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The Impact of a Combined Infrared-Hot Air System on the Thawing Process and Quality Attributes of Carrots

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ABSTRACT

Vegetables are perishable and cultivated seasonally. The aim of this study was to employ a combined thawing through hot air-infrared system, while investigating the effects of temperature, airflow velocity, and infrared radiation power on thawing time and the quality attributes of thawed carrots. In this research, carrot samples, having been washed and shaped using a cylindrical mold measuring 22.5 mm in diameter and 12 mm in height, were subjected to freezing at -18°C for 48 hours. Thawing parameters were air temperature (30°C and 40°C), airflow velocity (0.5 and 5 m/s), and infrared power (100 and 300 watts). The sample thawed at 25°C was control sample. Data analysis showed that reciprocal effect of increasing temperature, power of the radiation source and air flow speed had a significant effect on the thawing time, vitamin C, β-carotene, the thawing loss, and pH (P≤0.05). This system was able to significantly reduce the thawing time this time for the control sample was 47.66 minutes and for the shortest thawing time, the treatment 8 (F5P300T40) was 6.23 minutes. The lowest pH value was related to treatment 7 (F0.5P300T40) 5.81 and the highest value was related to treatment 1(F0.5P100T30) 6.15. The highest amount of β -carotene was related to treatment number 8 (F5P300T40) 48.12 mg/100g and the lowest amount was related to treatment 5 (F0.5P100T40) 14.03 mg/100g. The highest amount of vitamin C was related to treatment 4(F5P300T30) 12.36 mg/100g and the lowest amount was related to treatment 1(F0.5P100T30) 3.68 mg/100g. In the thawing loss, the highest amount was related to treatment 1 (F0.5P100T30) 19.7% and the lowest amount was related to the control sample7.44%. Combined thawing is widely used in the food industry and for various products. Due to the low start-up cost, shorter process time and favorable quality, hybrid defrosting is widely used in the food industry.

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1- Introduction

Carrot is one of the most popular vegetables because it has high fiber and many vitamins. In recent years, the consumption of carrots and related products has increased. Carrot has many uses because of its useful food compounds, and freezing carrots is very useful to maintain its quality and freshness [1, 2]. Freezing is a common and widely used method in the food industry and increases the shelf life of frozen food [3]. The freezing process occurs at low temperature by turning food water into ice crystals. The frozen food water stabilizes the cell structure and its tissue and makes it out of the reach of microbes and also loses its activity as a solvent [4]. The freezing process is very economical and desirable, the frozen product must be defrosted before consumption [5]. Defreezing is the reverse process of freezing and its goal is to obtain a high-quality product that has been defrosted in the shortest possible time [6]. The usual methods of freezing for a large amount of food are problematic for the industry. Long defrosting time, weight loss of defrosted food, quality reduction and the possibility of spoilage and microbial contamination are among the disadvantages of defrosting in the usual way, so electrical heating methods such as ohmic heating, microwave, carbon fiber plate and infrared have been proposed as alternative methods to reduce The duration of defrosting, reducing the cost of defrosting operation and minimizing changes in color and texture and nutritional ingredients [7]. One of the fastest methods of defrosting is the use of microwaves. The microwave penetrates into the food and causes the defrosting of the food by generating heat. It has been reported that microwaves, while reducing the time of defrosting, reduce weight loss, reduce microbial problems, and reduce chemical changes [8]. The disadvantage of using microwave is that after defrosting, some parts of food remain frozen; While some parts have reached the cooking temperature, this inhomogeneity is caused by the uneven distribution of microwaves between the liquid and solid phases of food water and the heterogeneous structure of food especially in large samples [9]. The ohmic heating method is another method of defrosting. This method is based on the generation of heat due to the passage of electric current through food that has a certain conductivity [10].. In ohmic heating, food is quickly defrosted. The time required to defrost tuna, beef and eggs by ohmic method is 66-75% less than using conventional defrosting methods [8]. On defrosting by ohmic method Not many studies have been done and there is not much information available for the use of ohmic heating for cubic and bulk products. This method does not generate high heat compared to the use of microwaves [9].

Electric heating with carbon fiber plate It includes a corrugated carbon plate heater. Today, the use of this method has increased due to its high efficiency and ability to be used at high temperatures, but this method is not suitable for high volume products [11].

one ofNew methods of defrosting are the use of infrared rays. Infrared Ray(ANDIt is a part of the electromagnetic spectrum that is mainly responsible for the heating effect of the sun, infrared waves are between visible light waves and visible radio waves and can be three different categories of near infrared rays.NIR), mid-infrared rays (ME(and far infrared rays)FOR) to be divided [12]. In comparison with microwave defrosting, the use of infrared rays is a gentler process, but sufficient information about the efficiency of infrared rays in the defrosting process has not been published, although it is expected that infrared defrosting is more effective than traditional defrosting methods such as air defrosting [13]. . Chen et al. (2022) used the infrared-microwave combined method to defrost carrots, green peppers, and cantaloupe. These defrosted samples were compared with the usual defrosting method. The samples were compared in terms of defrosting time, loss due to defrosting, moisture distribution, color, taste, ascorbic acid, hardness and cell damage. The results showed that the use of the combined method was very efficient [14].

