ISSN: 2994-872X

Research Article

International Journal of Botany and Horticulture Research

Influence of Cover Crops in Post-Harvest Cultivation and Refrigeration of Carrots

Lucas Silva Tizzo[1], Fernanda Salamoni Becker[2], Felipe Bonifacio[3], Filipe Pereira Oliveira[4] and Ana Paula Silva Siqueira[5*]

[1]*Agronomist, Federal Institute of Education, Science and Technology Goiano - Campus Morrinhos*

[2]*Food Engineer, Federal University of Goiás (UFG) Faculty of Agronomy*

[3]*Agronomist, Federal Institute of Education, Science and Technology Goiano - Campus Morrinhos*

[4]*Graduating in Nutrition, Federal Institute of Education, Science and Technology Goiano – Urutaí Campus*

[5]*Nutritionist, Federal Institute of Education, Science and Technology Goiano – Urutaí Campus*

[*]Corresponding Author
Ana Paula Silva Siqueira, Nutritionist, Federal Institute of Education, Science and Technology Goiano – Urutaí.

Submitted: 2023, Oct 20; **Accepted**: 2023, Nov 15; **Published**: 2023, Nov 21

Citation: Tizzo, L. S., Becker, F. S., Bonifacio, F., Oliveira, F. P., Silva Siqueira, A. P. (2023). Influence of Cover Crops in Post-Harvest Cultivation and Refrigeration of Carrots. *Int J Bot Hor Res, 1*(1), 106-114.

Abstract
Carrot (Daucus carota) is one of the most commercialized vegetables in the Brazilian market, but irrigation and weed incidence are limiting factors in the production of this vegetable. The aim of this study was to measure the post-harvest quality of carrot under the influence of cover crops and different storage temperatures. The experiment was installed in factorial scheme (4 x 2 x 6), with 8 covers with vegetal residue (C1- grass, C2- rice husk, C3- sugarcane straw and C4- control- without cover crop), 2 temperatures of storage, T1- refrigerated at 5°C and T2- room temperature at 25°C, and 6 evaluation periods (0 5, 10, 15, 20, 25 days) using 3 replications of 5 roots each. The treatments with cover crops and post-harvest refrigeration are efficient to maintain the physical-chemical quality of the roots. The firmness of the roots at room temperature was lower than refrigerated (150.3 and 167.5 respectively). Most of the cover crops had higher SS/AT ratio than the control (average of 12.09 and 10.16, respectively). Cover crops and heat treatment had a positive influence on the shelf life of carrots.

Keywords: Rice Husk, Post-Harvest Quality, Brasilia, Cooling

1. Introduction

Carrot (*Daucus carota*) is one of the most popular vegetables in the Brazilian market and occupies the fifth position regarding economic importance [1]. It can be planted throughout the year, since the cultivar is suitable to the planting season [2]. The barriers in the cultivation of this vegetable can generate a reduced supply of the product in the Brazilian market or the obtainment of lower commercial standard vegetables [3]. The cultivation of this vegetable occupies an approximate area of 26 thousand hectares, producing approximately one million tons. Goiás is the fourth largest producer of the country, reaching 745 ha of cultivated area in 2013 [4]. According to Filgueira, carrots have high concentration of vitamin A, soft texture and pleasant taste [5]. Its consumption can be 'in natura', cooked, in juices, canned vegetables, children foods and instant soups. Irrigation is one of the limiting factors in the cultivation of oleraceous, since the deficit or excess of water during the crop development period can affect root yield and quality [6]. The presence of weeds is also a limiting factor because it promotes competition of resources such as water, light and essential nutrients [7]. Thus, the management of soil cover is fundamental to reduce the interference imposed by these factors. According to the Brazilian Institute of Geography and Statistics, most Brazilian soils have low pH, and are considered potentially acidic and are also impoverished by weathering and conventional cultivation, with deficiencies in phosphorus and potassium [8]. This can cause nutritional deficiencies in plants, compromising yield and also becoming a gateway to some diseases. The cultivation of oleraceous in cropping systems that favor the formation of straw on the soil surface has become a new economically viable practice, as it favors the maintenance of soil moisture, the reduction of weeds emergence and green shoulder since it prevents the solar rays from crossing the surface layer of the soil, guaranteeing a better product quality [9].

The pre and pos harvest quality characteristics are fundamental to determine the success of the product on the shelf and generates income for the sector. The firmness may favor or harm the carrots transportation to the distribution centers. Size, acidity, vitamin content and pH are determinants to the type of processing that the products will be destined [10]. From harvest to the final consumer, the products can go through several steps that can reduce their shelf lives, such as transportation, storage, and deposition place of the product in the marketing and supply centers. A properly storage in refrigeration chambers can guarantee product quality for a longer period of time. Several authors have studied the influence of storage conditions on the product quality. Evaluating the sensory modifications in carrots in two types of cuts during refrigerated storage, observed that there was a reduction in appearance and coloring scores, while the taste and texture improved in both cuts [11]. Therefore, the purpose of this study was to verify the post-harvest quality and to quantify the shelf life of carrots packed in modified atmosphere submitted to different temperatures during storage.

