Food Sci. Biotechnol. Vol. 17, No. 2, pp. 421 ~ 424 (2008)

RESEARCH NOTE

Food Science and Biotechnology

Application of Edible Red Algae Paper Coated with Green Tea Extract for Shelf Life Extension of *Kimbab*

Kyoung-Ju Ku, Yun-Hee Hong, Yung Bum Seo[1], Kyung-Sook Chung[2], Mi-Sun Won[2], and Kyung Bin Song*

Department of Food Science and Technology, Chungnam National University, Daejeon 305-764, Korea
[1]Department of Forest Products, Chungnam National University, Daejeon 305-764, Korea
[2]Korea Research Institute of Bioscience and Biotechnology, Daejeon 305-806, Korea

Abstract Edible red algae paper coated with green tea extract was prepared and determined the microbial growth and quality change of *kimbab* wrapped with the paper during storage. The paper coated with green tea extract had the antimicrobial activity against *Listeria monocytogenes and Escherichia coli*. After 12 hr of storage of *kimbab*, packaging with the paper coated with green tea extract decreased populations of total aerobic bacteria by 1 log cycle. *Kimbab* wrapped with the red algae paper coated with green tea extract had 5.5 mg malondialdehyde (MDA)/kg after 12 hr, in contrast to the control of 7.4 mg MDA/kg. *Kimbab* with red algae paper with green tea extract was better than the control in terms of sensory qualities. These results clearly indicate that *kimbab* can be packaged with red algae paper coated with green tea extract, resulting in extending its shelf life.

Keywords: green tea extract, *kimbab*, red algae paper, shelf life, storage

Introduction

Kimbab is widely consumed as a major ready-to-eat food in Korea. However, there is always a hazard risk of food poisoning caused by contamination from the materials used for manufacturing of *kimbab* (1). In particular, raw materials as ingredients for *kimbab* are easily deteriorated by microbial growth, since *kimbab* contains high moisture content (2). Therefore, microbial safety of *kimbab* should be evaluated during storage and marketing.

For extending shelf life of foods, edible films are used as a packaging. Edible films include starch or protein based films, and they may contain nisin or chitosan (3) as a functional material in the formulation (4,5). Among the functional materials used for coating of edible films, green tea extract can be used as an anti-oxidative material (6,7).

Recently, the use of red algae pulp has been investigated for manufacturing papers (8). Therefore, the objectives of this study were to prepare edible red algae paper coated with green tea extract for food packaging, and to determine the microbial growth and quality change of *kimbab* packaged with the paper.

Materials and Methods

Materials Red algae paper was supplied by Pegasus International Co. (Daejeon, Korea). Green tea extract was purchased from Dongsoe Co. (Siheung, Korea). *Kimbab* was purchased from a local market in Daejeon, Korea.

Coating of red algae paper with green tea extract Red algae paper was coated with green tea extract (1.42, 2.83, and 5.6% in distilled water) by spraying, and then dried at 120°C for 1 min.

*Corresponding author: Tel: +82-42-821-6723; Fax: +82-42-825-2664
E-mail: kbsong@cnu.ac.kr
Received July 25, 2007; accepted September 18, 2007

Measurement of antimicrobial activity of red algae paper coated with green tea extract The antimicrobial activities of red algae paper coated with green tea extract were determined according to the modified Ko's method (9). *Listeria monocytogenes* and *Escherichia coli* were incubated in Tryptic Soy broth and Luria-Bertani broth (Difco Co., Detroit, MI, USA) at 37°C, respectively, until they reach 10^9 CFU/mL. Coated red algae paper was cut into 10×10 cm, treated with UV for 3 hr, and 40 μL of the bacterial suspension was placed onto the paper. The paper was then incubated at room temperature for 60 min. After incubation, the paper was placed in 26.95 mL of 0.1% peptone water, and homogenized for 3 min. The solution was then diluted with 0.1% peptone water and the populations of *L. monocytogenes* and *E. coli* were counted. All plates were incubated at 37°C for 24 hr. Each microbial count was the mean of 3 determinations and was expressed as colony forming unit (CFU/g).

