EFFECT OF ASCORBIC ACID AND CALCIUM FOLIAR APPLICATION ON GROWTH, YIELD AND MARKETABILITY OF BROCCOLI

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ABSTRACT

The experiments were carried out at the College of Agricultural Engineering Sciences - University of Baghdad during the fall season of 2021-2020 to study the effect of foliar application of ascorbic acid (0, 25, 50, 75 mg. L^{-1}) which were symbolized as A_0, A_1, A_2, and A_3, and chelated calcium (0, 1.0, 1.5, 2.0 g. L^{-1}) which were symbolized as Ca_0, Ca_1, Ca_2, and Ca_3 on the growth, yield and marketability of broccoli. A factorial experiment was carried out within the RCBD design, in a total of 16 treatments with three replicates. The main flowering heads were kept at temperatures 6-8° C for 20 days and 18-25° C for 4 days. The results were revealed that the individual and interaction treatments were recorded a significant values among the studied parameters, and the interaction treatment of A_3Ca_3 achieved the most significant increment of leaves area, total yield, heads weight, heads diameter, calcium content in leaves and heads, the chlorophyll and vitamin C content in the heads, 1962.54dm^2.plant^{-1}, 55.10 ton.ha^{-1}, 889.78 g.head^{-1}, 21.84 cm, 1.85% in leave, 1.68%, 152.35 mg.100g^{-1} and 305.07 mg.100g^{-1} respectively decreased weight loss, increased total soluble solids, and maintained chlorophyll and vitamin C in the flowering heads after storage reached 11.40%, 134.72 and 96.41 mg.100g^{-1}, 136.40 and 130.53 mg.100g^{-1} respectively at two temperatures.

Key words: ***Brassica oleracea,*** **spraying with, storage, vitamin C, chlorophyll.**

تأثير رش حامض الأسكوربيك والكالسيوم في النمو والحاصل والقابلية التسويقية لنبات البروكولي

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المستخلص

نفذت تجربتان تجربة حقلية ومخزنية في كلية علوم الهندسة الزراعية-جامعة بغداد للموسم الزراعي 2020-2021 بهدف دراسة تأثير رش حامض الأسكوربيك بالتراكيز (0، 25، 50، 75ملغم.لتر$^{-1}$) ورمز له A_0، A_1، A_2، A_3 والكالسيوم المخلبي (0، 1.0، 1.5، 2.0غم.لتر$^{-1}$) ورمز لها Ca_0، Ca_1، Ca_2، Ca_3 في نمو وحاصل والقابلية التسويقية لنبات البروكولي، كتجربة عاملية ضمن تصميم RCBD، ليبلغ عدد المعاملات 16 معاملة وبثلاثة مكررات، وحفظت الأقراص الزهرية الرئيسة في درجتي حرارة 6-8مْ لمدة 20يوم و 18-25مْ لمدة 4 أيام ، أظهرت النتائج أن المعاملات الفردية والتداخل تفوق معنوي بين الصفات المدروسة، وأن المعاملة التداخل A_3Ca_3 حققت افضل النتائج معنوياً في زيادة مساحة الورقية والحاصل الكلي ووزن القرص الرئيس ومعدل قطر القرص الرئيس والنسبة المئوية للكالسيوم في الأوراق والأقراص وزيادة تركيز الكلوروفيل وفيتامين Cفي الأقراص 1962.54دسم^2.نبات$^{-1}$ و55.10طن.هكتار$^{-1}$ و889.78غم.قرص$^{-1}$ و21.84سم و1.85% في الاوراق و1.68% و152.35ملغم.100غم$^{-1}$ و305.07ملغم.100غم$^{-1}$ بالتتابع، وأقل فقد بالوزن وزيادة النسبة المئوية للمواد الصلبة الذائبة الكلية والحفاظ على تركيز الكلوروفيل وفيتامين C في الأقراص الزهرية بعد الحفظ بلغت 11.40% و134.72و 96.41 ملغم.100غم$^{-1}$ و136.40و130.53 ملغم.100غم$^{-1}$ بالتتابع عند درجتي حرارة.