Hong et al. (2009) used infrared radiation to defreeze pork. The results showed that with the increase in the power of the radiation source and the speed of air flow, the loss due to defreezing decreases and the water holding capacity and shear force increase [15]. Hasieh et al. (2010) subjected chicken thigh meat to defrosting using two methods of using high voltage electrostatic field and storing it in a refrigerator at 4 degrees Celsius. It was thawed in a refrigerator at 4°C [16].

Bosumerj et al. (2005) frozen tiger shrimps by fluid bed method and cryogenic method. The samples were defrosted by two methods of using microwaves and keeping them in the refrigerator. The results showed that samples defrosted with microwaves had higher thiobarbituric acid index and loss due to freezing. [17]. Kai et al. (2020) used four methods to defreeze redfish, which are: the use of microwaves, the use of far-infrared rays, the combined method of applying magnetic nanoparticles-microwaves, and the combined method of magnetic nanoparticles-infrared rays. The results showed that the application of the combined method has improved the quality of the defrosting product [18].

Since the use of combined methods of defrosting is a new process in the food industry, so far not many researches have been conducted in this field, and no report has been published on the combined defrosting of carrots, and the existing methods are often expensive, or cause adverse changes in the defrosted product, or They are traditional and long-term, so the use of new methods to improve the quality of frozen food It is required. In this research, the combined infrared ray-hot air defrosting method was used to defrost carrots, and the sample defrosted by the combined method in terms of defrosting time, vitamins, beta-carotene, loss due to defrosting, pH with the control sample (sample defrosted by the method Traditional in room temperature 25) has been compared.

2- Materials and methods

2-1- Preparation of carrot samples

Carrot samples (*Daucus carrot*) They were freshly prepared from the local market of Gorgan and after washing, they were molded by a cylindrical mold with a diameter of 225 mm and a thickness of 12 mm, and their initial weight was recorded. In order to measure the temperature and reach the central temperature during defrosting to 1 degree Celsius, the thermometer sensor (Lutron Canada company modelTM-947SD) was placed in the center of the molded carrots at a distance of 6 mm from the surface of the carrot and then it was frozen for 48 hours in a freezer with a temperature of -18 degrees Celsius [19].

2-2-Defrost process system

To perform the defrosting operation, a combined infrared-heat air system (made by the Food Industry Department of Gorgan University of Agriculture and Natural Resources located in the Faculty of Food Industry of this university) was used and the mutual effect of air temperature, air flow speed, and infrared power on the qualitative characteristics of the samples Defrosted carrots were examined. Twenty minutes before the defrosting operation, the device was turned on and the defrosting operation was carried out in 8 treatments including 2 air temperatures (30 and 40 degrees Celsius) and 2 infrared radiation powers (100 and 300 W) and 2 air flow speeds (0.5 and 5 m/s) were compared with a control sample until the temperature of the center of the sample reached 1 °C (Table 1). In this study, the control sample was defrosted in a room with a temperature of 25 degrees Celsius. It is worth noting that the temperature is measured through a sensor thermometer (Lutron Canada modelTM-947SD) was equipped with a temperature recorder.

Table 1 Introduction of the treatments and variables used in the combined hot air-infrared ray defrosting system

Symbol	Air flow(m/s)	Infrared power(W)	Temperature(°C)	Trearments
F0.5P100T30	0.5	100	30	1
F5P100T30	5	100	30	2
F0.5P300T30	0.5	300	30	3
F5P300T30	5	300	30	4
F0.5P100T40	0.5	100	40	5
F5P100T40	5	100	*40*	6
F0.5P300T40	0.5	300	40	7
F5P300T40	5	300	40	8
Control	-	-	25	Control

2-3- Determining the duration of defrosting

The time it takes during the defrosting period for the temperature of the center of the frozen sample to reach 1 degree Celsius is the defrosting time. It is worth mentioning that the thermocouple sensor is placed in the center of the carrot samples before the freezing process [13]. The temperature of the frozen carrot samples after leaving the freezer is about -11 degrees Celsius.

2-4-MeasurementpH

5 grams of thawed carrot samples were homogenized with 45 ml of distilled water, and then its pH was determined by a microprocessor digital pH meter (model3BW/MV , Italy) was read [20].