2. Materials and Methods

The experiment was carried out under irrigation conditions in the experimental area located at 17º48'50.4"S, 49º12'16.5"W and altitude of 902 m, under a tropical climate, type Aw according to Köppen- Geiger; characterized by a rainy season from October to April, and a dry season from May to September, with average annual temperature between 23 and 25ºC and average annual rainfall between 1200 and 1400 mm from March 2016 to June 2016. Soil samples were collected for analysis before the experiment installation. Then, soil was prepared with a plowing and two harrows. Immediately after this, the sowing was performed manually with Brasilia cultivar, which has a 110-day cycle. The seeds were sown linearly and after their emergence the thinning was performed. Besides the control (without cover crop), three types of mulching were deposited: grass residue, rice husk and sugarcane straw. All crop treatments were performed when necessary. The experiment was installed in a factorial scheme (4 x 2 x 6), with 8 covers with vegetal residue, C1- grass, C2- rice husk, C3- sugarcane straw and C4- control (without cover crop), 2 temperatures of storage, T1- 5°C and T2- 25°C and 6 evaluation periods (0,5,10,15,20,25 days) using 3 replications of 5 roots each. At the end of the cycle, the roots were harvested and taken immediately to the agro-industry laboratory (IFGoiano - Morrinhos), where they were washed and sanitized with 100 ppm active chlorine and put onto polypropylene trays and covered with PVC (polyvinyl chloride), forming a modified atmosphere. Then, the material was stored under environment conditions at 5oC (cold room).

Evaluations of soluble solids were performed, and the Brix readings were performed in an analog refractometer (ABBÉ, model SBA -9006B). The total acidity was determined by titration with 0.01 N sodium hydroxide solution (NaOH). Soluble solids (SS) and titratable acidity (TA) were used to determine the maturation index ratio (SS / TA). Mass loss was evaluated using a precision balance. In addition, the texture was evaluated with the aid of a texturometer T.A.X.T. Plus (Stable Micro System) equipped with a 50-kg load cell using the Warner-Bratzler Knife with triangular blades with a deformation of 150%, pre and post-test speed of 2 mm / s, at 25 ° C. The ascorbic acid content was determined according to Strohecker and Henning and the results were expressed in milligrams of ascorbic acid per 100 grams of sample [12]. Finally, soluble solids (SS), titratable acidity (TA) and ratio were determined following the methodologies described by AOAC [13]. The determination of the color was performed in two distinct points of the fruit, through the reading of three parameters defined by the CIELAB system. The parameters L*, a* and b* were provided by the colorimeter (Hunterlab, Color Quest II), in which L* defines the luminosity (L* = 0 : black and L* = 100: white) and a* and b* define the chromaticity (+ A*: red and -a*: green, + b*: yellow and -b*: blue). Chromaticity and Hue angle were determined from these data. Data were submitted to analysis of variance and Scott Knott test and the interactions were represented at 1% and at 5% significance.

3. Results and Discussion

For titratable acidity, ratio, pH, color, luminosity, hue angle and vitamin C, the treatments with temperature were not significant (Table 1). Soluble solids content, firmness and mass loss were significant for the different temperatures. In the refrigerated samples the solids content was higher, and the refrigerated treatment was more efficient to maintain the firmness of the root and were the ones which suffered less losses of mass. Decreases in temperature can reduce the respiratory rates of fruits and roots. However, too low temperatures can lead to physiological lesions in fruits. This reduction in respiration is caused by the decrease in the rate of metabolic relationships mainly because of the ideal temperature range for the enzymes activity of the respiratory process, ethylene synthesis and metabolic reactions. Therefore, with the reduction of temperature, solids are not being used in large scale for respiration and at the same time, the slight loss of mass causes an apparent increase in solids. This low respiratory rate also justifies the lower mass loss, combined with the modified atmosphere. Similar results were observed by Souza et al. (2012) who worked with refrigerated storage potential in carrots cultivated in organic system (SS refrigerated carrot 11,67; SS environment carrot 10, 08).

