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Improving Postharvest Cabbage (*Brassica oleracea* L. **var.** *capitata*) Quality Using Alum and Newspaper Wrap

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Abstract

Three handling experiments with 4 treatments each (i.e., control, newspaper wrap, alum, alum with newspaper wrap) were conducted to verify the benefits of alum spray and newspaper wrapping in reducing soft rot incidence in cabbage (cv. Rareball). The cabbages were packed in polyethylene bags and transported from the trading post in La Trinidad, Benguet (in Northern Luzon) to Los Baños, Laguna (in Southern Luzon). In experiment A, the lowest soft rot infection upon arrival and opening of the bags was noted in heads sprayed with a single application of 15% alum and then wrapped with newspaper. The same trend was shown in experiments B and C. Alum sprayed singly resulted in slightly greater disease than when alum spray was followed by newspaper wrapping. Disease incidence, however, was lesser relative to the control heads and those which were wrapped with newspaper without alum spray. Disease reduction was more evident in the applied part (i.e., the butt end) compared to the head portion of the cabbage. Both alum spray and newspaper wrapping reduced disease incidence, the latter providing a drier condition for the cabbage during transport. Mechanical damage was least in the cabbages either wrapped in newspaper or treated with alum initially prior to wrapping. Sorting a day after removing the cabbages from the polyethylene bags can further reduce disease incidence. Alum and newspaper are readily available local materials. In decreasing the incidence of soft rot infection in cabbages, the commodity maintains the consistency of its quality and, thus, its acceptability in the market.

Keywords: alum; bacterial soft rot; *Brassica oleracea* L. var. *capitata*; cabbage; market quality; postharvest handling

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Abbreviations:

PEB - polyethylene bags
DMRT - Duncan's Multiple Range Test

Introduction

Problems that plague the vegetable industry in the Philippines include not only how to increase production but also how products can be moved without incurring too much wastage. In perishable crops such as vegetables, freshness, good quality, and longer shelf life are always desirable. Kramer and Twiggs (1970) defined *quality* as the composite of attributes that differentiate among units of a product and have significance in determining the degree of acceptability of the unit by the buyer. Produce quality of perishable crops may be expressed by means of quality criteria, which include, among others, physical, nutritional, hygienic, and technological (i.e., appearance, flavor, and texture) properties (Madakadze and Kwaramba, 2004). The genetic, preharvest, and postharvest practices contribute to the overall quality of the produce as it goes through a supply chain. Validating, understanding, and developing conditions for quality preservation systems for a fresh produce always pose a challenge (Tongdee, 2001).

Disease is a major cause of postharvest loss in perishables. For vegetables, this accounts for 40% to 50% of the losses (Pantastico, 1975; Estigoy, 2006). Bacterial soft rot (*Pectobacterium carotovorum* subsp. *carotovorum* [*Erwinia carotovora*]) is one such disease which continue to cause losses for the Philippine vegetable industry. The soft rot pathogen attacks both standing and harvested crops. The spread is much higher during the rainy season. Soft rot incidence and control also vary with vegetable cultivar.

Cabbage (*Brassica oleracea* L. var. *capitata*), an important vegetable crop in Northern Philippines, is susceptible to bacterial soft rot. The disease usually develops at the cut butt end of a cabbage head and is manifested as a soft mushy lesion with offensive, foul odor. Its spread can be controlled by trimming, but losses due to trimming can be enormous, ranging from 22% to 45% of the cabbage head weight after only 4 days from pathogen inoculation (Acedo et al., 1999). *P. carotovorum* subsp. *carotovorum* is one of the most common bacterial agents in many vegetable crops (Tournas, 2005). How to minimize this disease has been a great problem of growers of cabbage and other vegetable crops.

Alum has been reported as a potential postharvest control of cabbage soft rot (Geronimo, 1984; Estrada et al., 1988). The common alum of commerce is the potassium alum, which is the hydrated aluminum potassium sulfate. It is a cheap antibacterial agent. It inhibits bacterial growth; thus, it is commonly used as a deodorant. Alum powder is found among spices at most grocery stores. It is used in pickling recipes as preservative to maintain crispness.

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Wholesalers use newspaper wrapping for produce like cabbage, Chinese cabbage, and lettuce transported from Northern Luzon to Manila (Bayogan et al., 1998). This is also a practice by Chinese cabbage wholesalers in Eastern-central China (Xiangyang and Bagshaw, 2001).

This study was conducted to verify the efficiency of alum applied singly on a commercial cabbage shipment and to determine the benefits that could be derived by alum treatment and wrapping of each head with newspaper prior to packing and transport.