5-2- Measurement of ascorbic acid (vitamin C)

The amount of vitamin C in thawed carrot samples was measured by titration method. This method is based on the oxidation and reduction of iodine and solutionThe visionBased. In this experiment, 5 grams of carrot sample was homogenized with twenty milliliters of 8% acetic acid solution, and after extraction, 150 milliliters of distilled water and 1 milliliter of 0.5% starch indicator were added to it, and the above mixture was titrated with iodine solution until a dark blue color appeared. Finally, the amount of vitamin C (mg/100 grams of sample) was calculated according to equation (1) below [21].

(1) = amount of ascorbic acid

Consumption volume of standard solution x sample weight / (2 x 10 x consumption volume of iodine solution x volume of obtained extract)

6-2-Measurement of beta-carotene

5 grams of the sample is crushed and crushed in a Chinese mortar with the help of a few anhydrous sodium sulfate crystals and 10 to 15 ml of acetone. This process is repeated two or three times until the sample pigment is dissolved in acetone. Then the above solution was transferred to the separating funnel and 10 to 15 milliliters of petroleum ether was added to it to form 2 phases. The upper layer was collected and brought to a volume of 100 milliliters by petroleum ether and the absorption of this sample at a wavelength of 452 nm by a spectrophotometer (modelJenway England) is read [22]. Finally, the amount of beta-carotene (mg per 100 grams of sample) can be calculated from equation (2):

(2) = amount of beta-carotene

(sample weight x 1000 x 560)/(absorbance read by spectrophotometer x 10 x 13.9)^{4}× 100)

7-2-% weight loss due to defrosting

During the defrosting process, the weight of the samples decreases due to the release of nutrient water. The more inappropriate the freezing and thawing method, the greater the weight loss; Therefore, measuring the amount of weight loss is a suitable method for measuring the quality of the defrosting process. To calculate the percentage of weight loss due to defrosting, the amount of weight loss is divided by the initial weight of the samples and the result is multiplied by 100 [23].

3-Statistical analysis of data

In this research, in order to choose the optimal conditions, the data of carrot samples thawed by statistical software 20SPSS In the form of a completely randomized design, eight treatments were compared and analyzed by the combined method of defrosting with the infrared-heated air system compared to the control sample. Due to the use of the control sample in the random design, the accuracy of the samples increased and a significant difference was observed between the samples; (In case of using the factorial design and removing the control sample, the accuracy and probability of significance will decrease). Comparison of average data was done using Duncan's multiple range test at the 5% level. The independent variables used include the power of the radiation source at two levels of 100 and 300 watts, air temperature of 30 and 40 degrees Celsius, and air flow speed of 0.5 and 5 meters per second, and the measured parameters include defrosting time, vitamins, carotenoids, loss due to defrosting andpH They were. To analyze the data from the softwareSPSS 20 and to draw graphs from the softwareExcel 2017 was used.

4-Results and discussion

4-1-Duration of defrosting

The results of this research showed; In the combined infrared ray-hot air system, interaction effect; Temperature, radiation source power and air flow speed have a significant effect on the duration of defrosting (at the 0.05 level) (Figure 1). The temperature of the center of the samples reached -11 degrees Celsius during the freezing period, and during defrosting, this temperature increased and reached -7 degrees Celsius in a short period of time. As the defrosting process continues, the temperature increases and finally, when the temperature of the center of the samples reaches 1 degree Celsius, the defrosting process ends. The maximum defrosting time is between -7 and 1 °C: because with the continuation of the defrosting process, a huge part of the frozen crystals of food water turns into liquid and slows down the defrosting process, and the reason for this is the higher thermal conductivity of ice.W/(m^{2}K) 2 relative to waterW/(m^{2}K) It is 0.56. During defrosting with the infrared-hot air combined system, the duration of defrosting is reduced by increasing the temperature from 30 to 40 degrees Celsius and the air flow speed from 0.5 to 5 m/s and the power of the radiation source from 100 to 300 watts. The longest defrosting time in this research was for the control sample 46.77 minutes and the shortest defrosting time for treatment number 8 (sample defrosted at 40 degrees Celsius, air flow speed 5 m/s and infrared radiation power 300 watts) with 6.23 minutes and In the next rank, treatment sample 6 (temperature of 40 degrees Celsius, air flow speed of 5 m/s and infrared radiation power of 100 watts) was assigned with a time of 6.3 minutes.Hasieh et al. (2010) used high voltage electrostatic method to defrost chicken thigh meat compared to defrosting by keeping the samples in a normal refrigerator. The results showed that there is no significant difference in terms of biochemical and microbial indicators, but the use of high-voltage electrostatic method has significantly reduced the defrosting time compared to keeping the samples in a normal refrigerator [18]. Isir et al. (2016) used four ohmic methods for defrosting potato pieces, storing in a refrigerator, using microwave, and using a carbon fiber enclosure equipped with a heater. The shortest defrosting time was related to ohmic and microwave heating, and the longest time was Storage in the refrigerator was reserved [7]. Liu et al. (2020) investigated the effect of different defrosting methods on the flavor compounds and sensory characteristics of raspberries and showed that the shortest defrosting time is using microwave and ultrasonic methods and the longest defrosting method is related to defrosting at 4 degrees Celsius [24].