Treat-ments	TA	pH	SS	RATIO	FIRM-NESS	LM	CHRO-MA	LUM.	HUE	AA
Refriger-ated	0,80 a	6,09 a	8,40 a	11,82 a	167,5 a	582,9 a		49,59 a	67,16 a	72,2 a
Room tempera-ture	0,79 a	6,08 a	8,10 b	11,40 a	150,3 b	408,97 b		50,58 a	67,70 a	74,29 a
F1	0.051 ns	1,05 ns	6,09 *	1,90 ns	5,95 *	98,41 **	0,95 ns	1,78 ns	3,07 ns	1,05 ns
COVER CROPS										
1	0,69 c	6,12 a	7,90 b	12,75 b	172,2 a	539,90 a		50,61 a	66,08 c	71,5 b
2	0,96 a	6,08 b	8,87 a	9,69 c	159,9 a	570,08 a		51,44 a	68,07 b	75,7 a
3	0,63 d	6,11 a	7,72 b	13,83 a	162,03 a	446,6 b		49,05 a	65,59 d	69,14 b
4	0,91 b	6,04 c	8,7 a	10,16 c	141,5 b	372,9 c		49,24 a	69,38 a	76,65 a
F2	89,57 **	11,34 **	21,09**	43,29 **	3,29 *	35,43 **	0,921 ns	2,36 ns	28,18 **	3,03 *
PERIOD										
1	0,75	6,03	7,64	10,32	169,32	534,9		47,79	55,26	73,86
2	0,74	6,08	7,36	9,99	128,41	524,4		49,22	58,18	58,69
3	0,74	6,06	8,10	11,27	174,49	514,96		50,49	60,62	57,19
4	1,08	6,07	8,82	8,23	168,73	492,72		49,13	55,18	75,26
5	0,57	6,13	9,13	16,78	161,15	462,01		50,15	87,75	90,90
6	0,89	6,15	8,75	13,04	151,48	446,30		53,72	87,59	83,59
F3	63,58**	12,07 **	21,51**	64,22 **	3,85 ns	2,74 ns	99,4**	4,92*	1723,7 **	28,86 **
INTERACTIONS										
F1XF2	0,31ns	1,86 ns	1,46 ns	0,5 *	2,8 *	16,37 ns	0,15 ns	0,55 ns	4,95 **	3,04 *
F1XF3	1,52 ns	3,5 **	3,92 **	1,23 ns	0,95 ns	0,24 ns	1,48 ns	6,6 **	13,45 **	6,08 **
F2XF3	23,02**	3,33 **	2,33**	13,63**	1,16 ns	0,74 ns	0,41ns	0,78 ns	15,01 **	2,42 **
F1X-F2XF3	0,97 ns	0,80 ns	2,00 *	1,81*	1,18 ns	0,11 **	0,80 ns	1,35 ns	8,67 **	1,71 ns

[a, b, c] Same lowercase letters in the same column do not differ statistically from Scott Knott's test at 5% significance. *Significance at 1%; ** Significance at 5%; Ns Not significant; F1- interaction among treatments; F2- interaction among cover crops; F3- interaction among seasons

Table 1: Titratable acidity (AT), pH, soluble solids (SS), ratio, firmness, loss of mass, color (chroma, luminosity and hue angle) and ascorbic acid for carrots and interactions between these factors for refrigeration and environment, and periods.

It was observed that cover crops were not significant only for chroma and luminosity (Table 1). It was observed that the rice husk cover (C2) stood out for titratable acidity, loss of mass (lower), soluble solids and ascorbic acid content, and did not differ significantly in firmness in relation to the other cover crops. Satisfactory results as plant height, higher survival, larger and heavier roots were obtained in study performed by Resende using rice husk associated with wood shavings as cover for carrot cultivation [14]. Rice husk provides permeability and porosity to the substrate, contributes with residual organic and inorganic matter and improves water retention, and cation exchange capacity. The organic decomposition of it is only possible in aerobic environment with specific fungi. The effect of time on post-harvest parameters was largely significant. Even with considerable oscillations during the evaluation period, it was observed a greater loss of mass with time, reduction in firmness, and increase in titratable acidity, luminosity, hue, pH, ratio, soluble solids and ascorbic acid, which normally occurs during the evolution of the maturation process in fruits and vegetables. There was interaction between the types of cover crops and the evaluation seasons for titratable acidity (Figure 1). It can be seen that C1 and C3 maintained the titratable acidity at low levels, while C2 and C4 from the 10th day raise the titratable acidity levels, starting at 0.8 and reaching 1.4 (mg/100g). According to Chitarra and Chitarra (2005), the acidity decreases with the increase of pH, exactly what is observed for C1 and C3, where it starts with 0.8% in the first evaluation period and ends up around 0.4%. A similar result (0.8 to 0.63%) was observed by Guimarães with minimally processed carrots with edible film stored for 28 days [15].

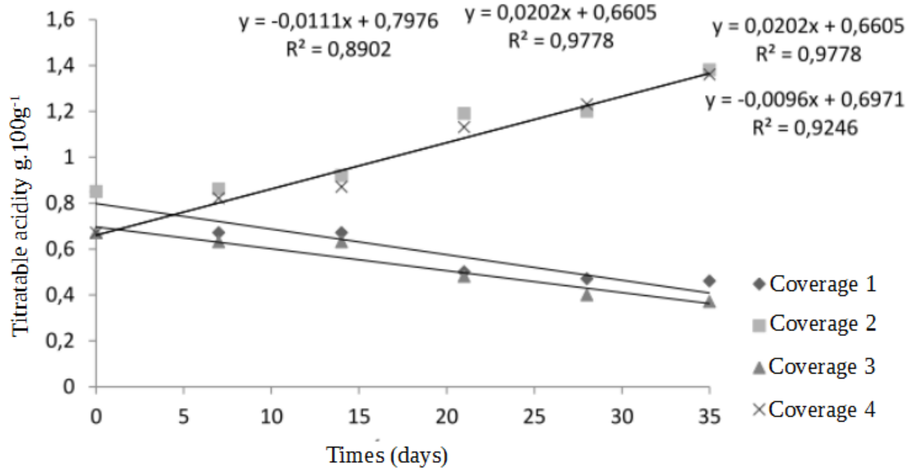

Figure 1: Interaction between Cover Crops and Period for Titratable Acidity (TA)