الكلمات المفتاحية: *Brassica oleracea* ، رش ورقي، حفظ ، فيتامين C، كلوروفيل

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INTRODUCTION

Broccoli, *Brassica oleracea*, var. italic, is belong to the Brassicaceae family that grown to obtain the inflorescences which were eaten in the vegetative flowering buds stage with thick, soft pedicels, it can be served cooked, boiled, or fresh. Broccoli contains antioxidants that protect the human cells from damage and the risk of cancer; it also contains large amounts of essential minerals and vitamins that increases the body's immunity through activating specific antioxidant genes and enzymes from immune cells and reducing free radicals (25, 43). Broccoli is the type of plants that stresses the soil by depleting a large amount of nutrients during the growth period (40, 41). Therefore, the foliar fertilization is one of the effective methods to provide the plant's requirements of nutrients; it is an effective method to transfer nutrients within plants and contribute to improve the growth, increases the quantity and quality of yield, and increases the nutrients availability within the soil, The foliar application of vitamins on plants can stimulates the growth by activating some enzymatic reactions which were considered as biological co-factors and co-enzymes within the various biological processes in the plant (4, 7, 45,). Ascorbic acid is a growth stimulator that affects physiological and metabolic processes such as protein synthesis, nucleic acids and enzymes. It has antioxidant functions, dissolves in water and has an important protection role against reactive oxygen species that consisted during the photosynthesis and respiration (2,19).

Metwaly (33) noted that the foliar application of ascorbic acid on the cabbage plant had a significant increment on plant height, leaves area, chlorophyll content, yield, and vitamin C concentration. It was also found (36) that the foliar application of ascorbic acid on broccoli plant for both seasons had a significant increment on leaves area, yield, and the concentration of vitamin C. Balouchi (13) noted that immersion of the flowering heads in the ascorbic acid was significantly increased the shelf life, the concentration of vitamin C, chlorophyll content, TSS, and recorded the least weight loss, these results agreed with (15), It was also found (6) Ascorbic acid significantly increased all vegetative growth, physical and chemical fruits properties of olive. Calcium is an important nutrient that has a physiological role in plant growth and development, cell division and enlargement. Many studies indicated that calcium deficiency causes oxidative stress as the plant loses the mechanisms of cellular defense signals that responsible for reducing free radicals, it also increases the oxygen species which leads to an oxidative stress ROS, It also damage the membranes while enhancing the leakage of cellular electrons, which increases the oxidative stress, the cell wall deterioration, and increased water loss, which leads to reduce the marketing life (8, 9, 10, 12, 30). Mohamed (34) recorded that the foliar application of calcium on the plant during both seasons achieved a significant increment in plant's height, the vitamin C, chlorophyll, and calcium content in cabbage plant. Kou (32) mentioned that immersing the flowering heads in calcium gave an increment in the marketing life, reduced the water loss and chlorophyll content (14, 20, 23, 47). The storage temperature greatly affects the duration of broccoli marketing life. Rhbarczyk-plonska (39) noted that storing broccoli at different temperatures affects the concentration of vitamin C, chlorophyll and TSS concentration (31, 46). Because of increase demand in the local markets for broccoli has increased and its short period of storage, the study was aimed to increase production in quantity and quality and to extend marketing life by the foliar application of ascorbic acid and calcium under different storage conditions.

MATERIALS AND METHODS

Two experiments were carried out; the first was a field experiment at the College of Agricultural Engineering Sciences - Research Station A during the fall season of 2020-2021. The field was prepared before the cultivation by plowing, smoothing, and leveling. Soil samples were taken to determining some physical and chemical properties (table 1). Then the field was divided into six rows, with a width of 0.90 m, and a distance between each other 0.90 m, which represents three replicates, each replicate included two rows. A dripping irrigation system was installed with two dripping tubes per each terrace, in a distance between each dripper was 20 cm, and they were covered with black mulching along the terrace. The seeds of the Jassmine hybrid broccoli produced by Delta Seeds were planted on 8-Aug-2020, After reaching to 4-5 true leaves, seeding were transplanted in permanent field on 1-Oct-2020. each experimental unit 15 plants with a distance of 45 cm between them.

