Topic: Applied Technology employing Ozone to Kill Germs in Fresh Vegetable Products

By

Khunwang Royal Project

Product Center of Mae Hia Royal Project

Thailand Institute of Scientific and Technological Research (TISTR)

Eastern Thai Consulting 1992 Company Limited

1. Background and Significance of the Study

According to guidelines for the implementation of Royal Project in response to royal idea, "Help farmers to support themselves in the cultivation of useful plants and to have a better standard of living," latest mission found that vegetables were the main products that were significantly driving and developing revenues for Royal Project. Therefore, it requires product development including surveillance and monitoring of residues in various products to ensure safety for consumers, farmers, and the environment. Nowadays, consumers are very active in the field of health and pay attention to food for safe health and more nutrition by consuming fresh vegetables that are not processed or slightly processed. These products are likely to be contaminated with germs that can cause diseases ranging from manufacturing processes, during the transportation, storage to distribution. The process of washing within the Royal Project currently uses the substances, Chlorine compounds, at a concentration of 50-200 ppm. Then features of fresh vegetables are not changed. It also results in the control of microorganisms. However, the use of chlorine compounds may be a risk of residues. Chlorine compounds, chloramines and tri-halogenated methane, could be toxic to consumers by causing side effects that are harmful. It is classified as carcinogenic. Washed vegetable may remain residual chlorine. Hence, we need to study and develop efficient technologies and do not cause toxic residues on the surface of vegetables. This is another attractive choice for consumers and enterprises.

Using ozone is another interesting option. Ozone can oxidize with organic substances and most inorganic substances in water and air. It can also kill germs quickly by binding to molecules and depredating contaminants by changing the structure of the compound without leaving any residue, but only oxygen. Thus, it does not harm or affect any humans, animals, and environment. It is effective at killing germs as well. Ozone dissolved in water at a concentration of 0.01 partition per million can kill 99% of bacteria within one minute. Ozone dissolved in water at a concentration of 0.4 partition per million can kill 99% of viruses within four minutes. In such principles, it clearly shows that ozone is effective in killing germs. Bringing ozone technology to apply in washing fresh vegetables, products in Royal Project, to reduce contamination from germs and residues in vegetables and pushing forward to be accepted as a standard would result in the maximum benefits to consumers.

2. Objectives

To kills microbes and germs which come with vegetables after harvest and before packaging or next process

3. Scope of the Study

3.1 Apply ozone technology in the process of washing vegetables in Royal Project to replace chlorine compounds

3.2 Collect samples to examine germs as Royal Project standard

4. Expected outcomes

4.1 Be able to utilize ozone technology to replace chlorine compounds in the process of washing vegetables to prevent left over chlorine, which produce harmful compounds, chloramines and tri-halogenated methane.

4.2 Decrease processes and expenses of washing vegetables

5. Relevant theories

Ozone (O3) is gas formed by nature phenomena such as lightning, thundering, and sunlight. It is most found in the Earth's atmosphere at an altitude of about 10 to 50 kilometers above the Earth's surface. It reduces danger from ultraviolet radiation from sunbeam. Oxygen molecule (O2) breaks down into atomic oxygen (O) and then combines with another oxygen molecule nearby to be ozone molecule (O3). This law of nature was discovered by a German chemist named Christian Friedrich Schönbein in 1840. He found that ozone was one form of active oxygen. It can oxidize with organic substances and most inorganic substances in water and air. It has the effect of strong sterilizing. Ozone binds to contaminant molecules and decays them by changing the structure of the substance. Ozone is structurally unstable gas. After oxidization, ozone could be converted back to be oxygen which does not harm or affects on humans, animals and environment.

5.1 Pollution elimination by ozone

Ozone can oxidize with organic substances and most inorganic substances in water and air. It also kills bacteria rapidly. Figure 1 shows the result after eliminating pollutions especially bacteria by binding to molecules and decays contaminants by changing the structure of the compound. It can also efficiently destroy odor, chemical, and toxic gas without leaving any residue other than oxygen. So, it does not harm or affect on any humans, animals, and environment.

