Analecta Technica Szegedinensia

Vol. 17, No. 4 ISSN 2064-7964 2023

CHANGES OF PHYSICAL AND CHEMICAL PARAMETERS OF ORGANIC AND CONVENTIONAL CARROTS DURING STORAGE

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Received: 25th February; Accepted: 10th November

ABSTRACT

In industrialised countries, around 670 million tonnes of food are lost every year, much of it still fit for human consumption. Due to the special nutrient management of organic farming, root vegetables have a higher dry matter content and a lower nitrate content, which also affects their shelf-life. The effect of storage under domestic conditions was investigated in our experiments on organic and conventional carrot lots. It was found that packaged organic carrots in a 4°C environment showed the longest shelf life, lowest nitrate content and weight loss during household storage.
The results of the experiment may contribute to lower food waste through changes in consumer habits.

Keywords: nitrate content, production system, post-harvest, shelf life

1. INTRODUCTION

Carrot (*Daucus carota subsp. sativus*) is a temperate biennial vegetable crop that is one of the ten most important vegetable crops in the world [1,2]. Their high nutritional value, favourable physiological and physical properties make them an essential crop in the human diet and suitable for cultivation worldwide.
There is no question about the environmental and economic importance of organic farming. The market for organic products is one of the fastest growing sectors today, and comparisons between organic and conventionally grown food are a common question [3]. Few studies have addressed the effects of different growing and harvesting practices on the long-term quality and shelf-life of organic fruits and vegetables [4]. Organic production systems use much lower nitrogen doses, which may be responsible for lower nitrate levels in root crops [5].
According to Alexander [6], around 670 million tonnes of food produced in industrialised countries are lost every year, much of it still fit for human consumption. Carrot wilting is a post-harvest after-reaction and is unavoidable, but its extent can be influenced.
The aim of our study was to follow the changes in physical and chemical parameters of carrot batches from organic and conventional production under different storage methods and temperatures.

2. MATERIALS AND METHODS

The employed experimental design is similar to that of Divéky-Ertsey et al. [7].

2.1. Plant material

Organic and conventional carrots were purchased from commercial sources. The carrots were pre-washed, either in polystyrol bags or in bulk format. Carrots were pre-selected based on size and visible defections and equal groups were created consisting of 15-15 carrots in the laboratory of the Department of Agroecology and Organic Agriculture, Hungarian University of Agriculture and Life Sciences on 16 March 2022.

DOI: https://doi.org/10.14232/analecta.2023.4.46-50

2.2. Experimental design

Two variables were identified as changing in typical household storage; these are temperature and packaging. For modeling refrigerator and pantry storage, 4°C and 12°C were set; besides bulk storage, certain carrot groups were put into sealable plastic bags. All individual carrots were numbered. Temperature × packaging × cultivation type variable combinations defined eight distinct storage technologies (*Table 1*). The duration of the storage experiment was planned to four weeks.

Table 1. ***Details and codes of employed storage technologies for carrot samples.***

Temperature	4°C				12°C			
Storage type	Bulk		Packaged		Bulk		Packaged	
Storage type code	CB4	OB4	CS4	OS4	CB12	OB12	CS12	OS12

Source: edited by the authors. Legend: C in codes refers to conventional, while O refers to organic cultivation origin.

2.3. Weight measurement

Every seven days, three carrots were removed from every group and retained for instrumental measurements. After removing ends, carrots were homogenized and freezed until instrumental measurements.
Weight was measured weekly for every carrot using a digital scale. Weight loss percentage was calculated for every carrot according to Equation (1):

$$W\%_n = (W_n / W_0) * 100 \tag{1}$$

where
$W\%_n$ = Weight loss after n weeks storage
W_n = Weight of carrot after n weeks storage
W_0 = Weight of carrot at the beginning of the experiment

W% results were averaged for every storage group and visualized using MS Office Excel.

