

INTERTEK TEST HİZMETLERİ A.Ş. EXAMINATION AND ANALYSIS REPORT

Report Number: FS10082747- FS10082748- FS10082749- FS10082750
FS10088227- FS10088228- FS10088229- FS10088230

Date: 22.06.2020

Customer Informations	
Customer Name	Arçelik A.Ş Araştırma&Geliştirme Direktörlüğü
Address	Termodinamik Teknolojileri Yöneticiliği Ankara Asfaltı Yanı 34950 Tuzla İstanbul TURKEY
Contact Person	Aylin Met

Sample Informations	
Name	RGB LED Technology
Description and Batch Number	The refrigerator contains "RGB LED Technology" that simulates day-cycle in crisper
Package and Quantity	
Sample Received on / Transport by	-
Sampling & Seal	Client None
Quotation No	2018R1
Production and Expiring Date	-
Start / End of Analysis	15.05.2019 / 05.08.2019
Purpose of Analysis	Claim verification test
Remarks	<p>It is declared by Arçelik A.Ş. is that "RGB LED technology" that simulates the day cycle in crisper developed by Arçelik A.Ş. can also be applied to different brands and models and technology name may change in the responsibility of Arçelik A.Ş.</p> <p>All the tests were performed in reference refrigerator Beko (MODEL 70560EI ; Class: SN-T ; Serial Nr:18-1000979-08) in Intertek facilities.</p>

A. Introduction

Fruits are important for health concern in terms of their vitamin content. To preserve the vitamin content in refrigeration conditions is crucial to maintain a good nutritional value. This report was issued in order to see the effect of light technology in the crisper of a refrigerator in comparison against with a dark conditioned refrigerator. The aim of this study is to prove the refrigerators preserve and even increase the vitamin content of fruits and vegetables during storage.

Verkerke et al. found out that in a model system with LEDs, preharvest illumination of fruits from anthesis to harvest increased the vitamin C concentration by 65% compared to a control of regularly grown tomatoes, and the higher vitamin C persisted a week after harvest [1]. In the same way, Ntagkas et al. had shown that LED light irradiation can affect ascorbic acid accumulation in detached tomato fruit. This is increase of ascorbic acid was noticed with increasing irradiance, peaking at levels over 265 µmol m⁻² s⁻¹ [2]. Jawanmardi et al. concluded after all the investigations that the use of LED technology as a source of light for transplant production is suitable, recommendable, and economical [3]. Murneek et al. indicated in the article that light intensity and direct exposure to light has a positive effect on tomatoes vitamin content when compared with greenhouse planted tomatoes [4]. Ntagkas, also found out that high irradiance induces accumulation of ASC in green tomato fruits [5].

Humidity is also an important factor in ripening of fruits however in this study, moisture is not focus point of this project.

Our findings were all supported with those articles that RGB LED light technology induced tomatoes and green peppers not only preserves Vitamin A and C content but also have a tendency to produce more vitamins compared to dark conditioned stored fruits.

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B. Test Details

- Tomatoes and green pepper were tested in different periods. Tomatoes were tested between 15.05.2019-23.05.2019; Green Peppers were tested between 24.07.2019-01.07.2019.
- Tomatoes and green pepper were collected from the wholesale market hall as fresh then transferred to laboratory on the same day. Sample acceptance into the laboratory was defined as Day 0.
- Tomatoes and green pepper were prepared without washing. Tomatoes were portioned as same sizes about 20 g, and green peppers were portioned as 8-10 g and 15-20 cm in length for each type of refrigerator.
- Tomatoes and green pepper were placed in the refrigerator crisper as 2/3 filled without any packaging or bagging.
- Customer defined that the one refrigerator has above mentioned light technology installed, the second one is a control refrigerator without any light technology (Darkness).
- The tests are conducted from Day 0 to Day 7. Vitamin A (beta-carotene) and Vitamin C (L-ascorbic acid) values were compared with Control Sample (Darkness) refrigerator and Day 0 results.
- Sampling of tomatoes and green pepper were taken from the center of crisper and from the inner part of the where samples were directly exposed to the light path. The samples taken were homogenized together and consisted of four tomatoes and four green peppers, two of them from the center and two of them from the direct light exposure part in the crisper.
- Pictures taken of the samples on test dates are available in the Annex I and Annex II of the test report.
- All the available results for each duplicates are all included in Annex III.