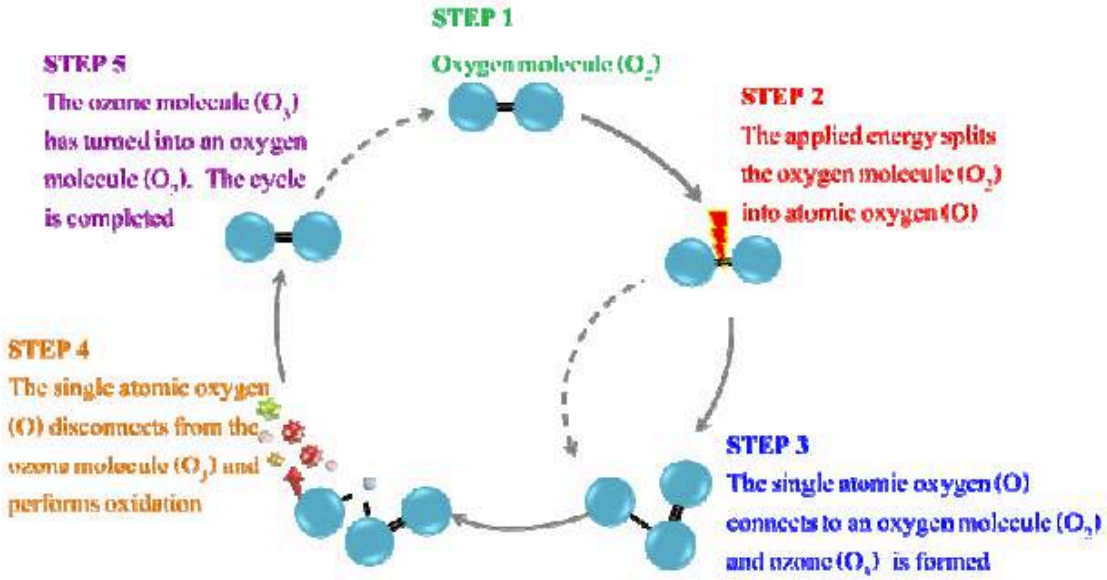

Figure 1 Principle of Pollution Elimination

Ozone features are as details below:

1) Be a substance susceptible to chemical reaction with both organic and inorganic compounds in a wide range without causing toxic residues.
2) Effective in killing germs. It is accepted that ozone can kill germs. For example,
   - Ozone dissolved in water at a concentration of 0.01 partition per million can kill 99% of bacteria within one minute.
   - Ozone dissolved in water at a concentration of 0.4 partition per million can kill 99% of viruses within four minutes.
3) Effective in reducing odors and volatiles by chemical reaction and structural changes.
   - Ozone reacts with formalin and results in water, oxygen, and carbon dioxide as shown below:

$$HCHO + 2O2 \text{---> } H2O + 2O2 + CO2$$

4) Effective in oxidizing heavy metals in wastewater i.e. by oxidizing with iron Fe2+ to Fe 3+, which can be precipitated and filtered out.
5) Effective to break the color in the effluent wastewater by chemical reaction and structural changes.
6) Effective in inhibiting the growth of algae and moss. The cooling tower makes heat transfer system better and saves more energy.

5.2 How to employ the ozone generator

1) Use in household such as washing fruits and vegetables, wash fresh food, and eliminating toxins, pesticides, and pathogens. Table 1 shows the recommended application of ozonated water. Table 2 shows a comparison of the advantages and disadvantages between chlorine and ozone.
2) Use with assembly of strainer for water production
3) Use for deodorization in rooms
4) Use in car for air condition
5) Use in medicine such as sterilizing germs in operation room or patient room
6) Use in water system for commercial and water system in community
7) Use for wastewater treatment to decontaminate chemicals, suspended matter, bleach, heavy metals, and germs in the final process
8) Use in aquaculture process such as fishponds, marine shrimp hatchery, and giant tiger pawn hatchery
9) Use for wastewater treatment in swimming pools to eliminate contaminant and germs
10) Use in water system of heating tower to control moss, prevent dregs, and reduce corrosion
11) Use for deodorization in industry and community such as animal feeding farms, smell of wastewater
12) Use in washing fresh food process before freezing to eliminate contaminant and germs
13) Use for deodorization and germ killing in entertainment spots such as hotels, hospitals, and massage parlors
14) Use in washing clothes process. It helps save expenses in using detergent and efficiently kills germs
15) Use for eliminating ink and thinner smells in printing houses and car painting rooms
16) Use for eliminating exhaust at car parking under high buildings

Table 1 How to employ ozonated water

Application	Conc. O_3	Contact Time (min)
Reverse Osmosis Water	0.3 – 0.5	4 – 5
Drinking Water	1.0 – 2.0	5 – 10
Pool	0.3 – 0.7	1
Seafood Wash	0.1 – 0.15	1-2
Fruit & vegetable wash	0.2 – 0.4	1-5
Hydroponic	0.1 – 0.2	2-5
Cooling Tower	0.2 – 0.5	2
Pre-surgical wash	3 – 5	3 – 5

Table 2 The comparison of the advantages and disadvantages between chlorine and ozone

Action in Water	Chlorine	Ozone
Water Half-Life	2-3 Hours	20 Min.
Oxidation Potential (Volts)	1.36	2.07
Disinfection: Bacteria Viruses	Moderate	Excellent
Environmentally Friendly	No	Yes
Color Removal	Moderate	Excellent
Carcinogen Formation	Likely	Unlikely
Organics Oxidation	Moderate	High
Micro flocculation	None	Moderate
pH Effect	Variable	Lower
Operation Hazards: Skin Toxicity	High	Moderate High
Implementation Complexity	Low	High
Capitol Cost	Low	High
Monthly Use Cost	Moderate-High	Low
Air Pre-treatment	None	Extensive

5.3 Ozone features for killing germs

Ozone is gas that is potential in oxidization up to 2.07 volt in Alkaline Solution when compared to chlorine which is 1.36 volt in Alkaline Solution. Table 3 shows redox potential and demonstrates that ozone is more potential in oxidization 1.52 times higher.

Table 3 Redox potential values

Parameter	Redox Potential (Volts)
Iron	2.85
Ozone	2.07
Hydrogen peroxide	1.76
Permanganate	1.68
Chlorine	1.36
Chlorine dioxide	0.95

Ozone has the ability to kill germs effectively. In some particular, it kills viruses faster than chlorine up to 10 times. Figure 2 and Table 4 show the relationship between the concentration of ozone and its ability to kill germs. The principle is to destroy cell walls of bacteria and will destroy viruses' coat proteins which make it difficult to grow. Especially at ORP over 600 mV or at ozone concentration higher than 0.5 mg per liter, it found that coliform bacteria were all done. Killing bacteria by chlorine may take up to four days while it takes only two minutes by ozone.

