Shelf-Life of Carrots (*Daucus carota*) Immersed in Calcium Lactate and Ascorbic Acid Solutions

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***Abstract*—The most common methods to prolong shelf-life of carrots is by refrigeration. This method is effective but the cost of production is high. In rural areas where refrigeration is a luxury, carrot growers suffered big losses during harvest season due to rotting and decay of their products. No studies have been conducted in Philippine setting on the use of simple and readily available chemical method that entails low cost in prolonging the shelf life of carrots. This study focuses on the simple chemical methods that can immediately be used by carrot growers and retailers on how to prolong the shelf-life of their products in the absence of refrigeration. Three treatments were used in this study. T1-control, no immersion, T2 carrots were immersed in 30g/l calcium lactate in different immersion time (10, 20, 30 minutes) and T3 carrots were immersed 30g/l. Ascorbic acid solution in different immersion time (10, 20, 30 minutes). Initial weight, initial volume, final weight, final volume, shelf-life in days and cost analysis per treatment was computed. Result showed significant difference on the final volume of the carrots after 10 days in favor of carrots immersed in 30g/l of Calcium lactate (T2). Same treatment also revealed the highest average final weight after 10 days of shelf-life.**

***Index Terms*—Daucus caurota, calcium lactate, ascorbic acid**

I. Introduction

Carrot is classified as a root vegetable, which grows as tall as one (1) meter. The wild carrot, from which the modern carrot's cultivation is based, has flowers that are rounded, which are bright white in color when it is in full bloom. Such flowers have the width of 3 to 7 centimeters, and the vegetable itself is known to have various colors, such as orange, red, purple, yellow or white. Carrots are extremely popular because of its numerous uses, and because of the many vitamins and minerals that it contains as indicated in Table I. For instance, its roots are edible, whether cooked or raw, and are used as an ingredient to soups and salad bowls. It has been found that carrot root juice is very rich in carotene, which in turn is converted to vitamin A by our liver, and is one of the vitamins that the body needs. Regular intake of carrot roots, in any manner, though recommended to be taken in juice form, improves eyesight. Particular substances that are contained in the roots have been discovered to be anti-cancer. That is the primary reason why carrot juice has become a popular drink, as it is associated with a wealth of health benefits. The roots of the carrot plant, when roasted, are also being used as a substitute for coffee. Extractions from the roots, known as carotene, are also being used commercially as a food dye. The leaves of this plant, which have high vitamin E content, are also being used as flavorings for soup. From the derived uses of this plant, it is evident that its roots, seeds, and leaves have particular functions which are known to be utilized by many [1]. Depending on the variety, carrots grow to maturity and are ready for market within 70 to 120 days. Because the carrot is so high in vitamin A, it has been used extensively in the diet to improve the eyesight [2].

TABLE I. Carrots (Daucus carota), Fresh, Raw, Nutrition Value per 100g. Total-Orac Value 666 umol TE/100g

Principle	Nutrient Value	Percentage of RDA
Energy	4.1 Kcal	2%
Carbohydrates	9.58 g	7%
Protein	0.93 g	1.5%
Total Fat	0.24 g	1%
Cholesterol	0 mg	0%
Dietary Fiber	2.8 g	7%
Vitamins		
Folates	19 µg	5%
Niacin	0.963 mg	6%
Pantothenic acid	0.273 mg	5.5%
Pyridoxine	0.138 mg	10%
Rivoflavin	0.058 mg	4%
Thiamin	0.066 mg	6%
Vitamin A	167.06 IU	557%
Vitamin C	5.9 mg	10%
Vitamin K	13.2 µg	11%
Electrolytes		
Sodium	69 mg	4.5%
Potassium	320 mg	6.5%
Minerals		
Calcium	33 mg	3%
Copper	0.045 mg	5%
Iron	0.30 mg	4%
Magnesium	12 mg	3%
Manganese	0.143 mg	6%
Phosphorous	35 mg	5%
Selenium	0.1 µg	<1%
Zinc	0.24 mg	2%
Phyto-nutrients		
Carotene-a	3427 µg	--
Carotene-B	8285 µg	--
Crpto-xanthin-B	0 µg	--
Lutein-zeaxanthin	256 µg	-

Source: USDA National Nutrient data base [5].