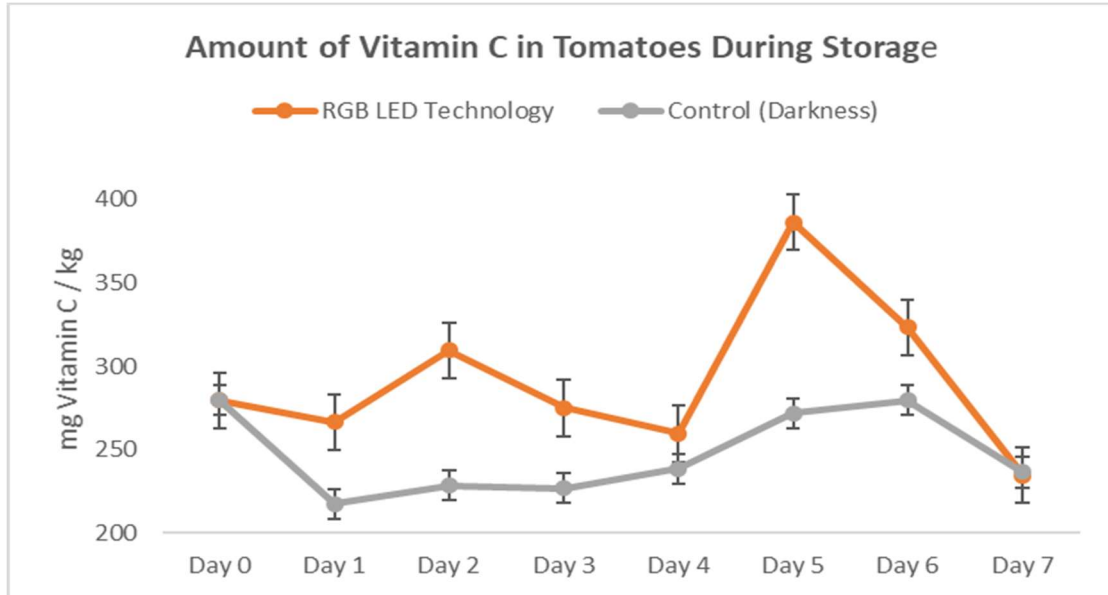
C. Results

Comments	<p>Refrigerator Conditions: Special test conditions like a specified temperature and humidity value were not applied during analysis, only one refrigerator contained "RGB LED Technology" that simulates day-cycle in crisper, other one is dark conditioned same type refrigerator.</p> <p>Sample Conditions: Tomatoes and green peppers were placed in crisper of refrigerators. Daily, approximately 40 g of tomatoes and 20 g of green pepper were picked up from center and the direct light exposure part in the crisper.</p> <p>Results:</p> <p>1.Helps to preserve vitamins (a) 2.Helps to increase Vitamin content (b)</p> <p>Footer Notes: a. Tested by Intertek based on Vitamin C and Vitamin A measurements in Tomatoes and Green Peppers directly exposed to the light technology compared to normal refrigerator conditions over a 7-day period. b. Tested by Intertek based on Vitamin C and Vitamin A measurements in Tomatoes and Green Peppers directly exposed to the light technology compared to normal refrigerator conditions over a 7-day period while storage in the crisper.</p> <p>The results do show an increase in vitamin C and A in peppers and the likelihood the stability will continue after 7 days. However with Vitamin C in tomatoes the graphs show an elevation and stability up to the large peak on day 5. If the predicted limit of variation is concerned at time 0 and comparison with the results after Day 0, it is observed that there is a significant difference at day 3 and 5.</p>
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Graph 1: Amount of Vitamin C in Tomatoes During Storage Representation including error bars

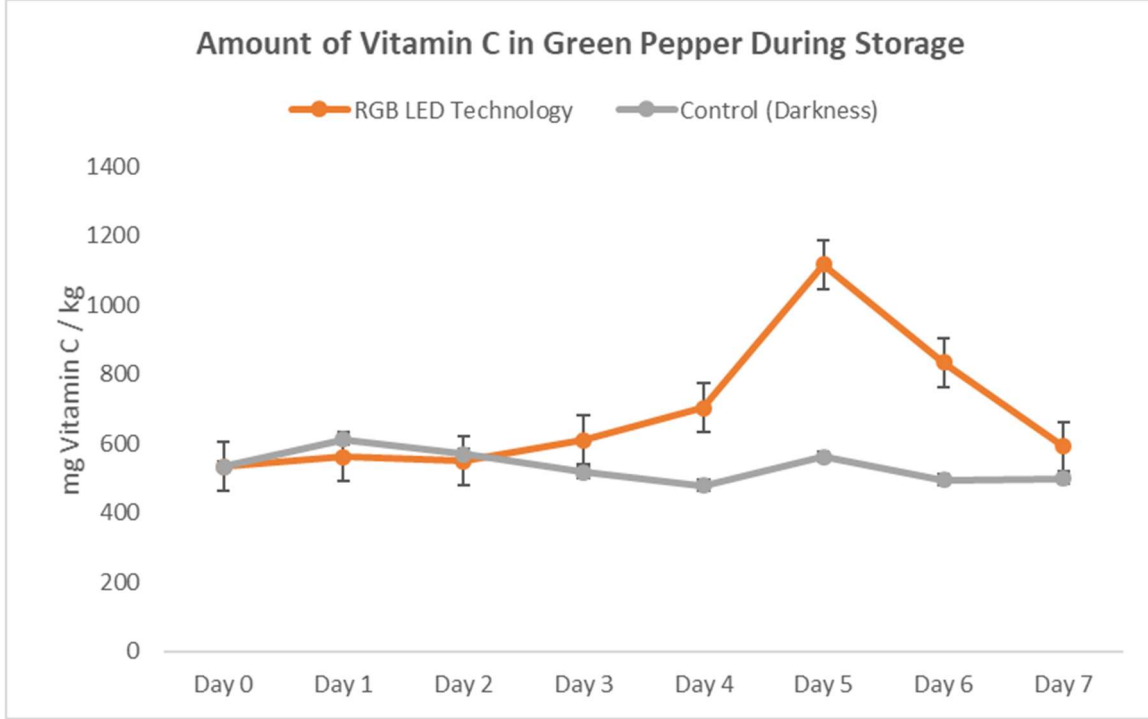
Amount of Vitamin C in Tomato During Storage (mg/kg)		
Storage Days	RGB LED Technology	Control (Darkness)
Day 0	279,6	279,6
Day 1	266,5	217,4
Day 2	309,5	228,6
Day 3	274,9	226,9
Day 4	259,6	238,6
Day 5	386,3	271,7
Day 6	323,1	279,7
Day 7	234,8	236,4
Average of 7 Days	293,5	242,8
Rate of Av.of 7 Days to Control	20,9	

Table 1: Amount of Vitamin C in Tomatoes During Storage Results (All results can be found in Annex III)

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Graph 2: Amount of Vitamin C in Green Pepper During Storage Representation including error bars

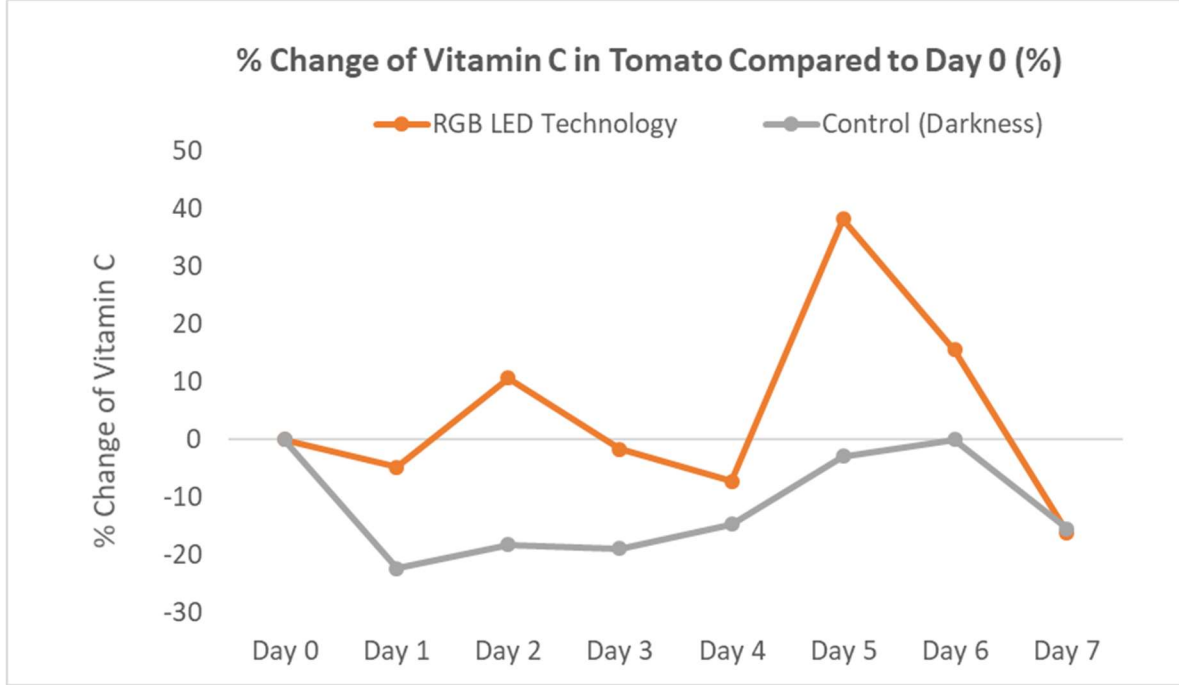
Amount of Vitamin C in Green Pepper During Storage (mg/kg)		
Storage Days	RGB LED Technology	Control (Darkness)
Day 0	534,0	534,0
Day 1	562,0	611,7
Day 2	549,1	570,2
Day 3	610,0	517,4
Day 4	703,7	478,1
Day 5	1118,2	562,4
Day 6	833,9	495,7
Day 7	591,0	498,1
Average of 7 Days	709,7	533,4
Rate of Av.of 7 Days to Control	33,1	