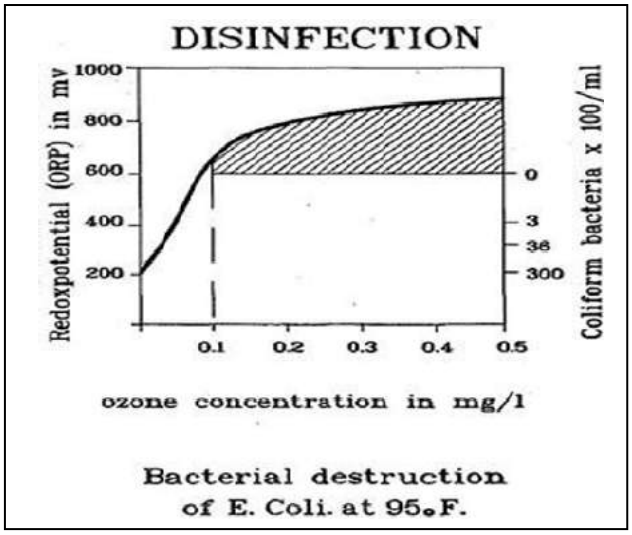

Figure 2 The relationship between the concentration of ozone and its ability to kill germs

Table 4 The relationship between the concentration of ozone and its ability to kill germs

Ozone Conc. mg/l (approx.)	Redox potential mV	Bacterial count E.coli/100 ml	Comment
0.0	50 to 100		Below 50 mV, anaerobic sediment, bacterial sludge.
0.1	200	300	Poor quality natural water
0.2	300	30	Good quality natural water desired minimum level for aquaculture
0.3	400	3	Upper limit for aquaculture and aquariums
0.4	500	2	Damage to the epithelial tissues if aquatic life
0.5	600	1	Sever damage to aquatic life, near 100% disinfection
0.6	700	0	Above 700 mV complete disinfection. Swimming pools, potable water treatment.

5.4 The principle of ozonated water generator

Create ozone by high-powered ozone generator to bring produced ozone dissolve in water. Use the cylinder to allow ozone gas dissolved in water until saturated, then it is sent to the ozonated water tank. Figure 3 shows the principle of the ozonated water generator.

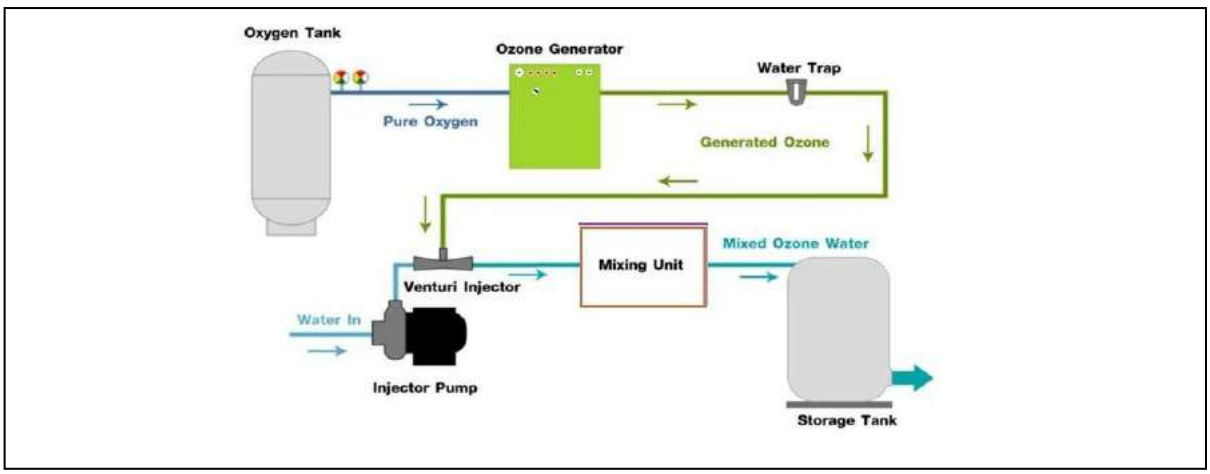

Figure 3 The principle of the ozonated water generator

6. Place of operation

Khunwang Royal Project Development Center, Tambon Mae Win, Amphoe Mae Wang, Chiang Mai

Product Center of Mae Hia Royal Project, Tambon Mae Hia, Amphoe Muang, Chiang Mai

7. Equipment for operation

Figure 4 shows components of the ozone generator. The components include the ozonated water generator at ozone dissolved in water production rate more than 0.6 ppm, liquid oxygen tank, and the ozonated water tank.

Figure 4 The components of the ozone generator

7.1 Specifications

1) Ozone dissolved in water production rate of 0.6 milligrams per liter.

2) Voltage using 220 volts, 50 Hz frequency (220 VAC ; 50 Hz)

3) Automatic time setting of 0-60 minutes

4) Power consumption 1.3 kilowatt

5) 2 ozone generator tubes inside, automatically alternate operation by time setting

6) Venturi injector system to drain ozone into water. Guided by the principle of creating a difference in pressure when the water pressure gets through Venturi injector.