Materials and Methods

Cabbages (cv. Rareball) that were traded at the La Trinidad Trading Post were used as the experimental materials. The cabbage crop was grown in Kibungan, Benguet, 73 km to La Trinidad, in Northern Luzon. The cabbage heads were harvested the previous day and were brought to the La Trinidad Trading Post early during the day of the trial. Most deliveries of vegetable crops marketed and handled at the trading post usually arrive in the afternoon. The cabbage heads (with 2 to 3 wrapper leaves intact) were purchased in the afternoon upon arrival (at around 1400h) and treated 2 hours later. These were packed and loaded in a 1-ton-capacity vehicle and transported to Los Baños, Laguna, in Southern Luzon at 0130h. In the vehicle, the bags of cabbages were arranged randomly in the middle portion. Non-experimental bags of cabbages were piled in the bottom, sides, and top portions of the vehicle. Upon arrival in Los Baños, the temperatures of the various locations in the cabbage pile at the back of the 1-ton-capacity vehicle were as follows: top, 34.9°C; middle, 31.6°C; and bottom, 26.9°C. The temperature inside the bag located at the middle of the vehicle was 28°C. The cabbage heads were then held in a packing house area with a temperature of 25°C to 28°C. Initial evaluation of the cabbage heads was done 12 hours after loading in the vehicle.

Experiment A. This consisted of cabbages packed in polyethylene bags (PEB), opened upon arrival (i.e., about 20 hours from treatment) in Los Baños, and evaluated at 1, 2, and 3 day/s after transport. All bags were opened but those labeled to be evaluated later were simply unpacked in plastic trays and held in ambient conditions.

Experiment B. This consisted of cabbages in PEB, which were opened 1 day from arrival. Heads were carefully spread on cemented floor lined with paper.

Experiment C. This consisted of bags of cabbages opened 1 day from arrival and then sorted for soft rot. This was followed by holding of sorted heads. The sorted heads were again evaluated for soft rot incidence 2 days after treatment (i.e., at day 3).

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Treatments for all the experiments consisted of the following:

1 control
2 heads wrapped in newspaper alone
3 15% alum sprayed on the butt end of the cabbage head
4 15% alum sprayed on the butt end of the cabbage head and wrapped with newspaper

Treatments were replicated 3 times with a replication consisting of about 20 kg of Rareball cabbage heads packed in PEB. The bags were arranged in a completely randomized design in the vehicle.

Data on soft rot incidence on the head and butt end of the cabbage and mechanical damage were obtained. Disease severity measurement used a scale of 1 to 5, where 1 means "no soft rot"; 3 means "16% to 30% of the surface area with soft rot"; 5 means "46% and more of the surface area with soft rot." Percentage data were transformed using arc sine transformation. Treatment means were compared using DMRT at P=0.05.

Results and Discussion

Total Disease Incidence

Experiment A results showed significant differences on the total disease incidence in cabbage heads sprayed with alum, whether wrapped with newspaper or not, and the control heads and those wrapped with newspaper alone (Table 1). This was observed upon arrival and 1 day after transport. Later evaluation at 2 and 3 days from transport, however, showed that disease incidence did not differ significantly among the treatments. The use of sheets of newspaper to provide dry conditions around the alum-treated butt end and portions of the head helped in further reducing disease incidence. Though not significant, consistently lower disease incidence was observed in cabbage heads treated with alum and wrapped with newspaper upon arrival up to the third day after transport. In Indonesia, the application of cement on the cut end of the cabbage head allowed for dry conditions in the produce. This was an important factor in the control of soft rot in cabbage heads (Hisao and Yamada, 2004).

In experiment B, a high soft rot incidence was observed after 1 day of holding at 25°C to 27°C. Alum-treated cabbage heads then wrapped in newspaper gave a lesser disease incidence of 49%. These cabbage heads wrapped with newspaper with or without alum gave a relatively lesser disease incidence over the control which were 80% soft rot infected. There were no significant differences in total disease incidence on the second and third days of evaluation. The more humid conditions inside the bag contributed to the higher disease levels of the produce.

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Table 1. Total disease incidence[1] (%) in cabbage heads treated with alum and wrapped in newspaper in La Trinidad, Benguet, then transported to Los Baños, Laguna

Experiment / Treatment	Day 0	Day 1	Day 2	Day 3
A				
Control	54[a]	67[a]	74[a]	76[a]
Newspaper wrap	43[a]	57[a]	69[a]	82[a]
Alum	9[b]	40[b]	58[a]	69[a]
Alum + newspaper wrap	3[b]	21[b]	40[a]	49[a]
B				
Control		80[a]	80[a]	87[a]
Newspaper wrap		66[ab]	75[a]	80[a]
Alum		70[ab]	78[a]	86[a]
Alum + newspaper wrap		49[b]	69[a]	79[a]
C				
Control				81[a]
Newspaper wrap				66[a]
Alum				64[a]
Alum + newspaper wrap				30[b]

[1] Means in a column within each experiment with common letters are not significantly different based on DMRT (P = 0.05).