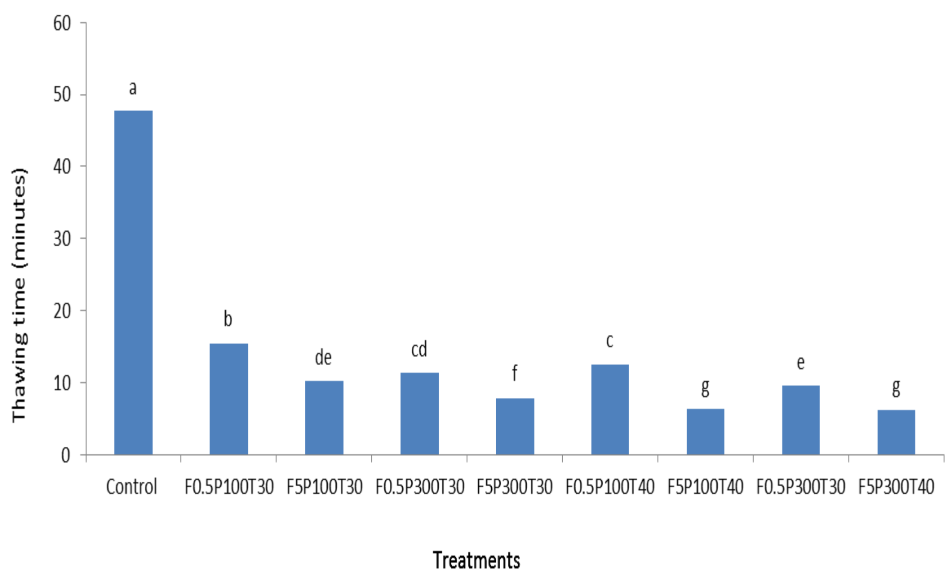

Fig 1 Comparison of thawing time of different treatments of carrot samples defrosted during the combined infrared-hot air defrosting system compared to the control sample

4-2- pH Defrosted carrot samples

This indicator mIt is an analogy to determine the acidity or alkalinity of an aqueous solution.In other wordsother,pH A solution, the hydrogen ion concentration of the solutionis in it The more acidic the solution, the numberpH The smaller, and the more playful, the numberpH It will be bigger. Changes in the number of microorganisms and enzyme activities as well as the rate of loss of acidic compounds of the samples affect the amount of this index [18].pH Raw carrot is about 5.7 because of ascorbic acid. During the process of freezing and defrosting, due to the loss and destruction of food vitamins,pH Thawed material frompH The raw sample is more. Another effective factor in reducing the amountpH Growth and activity of microorganisms and enzyme activities. In this research (Figure 2), the lowest amountpH For example, treatment 7(temperature 40 degrees Celsius, air flow speed 0.5 m/s and infrared radiation power 300 watts)was assigned And the maximum amountpH For example, treatment 1 That is, the sample that was defrosted with a temperature of 30 degrees Celsius, an air flow speed of 0.5 m/s and an infrared radiation power of 100 watts.. Hay et al. (2013) in their research on the defrosting of pork fillet meat by high voltage electrostatic field found significant changes between Treatments were not observed [25]. Davoudi et al. (2017) in their research on the defrosting of minced chicken meat stated that defrosting has a significant effect onpH has not had [26]. AtWeekly analysisKeh Ali et al. (2015) for six weeks on the defrosting of chicken breast meat In the refrigerator at a temperature of 4 degrees Celsius for 12 hourspH The samples did not observe significant changes [27]. In Kai et al.'s (2020) review, MizanpH In the samples defrosted by microwave, it was more than the samples that were defrosted by far infrared rays [18].

