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Extending Shelf-Life of Leaf Lettuce Using Active Packaging

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Abstract: Fresh leaf lettuce was packaged with 3 types of active packaging materials, namely Cerifeldspar, Alimac and Torustone and stored at 5 and 25°C for up to 5 days. The effects of active packaging on the physicochemical and sensory qualities of leaf lettuce were investigated. The fresh weight of all samples markedly decreased during storage regardless of storage temperature and packaging type but the reduction rates were significantly higher in samples stored at 25°C. On the whole, trends of color values of all lettuce samples during storage displayed a noticeable increase for L^*, a^*, b^* and ΔE. Vitamin C content decreased in all samples during storage regardless of storage conditions. There was a gradual loss of OVQ during 5 days of storage and the visual quality of lettuce deteriorated more rapidly at 25°C than at 5°C. The degree of yellowing increased rapidly when the samples stored at 25°C than those stored at 5°C. Samples stored in an Alimac-coated paper exhibited better overall quality as compared with others.

Key words: Active packaging, shelf-life, leaf lettuce, physicochemical, sensory

INTRODUCTION

Lettuce (*Lactuca sativa* L.) is an important dietary leafy vegetable and has been a major source of dietary carotenoids (Liu *et al*., 2007; Moeller *et al*., 2000). It is consumed fresh or in salad mixes and its per capita consumption has steadily increased. Leaf lettuce, like other leaf vegetables, readily deteriorates during storage due to high respiration rate. The limited shelf-life of fresh processed leafy lettuces is one of the major problems faced by commercial marketers (Soliva and Martin, 2003). Despite the use of Modified Atmosphere Packaging (MAP) is common to achieve the necessary post-harvest shelf-life (Brecht *et al*., 2003), it is very difficult to identify an optimal storage atmosphere (Saltveit, 2003). Therefore, it is desired to investigate any workable alternative preservation treatments. Recent development in packaging methods could be another answer to prolonged shelf-life of leaf lettuce.

The aim of this research was to study the effects of different types of active packaging materials (i.e., Cerifeldspar (C), Alimac (A) and Torustone (T)) which generate different numbers of anion on the physicochemical and sensory qualities of leaf lettuce during storage at 5 and 25°C for up to 5 days.

MATERIALS AND METHODS

Sample preparation: Fresh leaf lettuce was obtained from a local market (Hayang, Gyeongbuk, Korea) and washed by soaking bucket containing 40 ppm chlorinated water for 3 min. After removing excessive surface moisture, lettuce wrapper and core leaves were discarded and 5 pieces of whole leaves were placed in corrugated fiberboard boxes with overall dimensions of 11×27×5 cm. Three surfaces of box inside were covered with A4-sized papers coated with 5% solution containing selected minerals (particle size of c. 30 μm); Cerifeldspar (C), Alimac (A) and Torustone (T) using a bar coater #40. The containers were stored at 5 and 25°C for 5 days. The samples stored without coated papers used as a control.

Weight loss and moisture content measurements: Weight of cut lettuce was recorded initially and after storage and the difference was used to calculate percent weight loss. The moisture content was determined using convection oven at 105°C overnight. The samples were then placed in a desiccator before weighing. All samples were returned to the oven and dried until constant moisture was obtained. Each weight loss was measured 5 times and moisture analysis was performed in triplicate.

Color assessment: Surface color was measured using a Chromameter (model CR-200, Minolta Co., Osaka, Japan) calibrated with a calibration plate using Y=94.2, x=0.3131 and y=0.3201. Color was recorded using the *CIE*-$L^*a^*b^*$ uniform color space, where L^* indicates lightness, a^* indicates chromaticity on a green (-) to red (+) axis and b^* chromaticity on a blue (-) to yellow (+) axis. Measurements were taken for 10 positions from 5 samples and the average values were reported. The total color difference (ΔE) was calculated using the following equation.

$$\Delta E = \sqrt{(L*_o - L*)^2 + (a*_o - a*)^2 + (b*_o - b_o)^2}$$

Where, $L*_0$, $a*_0$ and $b*_0$ represented the readings at time zero and $L*$, $a*$ and $b*$ represented the individual readings at any storage condition.

Vitamin C measurement: Vitamin C content was determined by the method of Nourian *et al.* (2003) with some modifications. Three grams of each sample were extracted with 87 mL of 5% HPO_3 and filtered through a No. 1 Whatman filter paper. One to two drops of 0.2% indophenol solution was added to 2.0 mL of the filtrate, followed by 2 mL of 2.0% 2,4-Dinitro Phenylhydrazine (DNP) reagent and 2 mL of 1.0% thiourea. The test tubes were incubated in a water bath at 50°C for 30 min and cooled in ice. Five milliter of 85% H_2SO_4 to each tube and the absorbance was measured by an UV-spectrophotometer (UV-1201, Shimadzu Co, Ltd., Kyoto, Japan), at 540 nm, from which the ascorbic acid contents were computed.