Table 2: Amount of Vitamin C in Green Pepper During Storage Results (All results can be found in Annex III)

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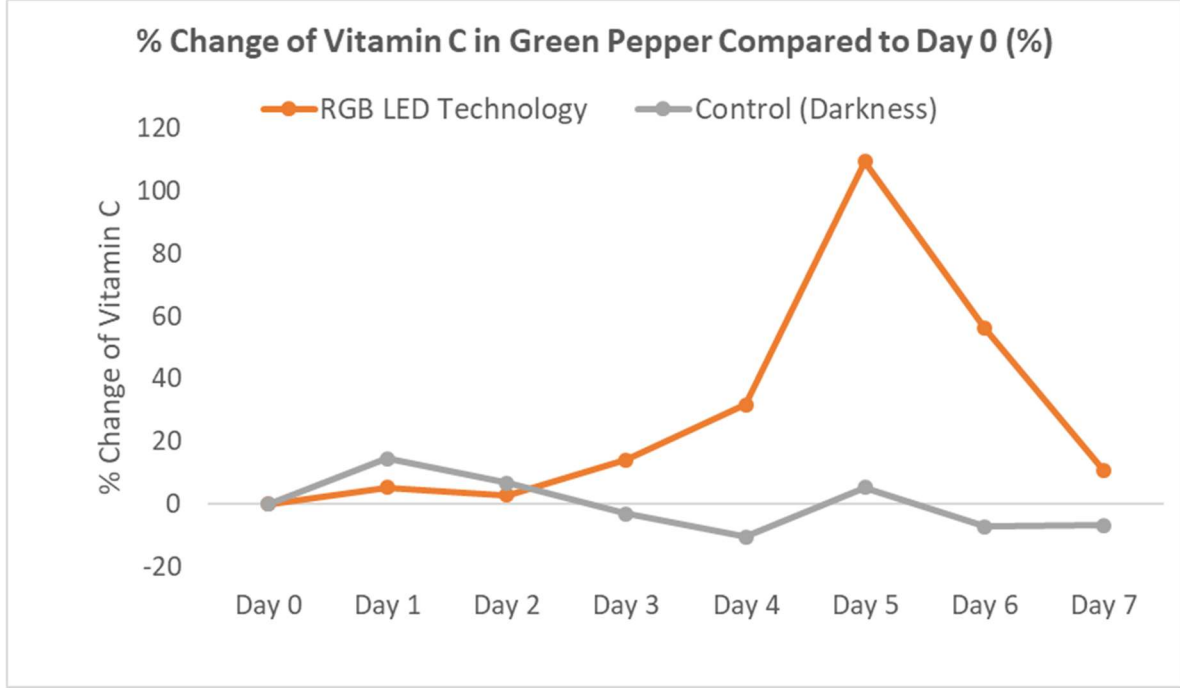
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Graph 3: % Change of Vitamin C in Tomato Compared to Day 0 (%) Representation

% Change of Vitamin C in Tomato Compared to Day 0 (%)		
Storage Days	RGB LED Technology	Control (Darkness)
Day 0	0	0
Day 1	-5	-22
Day 2	11	-18
Day 3	-2	-19
Day 4	-7	-15
Day 5	38	-3
Day 6	16	0
Day 7	-16	-15

Table 3: % Change of Vitamin C in Tomato Compared to Day 0 (%) Results



Graph 4: % Change in Vitaminc C in Green Pepper Compared to Day 0 Representation

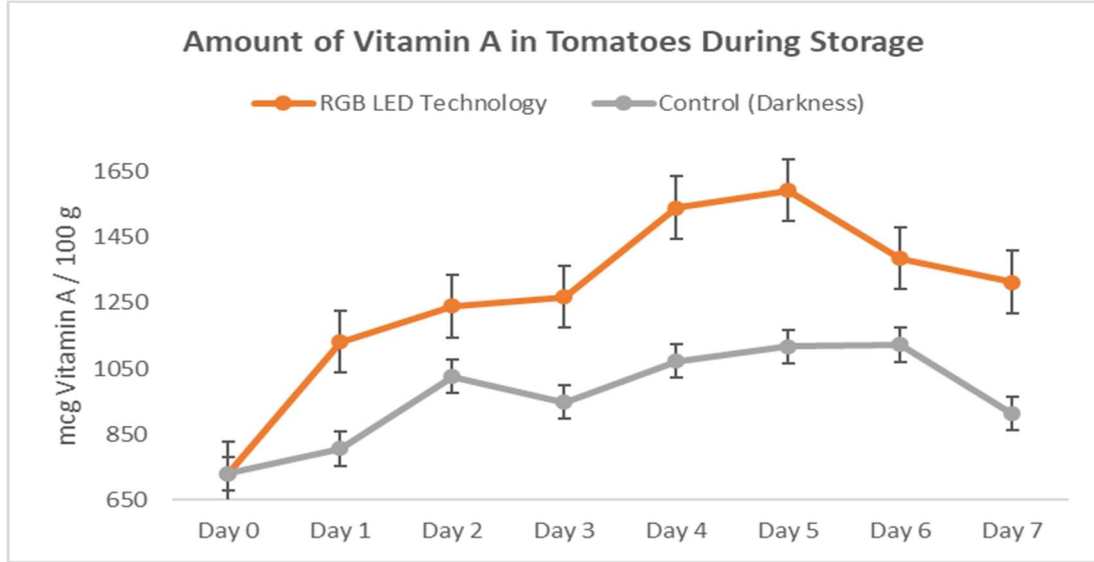
% Change of Vitamin C in Green Pepper Compared to Day 0 (%)		
Storage Days	RGB LED Technology	Control (Darkness)
Day 0	0	0
Day 1	5	15
Day 2	3	7
Day 3	14	-3
Day 4	32	-10
Day 5	109	5
Day 6	56	-7
Day 7	11	-7

Table 4: % Change in Vitaminc C in Green Pepper Compared to Day 0 Results

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Graph 5: Amount of Vitamin A in Tomatoes During Storage Representation including error bars