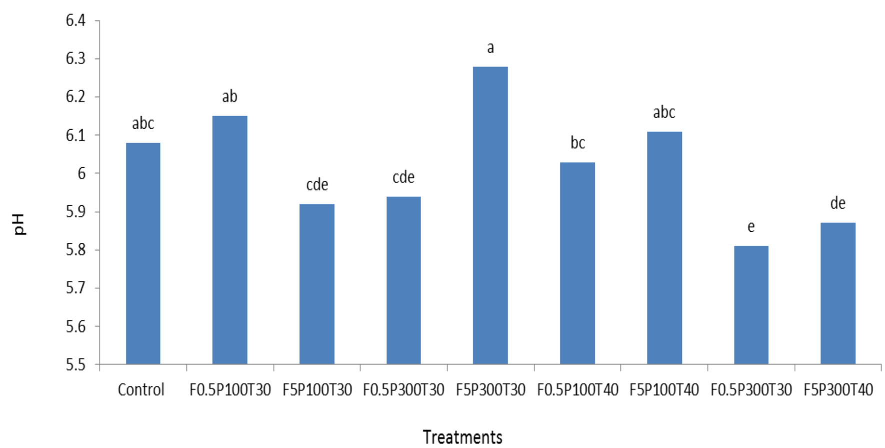

Fig 2 Comparison of the pH of defrosted carrot sample during the combined infrared-hot air defrosting system compared to the control sample

4-3-ascorbic acid (vitamin) defrosted carrot samples

Ascorbic acid or vitamin C is found in most vegetables and fruits.pH، Oxygen and oxidation are very sensitive, in the process of freezing and thawing, part of vitamin C is lost, so measuring this vitamin is a suitable criterion for measuring and finding a suitable method for thawing. During freezing, the intracellular water and the free water of the food freezes and is removed from the reach of microorganisms and biochemical activities in the form of ice crystals, if the freezing and thawing method is not suitable and the ice crystals cause the rupture of parenchymal cells.Parenchyma Cells) Carrot samples are the storage place for vitamin C, during defrosting due to the loss caused by freezing and the release of nutrient water, part of vitamin C is also removed. On the other hand, the process time is important for the survival of vitamin C. In longer times, part of vitamin C is lost due to oxidation. In this research, the interaction effect of temperature, radiation source power and air flow speed on the amount of vitamin C after defrosting the samples in eight treatments compared to the control sample has been one of the evaluation criteria for choosing the appropriate defrosting method. In this research, according to Figure 3, the greatest decrease in the amount of vitamin C in treatment sample No. 1 (De-frozen sample with a temperature of 30 degrees Celsius, air flow speed of 0.5 m/s and infrared radiation power of 100 watts) 3.68 milligrams per 100 grams of sampleand witness sample 857/3 milligrams per 100 grams of sample was dedicated, prolonging the time of the process caused the loss of part of the vitamin C of the samples, and the highest amount of vitamin C was given to treatment number 4(Sample defrosted with a temperature of 30 degrees Celsius, air flow speed of 5 m/s and infrared radiation power of 300 watts) 12.36 milligrams per 100 grams of sampleWas related. In this study, samples thawed at 30 degrees Celsius had more vitamin C than samples thawed at 40 degrees Celsius. It is clear that vitamin C is sensitive to high temperature and the increase in temperature is the cause of the loss of part of vitamin C in the defrosted food.Akagis et al. (2022) investigated the effect of microwave, hot water, and hot steam enzyme pretreatment on defrosted carrots and stated that the best defrosted sample in terms of preserving vitamin C was pretreated with steam for 30 seconds [28]. Chen et al. (2022) investigated the effect of combined infrared-microwave defrosting compared to the usual defrosting method at 25 °C on the quality of thawed carrot, green pepper, and cantaloupe. They stated that vitamin C content after defrosting compared to The raw sample is reduced. During defrosting, due to the loss of nutrient water, vitamin C (water-soluble vitamin) is also lost. Another reason for the loss of vitamins during the defrosting process in this research is the longer process time and higher temperature. The results of Chen et al.'s research in 2022 showed that by using the combined method, more vitamin C is preserved than the usual method, and the reason for this is the longer defrosting time and, as a result, more oxidation of vitamin C.[14].