Overall Visual Quality (OVQ) measurement: OVQ of minimally processed leaf lettuce was evaluated using a scale from 6-0 where 6 = excellent and 0 = very poor with at least 5 trained panel. Degrees of yellowing were also measured using a similar scale where 6 = complete and 0 = none. Quality evaluations were carried out immediately after removal of the sample from each treatment. An OVQ rating of 3 was considered the minimum score required for salability.

RESULTS AND DISCUSSION

Weight loss and moisture content: The influences of storage temperature and packaging type on weight loss of leaf lettuce are presented in Fig. 1. The fresh weight of all samples markedly decreased during storage regardless of storage temperature and packaging type but the reduction rates were significantly higher in samples stored in a

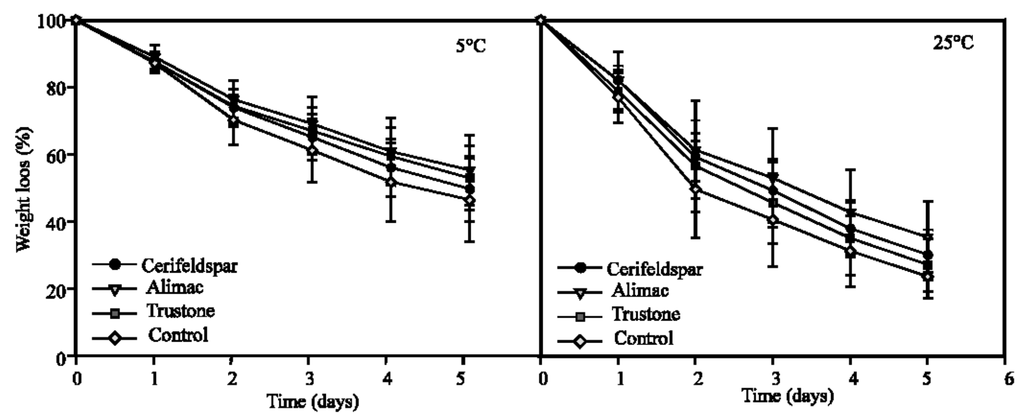

Fig. 1: Changes in weight loss of leaf lettuce as influenced by active packaging conditions

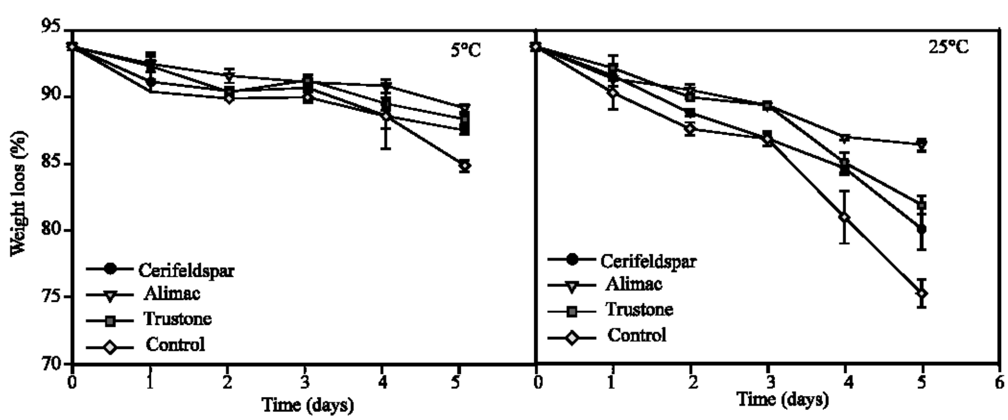

Fig. 2: Changes in moisture content of leaf lettuce as influenced by active packaging conditions