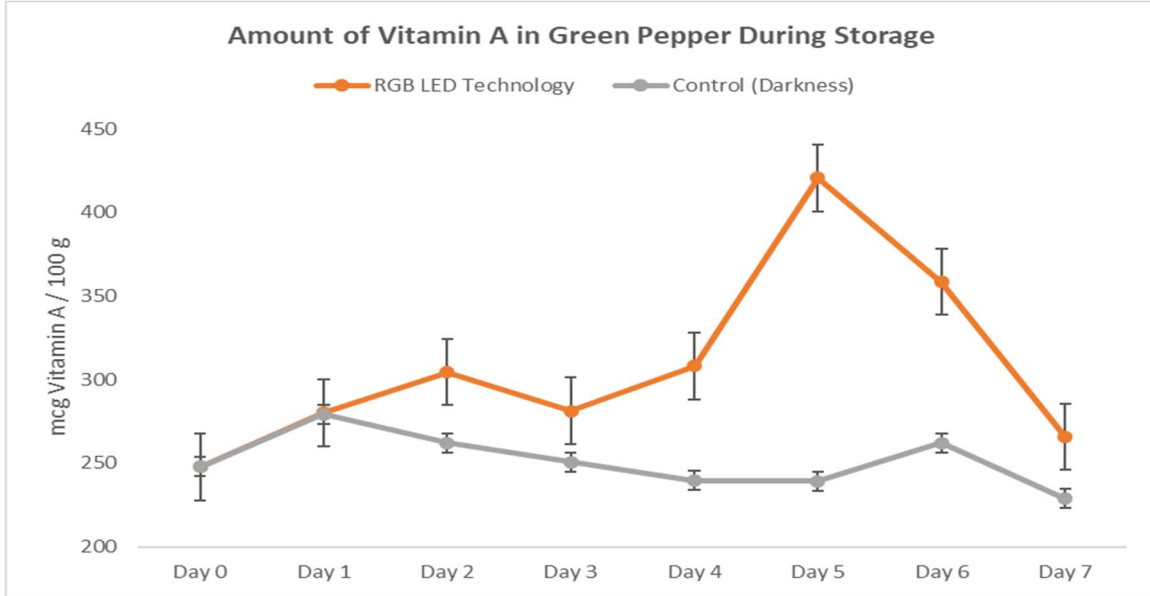
Amount of Vitamin A in Tomato During Storage (mcg/100g)		
Storage Days	RGB LED Technology	Control (Darkness)
Day 0	730,6	730,6
Day 1	1131,5	805,7
Day 2	1239,7	1025,8
Day 3	1268,5	947,9
Day 4	1539,9	1072,4
Day 5	1592,4	1117,4
Day 6	1385,2	1122,4
Day 7	1313,5	911,8
Average of 7 Days	1353,0	1000,5
Rate of Av.of 7 Days to Control	35,2	

Table 5: Amount of Vitamin A in Green Pepper During Storage Results (All results can be found in Annex III)

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Graph 6: Amount of Vitamin A in Green Pepper During Storage Representation

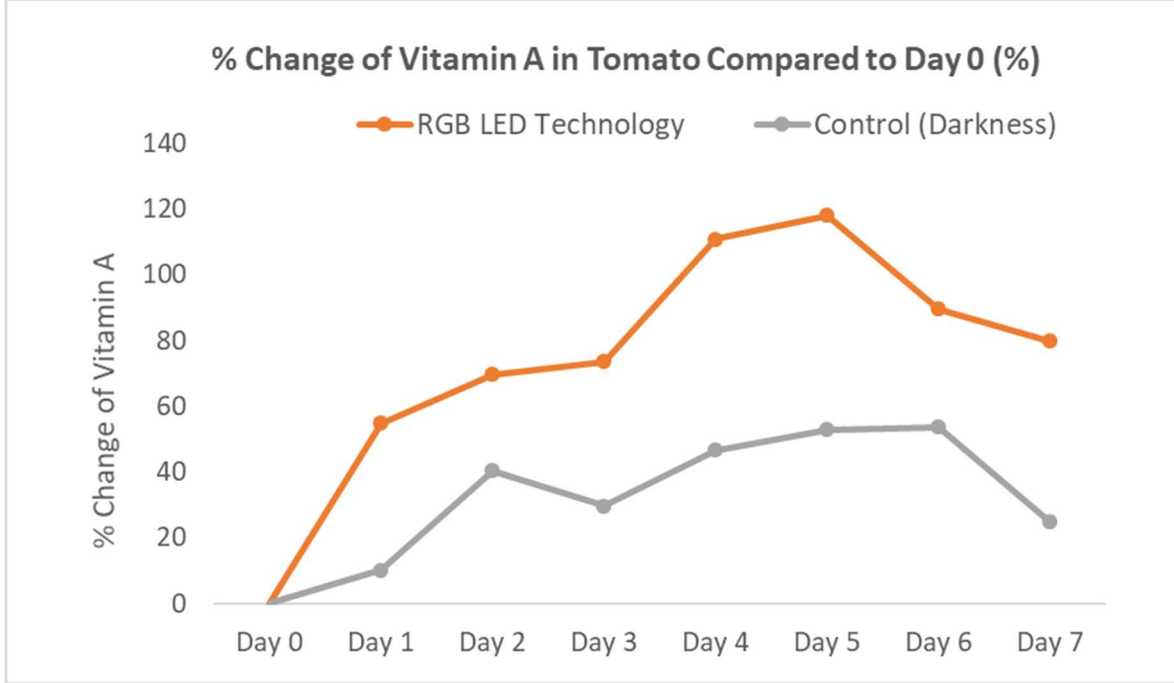
Amount of Vitamin A in Green Pepper During Storage (mcg/100g)		
Storage Days	RGB LED Technology	Control (Darkness)
Day 0	247,8	247,8
Day 1	280,3	279,4
Day 2	304,6	262,1
Day 3	281,3	250,7
Day 4	308,2	239,5
Day 5	420,7	239,3
Day 6	358,5	262,3
Day 7	265,7	228,9
Average of 7 Days	317,0	251,7
Rate of Av.of 7 Days to Control	27,4	

Table 6: Amount of Vitamin A in Green Pepper During Storage Results (All results can be found in Annex III)

