EAEF Engineering in Agriculture, Environment and Food
published by AABEA
Research Paper

EAEF 3(3) : 87-92, 2010

Development of Washing and Sterilization System for Leafy Vegetables

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Abstract

To ensure food safety of leafy vegetables such as lettuce, *Perilla*, and flat Chinese cabbage, various microorganisms and foreign materials commonly found on the leaf surfaces must be removed or inactivated by sterilization before these the food is consumed, especially when served in large restaurants or school cafeterias. This study was conducted to develop a washing and sterilization system for leafy vegetables. Results showed that the optimum washing times using air bubbles for lettuce and *Perilla* was five minutes and for flat Chinese cabbage was ten minutes. The percentage of bacteria removed after the optimum washing times were 94, 98, and 76% for lettuce, *Perilla*, and flat Chinese, respectively. The system was developed so that leafy vegetables contained in a box were continuously moved to pass through the washing, sterilization, and dehydration stages.

[Keywords] washing, washing system development, leafy vegetable

I Introduction

Recently, consumption of green leafy vegetables has been increasing due to greater diversification in dietary preference and growing demand for healthy foods (Hong, 2007). For leafy vegetables, it is necessary to develop techniques for cultivation as well as for retaining freshness, extending self-life and ensuring safety. If vegetables are eaten without first washing out foreign materials present on the leaves such as dust and microorganisms, toxic or poisonous effects are possible. Moreover, small amounts of hazardous materials may accumulate in the body over time to cause diseases later (Kim et al., 1996). Foreign materials on the leaves can be removed by air (Hussain et al.1984), water, and ultrasonic methods. However, some foreign materials and microbes stick very well to leaf surfaces that are wet and rough (Hong et al., 2005, Hong et al., 2007).

Therefore, a washing, sterilizing, and dehydrating system for leafy vegetables was developed, and its effect and performance on leafy vegetables was determined.

II Material and Methods

1. Preparation of samples

Lettuce, Perilla, and flat Chinese cabbage were purchased from a local market in Suwon, Korea within one day after harvest. The physical properties of each leafy vegetable are shown Table 1.

Table 1 Physical characteristics of the leafy vegetables.

Cultivar	Item	Length	Width	Thickness	Weight
Red lettuce	Range	140~165	105~120	0.20~0.25	3.0~5.0
	Mean	153.5	112.9	0.23	4.2
	SD*	±8.6	±5.4	±0.5	±0.5
Perilla	Range	120~135	110~120	0.21~0.24	1.1~1.3
	Mean	128.8	115.6	0.22	1.2
	SD*	±4.3	±2.9	±0.4	±0.1
Flat Chinese cabbage	Range	150~180	67~69	1~2	4~6
	Mean	167.4	65.4	1.5	5.1
	SD*	±10.7	±2.7	±0.6	±0.7

*SD : standard deviation

2. Counting of microorganisms

The total bacteria and coliform counts were performed under low room temperature. For the experiment, 50g each of washed and unwashed samples were homogenized and pulverized for one minute at 10,000 rpm. For microbial cultivation, 1 ㎖ of diluted sample was pipetted onto the petrifilm which was then put into an incubator (BOD incubator) for 24 ~ 48 hours at 32℃ (Fallik et al., 2003, Kader, 2002). After cultivation the total number of bacteria and coliform were counted using a commercial colony counter (3 M, England).

3. Measurement of foreign materials

To collect foreign materials from the leaf surfaces, 10g each of washed and unwashed leaf samples were selected, and each leaf was brushed with distilled water. The distilled water on the leaf surface was placed into a filter paper to collect the foreign materials. The filter paper was dried for 24 hours at 100℃ in a dryer and the remaining foreign materials were weighed using a precision balance (Sartouriou AG Germany).

This paper was written based on the sufficient original data and is meaningful form a viewpoint of the safety of leafy vegetables. I judged that this paper must be significant for the readers of our journal *1, KSAM Member, Researcher, *2, KSAM Member, Researcher, *3, KSAM Member, Senior Researcher, *4, KSAM Member, Researcher, Department of Agricultural Engineering National Academy of Agricultural Science, 150 suin- ro seodun-dong Suwon, 441-100, Korea; hong33@rda.go.kr.