7) L 61 cm. x W 61 cm. x H 172 cm.

7.1 Water quality before using ozone generator

Table 5 shows the water quality control before using the ozone generator. Water should be pure for the maximum benefit of killing germs.

Table 5 Recommended values before using ozone generator

Specifications	Water Quality Index	Unit	Maximum Rate
Physical	Color	Pt-Co	15
	Turbidity	NTU	5
	Acidity	-	6.5-8.5
Chemical	Total dissolved concentration	mg/l	600
	Iron	mg/l	0.3
	Manganese	mg/l	0.4
	Copper	mg/l	2
	Zinc	mg/l	3
	Total hardness	mg/l	300
	Sulfate	mg/l	250
	Chloride	mg/l	250
	Fluoride	mg/l	1
	Nitrate	mg/l	50
Toxic	Quicksilver	mg/l	0.001
	Lead	mg/l	0.01
	Arsenic	mg/l	0.01
	Selenium	mg/l	0.01
	Chromium	mg/l	0.05
	Cyanide	mg/l	0.07
	Cadmium	mg/l	0.003
	Barium	mg/l	0.7
Microbiological	Coliform bacteria	MPN:10	none
	E. Coli	MPN:10	none
	Staphylococcus aureus	Colonels	none
	Salmonella	Colonels	none
	Clostridium perfringens	Colonels	none

8. Methodology

8.1 Operate at Khunwang Royal Project Development Center

8.1.1 The study of ozonated water efficacy in washing sweet lettuces

The study of ozonated water efficacy in washing sweet lettuces is a good example for germ examination to reduce the amounts of germs, Escherichia coli, on its surface due to its rough structure as shown in Figure 5. Then report the difference between before and after. Test the difference between the initial amounts of germs, Escherichia coli, and the amounts of remaining germs after ozonated water washing process.

Figure 5 Sweet lettuces before washing

8.1.2 The study of appropriate duration of vegetable washing

Compare different duration of using ozonated water to wash 4 vegetables including sweet lettuces, tomatoes, broccolinis, and broccolis as shown in Figure 6. The durations are 10 seconds, 1 minute, and 5 minutes, respectively. Study shelf life in each day and grade as criteria as follow.

1 point means product damage less than 30%

2 points mean product damage between 30-70%

3 points mean product damage more than 70%

In this regards, points will be given by specialists at Khunwang Royal Project Development Center.

Figure 6 Vegetables before washing to kill germs

8.2 Operate at Product Center of Mae Hia Royal Project

8.2.1 The study of ozonated water efficacy in washing pak chai

Compare efficacy between employing ozonated water at the concentration more than 0.6 ml/l and chlorine water at the concentration of 1,000 ml/l in washing pack chai to reduce the amounts of germs, Escherichia coli, on its surface. Then report the difference between before and after. Testing is the difference between the initial amounts of germs, Escherichia coli, and the amounts of remaining germs after ozonated water washing process.

9. Results

9.1 Results at Khunwang Royal Project Development Center

9.1.1 The results of vegetable washing to kill germs

Regarding sweet lettuces washing with ozonated water, which was assigned the concentration of more than 0.6 ml/l, for five minutes, the results are shown in Table 6 and Figure 7.

Table 6 The results of Escherichia coli germ examination in sweet lettuces after ozonated water washing process

Parameter	Duration of ozonated water washing process	Amounts of Escherichia coli (MPN/g)		Efficacy
		Before	After	
Escherichia coli	5 minutes	240	3.6	98.5%

Regarding the study of sweet lettuce sampling to examine initial Escherichia coli before ozone waster washing process, the results show that the amounts of Escherichia coli are 240 MPN/g. When washing sweet lettuces by ozonated water at the concentration more than 0.6 ml/l for five minutes, it can reduce the amounts of Escherichia coli by 3.6 MPN/g. It means ozone is efficient for kills germs by 98.5%.

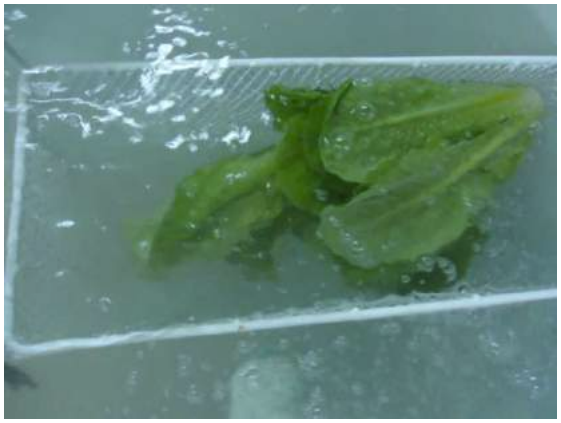

Figure 7 Sweet lettuces washing with ozonated water,
which was assigned the concentration of more than 0.6 milligrams per liter, for 5 minutes

9.1.2 The results of shelf life after ozonated water washing process

The study of shelf life of 4 vegetables includes sweet lettuces, tomatoes, broccolinis, and broccolis when washing with ozonated water at the concentration more than 0.6 ml/l (shown in Figure 8) with the different duration of washing including 10 seconds, 1 minute, and 5 minutes, respectively. Then give marks as criteria of each vegetable damage in each day as shown in Table 7.