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A study on Shelf life extension of carrots and potatoes: A comparison of H2O2, laser, UV, and microwave treatment revealed that the control shelf life was 3.6 days wherein samples were left at ambient temperature [3].

The use of a chemical that oxidizes ethylene to carbon dioxide and water can help carrot growers to lessen the cost of production thereby increasing profit. These products may absorb ethylene and extend storage life to some degree but the efficient destruction of ethylene requires large contact surface areas. Calcium lactate has been used in Human nutrition. A study on the use of calcium for Extending the Shelf Life of Fresh Whole and Minimally Processed Fruits and Vegetables showed that Calcium lactate caused a reduction in the respiration of lettuce. It reduces the respiration of minimally processed fresh vegetables. Since the rate of respiration of a vegetable is related to its senescence state, a lower consumption of oxygen might be due to a lower stress response in lettuce [4].

Calcium salts are the best known; they are used in the strengthening of cell walls. The cell walls are more stable to different treatments. This prevents the destruction of cell compartments and also the contact of PPO with polyphenols in the vacuole (Quiles, Hernando, Perez-Munuera & Lluch, 2007; Guan & Fan, 2010; Khunpon, Uthaibutra, Faiyue & Saengnil, 2011). The main agents of firmness are calcium lactate E327, calcium propionate E282, calcium chloride E509, calcium ascorbate E302 and sodium chloride [6].

There are many uses of Ascorbic acid in humans, animals and plants as part of their nutrition. However no studies had been conducted on the use of ascorbic acid to prolong the shelf-life of carrots. Ascorbic acid has many applications in the food industry. It is used as preservatives in the processed meats and removal of fungus in nuts. It is used to reduce browning in fruits and vegetables; as a processing aid and to reduce nitrosamine formation in cured and raw meat products; to reduce the oxidation of fats and lipids; and as a dough conditioner Ascorbic acid (vitamin C) is an antioxidant that keeps fruit from darkening and enhances destruction of bacteria during drying. A mixture of 2 1/2 tablespoons (34 grams) of pure ascorbic acid crystals into one quart (1000 milliliters) of cold water prevents darkening of fruits [7]. Fungi (molds) in nuts that are already roasted can be removed by rinsing it with water and ascorbic acid solution. Covering the nuts with water and Vitamin C powder about ¼ teaspoon for 5 minutes detoxifies it [8].

Carrot is grown preferably in elevated areas because it requires low temperature for root development. Carrot grows well and produces high quality root in areas with temperature range of 15.6℃ to 18.3℃. In higher temperature, it produces long, slender roots with pale color. Carrot matures in 65 to 110 days after planting. To harvest the plant uproot it and cut the leaves up to 2 centimeters from the base of the roots. Washing is not recommended until produce reaches the market. Carrot is sold either on a wholesale, contract, auction, or consignment basis. In Benguet, carrot is usually sold unsorted and unwashed as *buhos or palaspas* by growers [9].

This study was conceptualized due to the urgent need of carrot growers in *Sitio Pactil in Bauko Monamon Sur*, Mt. Province, Philippines. *Sitio Pactil* is located in mountainous slope range of 15 to 18 degrees. It is approximately 2300 meters above sea level [10]. Located in the highlands of the northern part of the country, the place is very much favorable for growing cold loving vegetables such as carrots. *Pactil* is one of the partner communities of San Beda College, Manila Philippines. It served as one of venues of community outreach activities of San Beda College. During harvest season of carrots growers in *Pactil* entailed a lot of losses due to the distance of the place to lowlands. Travel time is around 12 hours if they want to market their products in Manila. While on travel these vegetables are subject to shrinkage due to sudden change in temperature in the lowlands.

A. Objectives of the Study

This study will help carrot growers and retailers in areas where electricity is a problem, to prolong shelf life of their products using affordable methods thereby increase productivity. The result of this study will benefit carrot growers in *Pactil*, Mountain Province in the Philippines. Specifically it will determine the shelf life of carrots immersed in Calcium lactate and ascorbic acid solutions with different immersion time in terms of final weight and final volume. Identify low cost methods on how to prolong shelf life of their products.