2.4. Nitrate content measurement

Nitrate determination was done spectrophotometrically on 410 nm, according to Cataldo et al. [8], with slight changes in sample preparation. All measurements were done in triplicate. Based on the results, nitrate content change was calculated according to Equation (2):

$$N\%_n = (N_n / N_0) * 100 \tag{2}$$

where
$N\%_n$ = Nitrate content change after n weeks storage
N_n = Nitrate content of carrot after n weeks storage
N_0 = Nitrate content of carrot at the beginning of the experiment

Nitrate content change was calculated for both fresh and dry weight and visualized using MS Office Excel.

DOI: https://doi.org/10.14232/analecta.2023.4.46-50

3. RESULTS AND DISCUSSION

3.1 Weight loss percentage of stored carrot samples

Concerning weight loss of storage types, distinct patterns can be identified (Figure 1). Regardless of temperature and cultivation type, packaged carrots showed gradually lower losses, than bulk stored ones. It is also apparent, that temperature influenced the extent of losses as well; those stored on 4°C showed less than 10% decrease, while those on 12°C lost about 20-30% of their initial weight throughout storage. Interestingly, cultivation type had rather low impact on weight loss; for most cases, losses were lower for conventional samples. However, these differences were non-significant for organic-conventional treatment combinations. In comparison, CS4 and OS4 showed the lowest losses, which divided significantly from all, but OS12 and OB12 storages. The highest loss was recorded for OB12, followed by OB4, CB12, and CB4. This subset divides significantly only from CS4 and OS4. It should be also mentioned, that the storage of CB12 has to be terminated after three weeks due to serious fungal/bacterial infection, therefore the weight loss of this storage technology is comparable only with limitations.

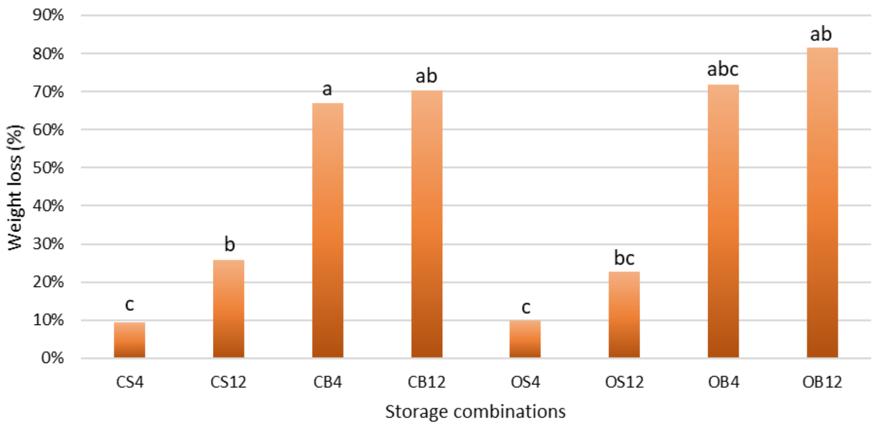

Figure 1. Comparison of weight loss percentages (mean±sd) of carrot samples stored in different packaging and temperature. Differing letters mean significant differences between test groups (p<0,05).

Moisture loss is caused by the continuous respiration of the root. It leads to shrinking of the skin, then follows to the internal tissues after a certain time [9,10]. Shibairo et al. [11] tested short term storage of 8 different carrot cultivars at 13°C temperature with 35 and 85% relative humidity. They found that moisture loss and transpiration coefficient was higher at the low relative humidity condition than in the higher one. A similar test has been carried out by [12]; the roots were stored for 120 h in climate-controlled chambers at temperatures of 10, 20 and 30°C, and air relative humidity of 45, 65 and 95%, respectively. This study has also shown that the transpiration coefficient was generally greater at lower relative humidity, and that roots stored at high humidity had a more acceptable quality in terms of marketability. These results agree with the results of the present study; Packaging of carrots provided gradually higher moisture content within the bags, which slowed down moisture loss. Less moisture loss equals to less weight loss. Also, higher temperatures are favourable for higher weight losses.