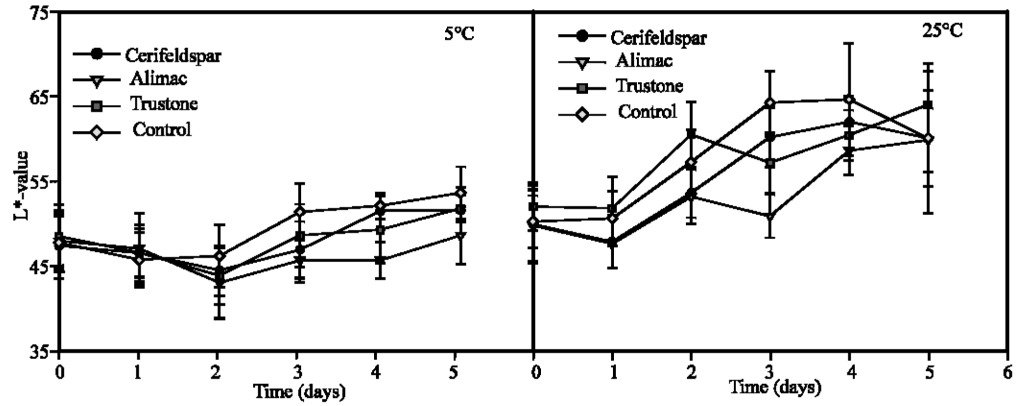

Fig. 3: Changes in L^*-value of leaf lettuce as influenced by active packaging conditions

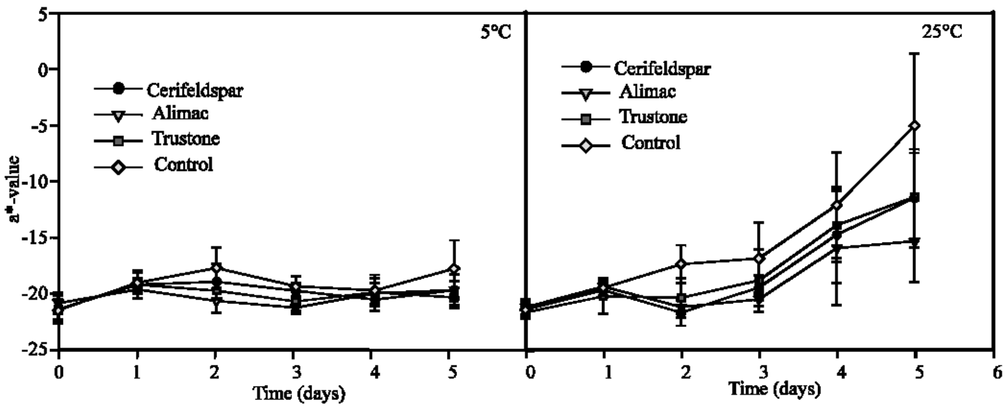

Fig. 4: Changes in a^*-value of leaf lettuce as influenced by active packaging conditions

higher temperature (25°C) as expected. The loss of weight with storage period is expected due to loss of water by continual transpiration of lettuce during storage. The weight loss in the control was most severe regardless of storage temperature as compared with samples stored with any mineral-coated papers. Especially, samples stored with Alimac-coated papers ("A") maintained better fresh weight during whole storage period regardless of storage temperatures. The control lost 53.63 and 76.51% of initial weight when stored in 5 and 25°C for 5 days, respectively. On the sother hand, "A" samples lost 44.72 and 64.69% at the same conditions. Different types of packaging may affect the quality changes and this reduction of weight loss may be related to the decrease of transpiration rate, the inhibition of respiratory activity and delaying senescence (Ben yehoshua *et al*., 1979).

Similar trends in the reduction of moisture content were found (Fig. 2). Samples stored in a higher temperature lost more moisture during storage regardless of packaging conditions. Again, "A" samples maintained more moisture while the control lost more moisture during whole storage period. Bae and Chung (2003) also reported that weight loss and decreasing of moisture contents were higher in the non-packaged lettuce than in the packaged.

Color: The color changes of leaf lettuce expressed by L^*, a^*, b^* and total color difference (ΔE) are shown in Fig. 3-6. On the whole, trends of color values of all lettuce samples during storage displayed a noticeable increase for L^*, a^*, b^* and ΔE. The increases were more evident in samples stored in 25°C than in 5°C as expected in general. The changes in all color parameters in the control were considerably higher than others regardless of storage temperature. Kim *et al*. (1995) also reported that a^* and b^*-values of crisphead lettuce increased during storage at 5°C. These color changes resulted in less attractive vegetable and may be a consequence of the greater moisture loss during storage. Changes in color were most noticeable in the control compared to "A" samples which maintained color parameters during storage better than others in general.

