a	0.00±0.00c
15	0±0.00a	0.56±0.02b
30	0±0.00a	0.68±0.00a
45	0±0.00a	0.69±0.00a
60	0±0.00a	0.67±0.00a

Mean ± SD within the same column followed by the same letter do not differ significantly at p=0.05 using the least significant difference test

Table A11 Ethion degradation in tangerine fruits after treated by TiO_2 photocatalysis for 60 min

Concentrations of TiO_2 (mg mL^{-1})	Ethion degration (ppm)				
	0 min	**15 min**	**30 min**	**45 min**	**60 min**
0	0±0.00a	26.3±0.26d	22.0±0.26e	27.7±0.36e	32.2±0.26d
15	0±0.00a	67±0.52c	66.1±0.26d	63.6±0.26d	62.7±0.26c
30	0±0.00a	75.4±0.26a	67.8±0.26c	72.0±0.26b	70.3±0.20a
45	0±0.00a	72±0.34b	73.7±0.20a	73.7±0.62a	70.3±0.26a
60	0±0.00a	72±0.26b	68.6±0.26b	66.1±0.36c	65.3±0.36b

Mean ± SD within the same column followed by the same letter do not differ significantly at *p*=0.05 using the least significant difference test

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Table A12 Changes in fruit firmness after washing with TiO_2 photocatalysis for 60 min and storage at 5°C for 45 days

Treatments	Firmness	
	0 day	45 day
Washed with distilled water	5.49±0.45a	4.87±0.72a
Unwashed	5.39±0.46a	4.53±0.87a
TiO_2	5.25±0.67a	4.72±0.70a

Mean ± SD within the same column followed by the same letter do not differ significantly at p=0.05 using the least significant difference test

Table A13 Changes in total soluble solids after washing with TiO_2 photocatalysis for 60 min and storage at 5°C for 45 days

Storage time (day)	Total soluble solids (TSS)	Exposure time (min)				
		0	15	30	45	60
0	**Control**	9.384b	9.588b	8.160b	9.792b	8.976b
	TiO_2 60 mg mL^{-1}	8.772b	9.384b	9.384b	9.588b	9.180b
45	**Control**	11.087a	11.087a	11.522a	11.523a	9.783a
	TiO_2 60 mg mL^{-1}	9.566b	11.957a	11.957a	10.653a	10.535a

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Table A14 Changes in titratable acidity after washing with TiO_2 photocatalysis for 60 min and storage at 5°C for 45 days

Storage time (day)	Titratable acidity (TA)	Exposure time (min)				
		0	15	30	45	60
0	Control	0.508a	0.493a	0.509a	0.572a	0.506a
	TiO_2 60 mg mL^{-1}	0.493a	0.541a	0.493a	0.556a	0.445a
45	Control	0.283b	0.271b	0.200b	0.224b	0.177c
	TiO_2 60 mg mL^{-1}	0.165c	0.177c	0.177b	0.201b	0.260b

Mean ± SD within the same column followed by the same letter do not differ significantly at p=0.05 using the least significant difference test

Table A15 Changes in ascorbic acid content after washing with TiO_2 photocatalysis for 60 min and storage at 5°C for 45 days

Storage Time (day)	Ascorbic acid	Exposure time (min)				
		0	15	30	45	60
0	Control	12.00a	11.56a	11.44a	10.94a	10.57a
	TiO_2 60 mg mL^{-1}	10.57b	10.00b	10.00b	10.00b	9.71b
45	Control	4.23c	4.23c	2.86c	4.09c	3.54c
	TiO_2 60 mg mL^{-1}	3.68d	4.64c	3.00c	3.82c	3.14c

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Table A16 Changes in peel L value after washing with TiO_2 photocatalysis for 60 min and storage at 5°C for 45 days

Storage Time (day)	Peel L value	Exposure time (min)				
		0	15	30	45	60
0	Control	28.00b	26.44c	21.51c	22.94c	25.10b
	TiO_2 60 mg mL^{-1}	20.08d	26.44c	24.38b	22.94c	22.23d
45	Control	29.40a	32.26a	25.67a	28.00a	27.22a
	TiO_2 60 mg mL^{-1}	25.67c	29.40b	25.67a	24.89b	24.11c

Mean ± SD within the same column followed by the same letter do not differ significantly at p=0.05 using the least significant difference test

Table A17 Changes in chroma values (a*) after washing with TiO_2 photocatalysis for 60 min and storage at 5°C for 45 days