A factorial experiment was carried out based on randomized complete block design (RCBD), including 16 treatments each on replicator three time, in total with 48 experiments. The first factor was ascorbic acid including four concentrations 0, 25, 50, and 75 mg. L^{-1} which were symbolized as A_0, A_1, A_2, A_3 respectively. While the second factor was the chelated calcium including four concentrations 0, 1.0, 1.5, 2.0 g. L^{-1} which were symbolized as Ca_0, Ca_1, Ca_2, Ca_3 respectively. The foliar Ascorbic acid sprayed of after 30 days of planting, while the foliar calcium was applied after 2 days of ascorbic acid sprayed; the second foliar application was done after 2 weeks of the first application. After harvesting, the second experiment was conducted, the experiment of storing the main flower heads in the Storage Laboratory of the Department of Horticulture and landscape gardening-College of Agricultural Engineering Sciences - University of Baghdad, by taking three main heads from each experimental unit and placing them in refrigerators at a temperature of 6-8 ° C for 20 days and three heads Stored at a temperature of 18-25°C for 4 days. The data were analyzed by Genstat and compared using the L.S.D test with a probability level of 0.05 (11), Using the T-Test to compare the two storage temperatures and comparing the calculated T with the tabulated T probability level of 0.05 (5).

Studied Charters

plant height (cm) measured using a metric tape.

Leaves area ($dm^2.plant^{-1}$) measure according to (44) method

Leaves and flower heads content of chlorophyll before and after storage (mg.100 g^{-1} wet weight) The chlorophyll content was estimated according to (21) method

Leaves and flower heads content of calcium (Ca%) was estimated using a flame photometer, according to (37) method.

The total plant's yield ($ton.ha^{-1}$) The total yield of one experimental unit was calculated by the sum of the main and lateral flowering heads to each experimental unit and then attributed to the hectare.

Flowering heads content of Vitamin C before and after storage (mg.100 g^{-1}) calculated as stated in (1).

Weight loss percent in the main flowering heads (%) calculated according to the following equation

Weight loss = (heads weight before storage – heads weight after storage) / (heads weight before storage) * 100

Total soluble solids (TSS%) in flowering heads calculated by hand refractometer according to (29) method

Table 1. Physical and chemical properties of the soil before the study

Characterize	The value	Standard unit
EC 1:1	1.4	Ds m^{-1}
PH 1:1	7.18	—
N available	27	$mg.kg^{-1}$ Soil
P available	4.7	$mg.kg^{-1}$ Soil
K available	223.4	$mg.kg^{-1}$ Soil
O.M	6.3	$g.kg^{-1}$
Carbonate	215	$g.kg^{-1}$
Ca^{+2}	3.85	$mm.L^{-1}$
Mg^{+2}	1.6	$mm.L^{-1}$
Na^{+}	4.13	$mm.L^{-1}$
K	0.97	$mm.L^{-1}$
Cl	10.4	$mm.L^{-1}$
HCO_3	0.9	$mm.L^{-1}$
CO_3^{-2}	Nil	$mm.L^{-1}$
So_4^{-2}	2.15	$mm.L^{-1}$
Sand	320	$g.kg^{-1}$ Soil
Silt	283	$g.kg^{-1}$ Soil
Clay	397	$g.kg^{-1}$ Soil
Texture	Clay loam	

The analysis was done in the graduate laboratories of the University of Baghdad-College of Agricultural Engineering Sciences

RESULTS AND DISCUSSION

Table 2 revealed that foliar application of ascorbic acid achieved significant differences of in plant height, leaves area and chlorophyll content the best level was so $mg.L^{-1}$ A_2 , which Rerecorded 85.69 cm, 1547.07 dm^2. $plant^{-1}$ and 286.26 mg.100 g^{-1}, respectively, compared to the control treatment. May due to the role of ascorbic acid to stimulates the cells division and enlargement increase the cells number (38). Ascorbic acid activated and maintain the chloroplasts (42) The calcium % percent in leaves at A_3 recorded the highest values reached 1.73% compared to the control treatment, which recorded 1.54%, which increases the secretion of organic acids from the roots to the soil, which contributes to increase in the solubility of most nutrients that are slowly released in the rhizosphere that were absorbed by plants (26).