Vitamin C: Changes in vitamin C during storage as affected by storage temperature and packaging materials

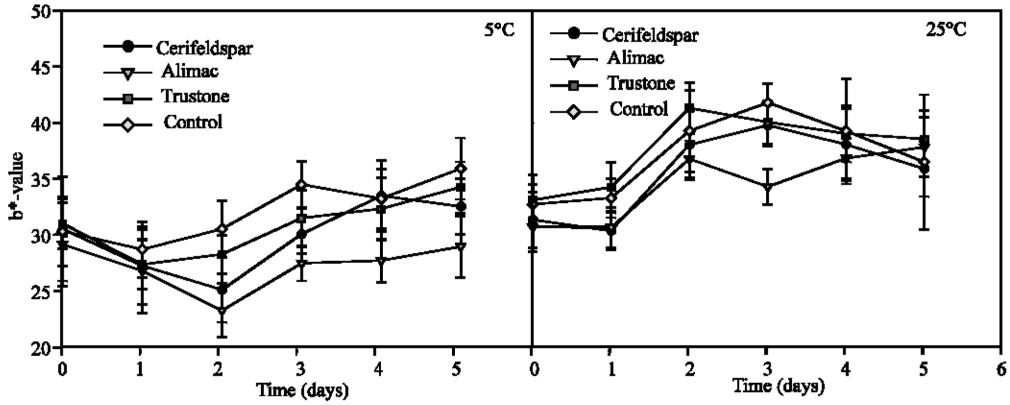

Fig. 5: Changes in *b**-value of leaf lettuce as influenced by active packaging conditions

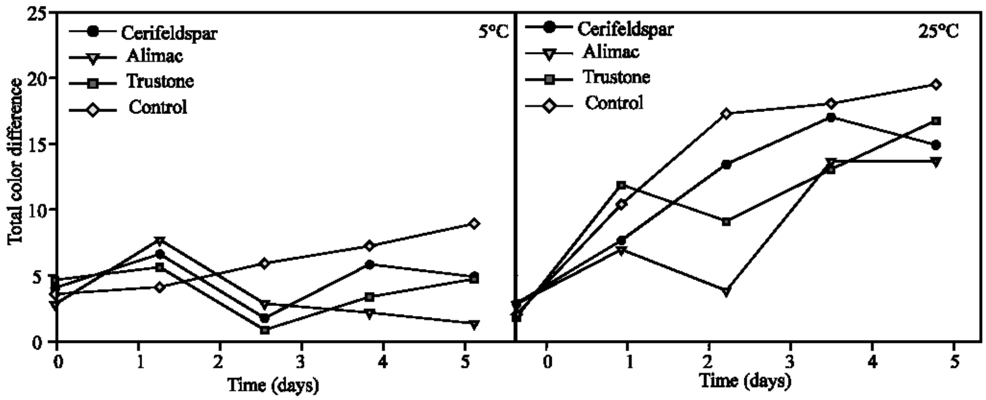

Fig. 6: Changes in of leaf lettuce as influenced by active packaging conditions

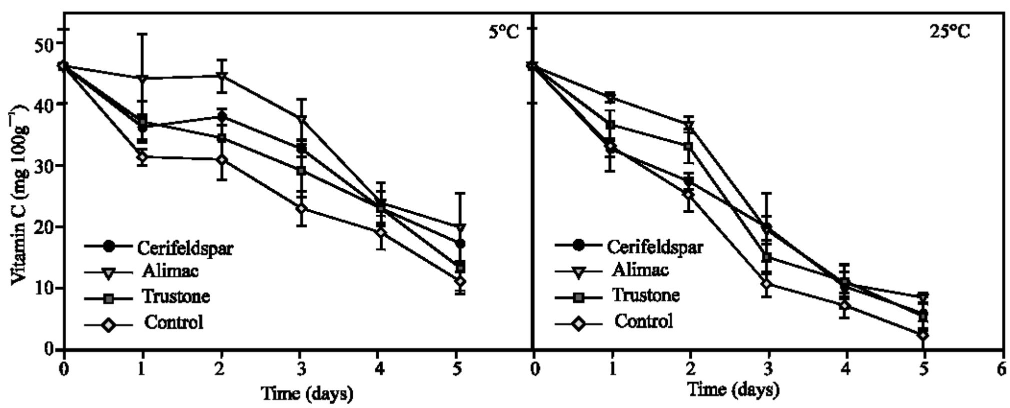

Fig. 7: Changes in vitamin C content of leaf lettuce as influenced by active packaging conditions

are shown in Fig. 7. Vitamin C content decreased in all samples during storage regardless of storage conditions. Similar decrease in the vitamin C content of leaf lettuce packaged with high-density polyethylene film during cold storage (0-1 and 4-5°C) for up to 40 days (Yang *et al.*, 1991) and crisphead lettuce stored at 5°C for 20 days (Kim *et al.*, 1995). They also indicated that the reduction was delayed for the samples stored at 0-1°C. We found that the reduction was more severe for the samples stored in higher temperature (25°C) than those in low temperature (5°C). This type of delay was reported for other fruits and vegetables (Hudson and Mazur, 1985; Yamaguchi *et al.*, 1980).