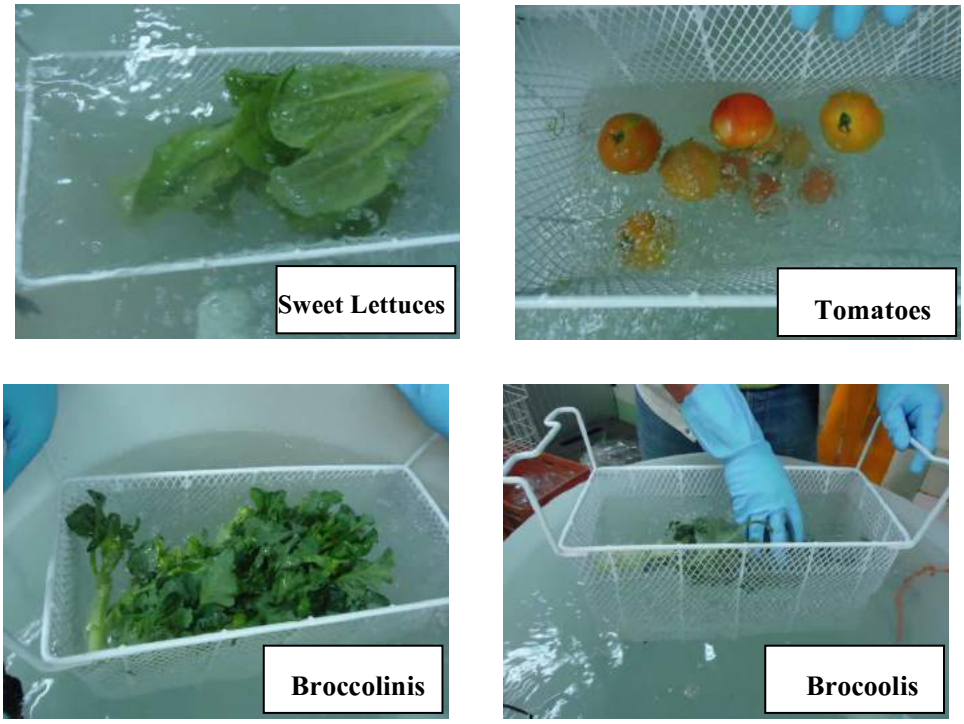

Figure 8 Sweet lettuces washing with ozonated water,
which was assigned to the concentration of more than 0.6 milligrams per liter

Sweet lettuces washed with ozonated water for duration of one and five minutes, respectively, create the best quality. The damage to the product is less than 30% in terms of freshness and color, as shown in Figure 9. They could be stored for at least five days in a cool room with temperatures around 5 degrees Celsius. When compared with control sets and the sets washed by water, it found that there was a change in terms of freshness from Day 3. It shows that ozonated water helps sweet lettuces remain freshness and a change of color of less than 30%, which could be stored for at least five days. In addition, it can also kill Escherichia coli, which is the cause of diarrhea in humans by 98.5%.

Figure 9 Sweet lettuces washing with ozonated water for 1 and 5 minutes,
which was assigned to the concentration of more than 0.6 ml/l

Tomatoes washed with ozonated water for duration of ten seconds, one and five minutes, respectively, create the best quality. The damage to the product is less than 30% in terms of freshness and color and they could be stored for at least five days at a room temperature, as shown in Figure 10. There are differences when compared to control sets and the sets washed by water.

Figure 10 Tomatoes washed with ozonated water,
which was assigned to the concentration of more than 0.6 ml/l

Broccolinis washed with ozonated water for ten seconds and one minute, respectively, creates the best quality. The damage to the product is less than 30% in terms of freshness and color, as shown in Figure 11. They could be stored for at least five days in a cool room with temperatures around 5 degrees Celsius. While washing with ozonated water for five minutes (as shown in Figure 12), it made the leaves dried and inflated into brown. It caused the damage to the product between 30-70% since Day 2 of storage period. The damage to the product is more than 70% since Day 4 of storage period by the top of the leaves were dry and bent. It shows that washing Broccolinis with ozonated water for five minutes is too long and not suitable. When compared with the control sets and the sets washed by water, it found a change in terms of freshness from Day 3. It demonstrates that ozonated water affects freshness and a change of color less than 30%. They can also be stored for at least five days. Nevertheless, duration of washing should be suitable and not too long.

Figure 11 Broccolinis washed with ozonated water for ten seconds and one minute, which was assigned to the concentration of more than 0.6 ml/l

Figure 12 Broccolinis washed with ozonated water for five minutes. The duration was too long and caused the decrease of the freshness.

Broccolis washed with ozonated water for a period of one minute creates the best quality. The damage to the product is less than 30% in terms of freshness and color, as shown in Figure 13. They could be stored for at least five days in a cool room with temperatures around 5 degrees Celsius. Whereas washing with ozonated water for a period of five minutes, it made the leaves pale and puffy. The damage to the product is between 30-70% since Day 2 of storage period. It shows that washing Broccolis with ozone water for five minutes is too long and not suitable. When compared with the control sets and the set washed with water, it found that there was a change in terms of freshness from Day 3. It shows that ozonated water affects Broccolis in terms of the freshness and a change of color less than 30%. They could be stored for at least five days. Nonetheless, duration of washing should be suitable and not too long.