4. Evaluation of washing methods

Tests were conducted to identify the best washing method and to develop a washing system that can efficiently handle large amounts of leafy vegetables. Three types of washing methods, by spray, flow, and air bubble, were tested (Fig. 1 and Table 2). The spray type has nozzles on both sides of the semi-cylindrical type water tank in which leafy vegetables were hung on the wire at the center. The flow type has holes on a pipe on both sides of the semi-cylindrical type water tank. The air bubble type has bubble-generating holes at the bottom of an acryl bath in which leaves in a washing box are placed.

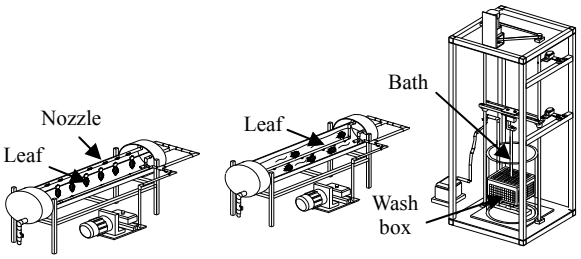

Fig. 1 Washing devices for leaf vegetables

Table 2 Specification of the washing devices

Item	Specification		
	Spray Type	Flow Type	Air Bubble Type
Dimension(L*W*H)	1,200*300	1,200*300	500(D)*600(L)
Discharge Rate(L/min)	40	60	40(air)
Power (kw)	0.37	0.37	0.37
Remarks	Nozzle pressure 0.01mm	Flow velocity 0.1m/s	Bubble velocity 0.02m/s

5. Effects of washing time

Washing time is an important factor for determining the efficiency of each washing method. Washing times were increased from one minute up to thirty minutes to find optimal washing times.

6. Effects of sterilized water

The sterilizing effects of electrolyzed acid water (Edokawa. 1999), ozonized water, and an ultrasonic method were evaluated. The electrolytic water generator, ozone generator, and ultrasonic generator are shown in Fig 2, and their respective specifications are shown in Table 3. The treatment time used for each sterilization method was five minutes (Kim et al 1996 & Hong 2007) for lettuce and Perilla leaf, and ten minutes for flat Chinese cabbage.

Fig. 2 Water sterilization devices used for leafy vegetables

Table 3 Specifications of the sterilization devices used for leafy vegetables

Item	Specification		
	Electrolyzed Acid Water Generator	Ozonized Water Generator	Ultrasonic Wave Generator
Dimension (L*W*H mm)	580*480*480	1,300*1,000*600	1,200*800*700
Capacity	100 (L/H)	300 (L/H)	500 L
Density of produce	1~100ppm	1.5 ppm	26 KHz
Power	0.5kw	0.5kw	0.5kw
Remark	Non sheet type	Injector type	with air bubble

7. Spin-drying performance tests

The spin-drying equipment consisted of a spin-drying drum, controller, and a body (Fig 3, Table4). The spin-drying speed was set between 0 ~ 1,000 rpm for leaf safety. The spin-drying rate was calculated based on leaf weights before and after washing. Moreover, a damaged leaf rate was computed from the weight of leaves that were damaged after spin-drying.

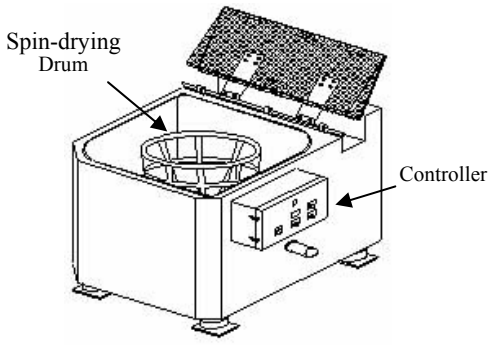

Fig. 3 Schematic diagram of spin-dryer