The third experiment made use of cabbages unpacked 1 day after transport followed by sorting. Sorting, combined with spraying 15% alum and individually wrapping the cabbages, resulted in a 63% reduction of disease relative to the control. The disease reduction levels observed in these trials may be further improved by a two-time alum application, right after harvesting and again after arrival in the market, as suggested by Estrada et al. (1988). This, however, is more time consuming and laborious.

Opening the film bags containing the heads immediately upon arrival minimized the spread of infection as evidenced by the lesser infection observed. This meant that infection was already present at harvest (Madakadze and Kwaramba, 2004) but symptoms were not distinct at packing. Incipient infections at harvest are a major cause of the decay that develops during marketing (Liu and Ma, 1983; Perombelon and Kelman, 1980). Several bacterial species classified in different genera can enzymatically macerate parenchymatous tissue and give the characteristic mushy lesions of diseased produce (Perombelon and Kelman, 1980). *P. carotovorum* subsp. *carotovorum* can quickly spread from

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Table 2. Disease incidence[1] (%) on the butt end of cabbage heads treated with alum and wrapped in newspaper in La Trinidad, Benguet, then transported to Los Baños, Laguna

Experiment / Treatment	Day 0	Day 1	Day 2	Day 3
A				
Control	46[a]	49[a]	49[a]	50[a]
Newspaper wrap	35[a]	43[a]	51[a]	54[a]
Alum	0[b]	11[b]	16[b]	18[b]
Alum + newspaper wrap	0[b]	5[b]	7[b]	7[b]
B				
Control		66[a]	66[a]	66[a]
Newspaper wrap		55[a]	55[a]	58[a]
Alum		55[a]	57[a]	57[a]
Alum + newspaper wrap		15[b]	29[b]	39[b]
C				
Control				81[a]
Newspaper wrap				74[a]
Alum				38[b]
Alum + newspaper wrap				22[b]

[1] Means in a column within each experiment with common letters are not significantly different based on DMRT (P = 0.05).

infected to non-infected vegetable during transport and storage as can happen in growing plants.

Disease Incidence on Butt End

Alum-treated cabbage heads and those sprayed then wrapped individually with newspaper consistently showed lower disease incidence at the butt end at 1 to 3 day/s after transport for experiment A. A similar trend was observed in experiments B and C (Table 2). The alum-treated cabbage heads in PEB opened immediately after transport showed minimal infection. A lower disease incidence was observed in cabbages treated with alum then wrapped in newspaper relative to heads which received alum treatment alone. On the third day from transport, the control heads and those wrapped in newspaper alone prior to packing in PEB showed high disease incidence of over 50%. This indicates presence of infection after harvest, and conditions during transport like high temperature encouraged the development and spread of the inoculum. Meanwhile, alum treatment alone did not also greatly inhibit soft rot infection of the butt end.

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Cabbages treated with 15% alum and those treated then wrapped with newspaper showed the lowest soft rot incidence at the butt end (experiment C). This indicates a reduction of soft rot occurrence in cabbages sprayed with alum than cabbages which were wrapped or unwrapped with newspaper along with sorting for soft rot.

Disease Incidence on Head

Experiment A. Disease incidences on the cabbage head were not statistically different among the treatments. This was because alum was sprayed only on the butt end of the cabbage heads (Table 3). For the untreated lot and those wrapped with newspaper alone, the infection of the head resulted from contact with the adjoining infected leaves or untreated butt ends of cabbage. This could have been aggravated by packing of the heads in unperforated polyethylene bags where temperature during transport generally increases.

Experiment B. Disease incidence on the head of the cabbages was greater on those sprayed with alum then wrapped with newspaper. This can be due

Table 3. Disease incidence[1] (%) at head part of cabbages treated with alum and wrapped in newspaper in La Trinidad, Benguet, then transported to Los Baños, Laguna

Experiment / Treatment	Day 0	Day 1	Day 2	Day 3
A				
Control	8[a]	18[a]	25[a]	26[a]
Newspaper wrap	8[a]	14[a]	19[a]	28[a]
Alum	9[a]	29[a]	42[a]	51[a]
Alum + newspaper wrap	3[a]	16[a]	33[a]	42[a]
B				
Control		14[a]	14[b]	21[b]
Newspaper wrap		11[a]	20[b]	22[b]
Alum		15[a]	21[b]	29[b]
Alum + newspaper wrap		34[b]	52[a]	61[a]
C				
Control				79[a]
Newspaper wrap				62[a]
Alum				26[b]
Alum + newspaper wrap				20[b]

[1] Means in a column within each experiment with common letters are not significantly different based on DMRT (P = 0.05).