Figure 13 Broccolis washed with ozonated water for one minute, which was assigned to the concentration of more than 0.6 ml/l

Figure 13 Broccolis washed with ozonated water for five minutes. The duration was too long and caused the decrease of the freshness.

Table 7 The following table shows the results based on the damage of each type of vegetable.

Sweet lettuces

Day	No washing (Control sets)		Washing (H_2O)		Ozonated water with the concentration of more than 0.6 mg/l						Observation results
					10 Sec		1 Min		5 Min		
	Freshness	Color	Freshness	Color	Freshness	Color	Freshness	Color	Freshness	Color	
1	1	1	1	1	1	1	1	1	1	1	
2	1	1	1	1	1	1	1	1	1	1	
3	2	1	1	1	1	1	1	1	1	1	
4	2	1	1	1	1	1	1	1	1	1	
5	3	1	2	1	2	1	1	1	1	1	

Tomatoes

Day	No washing (Control sets)		Washing (H_2O)		Ozonated water with the concentration of more than 0.6 mg/l						Observation results
					10 Sec		1 Min		5 Min		
	Freshness	Color	Freshness	Color	Freshness	Color	Freshness	Color	Freshness	Color	
1	1	1	1	1	1	1	1	1	1	1	
2	1	1	1	1	1	1	1	1	1	1	
3	1	1	1	1	1	1	1	1	1	1	
4	1	1	1	1	1	1	1	1	1	1	
5	1	1	1	1	1	1	1	1	1	1	

Broccolinis

Day	No washing (Control sets)		Washing (H_2O)		Ozonated water with the concentration of more than 0.6 mg/l						Observation results
					10 Sec		1 Min		5 Min		
	Freshness	Color	Freshness	Color	Freshness	Color	Freshness	Color	Freshness	Color	
1	1	1	1	1	1	1	1	1	1	1	• Control sets became a bit dry • Best washed O3 for 1 min • Washed O3 for 5 min, leaves became black
2	1	1	1	1	1	1	1	1	2	1	• Washed O3 for 5 min, leaves became dried and inflated into brown
3	2	1	2	1	1	1	1	1	2	1	
4	3	1	2	1	1	1	1	1	3	1	• Washed O3 for 5 min, leaves became dried and inflated into brown
5	3	1	2	1	1	1	1	1	3	1	

Broccolis

Day	No washing (Control sets)		Washing (H_2O)		Ozonated water with the concentration of more than 0.6 mg/l						Observation results
					10 Sec		1 Min		5 Min		
	Freshness	Color	Freshness	Color	Freshness	Color	Freshness	Color	Freshness	Color	
1	1	1	1	1	1	1	1	1	1	1	
2	1	1	1	1	1	1	1	1	1	2	• Washed O3 for 5 min, leaves became pale and inflated
3	2	1	2	1	1	1	1	1	1	2	
4	2	1	2	1	1	1	1	1	1	2	
5	3	1	3	1	2	1	1	1	1	2	

9.2 The results at Product Center of Mae Hia Royal Project

9.2.1 The results of pak chai washing with ozonated water to kill germs

Regarding pak chai washing with ozonated water, which was assigned the concentration of more than 0.6 milligrams per liter, for five minutes, compared with pak chai washing with chlorine as shown in Table 8 and Figure 14

Figure 14 Pak chai washing with ozonated water,
which was assigned the concentration of more than 0.6 ml/l

Table 8 The results of Escherichia coli germ examination of pak chai after washing with ozonated water and chlorine

Parameter	Concentration (mg/l)	Amount of Escherichia coi germ (MPN/g)		Efficacy
		Before	After	
Ozonated water	0.6	23	< 3.0	> 87.0 %
Chlorine	1,000	23	< 3.0	> 87.0 %

Regarding the study of pack chai samples to examine Escherichia coli before washing with ozonated water, it found 23 MPN per gram of germs. When pak chai was washed with ozonated water assigning the concentration of more than 0.6 ml/g for 5 minutes to reduce Escherichia coli to be less than 3.0 MPN per gram and compared to chlorinated water at the concentration of 1,000 mg/l, it found that it could reduce the amount of germs to be less than 3.0 MPN per gram as well. It shows that ozone has efficacy to kill germs up to 87.0%, which is effectively equivalent to chlorinated water at the concentration of 1,000 mg/l.

10. The conclusion of the study

The application of ozone technology for washing vegetables to kill Escherichia coli found that it was highly effective. It reduced the amount of germs in sweet lettuces and pak chai up to 98.5% and 87%, respectively. In addition, it could also help extend the shelf life of vegetables to maintain freshness and no change of color at least five days. It might maintain freshness longer than not washing or washing with water. The change of these occurred on Day 3 of storage period. However, duration of washing with ozonated water affected different kinds of vegetables. The sweet lettuces and tomatoes could be washed for five minutes without the effect of storage duration of at least five days. On the contrary, this duration was not suitable for washing broccolinis and broccolis. This caused a change within two days. The appropriate duration was just one minute. Nevertheless, to wash vegetables with ozonated water would help vegetables remain freshness noticeably. The next method to study is to spray ozonated water on vegetables to achieve freshness and look appetizing at all times.