For pH evaluation there was interaction between heat treatment and period (Figure 2) and interaction between cover crops and time (Figure 3). There was an intersection for pH values of the refrigerated environment and without refrigeration, indicating that there is no more influence of temperature from that point. And for the second interaction between cover crops and period, there was intersection only between rice husks and sugarcane straw. The pH values are similar to the ones found by Silva, where the pH of the minimally processed carrot was around 6.0 [16].

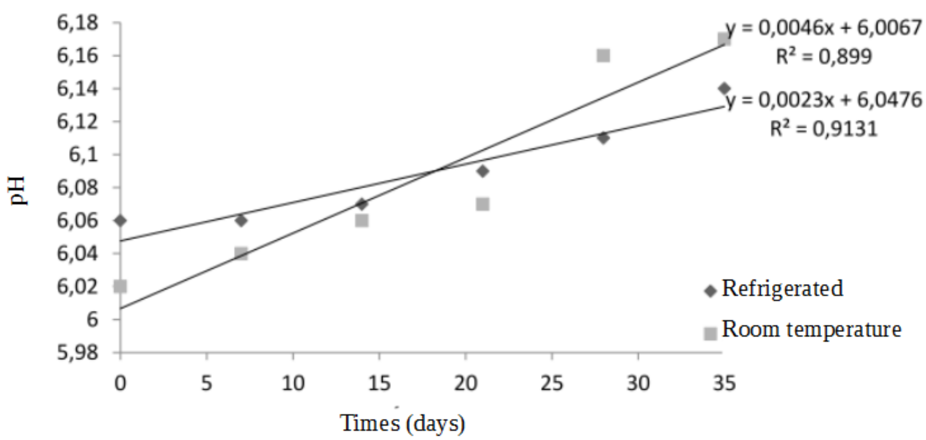

Figure 2: Interaction between Heat Treatment and Period for pH

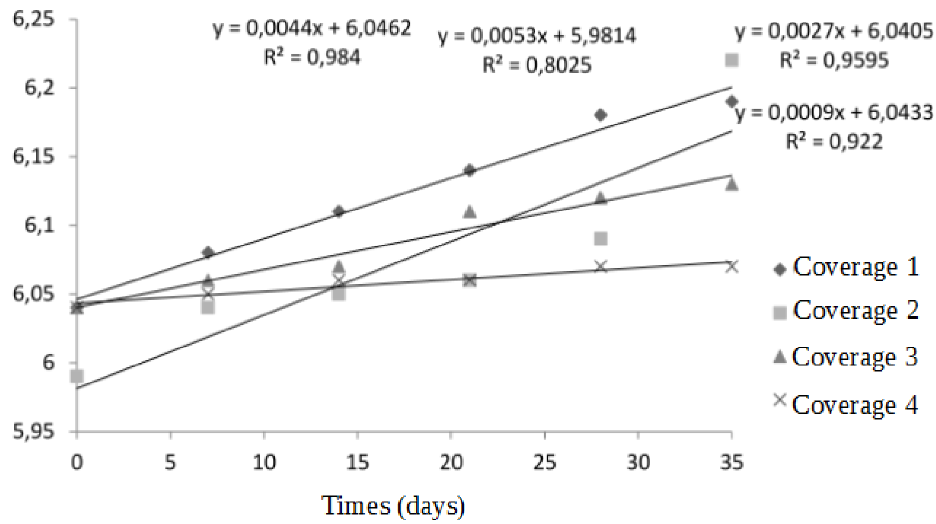

Figure 3: Interaction between Cover Crops and Period for pH

There was interaction for firmness between the types of cover crops and heat treatment (Figure 4). In the refrigerated environment all the covers were efficient in maintaining the firmness. This is probably because the environment temperature accelerates the metabolism of the product and there is a greater solubility of pectic substances. With the refrigeration, the opposite happens. However, at room temperature, cover 1 (grass) and cover 2 (rice husk) stood out when compared to the other cover crops. Firmness is one of the main characteristics evaluated by the consumer when buying in natural products [17]. It is generally associated with the solubility of pectic substances. According to Chitarra and Chitarra, the process of solubilization of pectins contributes to the softening of tissues due to the reduction of the cohesive force among the cells [18].