Packaging of *kimbab* with red algae paper *Kimbab* was wrapped with red algae paper, and red algae paper coated with green tea extract (2.83%), respectively. The control was the *kimbab* in the plain paper box supplied by a manufacturer. *kimbab* was stored at room temperature for 36 hr.

Microbiological analysis of *kimbab* during storage Ten g of *kimbab* samples was removed using a sterile scalpel, and placed in 90 mL of 0.1% peptone water. Samples were then homogenized in a sterile stomacher bag using a Stomacher (MIX 2; AES Laboratoire, France) for 3 min, filtered through a sterile cheese cloth, and diluted with peptone water for microbial count. Serial dilutions were performed in triplicate on each selective agar plate. Total bacterial counts were determined by plating appropriately diluted samples onto plate count agar (PCA, Difco Co.). Samples were evenly spread on the surface of the plates with a sterile glass rod. Coliforms were plated on

Luria-Bertani agar (Difco Co.). Both plates were incubated at 37°C for 48 hr. Each microbial count was the mean of 3 determinations, and was expressed as log CFU/g.

Measurement of lipid oxidation of *kimbab* during storage Degree of lipid oxidation of *kimbab* was determined according to the methods of Zhu *et al.* (10). Samples were homogenized in 15 mL of distilled water using a blender for 1 min. Sample solution of 1 mL was transferred to a disposable test tube, and 2-thiobarbituric acid/ trichloroacetic acid (TBA/TCA) solution of 2 mL was added. The mixture was then vortexed and boiled in a water bath for 15 min. The sample was cooled at room temperature for 10 min and then centrifuged for 15 min at 2,000×g. The absorbance of the resulting supernatant solution was determined at 531 nm. Thiobarbituric acid reacted substance (TBARS) value was expressed as mg malondialdehyde per kg sample (MDA/kg).

Sensory evaluation Samples were analyzed during storage for freshness, texture, flavor, color, and overall acceptability by 7 trained panelists. Sensory qualities of samples were evaluated using a 5-point hedonic scale method. Sensory scores were 5: very good, 4: good, 3: fair, 2: poor, 1: very poor. Analysis of variance and Duncan's multiple range tests were performed to analyze the results statistically using a SAS program (11).

Results and Discussion

The antimicrobial activities of red algae paper coated with green tea extract against *L. monocytogenes and E. coli* are shown Fig. 1. Increase of green tea extract concentration increased the degree of inhibition of microbial growth. Catechin is a polyphenolic compound in green tea extract, which are known to be antioxidant and antibacterial (12). Park *et al.* (13) reported that green tea extract contains 35.34 g of catechin and has antimicrobial activity as well as antioxidative property. Sung (14) also reported that populations of *Salmonella typhimurium* were reduced by 0.9 log CFU/g within 24 hr by addition of 1% green tea extract.

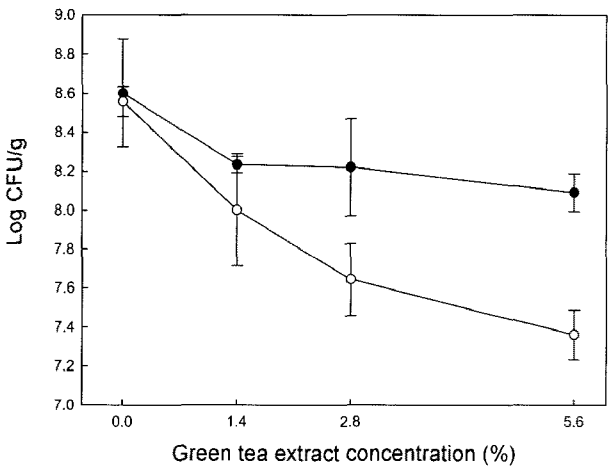

Fig. 1. Antimicrobial activity of red algae paper coated with green tea extract. ●, *Listeria monocytogenes;* ○, *Escherichia coil.*

We determined the microbial growth and quality change of *kimbab* packaged with red algae paper during storage. Figure 2 represents the results of total aerobic bacteria counts of *kimbab* during storage. Populations of total aerobic bacteria of *kimbab* wrapped with red algae paper coated with green tea extract were reduced significantly, compared to the control. After 12 hr of storage, packaging with red algae paper coated with green tea extract decreased populations of total aerobic bacteria by 1 log cycle. In addition, there was a difference of 0.5 log CFU/ g between the control and the red algae paper packaging in terms of bacterial count after 36 hr of storage. This difference is due to the characteristic property of the red algae paper, which mainly consists of polymerized galactose.