Table 2. Effect of ascorbic acid and calcium on the vegetative and chemical characteristics of Broccoli in the leaves

Treatments	Plant's height (cm)	Leaves area ($dm^2.plant^{-1}$)	Leaves content of chlorophyll ($mg.100\ g^{-1}$ wet weight)	Ca (%)
A_O	82.86	1205.40	177.96	1.54
A_1	84.05	1369.00	213.11	1.64
A_2	85.69	1547.07	286.26	1.66
A_3	84.33	1538.11	260.91	1.73
L.S.D	1.31	103.90	17.88	0.02
Ca_0	81.75	1284.68	167.94	1.48
Ca_1	85.64	1493.10	238.56	1.68
Ca_2	84.72	1342.55	270.83	1.66
Ca_3	84.83	1539.26	260.90	1.75
L.S.D	1.31	103.90	17.88	0.02
A_0Ca_0	79.89	1094.60	134.88	1.41
A_0Ca_1	84.22	1200.74	199.72	1.55
A_0Ca_2	84.33	1183.31	176.24	1.59
A_0Ca_3	83.00	1333.96	200.98	1.59
A_1Ca_0	80.78	1158.37	145.81	1.48
A_1Ca_1	85.33	1356.01	200.93	1.69
A_1Ca_2	85.11	1439.40	259.88	1.65
A_1Ca_3	85.00	1522.23	245.83	1.74
A_2Ca_0	85.22	1452.50	185.47	1.50
A_2Ca_1	89.56	1941.97	311.69	1.66
A_2Ca_2	84.11	1455.51	388.90	1.68
A_2Ca_3	83.89	1338.31	258.97	1.81
A_3Ca_0	81.11	1433.24	205.61	1.52
A_3Ca_1	83.44	1464.69	241.90	1.84
A_3Ca_2	85.33	1291.96	258.31	1.72
A_3Ca_3	87.44	1962.54	337.80	1.85
L.S.D	2.63	207.80	35.76	0.05

A_1=25mg.L^{-1}, A_2=50mg.L^{-1}, A_3=75mg.L^{-1}, Ca_1=1.0g.L^{-1}, Ca_2=1.5g.L^{-1}, Ca_3=2.0g.l^{-1}

Also, the foliar application of calcium was recorded a significant increment in plant height, reached 85.64cm at Ca_1, compared to the control treatment which recorded 81.75cm, At Ca_2 recorded a significant increment in the leaves content of chlorophyll reached 270.83 mg. 100 g^{-1} . While the concentration of Ca_3 recorded the highest values in leaves area and Ca content reached 1539.26 dm^2. $plant^{-1}$ and 1.75% respectively, compared to the control treatment which recorded 1284.68 dm^2. $plant^{-1}$ and 1.48% respectively. This can be due to the calcium function through the formation of Ca-Pectate, which reflected on the strength of the cell tissue, as well as its role as a carrier of hormones that contributes in the cells division and expansion (27). Calcium is a stable nutrient in plants; therefore, calcium accumulates in the leaves in the form of chelated compounds within the protoplasm, and the vacuoles in the form of calcium oxalate (3). The interaction treatment was achieved a significant differences in plant height, which recorded 89.56 cm at A_2Ca_1 compared to the control treatment which recorded 79.89 cm. while treatment of A_3Ca_3 recorded the highest values in leaves area and Ca % in leaves 1962.54 dm^2. $plant^{-1}$, 1.85%, respectively, compared to the control treatment which recorded 1094.60 dm^2. $plant^{-1}$ and 1.41%, while the treatment of A_2Ca_2 recorded the highest values of chlorophyll content reached 388.90 mg. 100 g^{-1} wet weight, compared to the control treatment which recorded 134.88 mg. 100 g^{-1} wet weight respectively. This may be due to combined effect of ascorbic acid and calcium improvement of some physiological processes. Table 3 shows that foliar application of ascorbic acid had a significant increment in the main heads weight, head's diameter, total yield, calcium percent and vitamin C content in the flowering heads at treatment A_3 reached 791.75 g. $head^{-1}$, 20.77 cm, 47.32 tons. ha^{-1}, 1.60% and 276.10 mg. 100 g^{-1}, respectively, compared to the control treatment that recorded 557.90 g. $head^{-1}$, 17.82 cm, 34.16 tons. ha^{-1}, 1.42%, and 183.33 mg. 100 g^{-1}. Results also revealed a significant increment in the flowering heads content of chlorophyll under the treatment of A_1 which were recorded 132.20 mg. $100g^{-1}$ compared to the control treatment which recorded 112.49 mg. 100 g^{-1}.