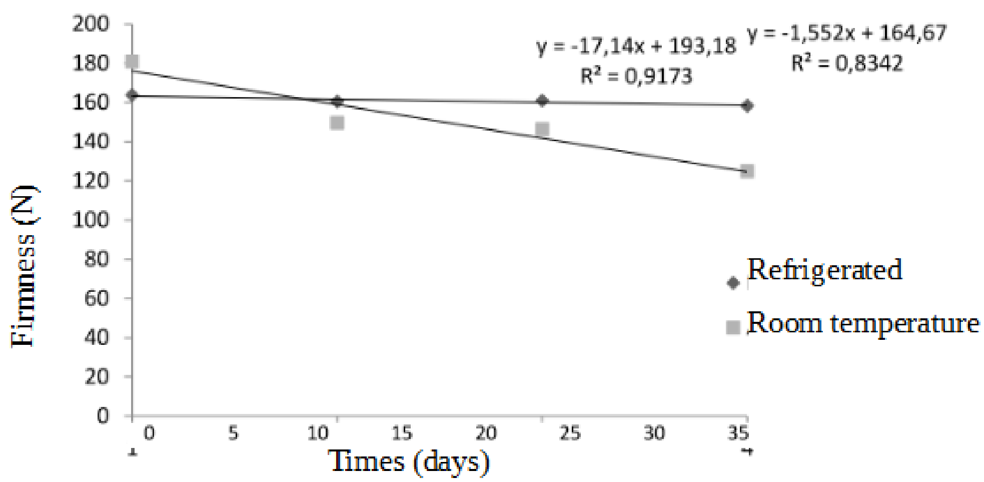

Figure 4: Interaction between Cover Crops and Heat Treatment for Firmness.

The interactions in the parameters referring to color indicate a yellowing and a decrease in the intensity of the orange color with time (Figure 5; Figure 6). It is natural due to the long exposure of the pigments to light and oxygen. Therefore, carrots stored at 5°C had a better color than the carrots that remained at room temperature.

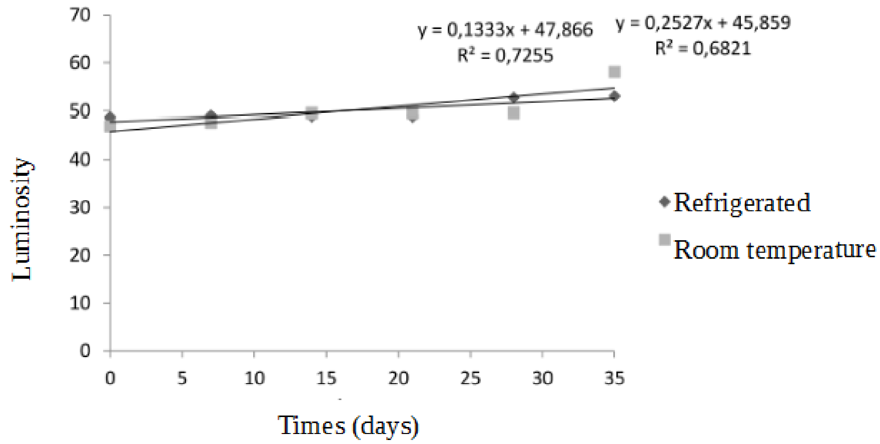

Figure 5: Interaction between Heat Treatment and Period for Luminosity

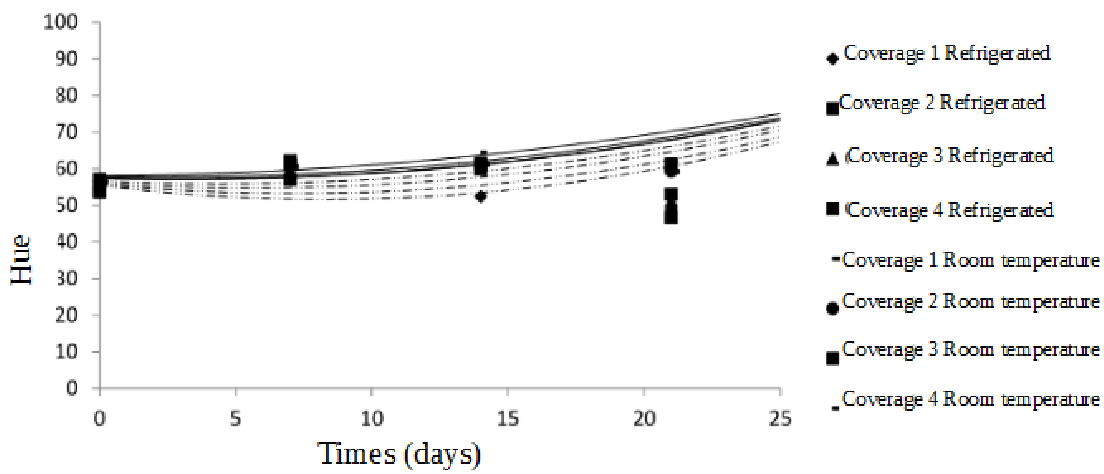

Figure 6: Interaction between Cover Crops, Heat Treatment and period for Hue.