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to soft rot infection in the field, during packing and storage for one day at high temperature (i.e., 25ºC to 28ºC). These are factors that favor soft rot development. During transport, the outer leaves of the cabbages tend to rub the adjoining heads, thereby contributing to greater contamination. Meanwhile, the control, newspaper-wrapped, and alum-treated heads had lesser soft rot infection.

Experiment C. Disease incidence on the head portion of the cabbages showed that lower infection was sustained by those cabbages which were sprayed with alum then wrapped with newspaper. Meanwhile, cabbages which were wrapped with newspaper alone did not differ significantly from the control.

Disease Severity

Soft rot disease was consistently most severe in the control heads and those wrapped with newspaper with means of 2.70% and 2.26%, respectively (Table 4). Similarly, cabbages treated with alum then wrapped with newspaper consistently gave the lowest disease incidence with a mean of 1.45%. In the 3 experiments, alum application figured as the second-best treatment in reducing disease incidence and, thus, improving visual quality.

Mechanical Damage

Mechanical damage in cruciferous vegetables is caused by rough handling at all stages after harvest like throwing the head onto the ground, walking over the pile of packed cabbages on the truck, and overloading of trucks (Xiangyang and Bagshaw, 2001). In the present study, the control cabbages and those that were not wrapped with newspaper but treated with 15% alum sustained greater mechanical damage with a mean of 76.83% and 66.72%, respectively (Table 5). Reduced damage was exhibited by the cabbages which were wrapped with newspaper, whether initially treated or not treated with alum. The newspaper wrapper served to protect the heads from damage during transport as it also

Table 4. Disease severity[1] (%) in cabbage heads treated with alum and wrapped in newspaper in La Trinidad, Benguet, then transported to Los Baños, Laguna

Treatment	A	B	C
Control	2.37[a]	2.38[a]	3.36[a]
Newspaper wrap	2.00[a]	2.53[a]	2.25[a]
Alum	1.57[ab]	1.77[b]	2.03[b]
Alum + newspaper wrap	0.67[a]	1.69[b]	1.99[b]

[1] Means in a column with common letters are not significantly different based on DMRT (P = 0.05).

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Table 5. Mechanical damage[1] (%) in cabbage heads treated with alum and wrapped in newspaper in La Trinidad, Benguet, then transported to Los Baños, Laguna

Treatment	A	B	C
Control	67.67[a]	79.33[a]	83.50[a]
Newspaper wrap	42.33[ab]	50.33[a]	59.00[a]
Alum	67.33[a]	76.33[a]	56.50[a]
Alum + newspaper wrap	34.00[b]	70.33[a]	45.50[a]

[1] Means in a column with common letters are not significantly different based on DMRT (P = 0.05).

minimized contact between heads. The newspaper wrap resulted in reduced disease severity (Table 4).

Identifying the individual source of mechanical damage into burst heads, compression, bruises, and cuts, however, gave no significant differences among treatments (data not shown).

The control heads showed the greatest mechanical damage and the highest disease incidence. Cuts, bruises, compression, burst heads, and torn leaves that resulted during packing and transport often serve as entry points to infection by the soft rot organism, which could partly explain the severity of the disease. Trimming may still improve the visual quality of the cabbages as these were packed and transported with some wrapper leaves intact.

Alum (15%) application on the butt end of the cabbage and wrapping individual heads in newspaper prior to packing in 20-kg polyethylene bags (i.e., modified atmosphere packaging) constitute steps in quality management of this perishable produce. This results in reduced soft rot incidence and availability of more produce at acceptable market quality. These simple technologies when used alongside other postharvest technologies such as sorting, proper trimming, and packing, as well as use of proper packing materials, increase the supply of fresh produce due to reduction of physical damage and the rate of decay (Serrano, 2005).

Conclusions

Alum (15%) sprayed at the butt end of cabbage both wrapped and not wrapped with newspaper prior to transport reduced the soft rot incidence by a mean of 34.4% after 1 day from transport as shown by total incidence in experiments A and B. This trend was evident up to day 2, but not at day 3. This shows the need for a two-time application of alum, a treatment that would require more time and effort, as recommended by Estrada et al. (1988).

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Mechanical damage was reduced by a mean of 26.9% when wrapping heads of cabbage with newspaper individually after alum application. The wrapper alone provided a mean of 10% additional protection for the cabbage compared with no newspaper wrap during transport.

Together, alum treatment and the newspaper wrap reduced bacterial soft rot incidence—the wrapping providing a slightly drier condition that discouraged the development of the disease—and, thus, improved the physical and visual quality of transported cabbage packed in polyethylene bags. Another postharvest practice like sorting, done alongside alum spraying and wrapping in newspaper, further reduced soft rot incidence.

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