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3.2 Nitrate content changes of stored carrot samples

Nitrate content changes show a somewhat correlation with nitrate values. Packaged carrots show significantly lower values from those stored as bulk, the only exception is OB21, which do not divide statistically from CS4 and CS12. Within cultivation type, no major differences are seen among the sacked samples, however, organic samples had lower nitrate content both for dry and fresh weight. OS12 had the significantly lowest values, although some overlapping is visible for CS12 and OS4.
For bulk samples, gradually higher results were measured. Here, organic samples divided significantly from conventional ones, for both temperatures and traits. Within cultivation type, bulk samples also divide significantly and shows lower results for organic ones. The highest nitrate accumulation was found in the case of CB storage combinations, followed by OB ones. However, storage of CB12 had to be terminated after 2 weeks due to infections.

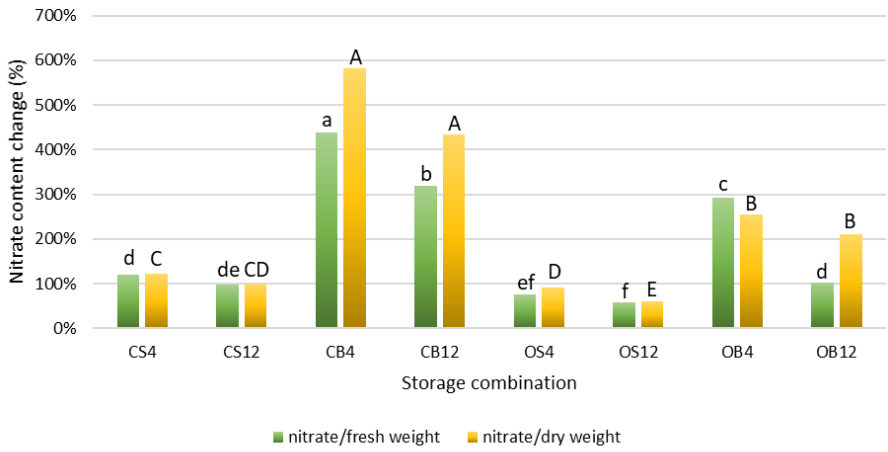

Figure 2. Comparison of nitrate content (fw, dw) change percentages (mean±sd) of eight carrot samples stored in different packaging and temperature. Differing letters mean significant differences between test groups within a trait. (p<0,05).

Nitrate accumulation depends on many varietal and environmental factors. Nitrate content is a very important factor in the quality of this vegetable [5, 13] Also, improper storage conditions can induce nitrite formation, which confers direct health risk, especially for infants. Microbial activity promotes the accumulation of nitrites, the activity of which is rising on higher temperatures [5]. [14] found that short-term refrigerator storage inhibited nitrate accumulation, which agrees with our results.

4. CONCLUSIONS

As the origin of marketed samples cannot be documented, the objective comparison of cultivation types would not provide reliable results, therefore the evaluation is not inclusive for this trait.
Packed samples stored on 4°C showed 10% weight loss, and no significant difference between organic and conventional carrots has been found. The difference between organic and conventional carrots was 3% on 12°C storage. For nitrate content, packaged samples performed better than bulk ones, but differences were found depending on temperature and cultivation method. Conventional carrots at 4°C had slightly increasing nitrate numbers, whereas 12°C had a suppressive effect on nitrate accumulation, regardless of cultivation type. The results suggest that losses in weight does not necessarily increase nitrate content in carrots.
However, in case of bulk stored samples high losses in weight went along with higher nitrate accumulation. Organic samples showed significantly lower nitrate levels. On 12°C storage, although weigh losses were

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high, nitrate accumulation was lower in comparison with samples stored on 4°C. From this viewpoint, the highest nitrate content was given by CB4, and the most favourable was OB12.

It can be concluded that all variables (i.e., temperature, packaging, and cultivation type) had an impact on the investigated traits, especially on weight loss and nitrate content. From a practical approach, the most ideal combination is 4°C and plastic bag for log-term household storage.

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