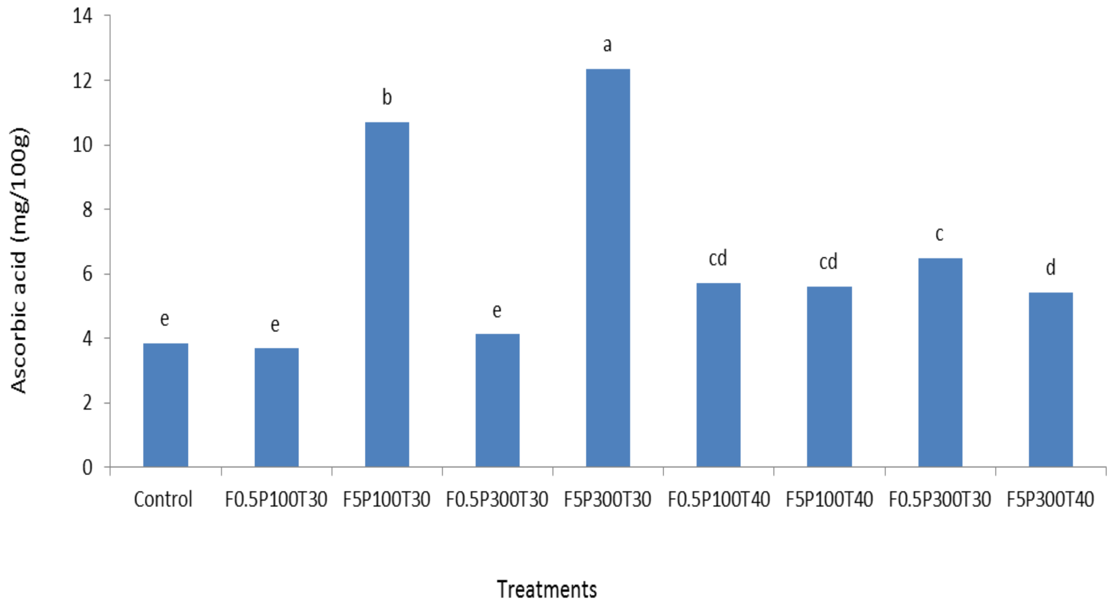

Fig 3 Comparison of the average amount of vitamin C (mg/100g) of defrosted carrot samples during the combined infrared-hot air defrosting system compared to the control sample

4-4-beta-carotene of thawed carrot samples

beta carotene[1] (lipophilic pigment[2]) is a precursor of vitamin A. Carrot is one of the important food sources due to its carotenoids including beta-carotene and antioxidant capacity, aroma and natural color.The amount of carotenoids can be used as an important indicator to evaluate the quality of carrots during the process. Carrots have a significant amount of beta-carotene and some alpha-carotene[3] and a small amount of lycopene[4] and lutein[5] has [29]. In this research, according to Figure 4, the highest amount of beta-carotene was obtained in treatment 8 (defrosted sample with temperature of 40 degrees Celsius, air flow speed of 5 m/s and infrared radiation power of 300 watts).12/48 milligrams per 100 grams of sampleand the lowest amount of beta-carotene in treatment 5 (defrosted sample with a temperature of 40 degrees Celsius, air flow speed of 0.5 m/s and infrared radiation power of 100 watts) 03/14 milligrams per 100 grams of samplebelongs. In the research of Chen et al. (2022), the results showed that in the normal method of defrosting carrot samples at 25 degrees Celsius, due to the longer process time and greater degradation, the amount of carotenoids decreased compared to other treatments [14].. In a research conducted by Ixiu et al. in 2016 under the title of investigating the effect of freezing-thawing temperature on the viscoelastic and nutritional properties of carrots, they stated that when the quick thawing method by liquid nitrogen at -196 degrees Celsius is used to freeze carrots, the content of carotenoids In particular, beta-carotene is more than the usual methods of freezing in the freezer at -20 degrees Celsius and the cryogenic freezer at -70 degrees Celsius, and the samples thawed at 18 degrees Celsius have a higher beta-carotene content than the samples thawed at 4 degrees Celsius. [29].

[1] β-Carotene
[2] Lipophilic Pigment
[3] α-Carotene
[4] Lycopene
[5] Lutein

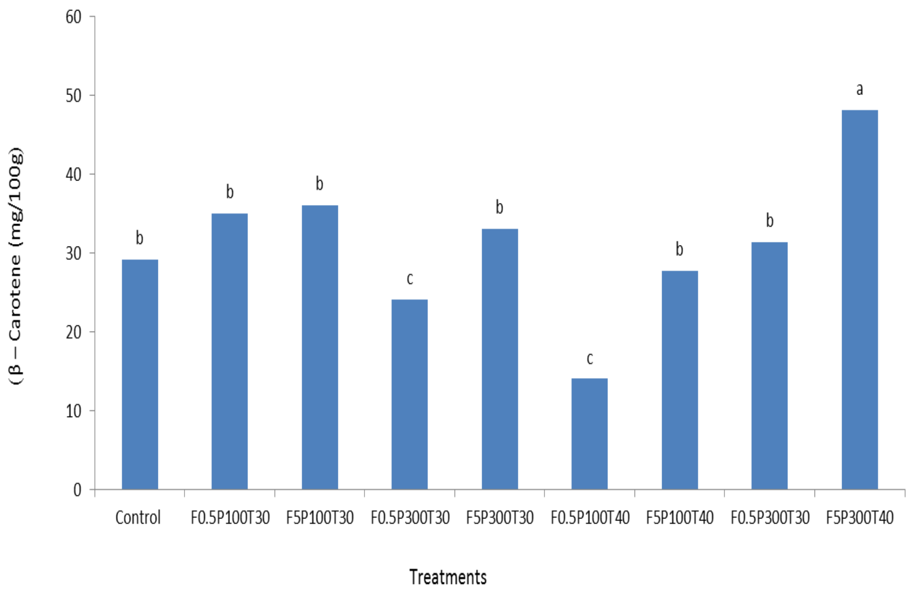

Fig 4 Comparison of the average amount of beta-carotene (mg/100g) of defrosted carrot samples during the combined infrared-hot air defrosting system compared to the control sample