For the variable vitamin C, there were three different interactions: interaction between cover crops and heat treatment, between heat treatment and periods, cover crops and periods. In the first interaction, it was observed a high increase in vitamin C in cover 4 in the refrigerated temperature (Figure 7). In the second interaction, the refrigerated treatments had a slightly higher value of vitamin C during the periods of evaluation (Figure 8). In the third interaction, it can be observed that C2 maintained a slightly higher value of vitamin C than the other cover crops during the storage period (Figure 9). Vitamin C values were higher than those found by Silva, in freshly processed (18.3mg / 100g) and in natura (21.30 mg / 100g) carrots [16]. This can also be justified due to the cultivar that was used.

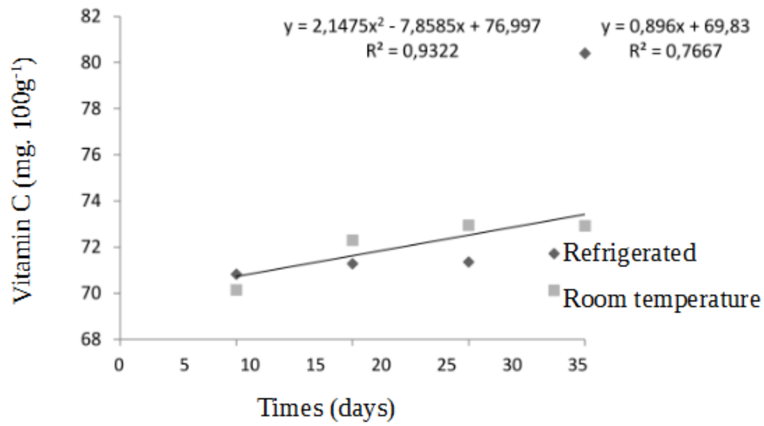

Figure 7: Interaction between Cover Crops and Heat Treatment for Vitamin C

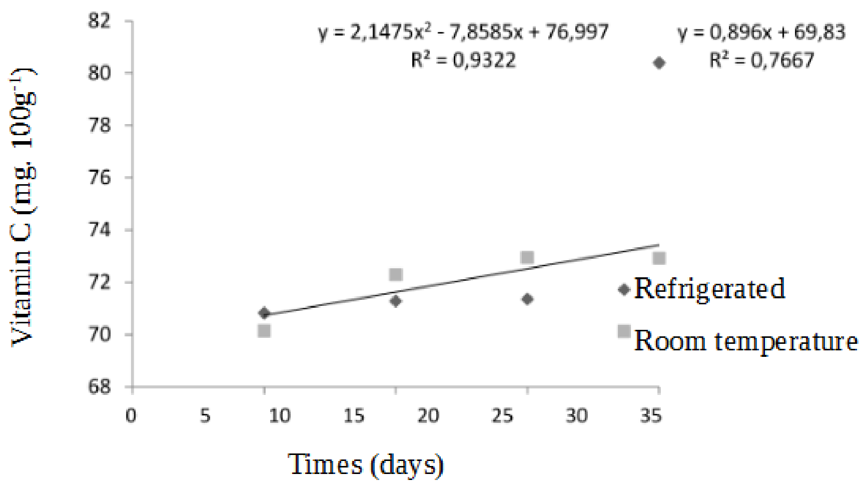

Figure 8: Interaction between Heat Treatment and Periods for vitamin C

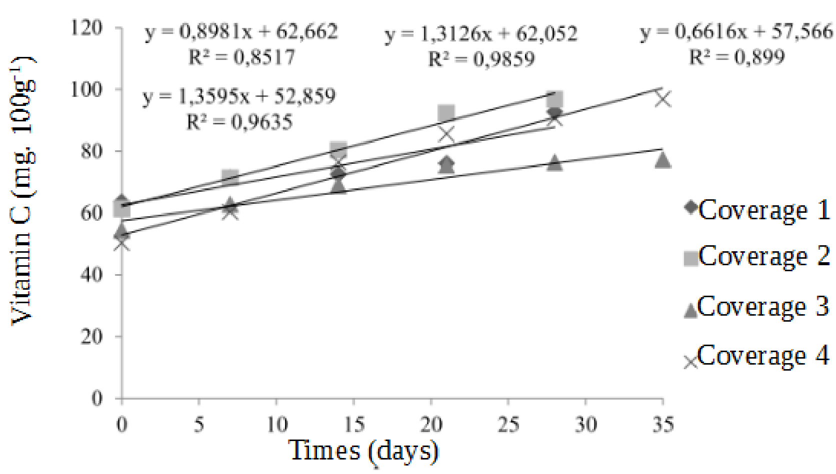

Figure 9: Interaction between Cover Crops and Periods for Vitamin C

Loss of mass, soluble solids and ratio showed interaction for cover, heat treatment and period (Figure 10, Figure 11 and Figure 12, respectively). The carrots submitted to pretreatment with cover crops, in refrigeration lost less mass and had higher solids content and better ratio.