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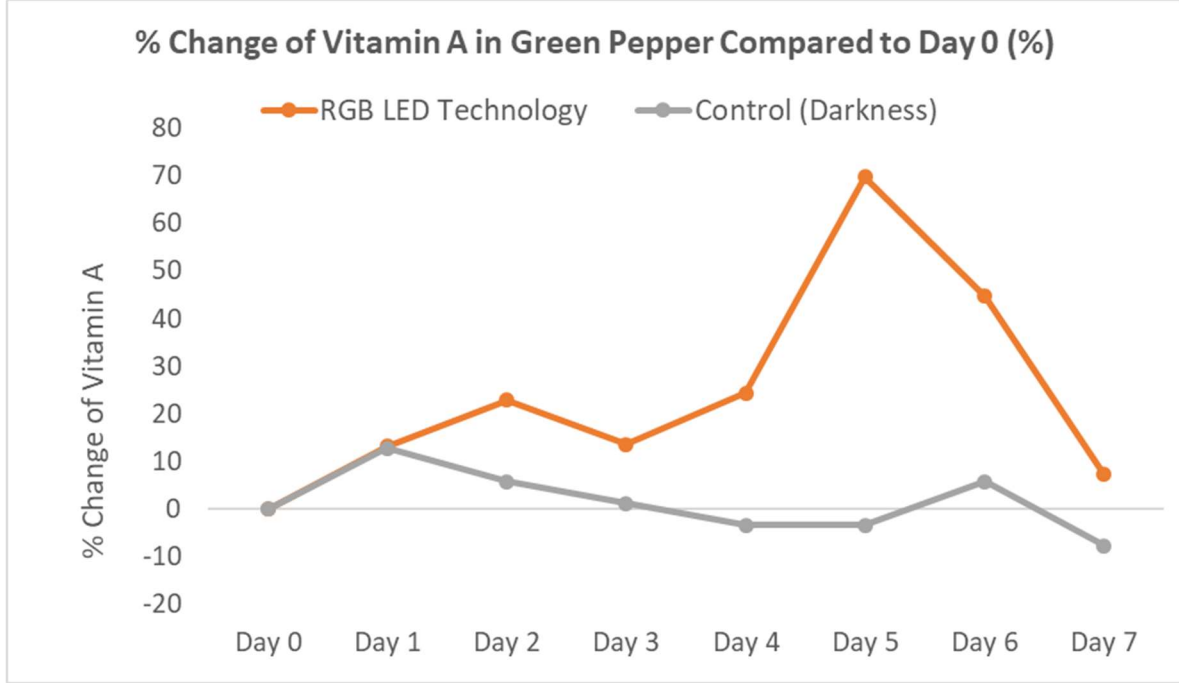
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Graph 7: % Change of Vitamin A in Tomato Compared to Day 0 Representation

% Change of Vitamin A in Tomato Compared to Day 0 (%)		
Storage Days	RGB LED Technology	Control (Darkness)
Day 0	0	0
Day 1	55	10
Day 2	70	40
Day 3	74	30
Day 4	111	47
Day 5	118	53
Day 6	90	54
Day 7	80	25

Table 7: % Change of Vitamin A in Tomato Compared to Day 0 Results



Graph 8: % Change of Vitamin A in Green Pepper Compared to Day 0 Representation

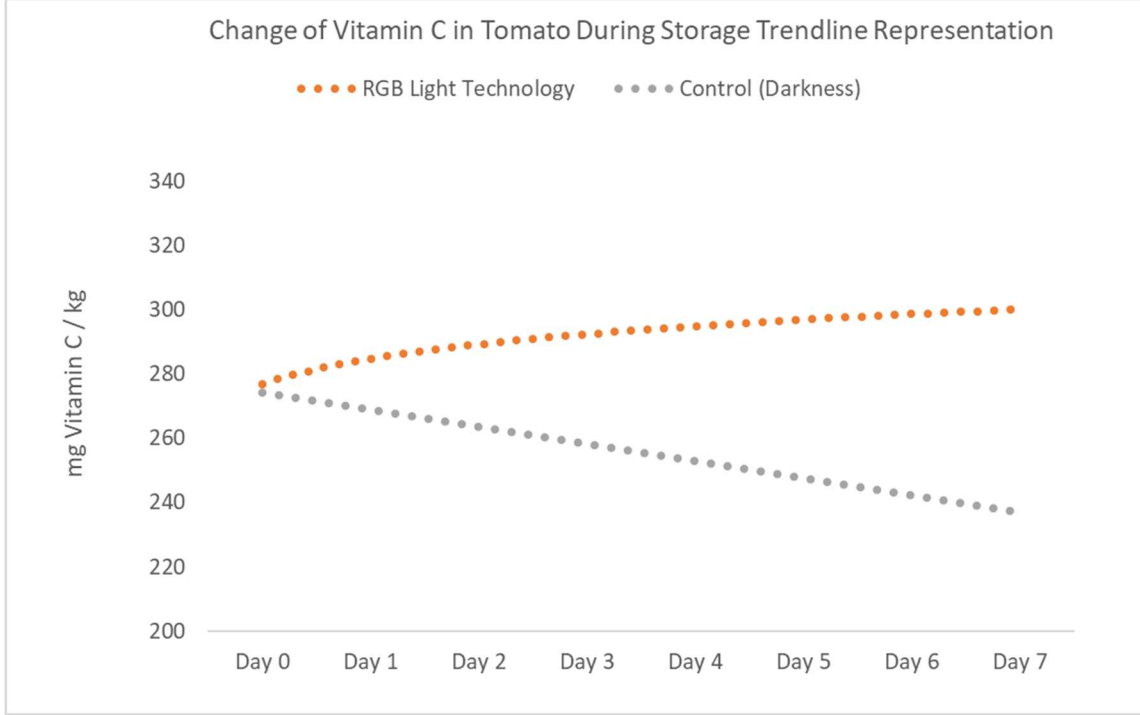
% Change of Vitamin A in Green Pepper Compared to Day 0 (%)		
Storage Days	RGB LED Technology	Control (Darkness)
Day 0	0	0
Day 1	13	13
Day 2	23	6
Day 3	14	1
Day 4	24	-3
Day 5	70	-3
Day 6	45	6
Day 7	7	-8

Table 8: % Change of Vitamin A in Green Pepper Compared to Day 0 Results

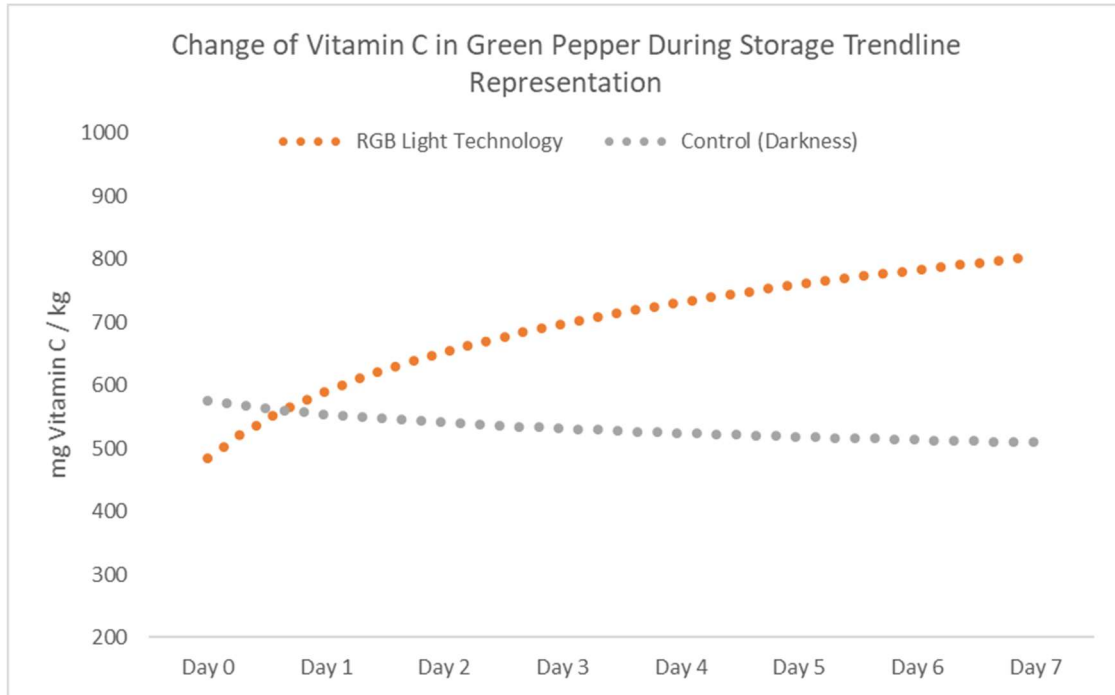
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Graph 9: Change of Vitamin C in Tomato During Storage Trendline Representation