Figure 3 represents the results of changes in populations of coliforms in *kimbab* during storage. Like total aerobic bacteria, populations of coliforms were also reduced by packaging with red algae paper coated with green tea extract. After 24 hr of storage, the control reached 6.9 log CFU/g, while wrapping with red algae paper coated with

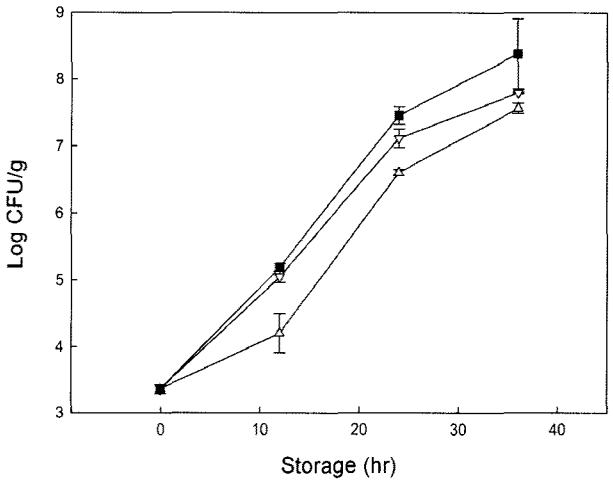

Fig. 2. Changes in total aerobic bacteria counts of *kimbab* during storage. ■, Control; ▽, red algae paper; △, red algae paper coated with green tea extract.

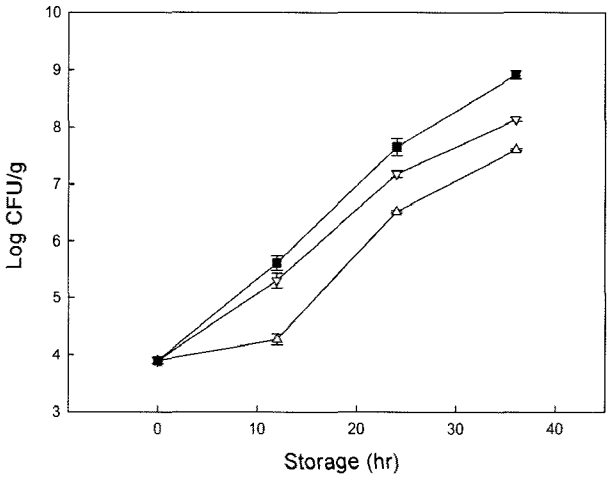

Fig. 3. Changes in populations of coliforms of *kimbab* during storage. ■, Control; ▽, red algae paper; △, red algae paper coated with green tea extract.

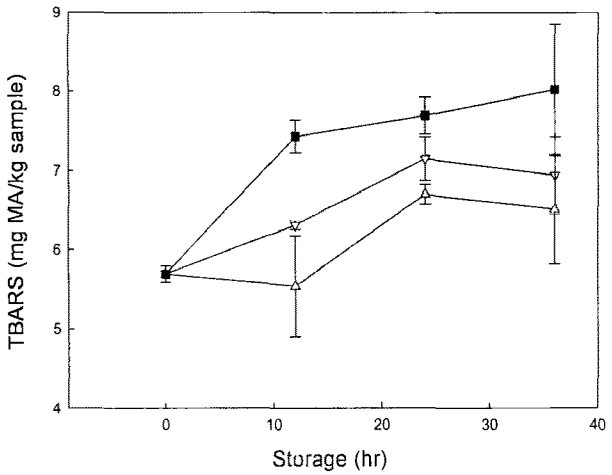

Fig. 4. Changes in thiobarbituric acid reacted substance values of *kimbab* during storage. ■, Control; ▽, red algae paper; △, red algae paper coated with green tea extract.

green tea extract had 6.1 log CFU/g. These results had a similar pattern as gamma irradiation treatment of *kimbab* at 1 kGy (15). Kim *et al.* (15) have reported that *kimbab* is usually contaminated during preparation of *kimbab* rather than raw materials. Considering that *kimbab* had 8.2 log CFU/g of total aerobic bacteria, 9.0 log CFU/g of coliforms after 36 hr, it needs quality assurance of *kimbab* during marketing. Therefore, these results clearly suggest that strict regulation on shelf life of *kimbab* should be required. TBARS values of *kimbab* during storage are shown in Fig. 4.