II. Materials and Methods

A. Materials

This research employed experimental research method with 3 treatments and 3 groups. Two thousand one hundred three (2103 grams) of newly harvested carrots from the same batch were used. Treatment 1, composed of 747 grams as the control. Treatment 2, 675 grams and Treatment 3, 681 grams. Treatment 2 and treatment 3 were further divided in 3 different groups and immersed in different immersion time (10, 20 and 30 minutes). In treatment 2, 30g of Calcium lactate in 1 liter of tapwater was used as immersing solution. In treatment 3, 30g of Ascorbic Acid in 1 liter of tapwater was used as immersing solution Prior to the conduct of the study materials such as plastic basin, plastic crates as containers, powdered Calcium lactate, ascorbic acid, digital weighing scale, graduated cylinder, caliper and tapwater were prepared.

B. Methods

1) The carrots

Two thousand one hundred three grams of carrots was harvested from the same batch and same source in *Pactil*, Moutain Province, Philippines. It was transported to experimental site (Makati, Philippines).

2) Preparation of solutions

Using a graduated cylinder and weighing scale the following solutions were prepared; treatment 1 (control) were washed with tap water. For treatment 2, carrots were immersed in 30g/l of Calcium Lactate in different immersion time. T2 Group 1 for 10 minutes, T2G2 for 20

minutes and T2G3 for 30 minutes. Carrots in treatment 3 were immersed in 30g/l of Ascorbic Acid in different immersion time. T3 Group 1 for 10 minutes, T3G2 for 20 minutes and T3G3 for 30 minutes.

3) Grouping of carrots

The carrots in T1 all groups were washed in cleaned in flowing water, to remove the dirt and dust that accumulate and it was air dried. Carrots in T2 and T3 were immersed in different solutions as shown in Table II. The experiment was conducted in a room whose temperature, ranges from 30-32 degrees centigrade.

Carrots in treatments 2 and 3 were immersed on the different solutions as what was indicated in the experimental set-up as shown in Fig. 1.

TABLE II. EXPERIMENTAL LAY-OUT

T1G1 248 grams	T2G1 208 grams immersed in 30 g/l of Calcium Lactate for 10 minutes	T3G1 243 grams immersed in 30 g/l of ascorbic acid for 10 minutes
T1G2 227 grams	T2G2 270 grams immersed in 30 g/l of Calcium Lactate for 20 minutes	T3G2 199 grams immersed in 30 g/l of ascorbic acid for 20 minutes
T1G3 272 grams	T2G3 197 grams in 30 g/l of Calcium Lactate for 30 minutes	T3G3 239 grams immersed in 30 g/l of ascorbic acid for 30

T2. Carrots immersed in 30g/l Calcium Lactate

T3. Carrots immersed in 30g//l Ascorbic acid Solution

Figure 1. Carrots in T2 and T3 immersed in different solutions

4) Data gathered

To obtain accurate result, observation was done daily. The following data needed to support the claims in this study are as follows; Average initial weight in grams of the carrots per group per treatment. Average initial volume in centimeters was also recorded and computed. Final weight in grams and final volume was also recorded. Shelf-life per treatment expressed in days. Cost per treatment was also computed. Two-way factorial ANOVA was employed to determine degree of significance among the treatments. Duncan Multiple Range Test was used to identify what treatment is significant over the other.

III. RESULTS AND DISCUSSION

A. Average Initial Weight in Grams

Prior to the conduct of the study, 2,103 grams carrots were randomly assigned. Table III-A shows the average initial weight in grams. T1 (control) had a mean weight of 249 grams. T2 (30 grams of Calcium Lactate per liter) had a mean weight of 225 grams andT3 (30 grams of Ascorbic acid per 1 liter of water) had a mean weight of 227 grams. The difference in their mean weight is negligible which was affirmed by the no significance in the analysis of variance (Table III-B). Carrots are treated equal on the start of the study, to avoid bias on the result.