4-5- Weight loss due to defrosting

In terms of product performance and quality, loss due to defrosting is one of the most important indicators in optimizing the defrosting process [30]. In this research, according to Figure 5, the highest amount of weight loss was given to treatment number 1 (sample defrosted at 30 degrees Celsius, air flow speed of 0.5 m/s and infrared radiation power of 100 watts) with a value of 19.7% and the lowest value of the control sample was 44%. 7.7% and secondly it belonged to treatment number 8 (sample thawed at 40 degrees Celsius, air flow speed of 5 m/s and infrared radiation power of 300 watts) by 10.56%. The long process time increases the amount of loss due to defrosting. In the control sample, despite the increase in the process time, due to the lack of air flow and the reduction of moisture evaporation from the surface of the carrot samples being defrosted and maintaining the moisture of the carrot samples, it has the minimum amount of loss due to defrosting. They were. In the research that Davoudi et al. (2017) conducted on the defrosting of minced chicken meat, they stated that the interaction effect of temperature and power of the radiation source compared to the interaction effect of temperature and air flow speed had the least effect on the loss caused by defrosting [26]. Based on the research conducted by Ixia et al. (2012) on pig muscle thawing, they reported: microwave thawing has the highest loss due to thawing and using the thawing method at a temperature of 4 degrees Celsius in the refrigerator has the lowest amount of loss due to thawing [23]. Liu et al. (2020) used different methods to defrost raspberries and stated that the use of microwaves to defrost raspberries causes the largest amount of loss due to defrosting in the defrosted product [24]. Kai et al. (2020) used the combined method of magnetic nanoparticles with microwave and far-infrared rays to defreeze sea redfish and stated that the loss caused by defrosting in samples defrosted using microwave and the combined method of magnetic nanoparticles-microwave is more than the method The use of far infrared rays [18]. Charon Rin et al. (2016) in a study on mango defrosting during several periods of freezing and defrosting, stated that slow freezing increases the loss caused by defrosting [6]. Fuchigami et al. (1995) consider the reason for the increase in loss due to defrosting to be the formation of large ice crystals during slow freezing [19].

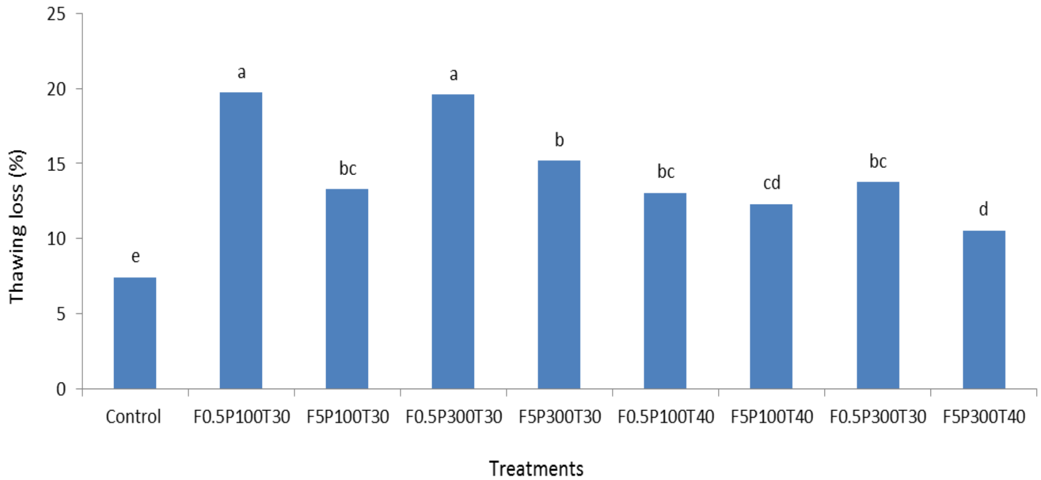

Fig 5 Comparison of the weight loss percentage of carrot samples defrosted during the combined infrared-hot air defrosting system compared to the control sample