Table 3. Effect of ascorbic acid and calcium on yield and quality characteristics of the flowering heads

Treatments	Heads weight (g. $head^{-1}$)	Heads diameter (cm)	Total yield (Ton. Ha^{-1})	Chlorophyll (mg. $100g^{-1}$ wet weight)	Ca (%)	Vitamin C (mg. 100 g^{-1})
A_0	557.90	17.84	34.16	112.49	1.42	183.33
A_1	674.84	19.52	40.73	132.20	1.56	218.17
A_2	749.90	20.09	43.73	129.57	1.58	231.74
A_3	791.75	20.77	47.73	129.54	1.60	276.10
L.S.D	19.42	0.38	1.81	10.41	0.04	17.55
Ca_0	535.37	17.41	32.41	99.77	1.41	200.57
Ca_1	692.28	19.65	42.19	137.74	1.57	220.00
Ca_2	759.37	20.26	44.56	130.50	1.55	247.50
Ca_3	787.37	20.90	46.77	135.80	1.62	241.27
L.S.D	19.42	0.38	1.81	10.41	0.04	17.55
A_0 Ca_0	485.22	16.71	28.04	83.15	1.29	161.33
A_0 Ca_1	501.47	17.22	31.58	108.50	1.42	183.33
A_0 Ca_2	586.71	17.99	37.55	117.40	1.41	183.33
A_0 Ca_3	658.18	19.44	39.46	140.92	1.54	205.33
A_1 Ca_0	516.98	17.51	29.90	114.19	1.42	212.67
A_1 Ca_1	707.91	20.04	43.93	166.19	1.65	205.33
A_1 Ca_2	702.15	19.50	43.43	128.79	1.52	242.00
A_1 Ca_3	772.33	21.02	45.65	119.63	1.64	212.67
A_2 Ca_0	567.00	17.37	36.87	101.12	1.43	208.27
A_2 Ca_1	784.16	20.68	47.59	134.27	1.64	212.67
A_2 Ca_2	819.25	21.02	43.60	152.58	1.64	264.00
A_2 Ca_3	829.18	21.30	46.86	130.29	1.61	242.00
A_3 Ca_0	572.27	18.07	34.83	100.63	1.50	220.00
A_3 Ca_1	775.58	20.67	45.68	141.98	1.57	278.67
A_3 Ca_2	929.38	22.51	53.67	123.21	1.64	300.67
A_3 Ca_3	889.78	21.84	55.10	152.35	1.68	305.07
L.S.D	38.85	0.76	3.63	20.82	0.07	35.09

A_1=25mg.L^{-1}, A_2=50mg.L^{-1}, A_3=75mg.L^{-1}, Ca_1=1.0g.L^{-1}, Ca_2=1.5g.L^{-1}, Ca_3=2.0g.l^{-1}