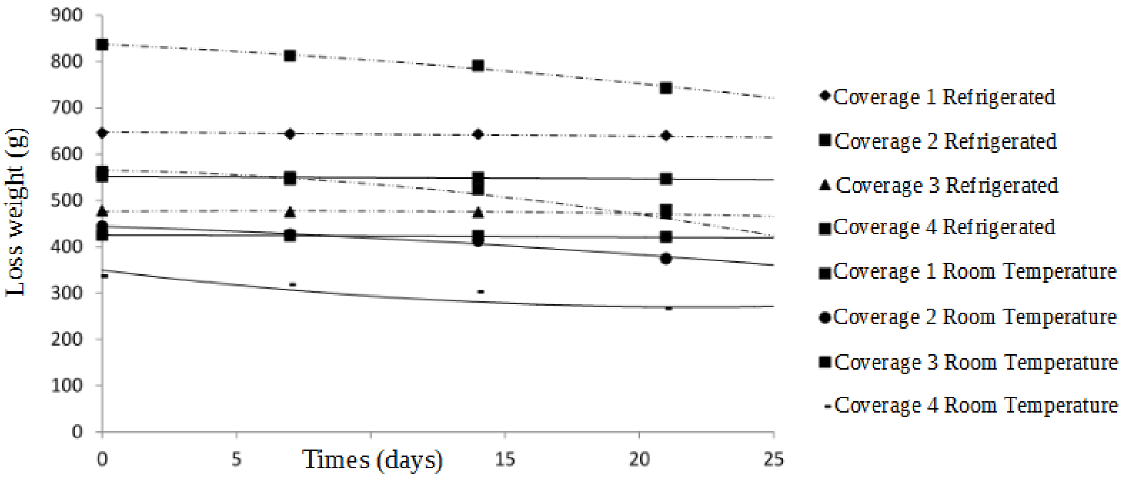

Figure 10: Interaction between Cover Crops, Heat Treatment and periods for loss of mass.

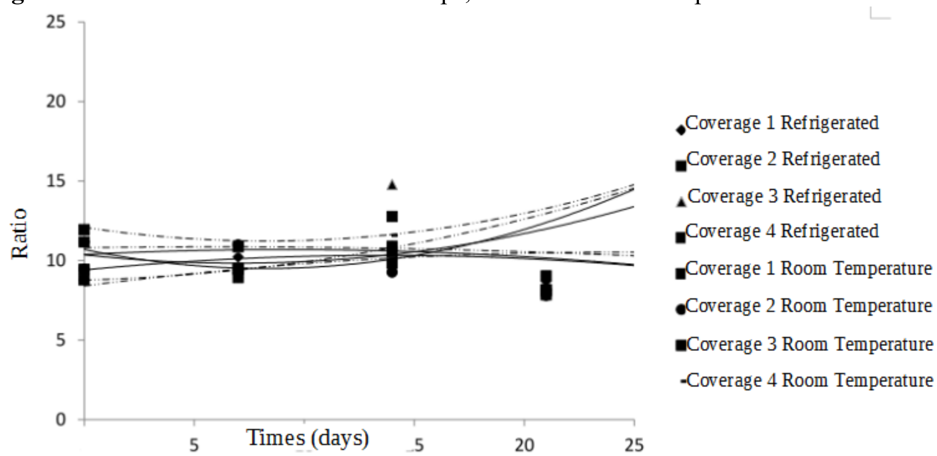

Figure 11: Interaction between cover crops, heat treatment and periods for ratio.

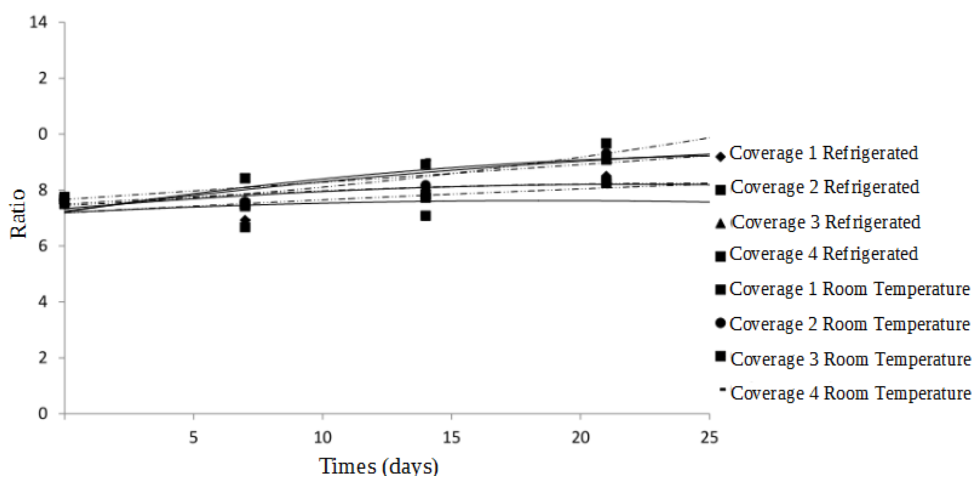

Figure 12: Interaction between cover crops, heat treatment and period for SS.