TABLE III-A. INITIAL WEIGHT OF CARROTS

	G1	G2	G3	Total	Mean
T1-control-no immersion	248	227	272	747	249
T2 (Calcium Lactate)	208	270	197	675	225
T3 (Ascorbic acid)	243	199	239	681	227

TABLE III-B. ANOVA FOR INITIAL WEIGHT OF CARROTS

SV	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Rows	338.76	2	169.38	$1.096^{n.s}$	0.41	6.94
Columns	276.43	2	138.21	$0.89^{n.s}$	0.47	6.94
Error	617.74	4	154.43			
Total	1232.94	8				

Legend: n.s = not significant at p=.05

B. Average Initial Volume in Centimeters

The initial volume was computed after measuring the radius and height of the plants (using a caliper) in centimeter and is shown in Table IV-A. The formula for the volume of the cone used is $V= 1/3 \times pi \times r^2 \times h$. T1 had a mean volume of 86.31 centimeters. T2 is 86.78 and T3 is 73.54. Analysis of Variance (Table IV-B) showed no significant difference among the treatment means.

TABLE IV-A. INITIAL VOLUME OF CARROTS

	G1	G2	G3	Total	Mean
T1-control-no immersion	77.46	94.34	87.13	258.93	86.31
T2 (Calcium Lactate)	84.13	105.25	70.96	260.34	86.78
T3 (Ascorbic acid)	83.6	68.08	68.93	220.61	73.54

TABLE IV-B. ANOVA FOR INITIAL VOLUME

S.V	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Rows	1064	2	532	$0.404^{n.s}$	0.69	6.94
Columns	26	2	13	$0.009^{n.s}$	0.99	6.94
Error	5270	4	1317.5			
Total	6360	8				

Legend: n.s = not significant at p=.05

C. Final Volume in Centimeters

The final volume as shown in Table V-A was computed after 10 days, when the carrots shriveled and lost their marketable appearance. The radius and height of the plants in centimeter was measured. The formula for the volume of the cone used is $V= 1/3 \times pi \times r^2 \times h$.

The result indicate that carrots immersed in 30 g/l of Calcium lactate had the highest mean volume of 50.3 grams, followed by carrots in T3 which is 42.3. Carrots in T1 (control) had the least volume of 27 grams. Analysis of variance (Table V-B) showed a significant difference on the treatments in favor of carrots in treatment 2.

Duncan Multiple Range Test showed a significant difference between T1 and T2 and T1 and T3. No significant difference between T2 and T3 as revealed in the Duncan Multiple Range Test. The result implied that any of the solutions could prolong the shelf-life of the carrots, however basing on the average volume of carrots immersed in Calcium lactate solution retained higher volume compared with the carrots in other treatments. It be could be supported by the study on Calcium Lactate used in processed peaches. Shelf life studies on processed peaches calcium lactate at 2% level was best in terms of texture and overall appearance [11]. A study on the effects of calcium chloride and calcium lactate on quality and shelf-life of fresh-cut guava slices, showed that 3.6% calcium lactate exhibited better results than other concentrations and control with storage life of 8 days at 5℃±2℃ [12]. In fruit preservation practices, when fruit parenchyma cells are dipped in a calcium salt solution, calcium ions are transported primarily through the apoplast, or intercellular spaces, where they are attracted by negatively charged carboxyl groups in the homo galacturonan that constitutes pectin in the middle lamella and cell wall. The negatively charged chloride or lactate ions remain unbound in solution [13]. Calcium ions protect the membrane from lipid degradation by stabilizing the plasma membrane. This reduces the chances for degradation by lipolytic enzymes. The calcium bridges formed in cell walls have also been reported to reduce accessibility to fungal or bacterial hydrolases that cause decay [14].

The result further implied that carrot growers and retailers could use the solution of 30g/l of Calcium Lactate or Ascorbic Acid 30g/l to prolong the shelf-life and maintain the higher volume of their products in areas where refrigeration is impossible.

TABLE V-A. FINAL VOLUME OF CARROTS

	G1	G2	G3	Total	Mean
T1-control-no immersion	28.49	28.57	24.10	81	27^{a}
T2 (Calcium Lactate)	53.45	62.65	34.93	151.09	50.3^{b}
T3 (Ascorbic acid)	52.81	40.14	33.91	126.86	42.3^{b}

TABLE V-B. ANOVA FOR FINAL VOLUME

SV	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Rows	843.50	2	421.75	7.07*	0.048	6.94
Columns	358.27	2	179.14	$3.00^{n.s}$	0.159	6.94
Error	238.53	4	59.63			
Total	1440.30	8				

Legend: * significant at p=.05
n.s =not significant at p=.05

D. Final Weight in Grams

Final weight as shown in Table VI-A, was obtained by weighing the carrots after 10 days when all carrots in the treatments lost its marketable value. Carrots in T2 had the highest final mean weight of 96.3 grams, followed by carrots in T2 with a final mean weight of 93 grams. The least final mean weight was observed in T1-control, 83 grams. Analysis of Variance (Table VI-B) showed no significant difference in their final weight. The result denotes that the final weight was not affected by the different solutions.