This can be attributed to its role in increasing the efficiency of the photosynthesis process by maintaining the plant pigments from oxidative damage that occurs as a result of vital processes, which leads to an increased the carbohydrates (16) and acts as an antioxidant agent and activating many enzymes as it enters the electron transport system and maintains on chlorophyll from oxidation (35). Results of table 2 revealed that the applicant spraying of calcium recorded a significant increment among the studied parameters; the application of calcium at treatment of Ca_3 recorded the highest values of main heads weight, heads diameter, total yield and calcium percent reached 787.37 g. $head^{-1}$, 20.90 cm, 46.77 tons. ha^{-1} and 1.62% compared to the control treatment which recorded 535.37 g. $heads^{-1}$, 17.41 cm 32.41 tons. ha^{-1} and 1.41% While the treatment of Ca_1 recorded the highest values of leaves content of chlorophyll reached 137.74 mg. 100 g^{-1} wet weight compared to the control treatment, which recorded 99.77 mg. $100g^{-1}$ wet weight. Also, the treatment of Ca_2 recorded significant value of vitamin C reached 247.50 mg. $100g^{-1}$ compared to the control which recorded 200.57 mg. 100 g^{-1}. May due to the role of calcium to the various structural and physiological activities that it plays within the plant, including the structure of cell walls and works to link the components of the pectic wall and the polysaccharide compounds (18). It also plays an important role in plant growth, development, and the transmission of external and internal signals, and it is one of the necessary nutrients that plants require in the formation of cells membranes (22). The interaction between ascorbic acid and calcium at A_3Ca_2 also recorded significant values in the main heads weight, main heads diameter, reached 929.38 g. $head^{-1}$ and 22.51 cm respectively, in comparison to the control which were recorded 485.22 g. $head^{-1}$, and 16.71 cm respectively, while the total yield, the calcium percent, and the vitamin C concentration at A_3Ca_3 recorded the highest values reached 55.10 ton. ha^{-1} and 1.68% and 305.07 $mg.100g^{-1}$, respectively, compared to the control treatment, which were recorded 28.04 tons. ha^{-1}, 1.29 % and 161.33 $mg.100g^{-1}$, respectively. While the interaction at A_1Ca_1 recorded the highest values in leaves content of chlorophyll reached 166.19 mg. 100 g^{-1} compared to the control treatment which recorded 83.15 mg. 100 g^{-1}. Results in Table 4 showed that the foliar application of ascorbic acid at the treatment of A_3 was significantly reduced the weight loss, increased the TSS% and maintained chlorophyll and vitamin C content under both temperatures 8-6 C for 20 days, and 18-25 C for 4 days reached 14.37, 13.03%, 8.21, 7.88%, 119.32, 81.40 mg.100 g^{-1}, 120.63, and 117.33 mg. 100 g^{-1}, respectively, compared to the control which recorded 23.78, 17.93%, 7.04, 6.84%, 91.83, 49.39 mg.100 g^{-1}, and 57.20, 47.67 mg. 100 g^{-1}, respectively. This can be attributed to the non-enzymatic antioxidant role of ascorbic acid and the ability to resist oxidation through the formation of inactive free radicals during chemical reactions, and that its role lies in treating the catabolism that occurs through cellular activity to maintain the organelles in cells from destruction (24). It also increases the plant's resistance to environmental conditions and reduces the heat stress, light intensity, and toxins, stimulates respiration processes, and increases the speed of cell division (35). Also the faliar application of calcium had a significant effect at the treatment of Ca_3 in reducing weight loss, increasing the percentage of total soluble solids, and maintaining the total chlorophyll and vitamin C content for both temperatures 8-6 ° C for 20 days, 18-25 ° C for 4 days reached 15.37, 13.03, 7.96, 8.08%, 120.77, 83.16 mg.100 g^{-1}, 104.13, 93.13 mg.100 g^{-1} respectively, compared to the control treatment 25.15, 17.60 %, 6.88, 6.88 %, 84.01, 50.80 mg.100 g^{-1}, 77.73, and 75.17 mg.100 g^{-1} respectively. This can be attributed to its role the reinforcement of cells wall and decreasing the permeability through its contribution to the process of linking pectin with protein in the cell membranes and linking the contiguous cells (17) and decrease the oxidation process in the flowering heads and may also reduce the decomposition of acids and thus maintain the Cells acids content (28). The interaction between ascorbic acid and calcium also revealed a significant effect in reducing weight loss, increasing the TSS percent, chlorophyll, and vitamin C content at both temperatures 8-6 ° C for 20 days, 18-25 ° C for 4 days at treatment of A_3Ca_3 reached 11.82, 11.40%, 9.17, 8.67 % 142.56, 96.41 mg. 100 g^{-1}, 136.40, and 130.53 mg. $100g^{-1}$ respectively, Compared to the control which recorded 33.79, 20.88%, 6.33, 6.17%, 54.75, and 40.12 mg. 100 g^{-1}, 48.40, and 42.53 mg. $100g^{-1}$ respectively. This may be due to the non-contrary in the effect between ascorbic acid and calcium, they also have a mutual role in the physiological processes. We conclude that the foliar application of ascorbic acid and calcium (50, 75 mg. L^{-1}, and 1.5, 2.0 g. L^{-1}, respectively) were significantly increased the vegetative growth characteristics, qualitative, and quantitative yield characteristics, and marketability.