11. Researcher Team

11.1 Khunwang Royal Project Development Center

1) Mr. Anan Boonmee	Director of the Development Center of Khungwang and Mon Ngor Royal Project
2) Mr. Watchara Panthong	Head of Khunwang Royal Project Development Center
3) Mr. Kecha Thongnoi	Researcher of Khunwang Royal Project Development Center

11.2 The Production Center of Mae Hia Royal Project

1) Assoc. Prof. Danai Boonyakiat	Director of the Production Center of Mae Hia Royal Project Position of Associate Professor Plant Science and Natural Resources Department, Faculty of Agriculture, Chiang Mai University
2) Mr. Krairop Janchamnoi	Researcher of the Production Center of Mae Hia Royal Project

11.3 Thailand Institute of Scientific and Technological Research (TISTR)

1) Mr. Somsak Chaimongkol	Senior Researcher Agriculture Technology Section Thailand Institute of Scientific and Technological Research
2) Dr. Chana Pomthong	Researcher Biological Science Section Thailand Institute of Scientific and Technological Research

11.4 Eastern Thai Consulting 1992 Company Limited

1) Mr. Kitipol Srisomchai	Deputy Manager, Technical and Engineering Department
2) Miss Ananpapa Chuensap	Engineer
3) Miss Natchanok Kaewsan	Engineer
4) Mr. Montri Buasatian	Chief Technician
5) Mr. Somchai Chingchom	Chief Technician
6) Mr. Thawin Panjamas	Technician
7) Mr. Jakrarat Mongkol	Technician
8) Mr. Pairat Tiewtrakul	Technician
9) Mr. Tee Khudthong-ngam	Technician

The Report of Escherichia coli Analysis Result

บริษัท ห้องปฏิบัติการกลาง (ประเทศไทย) จำกัด
Central Laboratory (Thailand) Co.,Ltd.
สาขาเชียงใหม่ : 164/86 หมู่ที่ 3 ต.ดอนแก้ว อ.แม่ริม จ.เชียงใหม่ 50180
Chiangmai Branch : 164/86 Moo 3 Donkaew, Maerim, Chiangmai 50180 Thailand
Tel : (66) 0 5389 6131, (66) 0 5389 6133, (66) 0 5389 6248
Fax : (66) 0 5389 6052, (66) 0 5389 6131 ต่อ 705
http://www.centrallabthai.com

Accreditation No. 1079/48

Central Lab
One Stop & Fast Services

Issued date: 26 February 2014
Report no.: TR (CM) 56/03668

The Test Result Report

Customer name and address	Eastern Thai Consulting 1992 Company Limited 683 Moo. 11, Sukha Phiban 8, Tambon Nongkham, Amphoe Sriracha, Chonburi Province 20230
Sample description	Sweet lettuces before washing with ozonated water 1
Sample code	CM56/01206-001
Sample description and condition	Sample type: Sweet lettuces Container: Plastic bag with seal, Amount: 1 bag, Weight/volume: 443 g. Temperature at receiving: Room temperature, normal condition
Received date:	12 February 2014
Test date:	13 – 26 February 2014

Test Result

Test Item	Test Result	Unit	LOD	Test Reference
Escherichia coli	240	MPN/g	-	FDA BAM online (2002) Chapter 4
Salmonella spp.	Not Detected	in 25 g.		ISO 6579 : 2002(E)Amenment:2007

Approved by

(Mrs. Chamoi Thonglue)
Director of Laboratory
Chiang Mai Branch

CERTIFIED

บริษัท ห้องปฏิบัติการกลาง (ประเทศไทย) จำกัด
Central Laboratory (Thailand) Co.,Ltd.
สาขาเชียงใหม่ : 164/86 หมู่ที่ 3 ต.ดอนแก้ว อ.แม่ริม จ.เชียงใหม่ 50180
Chiangmai Branch : 164/86 Moo 3 Donkaew, Maerim, Chiangmai 50180 Thailand
Tel : (66) 0 5389 6131, (66) 0 5389 6133, (66) 0 5389 6248
Fax : (66) 0 5389 6052, (66) 0 5389 6131 ต่อ 705
http://www.centrallabthai.com

Accreditation No. 1079/48

Issued date: 26 February 2014
Report no.: TR (CM) 56/03673

The Test Result Report

Customer name and address	Eastern Thai Consulting 1992 Company Limited 683 Moo. 11, Sukha Phiban 8, Tambon Nongkham, Amphoe Sriracha, Chonburi Province 20230
Sample description	Sweet lettuces after washing with ozonated water 3
Sample code	CM56/01206-006
Sample description and condition	Sample type: Sweet lettuces Container: Plastic bag with seal, Amount: 1 bag, Weight/volume: 555 g. Temperature at receiving: Room temperature, normal condition
Received date:	12 February 2014
Test date:	13 – 26 February 2014

Test Result

Test Item	Test Result	Unit	LOD	Test Reference
Escherichia coli	3.6	MPN/g	-	FDA BAM online (2002) Chapter 4
Salmonella spp.	Not Detected	in 25 g.		ISO 6579 : 2002(E)Amenment:2007