TBARS value represents the degree of lipid oxidation of foods. TBARS values of *kimbab* samples increased with time during storage. *Kimbab* that wrapped with the red algae paper coated with green tea extract had 5.5 mg MDA/kg after 12 hr, in contrast to the control of 7.4 mg MDA/kg. These results represent that lipid oxidation of *kimbab* was deterred by wrapping with red algae paper coated with green tea extract.

Sensory evaluation results of *kimbab* during storage are shown in Table 1. Sensory qualities such as freshness, texture, flavor, color, and overall acceptability were examined during storage. Score up to 3 was evaluated as being acceptable.

Kimbab was edible after 12 hr of storage, but after 24 hr most samples were not acceptable. However, it should be noted that *kimbab* wrapped with red algae paper with green tea extract were better in terms of all aspects of sensory qualities. Therefore, our results in this study clearly indicate that *kimbab* can be packaged with edible red algae paper coated with green tea extract, resulting in extending shelf life for at least 6 hr more based on microbial growth pattern of *kimbab* during storage.

Acknowledgments

This study was supported by a grant from the Daedeok Innopolis, Ministry of Science & Technology, Korea.

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Table 1. Sensory evaluation of *kimbab* during storage

	Packaging type	Storage period[1)] (hr)			
		0	12	24	36
Taste	Control	5.00±0.00^{a}	4.00±0.00^{b}	3.00±0.54^{a}	1.00±0.00^{b}
	Red algae paper	5.00±0.00^{a}	4.43±0.54^{ba}	2.29±0.49^{a}	1.14±0.38^{b}
	+ Green tea extract	5.00±0.00^{a}	4.71±0.49^{a}	2.86±0.38^{a}	1.71±0.49^{a}
Flavor	Control	5.00±0.00^{a}	3.86±0.90^{ba}	1.86±0.90^{a}	1.00±0.00^{b}
	Red algae paper	5.00±0.00^{a}	4.00±0.82^{ba}	2.00±0.58^{a}	1.29±0.49^{ba}
	+ Green tea extract	5.00±0.00^{a}	4.57±0.79^{a}	2.71±0.49^{a}	1.57±0.53^{a}
Color	Control	5.00±0.00^{a}	3.86±0.69^{b}	2.86±0.69^{a}	1.00±0.00^{c}
	Red algae paper	5.00±0.00^{a}	4.14±0.69^{ba}	2.71±0.76^{a}	1.43±0.54^{bc}
	+ Green tea extract	5.00±0.00^{a}	4.71±0.49^{a}	3.43±0.79^{a}	1.86±0.38^{ba}
Texture	Control	5.00±0.00^{a}	3.71±0.70^{a}	2.29±0.88^{a}	1.00±0.00^{b}
	Red algae paper	5.00±0.00^{a}	4.00±0.00^{a}	2.57±0.50^{a}	1.57±0.73^{ba}
	+ Green tea extract	5.00±0.00^{a}	4.14±0.35^{a}	2.57±0.50^{a}	1.86±0.83^{a}
Overall acceptance	Control	5.00±0.00^{a}	3.57±0.54^{c}	2.57±0.79^{b}	1.00±0.00^{d}
	Red algae paper	5.00±0.00^{a}	4.00±0.58^{cb}	2.43±0.54^{ba}	1.57±0.54^{bc}
	+ Green tea extract	5.00±0.00^{a}	4.86±0.38^{a}	3.00±0.00^{a}	2.00±0.00^{a}

[1)]Mean±SD. Any figures in the same column with different letters are significantly different at $p<0.05$ level by Duncan's multiple range test.

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