Table 4. Effect of ascorbic acid and calcium on the storage experiment characteristics of the main flowering heads

Treatments	Weight Loss (%)		TSS (%)		Chlorophyll ($mg.100g^{-1}$)		Vitamin C ($mg.100g^{-1}$)	
	Temperature		Temperature		Temperature		Temperature	
	6-8C	18-25C	6-8C	18-25C	6-8C	18-25C	6-8C	18-25C
A_0	23.78	17.93	7.04	6.84	91.83	49.39	57.20	47.67
A_1	23.16	14.11	7.46	7.77	114.67	66.87	91.67	85.43
A_2	16.23	14.07	7.79	7.79	114.05	76.41	101.20	96.07
A_3	14.37	13.03	8.21	7.88	119.32	81.40	120.63	117.33
L.S.D	0.77	0.87	0.37	0.34	8.13	3.95	4.38	3.15
Ca_0	25.15	17.60	6.88	6.88	84.01	50.80	77.73	75.17
Ca_1	19.36	14.23	7.75	7.61	119.26	68.92	92.03	87.63
Ca_2	17.75	14.29	7.92	8.08	115.82	71.18	96.80	90.57
Ca_3	15.37	13.03	7.96	7.71	120.77	83.16	140.13	93.13
L.S.D	0.77	0.87	0.37	0.34	8.13	3.95	4.38	3.15
A_0 Ca_0	33.79	20.88	6.33	6.17	54.75	40.12	48.40	42.53
A_0 Ca_1	22.29	19.71	7.00	6.60	81.46	48.11	57.20	49.87
A_0 Ca_2	21.48	17.54	7.50	7.50	110.45	52.92	57.20	49.87
A_0 Ca_3	17.55	13.61	7.33	7.10	120.66	56.40	66.00	48.40
A_1 Ca_0	28.59	17.62	6.83	7.00	94.77	46.02	83.60	82.13
A_1 Ca_1	21.68	11.83	7.67	8.17	142.56	57.94	89.47	83.60
A_1 Ca_2	23.40	14.45	8.00	8.00	116.61	73.08	95.33	85.07
A_1 Ca_3	18.96	12.54	7.33	7.90	104.74	90.42	98.27	90.93
A_2 Ca_0	20.60	16.71	7.00	7.50	88.34	59.20	88.00	88.00
A_2 Ca_1	18.09	12.21	8.50	8.00	126.03	78.47	96.80	95.33
A_2 Ca_2	14.31	12.81	7.67	8.50	118.84	78.55	104.13	98.27
A_2 Ca_3	12.27	14.56	8.00	7.17	122.97	89.40	115.87	102.67
A_3 Ca_0	17.60	15.19	7.33	6.83	98.17	57.86	90.93	88.00
A_3 Ca_1	15.37	13.18	7.83	7.67	127.00	91.15	124.67	121.73
A_3 Ca_2	11.82	12.34	8.50	8.33	117.37	80.18	130.53	129.07
A_3 Ca_3	12.69	11.40	9.17	8.67	134.72	96.41	136.40	130.53
L.S.D	1.54	1.75	0.74	0.68	16.25	7.90	8.75	6.30

A_1=25 mg. L^{-1}, A_2=50 mg. L^{-1}, A_3=75 mg. L^{-1}, Ca_1=1.0 mg. L^{-1}, Ca_2=1.5 mg. L^{-1}, Ca_3=2.0 mg. L^{-1}

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