A study on banana ripening yielded similar result. It states that ripening is a physiological maturation catalyzed by the plant hormone ethylene (C2H4). Ethylene starts a cascade of reactions leading to a respiratory climacteric (basically a brief but significant spike in respiration). Carbohydrates are used as substrate, hence the decrease in weight. Thus there is a direct correlation between weight loss and ripening. However, weight loss is also a cause of the ripening process. During the climacteric, ethylene is produced in situ as one product of respiration. This induces the production of more ethylene, which further ratchets up the process [15].

TABLE VI-A. FINAL WEIGHT OF CARROTS

	G1	G2	G3	Total	Mean
T1-control-no immersion	74	62	113	249	83
T2 (30g/l. Calcium Lactate	117	87	75	289	96.3
T3 (30g/l. Ascorbic Acid	115	86	78	279	93

TABLE VI-B. ANOVA FOR FINAL WEIGHT

SV	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Rows	2790.2	2	1395.1	$3.843^{n.s}$	0.117	6.944
Columns	672.2	2	336.1	$0.926^{n.s}$	0.467	6.944
Error	1451.8	4	362.95			
Total	4914.2	8				

Legend: n.s = not significant at p=.05

TABLE VII. SHELF LIFE OF CARROTS IN DAYS

	G1	G2	G3
T1-control-no immersion	4	4	4
T2 (30 g/l. Calcium Lactate	7	7	7
T3 (30 g/l. Ascorbic Acid	7	7	7

E. Shelf-Life of Carrots

The shelf-life of carrots was recorded on the day that it shriveled and lost its marketable appearance. Fungal population was also observed in treatment 1. Table VII shows that carrots in the control lost its marketable value on the 4th day. Carrots in treatments 2 and 3 lost their marketable appearance on the 7th day.

F. Cost per Treatment

The cost per treatment as shown in Table VIII indicates that, T1 had the lowest cost per treatment (PhP72.60). T1 is the control which means no additional chemicals was added. T3 is PhP99.30 and the biggest cost per treatment is in T3 (PhP142.90). Calcium Lactate is more expensive than Ascorbic acid. However T3 is still the treatment that yielded higher final weigh and

significant result in final volume. The researcher would like to recommend the use of Calcium lactate to prolong the shelf-life of carrots in 7 days under room temperature that ranges from 30-32 degrees Centigrade since it can maintain rigidity of the cell wall thus, hindering deterioration.

TABLE VIII. COST PER TREATMENT

Item	T1	T2	T3
1. Cost of carrots	PhP37.35	PhP33.75	PhP34.05
2. Cost of medicine	PhP00.00	PhP 48.00	PhP30.00
3. Plastic basket	PhP15.00	Ph15.00	Ph15.00
4. Plastic basin	PhP15.00	Ph15.00	Ph15.00
5. Depreciation of digital balance	PhP 5.25	PhP 5.25	PhP 5.25
TOTAL	PhP72.60	PhP117.00	PhP99.30

IV. CONCLUSION

Carrot growers in Mountain Province, Philippines are often beset with problems in marketing their products due to rapid decay once it reaches lowland areas due to change in temperature. In areas where cold storage is expensive, simple chemical method could be used to prolong the shelf-life during transport of the products. The result of this study expressed that the shelf-life of carrots kept at room temperature of 30-32 degrees centigrade could be prolonged by using non expensive method, like the immersion of carrots in 30 grams of Calcium Lactate in 1 liter of water. Likewise the final weight and volume of carrots immersed in the solution is much higher compared with other treatments. A follow-up study on the use of this solution on other tropical fruits and vegetables with peel should be conducted.

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