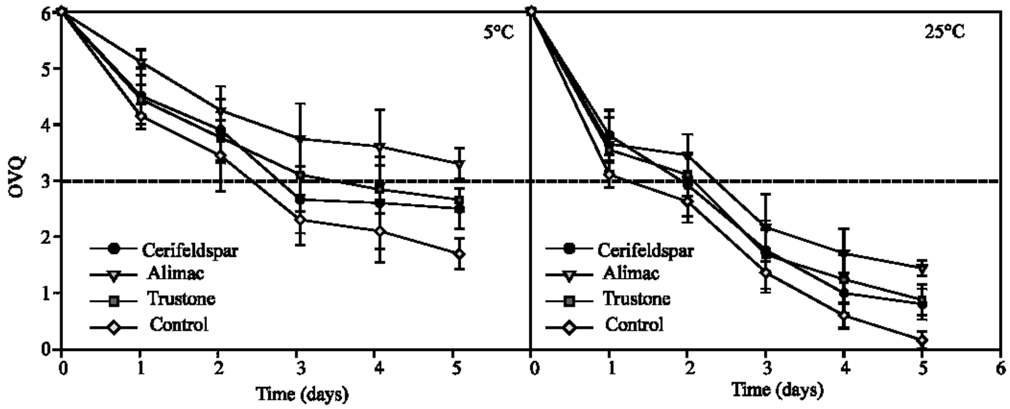

Fig. 8: Changes in Overall Visual Quality (OVQ) of leaf lettuce as influenced by active packaging conditions

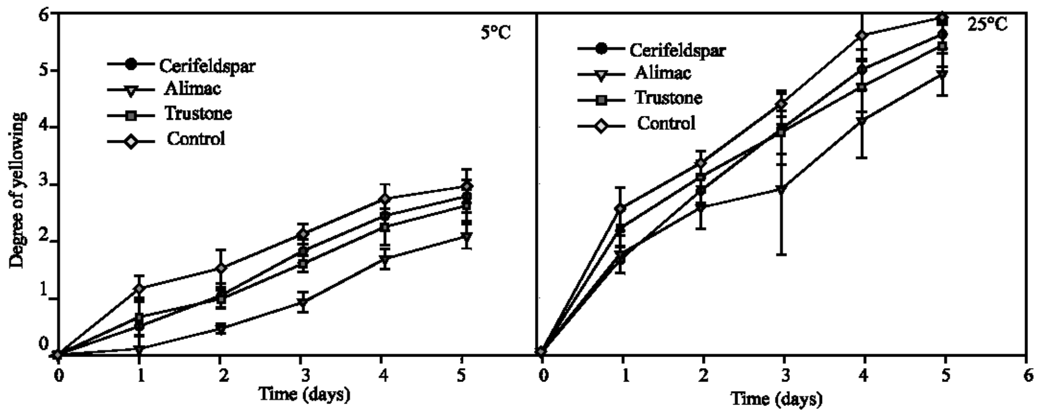

Fig. 9: Changes in degree of yellowing of leaf lettuce as influenced by active packaging conditions

OVQ and degrees of yellowing: Overall visual quality and degrees of yellowing determined by trained panel are shown in Fig. 8 and 9, respectively. There was a gradual loss of OVQ during 5 days of storage and the visual quality of lettuce deteriorated more rapidly at 25°C than at 5°C (Fig. 8). On day 3, the OVQ of all samples stored at 25°C, regardless of treatment, was below the limit of salability. Sample "A" exhibited a better OVQ retention compared to other treatments during storage and it is noted that the sample scored 3.3 even at day 5 on the 6-point hedonic scale, representing above the limit of salability, which was considerably different from the others. On the other hand, the control sample exhibited a high decline in OVQ during storage and was scored 1.7 and 0.16 at day 6 at 5 and 25°C, respectively.

One of the most important quality deterioration during postharvest, transport and storage period is the loss of green color (i.e., leaf yellowing). The degree of yellowing increased rapidly when the samples stored at 25°C than those stored at 5°C. Similar temperature effects were reported for romaine lettuce (Aharoni and Ben-yehoshua, 1973). It is also noted that the degree of yellowing was significantly less changed for the samples packaged with Alimac ("A") than for the control regardless of temperature condition. This increase in the degree of yellowing during storage would probably result from the loss of chlorophyll during storage (Bolin and Huxsoll, 1991).

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