5. Conclusion

Combined defrosting is one of the new methods of defrosting, which is widely used in the food industry and for various products. The cost of setting up this system is small. In addition to significantly reducing the time of the defrosting process, this method preserves the quality of the food to some extent. In this research, the use of the combined process of infrared rays and hot air significantly reduced the defrosting time, so that the defrosting time was significantly The average decreased from 47.66 minutes for the control sample to 6.23 minutes for treatment 8 (defrosted sample at 40 degrees Celsius, air flow speed of 5 m/s and infrared radiation power of 300 watts). In the measurement testpH Most of the measurepH to treatment 4 (6/28) and the lowest amountpH It was related to treatment 7 (5.81) and next to treatment 8 (5.87). In the vitamin C test, the highest content of vitamin C was related to treatment 4 (12.36 mg/100 g of sample) and the lowest content was related to treatment 1 (3.68 mg/100 g of sample) and control (3.857 mg/100 g of sample) in treatment 1. And the control sample loses more vitamins due to the long defrosting time. in the beta-carotene measurement test; The highest amount of beta-carotene was assigned to treatment 8 (48.12 mg/100 g of sample) and the lowest amount of beta-carotene was assigned to treatment 5 (14.03 mg/100 g of sample) and treatment 3 (24.05 mg/100 g of sample). During defrosting, the samples lose weight compared to the initial weight. In this study, the highest amount of weight loss was related to treatment 1 (19.7 percent) and treatment 3 (19.6 percent), and the lowest amount of weight loss was related to the control sample (7.44 percent).

6- Resources

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مقاله علمی_پژوهشی

اثر سامانه ترکیبی مادون‌قرمز-هوای گرم بر فرآیند انجمادزدایی و ویژگی های کیفی هویج

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چکیده

سبزیجات فسادپذیر هستند و به صورت فصلی کاشته می‌شوند. از بهترین روش‌های نگهداری موادغذایی انجماد می‌باشد و برای استفاده از محصول منجمد، فرآیند انجمادزدایی مورد نیاز می‌باشد. هدف از این مطالعه، استفاده از انجمادزدایی ترکیبی اشعه مادون‌قرمز-هوای گرم و تاثیر متقابل دما، سرعت جریان هوا و توان منبع تابش مادون قرمز بر زمان انجمادزدایی و خصوصیات کیفی هویج‌های انجمادزدایی شده می‌باشد. نمونه‌های هویج پس از شستشو، با قالب استوانه ای به قطر ۲۲/۵ و ارتفاع ۱۲میلی‌متر قالب‌گیری و در دمای ۱۸- درجه سانتی‌گراد ۴۸ ساعت منجمد شد و تاثیر پارامترهای رفع انجماد، دمای هوا (۳۰ و۴۰ درجه سانتی‌گراد)، سرعت جریان هوا (۰/۵ و ۵ متربرثانیه) و توان اشعه مادون قرمز (۱۰۰ و ۳۰۰ وات) بر خصوصیات کیفی هویج‌های انجمادزدایی شده در طرح آماری کاملا تصافی بررسی گردید. نمونه شاهد در اتاق با دمای ۲۵ درجه سانتی‌گراد انجمادزدایی شد. آنالیز داده‌ها و تفسیر نتایج نشان داد، اثر متقابل افزایش دما، توان منبع تابش و سرعت جریان هوا بر روی زمان انجمادزدایی، میزان ویتامین‌ث، بتاکاروتن، افت ناشی از انجمادزدایی و pH تاثیر معنی‌دار داشته است (P≤۰/۰۵). این سامانه زمان انجمادزدایی را به طورقابل ملاحظه‌ای کاهش داد، زمان برای نمونه شاهد ۴۷/۶۶ و برای تیمار۸ (F5P300T40) ۶/۲۳ دقیقه بود. کمترین میزان pH به تیمار۷ (F0.5P300T40) ۵/۸۱ و بیشترین میزان به تیمار۱ (F0.5P100T30) ۶/۱۵ مربوط بود. بیشترین میزان بتاکاروتن به تیمار۸ (F5P300T40) (۴۸/۱۲ میلی‌گرم بر ۱۰۰ گرم نمونه) و کمترین میزان به تیمار ۵ (F0.5P100T40) (۱۴/۰۳ میلی‌گرم بر ۱۰۰ گرم نمونه) مربوط بود. تیمار۴ (F5P300T30) ۱۲ /۳۶ میلی‌گرم بر۱۰۰ گرم نمونه و تیمار ۱ (F0.5P100T30) ۳/۶۸ میلی‌گرم بر ۱۰۰ گرم نمونه به ترتیب بیشترین و کمترین میزان ویتامین‌ث را داشتند. افت ناشی از انجمادزدایی تیمار۱ (F0.5P100T30) ۱۹/۷٪ بیشترین و نمونه شاهد ۷/۴۴٪ کمترین بود. به دلیل هزینه راه‌اندازی اندک، زمان کوتاهتر فرآیند و کیفیت مطلوب، انجمادزدایی ترکیبی به‌طور گسترده در صنایع غذایی کاربرد دارد.