Storage Time (day)	Peel a*value	Exposure time (min)				
		0	15	30	45	60
0	Control	-5.492b	-4.868b	-5.178b	-5.491a	-4.864a
	TiO_2 60 mg mL^{-1}	-6.590a	-5.805a	-6.276a	-3.452b	-4.560a
45	Control	-2.693d	-2.040d	-2.938d	-2.774c	-2.203b
	TiO_2 60 mg mL^{-1}	-3.509c	-2.856c	-3.182c	-1.714d	-2.448b

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Table A18 Changes in hue angle value (b*) after washing with TiO_2 photocatalysis for 60 min and storage at 5°C for 45 days

Storage Time (day)	Peel b*value	Exposure time (min)				
		0	15	30	45	60
0	Control	22.30a	22.36a	21.63a	21.23a	20.18a
	TiO_2 60 mg mL^{-1}	21.63a	22.90a	21.27a	20.45a	20.18a
45	Control	13.00b	14.62b	12.37c	11.25c	11.75c
	TiO_2 60 mg mL^{-1}	12.00c	13.87b	13.50b	13.87b	12.75b

Mean ± SD within the same column followed by the same letter do not differ significantly at p=0.05 using the least significant difference test

Tab le A19 Weight loss of tangerine fruits after washing with distilled water and TiO_2 photocatalysis for 60 min during storage at 5ºC for 45 days

Exposure time (min)	Weight loss (%)	
	Control	TiO_2 60 mgmL^{-1}
0	11.49±0.03a	14.01±0.01a
15	10.05±0.04b	12.21±0.02b
30	9.69±0.03c	11.49±0.03c
45	9.69±0.03c	8.97±0.02d
60	8.26±0.05d	7.90±0.02e

Mean ± SD within the same column followed by the same letter do not differ significantly at p=0.05 using the least significant difference test

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Table A20 Total microorganism count of tangerine fruits after washing with TiO_2 photocatalysis for 60 min and storage at 5ºC for 45 days

Treatments	Microorganism count (CFU)	
	Day- 0	Day-45
Unwashed	169.0±16.09a	166.7±6.69b
Washing with distilled water	166.7±10.59b	172±5.56a
Washing with TiO_2 photocatalysis	106.0±5.29c	112±3.76c

Mean ± SD within the same column followed by the same letter do not differ Significantly at p=0.05 using the least significant difference test

Table A21 Ethion residue in tangerine fruits after treated TiO_2 photocatalysis for 60 min and storage at 5 ºC for 45 days

Concentrations of TiO_2 (mg mL^{-1})	Ethion residue (ppm)	
	Day-0	Day-45
Control	1.00±0.00 a	0.32±0.32a
TiO_2 60 mg mL^{-1}	1.00±0.00 a	0.02±0.01b

Mean ± SD within the same column followed by the same letter do not differ significantly at p=0.05 using the least significant difference test

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Table A22 LC_{50} value to the brine shrimp (*Artemia salina* L.) toxicity of ethion after treated by TiO_2 photocatalysis for 15, 30, 45 and 60 min

Exposure time Of TiO_2 (min)	**LC_{50} value (mg mL^{-1})**
0	1.01± 0.03e
15	8.21±0.03d
30	30.25±0.04c
45	312.5±0.02b
60	765.8± 0.45a

Mean ± SD within the same column followed by the same letter do not differ significantly at p=0.05 using the least significant difference test

Table A23 Ethion concentration of wastewater from tangerine washing by TiO_2 photocatalysis for 15, 30, 45 and 60 min

Concentrations Of TiO_2 (mg mL^{-1})	**Ethion concentration (ppm)**
0	1.45± 0.05a
15	1.18± 0.05a
30	1.14± 0.05a
45	0.95±0.05b
60	0.90±0.04b

Mean ± SD within the same column followed by the same letter do not differ significantly at p=0.05 using the least significant difference test

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Publications	Hassarangsee, S., Chantara, S., Whangchai, K., and Uthaibutra, J., "Photocatalysis of Titanium Dioxide to Decompose Pesticide Ethion in Tangerine," Acta Horticulturae, Vol.1088, Dedicated for SEAsia2013, 4-6 December 2013 in Vientiane, Laos, 2015. Hassarangsee, S., Uthaibutra, J., Nomura, N., and Whangchai, K., "Degradability of Treated Ethion Insecticide by TiO_2 Photocatalysis," Pakistan Journal of Biology Sciences, Vol. 18, No. 1, pp. 27-31, 2015.

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Experience	Conducting on appropriate technology research for tropical fruits, vegetables and mushroom production in northern Thailand
Others	-

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