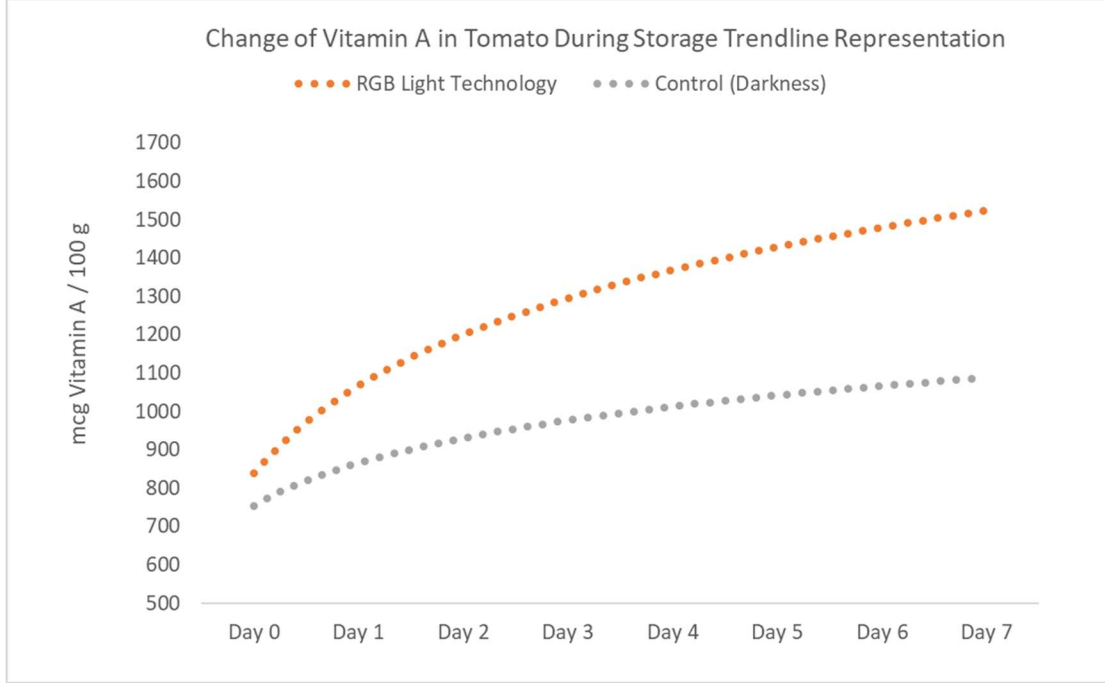


Graph 10: Change of Vitamin C in Green Pepper During Storage Trendline Representation

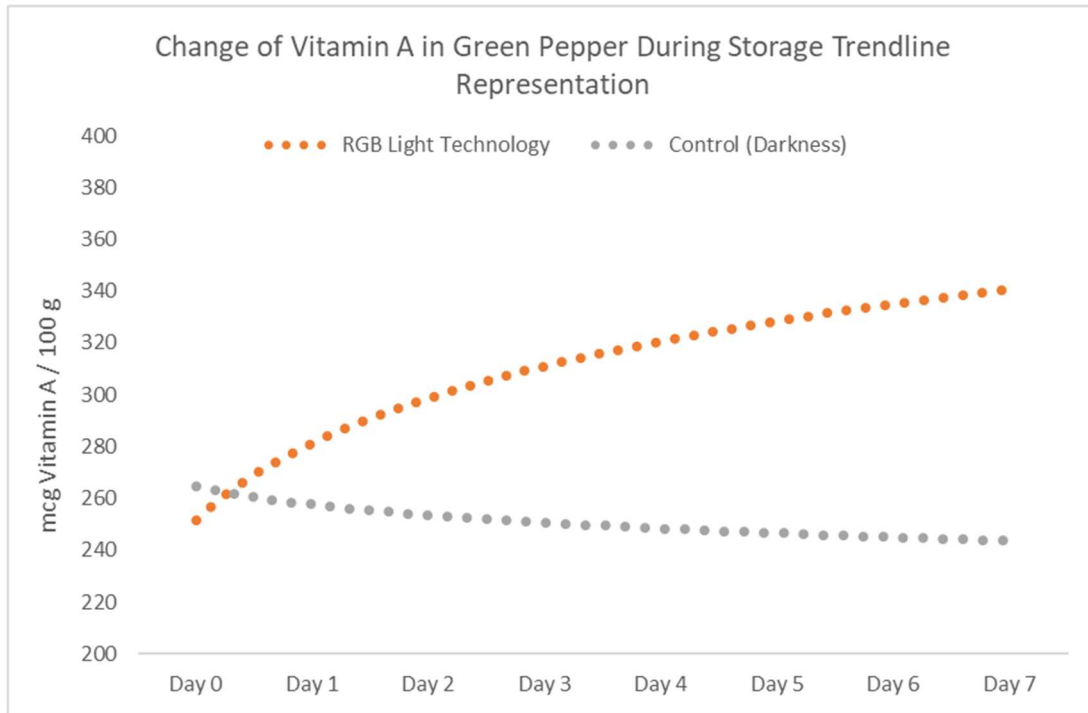
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Graph 11: Change of Vitamin A in Tomato During Storage Trendline Representation



Graph 12: Change of Vitamin A in Green Pepper During Storage Trendline Representation

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D. Interpretation

- 1.Helps to preserve vitamins (a)
- 2.Helps to increase Vitamin content (b)

Footer Notes:

- a. Tested by Intertek based on Vitamin C and Vitamin A measurements in Tomatoes and Green Peppers directly exposed to the light technology compared to normal refrigerator conditions over a 7-day period.
- b. Tested by Intertek based on Vitamin C and Vitamin A measurements in Tomatoes and Green Peppers directly exposed to the light technology compared to normal refrigerator conditions over a 7-day period while storage in the crispser.