4. Conclusion

Cover and heat treatment directly influenced the shelf life of carrots. The husk cover and the refrigerated treatment promoted better physio-chemical characteristics in the post-harvest [19,20].

References

1. Marouelli, W, A. et al. Carrot Irrigation. Circular Technique, v.48, p.1-4. 2007.
2. Luz, J. M. Q., Silva Júnior, J. A., Teixeira, M. S., Silva, M. A., Severino, G. M., & Melo, B. D. (2009). Desempenho de cultivares de cenoura no verao e outono-inverno em Uberlândia-MG. Horticultura Brasileira, 27, 96-99.
3. Santos, C. A. B., Zandoná, S. R., Espindola, J. A. A., Guerra, J. G. M., & Ribeiro, R. D. L. (2011). Efeito de coberturas mortas vegetais sobre o desempenho da cenoura em cultivo orgânico. Horticultura Brasileira, 29, 103-107.
4. Dumbra, J.G.R. Recordes em 2013: Setor tem o maior e o menor preço da série histórica. Hortifruti Brasil. 2014.
5. Filgueira F.A.R. Novo manual de olericultura: agrotecnologia moderna na produção e comercializacao de hortaliças. Universidade Federal de Viçosa, Viçosa, 3.ed, 412p, 2008.
6. Marouelli, W. A., do CN Guiducci, R., Braga, M. B., Barreto, Y. C., & de Macedo, T. C. (2012). Eficiência econômica do uso de sistemas de irrigação para a produção de tomate orgânico, nas condições de Brasil Central. Hortic. bras, 30(2).
7. Balbinot Junior, A. A., Procópio, S. D. O., Debiasi, H., Franchini, J. C., & Panison, F. (2015). Semeadura cruzada em cultivares de soja com tipo de crescimento determinado. Semina Ci. agr., 1215-1226.
8. Instituto Brasileiro De Geografia E Estatística – IBGE. Manual Técnico de Pedologia. 2.ed, n.4, 2007.
9. Instituto Brasileiro De Geografia E Estatística – IBGE. Manual Técnico de Uso da Terra. 3.ed, n.7, 2013.
10. Carvalho, J. O., Luz, J. M., Juliatti, F. C., Melo, L. C., Teodoro, R. E., & Lima, L. M. (2003). Desempenho de famílias e híbridos comerciais de tomateiro para processamento industrial com irrigacao por gotejamento. Horticultura Brasileira, 21, 525-533.
11. Resende, J. M., Coelho, A. F. S., Castro, E. C. D., Saggin Júnior, O. J., Nascimento, T. D., & Benedetti, B. C. (2004). Modificações sensoriais em cenoura minimamente processada e armazenada sob refrigeracao. Horticultura Brasileira, 22, 147-150.
12. Strohecker, R., & Henning, H. M. (1967). Analisis de vitaminas: métodos comprobados: Paz Montalvo. Madrid. 428p.
13. AOAC - Association Official Analytical Chemistis. Official Methods of Analysis of AOAC International. 18. ed. Gaithersburg: AOAC, 2010.
14. Resende, F. V., Souza, L. S. D., Oliveira, P. S. R. D., & Gualberto, R. (2005). Uso de cobertura morta vegetal no controle da umidade e temperatura do solo, na incidência de plantas invasoras e na producao da cenoura em cultivo de verão. Ciência e agrotecnologia, 29, 100-105.
15. Guimarães, I. C., Menezes, E. G. T., Rodrigues, L. F., Rodrigues, A. C., Monteiro, A. G. D. P., dos Reis, K. C., & Boas, E. V. D. B. V. (2016). Filme Comestível a base de amido e micro/nanofibrilas de celulose de cenoura prolonga a vida útil de cenoura minimamente processada. Boletim do Centro de Pesquisa de Processamento de Alimentos, 34(1).
16. Silva, A. C. B., dos Santos Schuquel, L. C., da Silva, C. O., & Pascoal, G. B. (2016). Qualidade nutricional e físico-química em cenoura (Daucus carota L.) in natura e minimamente processada. DEMETRA: Alimentação, Nutrição & Saúde, 11(2), 355-367.
17. Andreu, M. A. (2005). Associação entre características agronômicas da batata nos plantios de primavera e outono no Rio Grande do Sul. Ciência e Agrotecnologia, 29, 925-929.
18. Chitarra, M. I. F., & Chitarra, A. B. (2005). Pós-colheita de frutas e hortaliças: fisiologia e manuseio (Vol. 1). Lavras: Universidade Federal de Lavras.
19. Botrel, N., de Souza, R. B., Braga, D. O., Resende, F. V., BRAGA, D. O., & RESENDE, F. V. (2013). Potencial do armazenamento refrigerado para cenouras cultivadas em sistema orgânico e convencional. Hortic. bras, 30(2).
20. HunterLab, C. I. E. (1996). L* a* b* color scale. Applications note, Virginia, USA.