Approved by

(Mrs. Chamoi Thonglue)
Director of Laboratory
Chiang Mai Branch

CERTIFIED

บริษัท ห้องปฏิบัติการกลาง (ประเทศไทย) จำกัด
Central Laboratory (Thailand) Co.,Ltd.
สาขาเชียงใหม่ : 164/86 หมู่ที่ 3 ต.ดอนแก้ว อ.แม่ริม จ.เชียงใหม่ 50180
Chiangmai Branch : 164/86 Moo 3 Donkaew, Maerim, Chiangmai 50180 Thailand
Tel : (66) 0 5389 6131, (66) 0 5389 6133, (66) 0 5389 6248
Fax : (66) 0 5389 6052, (66) 0 5389 6131 ต่อ 705
http://www.centrallabthai.com

Accreditation No. 1079/48

Issued date: 27 February 2014
Report no.: TR (CM) 56/03730

The Test Result Report

Customer name and address	Eastern Thai Consulting 1992 Company Limited 683 Moo. 11, Sukha Phiban 8, Tambon Nongkham, Amphoe Sriracha, Chonburi Province 20230
Sample description	Pak Chai, Royal Project before washing with ozonated water
Sample code	CM56/01230-004
Sample description and condition	Sample type: Pak chai Container: Plastic bag with seal, Amount: 1 bag, Weight/volume: 686 g. Temperature at receiving: Room temperature, normal condition
Received date:	13 February 2014
Test date:	14 – 26 February 2014

Test Result

Test Item	Test Result	Unit	LOD	Test Reference
Escherichia coli	23	MPN/g	-	FDA BAM online (2002) Chapter 4
Salmonella spp.	Not Detected	in 25 g.		ISO 6579 : 2002(E)Amenment:2007

Approved by

(Mrs. Chamoi Thonglue)
Director of Laboratory
Chiang Mai Branch

CERTIFIED

บริษัท ห้องปฏิบัติการกลาง (ประเทศไทย) จำกัด
Central Laboratory (Thailand) Co.,Ltd.
สาขาเชียงใหม่ : 164/86 หมู่ที่ 3 ต.ดอนแก้ว อ.แม่ริม จ.เชียงใหม่ 50180
Chiangmai Branch : 164/86 Moo 3 Donkaew, Maerim, Chiangmai 50180 Thailand
Tel : (66) 0 5389 6131, (66) 0 5389 6133, (66) 0 5389 6248
Fax : (66) 0 5389 6052, (66) 0 5389 6131 ต่อ 705
http://www.centrallabthai.com

Accreditation No. 1079/48

Issued date: 27 February 2014
Report no.: TR (CM) 56/03732

The Test Result Report

Customer name and address	Eastern Thai Consulting 1992 Company Limited 683 Moo. 11, Sukha Phiban 8, Tambon Nongkham, Amphoe Sriracha, Chonburi Province 20230
Sample description	Pak Chai, Royal Project after washing with ozonated water
Sample code	CM56/01230-006
Sample description and condition	Sample type: Pak chai Container: Plastic bag with seal, Amount: 1 bag, Weight/volume: 778 g. Temperature at receiving: Room temperature, normal condition
Received date:	13 February 2014
Test date:	14 – 26 February 2014

Test Result

Test Item	Test Result	Unit	LOD	Test Reference
Escherichia coli	< 3.0	MPN/g	-	FDA BAM online (2002) Chapter 4
Salmonella spp.	Not Detected	in 25 g.		ISO 6579 : 2002(E)Amenment:2007

Approved by

(Mrs. Chamoi Thonglue)
Director of Laboratory
Chiang Mai Branch

CERTIFIED

บริษัท ห้องปฏิบัติการกลาง (ประเทศไทย) จำกัด
Central Laboratory (Thailand) Co.,Ltd.
สาขาเชียงใหม่ : 164/86 หมู่ที่ 3 ต.ดอนแก้ว อ.แม่ริม จ.เชียงใหม่ 50180
Chiangmai Branch : 164/86 Moo 3 Donkaew, Maerim, Chiangmai 50180 Thailand
Tel : (66) 0 5389 6131, (66) 0 5389 6133, (66) 0 5389 6248
Fax : (66) 0 5389 6052, (66) 0 5389 6131 ต่อ 705
http://www.centrallabthai.com

Accreditation No. 1079/48

Central Lab
One Stop & Fast Services

Issued date: 27 February 2014
Report no.: TR (CM) 56/03733
Page: 1/1

The Test Result Report

Customer name and address	Eastern Thai Consulting 1992 Company Limited 683 Moo. 11, Sukha Phiban 8, Tambon Nongkham, Amphoe Sriracha, Chonburi Province 20230
Sample description	Pak chai after washing with chlorine
Sample code	CM56/01230-007
Sample description and condition	Sample type: Pak chai Container: Plastic bag with seal, Amount: 1 bag, Weight/volume: 2.61 kg. Temperature at receiving: Room temperature, normal condition
Received date:	13 February 2014
Test date:	14 – 26 February 2014

Test Result

Test Item	Test Result	Unit	LOD	Test Reference
Escherichia coli	< 3.0	MPN/g	-	FDA BAM online (2002) Chapter 4
Salmonella spp.	Not Detected	in 25 g.		ISO 6579 : 2002(E)Amenment:2007

Approved by

(Mrs. Chamoi Thonglue)
Director of Laboratory
Chiang Mai Branch

CERTIFIED