E. References

- [1] Verkerke et al., 2014, The effect of light intensity and duration on vitamin concentration in tomato fruits, XXIX IHC – Proc. VI Int. Symp. on Human Health Effects of Fruits and Vegetables (FAVHEALTH 2014), pg.49-54
- [2] Ntagkas et al., 2016, Illuminating tomato fruit enhances fruit vitamin C content, Proc. VIII Int. Symp. on Light in Horticulture, pg. 351-356
- [3] Javanmardi et. al., 2013, Response of Tomato and Pepper Transplants to Light Spectra Provided by Light Emitting Diodes, International Journal of Vegetable Science, Vol 19:138–149
- [4] Murneek et al. 1954, Ascorbic Acid (Vitamin C) Content of Tomatoes and Apples, Research Bulletin 568, University of Missouri College of Agriculture, Agricultural Experiment Station
- [5] Ntgaskas et al., Light-Induced Vitamin C Accumulation in Tomato Fruits is Independent of Carbohydrate Availability, Plants, Vol 8:86

Panel Chairman

Ahu Üner Akbalık

**Supervisor of Physical
Analysis Section**

Özgenur Özdemir

**Supervisor of Sample Receiving
and Reporting Section**

Özgür Can Feridun

**Supervisor of Additive-Residue
Analysis Section**

Namık Özer Şenol

**Approved by
Laboratory Manager**

Çiğdem Kalın Vatanserver

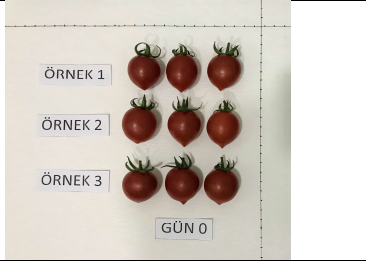


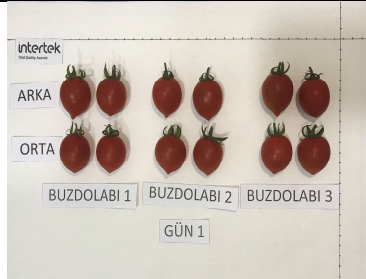
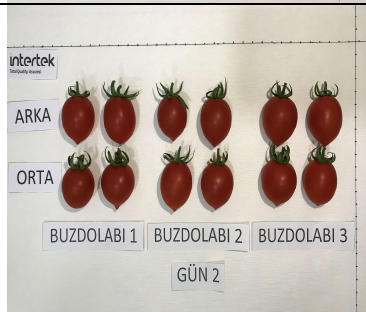
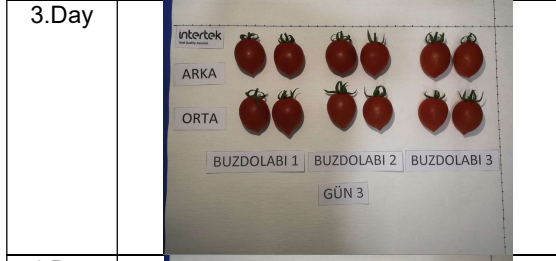
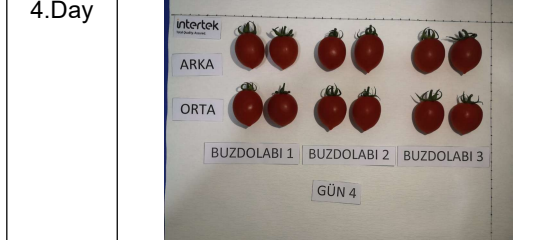
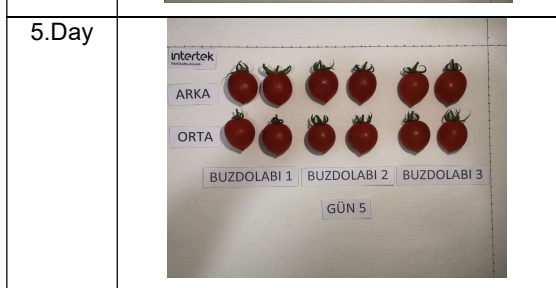
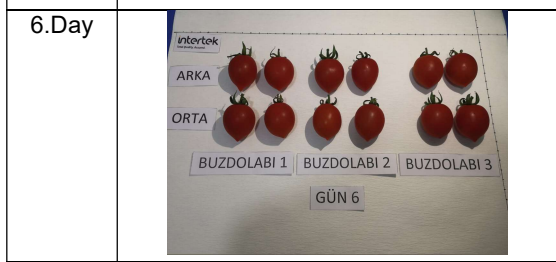
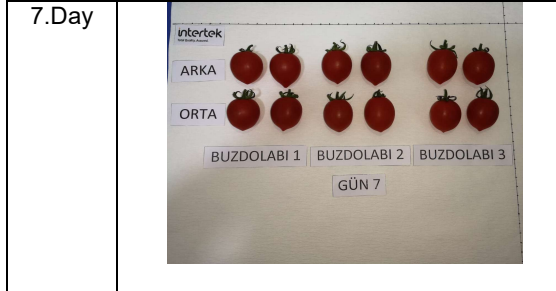
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ANNEX I – PICTURES OF TOMATO


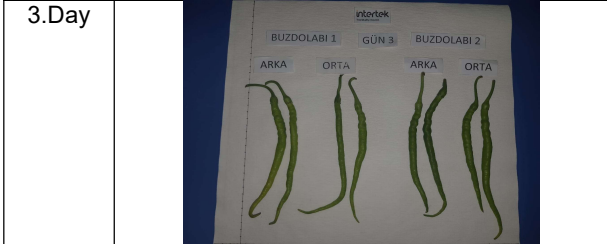

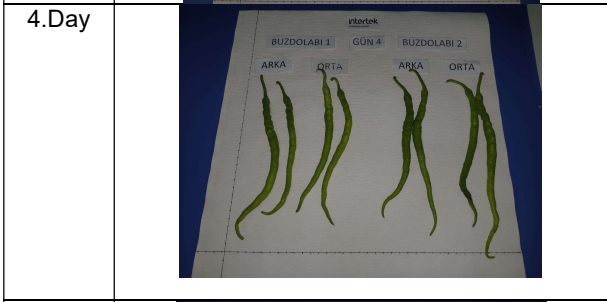

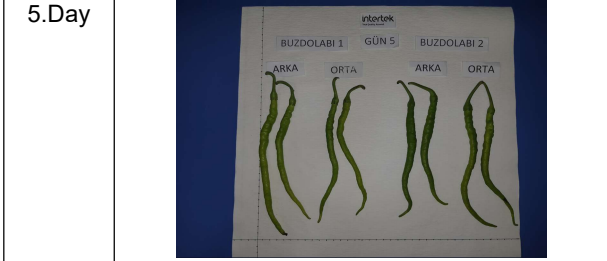
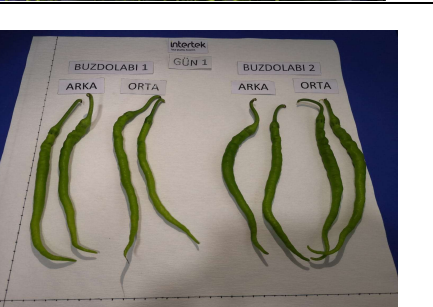
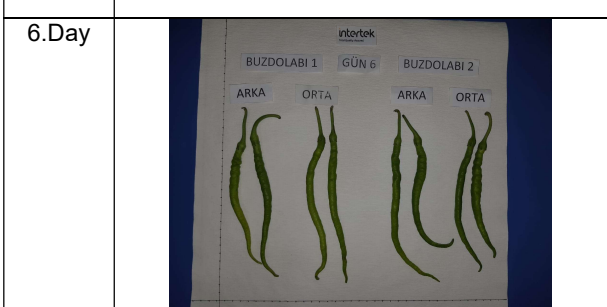
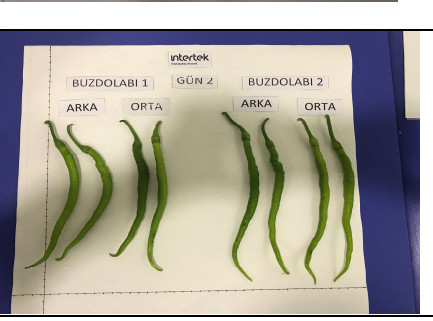
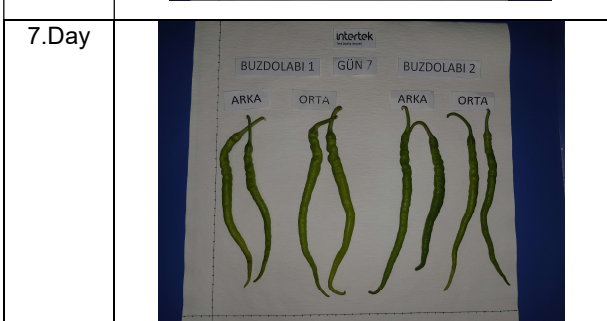
0.Day	
0.Day	
0.Day	
1.Day	
2.Day	
3.Day	
4.Day	
5.Day	
6.Day	
7.Day	

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ANNEX II – PICTURES OF GREEN PEPPER

0.Day		3.Day	
0.Day		4.Day	
0.Day		5.Day	
1.Day		6.Day	
2.Day		7.Day	

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ANNEX III – RESULTS of VITAMIN C and VITAMIN A

Amount of Vitamin C in Tomatoes During Storage (mg/kg)								
Storage Days	RGB LED Technology				Control (Darkness)			
	A	B	Average	stDev	A	B	Average	stDev
Day 0	279,6	279,6	279,6	0,0	279,6	279,6	279,6	0,0
Day 1	255,4	277,5	266,5	11,1	229,0	205,72	217,4	16,5
Day 2	309,5	309,5	309,5	0,0	225,3	232,02	228,6	4,8
Day 3	265,6	284,2	274,9	9,3	246,7	207,19	226,9	27,9
Day 4	254,2	265,0	259,6	5,4	249,5	227,78	238,6	15,4
Day 5	386,1	386,5	386,3	0,2	276,0	267,36	271,7	6,1
Day 6	329,0	317,3	323,1	5,9	267,3	292,13	279,7	17,5
Day 7	239,4	230,1	234,8	4,6	251,1	221,75	236,4	20,8
Average of 7 days	291,3	295,7	293,5	2,2	249,3	236,28	242,8	9,2
Rate of Av.of 7 Days to Control	20,9							

Amount of Vitamin C in Green Pepper During Storage (mg/kg)								
Storage Days	RGB LED Technology				Control (Darkness)			
	A	B	Average	stDev	A	B	Average	stDev
Day 0	534,0	534,0	534,0	0,0	534,0	534,0	534,0	0,0
Day 1	607,2	516,7	562,0	45,3	632,4	591,0	611,7	29,3
Day 2	554,2	543,9	549,1	5,2	574,6	565,7	570,2	6,3
Day 3	618,1	601,9	610,0	8,1	530,6	504,1	517,4	18,7
Day 4	689,7	717,7	703,7	14,0	461,0	495,2	478,1	24,2
Day 5	1045,3	1191,0	1118,2	72,9	624,8	500,0	562,4	88,2
Day 6	812,7	855,0	833,9	21,2	462,8	528,6	495,7	46,5
Day 7	590,2	591,7	591,0	0,8	484,5	511,7	498,1	19,2
Average of 7 days	702,5	716,8	709,7	7,2	538,7	528,0	533,4	7,5
Rate of Av.of 7 Days to Control	33,1							

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Amount of Vitamin A in Tomatoes During Storage (mcg/100g)								
Storage Days	RGB LED Technology				Control (Darkness)			
	A	B	Average	stDev	A	B	Average	stDev
Day 0	730,6	730,6	730,6	0,0	730,6	730,6	730,6	0,0
Day 1	1198,0	1065,1	1131,5	94,0	855,9	755,6	805,7	70,9
Day 2	1163,8	1315,6	1239,7	107,3	1091,1	960,5	1025,8	92,4
Day 3	1207,4	1329,7	1268,5	86,5	940,9	955,0	947,9	10,0
Day 4	1678,9	1400,8	1539,9	196,6	1154,4	990,3	1072,4	116,0
Day 5	1734,0	1450,7	1592,4	200,4	1076,9	1157,8	1117,4	57,2
Day 6	1319,8	1450,7	1385,2	92,5	1082,6	1162,1	1122,4	56,2
Day 7	1111,5	1515,5	1313,5	285,7	941,1	882,6	911,8	41,4
Average of 7 days	1344,8	1361,1	1353,0	11,6	1033,6	980,6	1007,1	37,5
Rate of Av.of 7 Days to Control	34,3							

Amount of Vitamin A in Green Pepper During Storage (mcg/100g)								
Storage Days	RGB LED Technology				Control (Darkness)			
	A	B	Average	stDev	A	B	Average	stDev
Day 0	247,8	247,8	247,8	0,0	247,8	247,8	247,8	0,0
Day 1	282,9	277,6	280,3	3,7	291,6	267,2	279,4	14,1
Day 2	300,8	308,3	304,6	5,3	250,3	273,8	262,1	13,6
Day 3	298,6	263,9	281,3	24,5	248,6	252,8	250,7	2,4
Day 4	308,6	307,8	308,2	0,6	240,9	238,0	239,5	1,7
Day 5	406,4	435,0	420,7	20,2	233,4	245,2	239,3	6,8
Day 6	358,6	358,4	358,5	0,1	262,6	261,9	262,3	0,4
Day 7	269,6	261,8	265,7	5,5	214,9	242,8	228,9	16,1
Average of 7 days	317,9	316,1	317,0	1,3	253,6	253,7	253,6	0,1
Rate of Av.of 7 Days to Control	25,0							