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EFFECT OF *NATURESEAL® AS5* AND PACKAGING MATERIALS ON THE MICROBIOLOGICAL QUALITY OF SHREDDED CARROTS DURING STORAGE

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Abstract

The aim of the study was to investigate microbiological quality changes of shredded carrots processed with *Natureseal® AS5* solution during storage in several packaging materials. Before packaging, shredded carrots were processed with commercial 2.5% *Natureseal® AS5* solution at temperature +19±1 °C for 5 min±2 s. Processed products were packed in different packaging materials: cellulose based biodegradable packaging *Polilactid BIO-PLA* containers and *NatureFlex NVS*, hermetically closed by breathing polymer film *BOPP PropafilmTM P2GAF*. Carrot samples were stored at the temperature +4±1 °C for 12 days. Quality indicators using standard methods were determined O_2 and CO_2 concentration inside several packaging and microbiological analysis of carrots.

Analysis of the carrot samples was tested out before and after packaging 3, 5. 8, 10 and 12 days of storage. Treatment of carrots with 2.5% *NatureSeal® AS5* water solution and subsequent storage for 12 days in biologically degradable and conventional packaging materials ensured a significant decrease of total count and yeast count ($p<0.05$). This indicates that 2.5% *NatureSeal® AS5* water solution can be successful agent towards a ample range of spoilage microorganisms and makes it attractive for food preservation.

Keywords: carrots, *NatureSeal® AS5*, storage, treatment

Introduction

The carrot (*Daucus carrota* L.) is a root vegetable that has world-wide distribution. Carrots are amply consumed in the diet either treated in beverages and meals or fresh (Augspole et al., 2014; Hag, Prasad, 2018; Scarano et al., 2018; Wang et al., 2015). The consumption of carrots, both fresh and processed, has increased due to the introduction of new carrot-obtained health and nutritional goodness (Gamboa-Santos et al., 2012). In the last years the demand for fresh-cut and natural products has noticeably increased. They are vegetables with good dietary and taste properties. Fresh carrot products such as shredded carrots, carrot disks, batons an important part of the fresh-cut vegetable industry Wang et al., 2015). Scientist Yu et al. (2018) reported that carrot is well known vegetable used to make home cooked meals, salads and convenient ready to eat products. Treated carrots are prepared by peeling off the outer layer of the carrot root and cutting into slices or small cubes, shredding and keeping refrigerated in packaging. Processed carrots oft suffer from excessive microbial growth, carrot enzymatic browning, increasing of respiration, tissue softening and carrot enzymatic browning, limits storage time and its market value of products (Yu et al., 2018). Minimal processing for fresh-cut carrots production usually includes – shredding, slicing, peeling and dicing before packaging and storage. Processed carrots have a major effect on the quality of the prepared product, amount of nutrients and storage time. To retain valuable carrot nutrients and protect from spoilage, proper packaging and storage conditions play an important role. Most of the producers and suppliers give importance to the vegetables packaging and storage conditions of their product (Islam et al., 2018). Minimal processing for fresh-cut carrots production include grading, washing, sorting, peeling, cutting and shredding, packaging and their storage (Wang et al., 2015). Due to a high respiration rate, loss of firmness, microbial quality and discoloration, minimally processed carrots has shelf life limitation from 4 to 5 days (Augspole et al., 2014).

Wang et al. (2015) informed that minimal processing of shredded carrots causing undesirable microbiological quality, physiological and biochemical changes to treated vegetables, even decreasing the products nutritional quality and shortening shelf life. Saranraj et al. (2016) highlights that water used for rinsing vegetables and sprinkling is a supply of different potential sources of microorganisms embrace soil, water, handling of the merchandise, gathering and process instrumentation and transport. Researcher Oliveira (2017) reported that microbial risk is found during treated carrots, mostly during the washing and shredding steps. In turn cutting operation releases nutrients which can promote microbiological growth. Literature data suggest that packaging is an integral part of the commercial industrial and food supply part. Various packaging technologies can be used for shelf life prolongation of processing products. Each packaging film has a specific O_2 and CO_2 permeability (Krasnova et al., 2012). Packaging not only acts as a barrier to protect the product from environmental obstacles and harmful germs and insects, but also it works as a trade mark of product (Islam et al., 2018).

Krasnova et al. (2012) previously described that *Innovia films Limited* non-perforated and breathable biaxially oriented *BOPP* films *PropaFresh P2GAF and P2G* for fresh vegetable produce packaging are tailor made to fulfil the specific needs of food packaging industry. In turn *BOPP* film a longer shelf life can be ensured with the assurance for freshness being intact and preserved. Some researchers found that inhibitors of browning in processed fruits include using ascorbic acid, citric acid

or their derivates (Rahman et al., 2011). Abubakr (2016) in his study has shown that *NatureSeal® AS1* and *NatureSeal® AS5* products can reduce browning in fresh cut fruit slice. Many authors (Augspole et al., 2017; Saha et al., 2009; Rössle et al., 2009) in their studies emphasize that the N*atureSeal™* is a calcium ascorbate powder used in the food industry. Asrey et al. (2008) in their studies described that *NatureSeal® AS5* is the first antioxidant product of its kind, which doesn't have a bad aftertaste or product residue. In turn researcher Rößle et al. (2009) accented that *NatureSeal® AS5* is already used commercially in Europe and elsewhere, thus adding practical value to the research. Researcher Abubake (2006) described that application of *NatureSeal™* agents is a popular approach for prevention enzymatic browning in fresh-cut vegetables. In her study Augspole et al. (2017) showed that *NatureSeal® AS5* water solution has antimicrobial activity, thus it may be possible that it has a essential effect on the microbiological quality of fresh-cut carrots during storage.

Therefore, the aim of the research was to investigate microbiological quality changes of shredded carrots treated with *NatureSeal® AS5* during storage in several packaging materials.

Materials and Methods

Materials

The object of the research was serotinous ′Nante′ carrot (*Daucus carota* L.) hybrid ′Nante/Forto′ harvested in Latvia, Jelgava region (the GPS-coordinates: 56° 39' 3.992" N 23° 43' 16.874" E).

'Nante/Forto' carrots were rinsed under running tap water and peeled. Then carrots were washed under water. Carrots were shredded using (Philips Comfort HR 7605, Austria). Carrots were shredded (cross-section 1.3×4.0 mm, length 30-45 mm) using shredder (Philips Comfort HR 7605, Austria). *NatureSeal® AS5* powder *AgriCoat NatureSeal™* is a commercial product – blend of dry ascorbic acid and calcium compound patented (No 1011342) by the Ministry of Agriculture the USA (*AgriCoat NatureSeal™* Ltd, England). Prepared *NatureSeal® AS5* solution used for treatment of shredded carrots. Carrots were immersed on prepared solution for 5 min±2 s. Treated carrots were placed on non-corrosive steel sieve (grid diameter 0.2±0.1 mm) to draw of the accumulated water (3 min ± 2 s) then packaged by 70±1 g in conventional and cellulose based biodegradable packaging materials. Polypropylene *DuniForm PP* boxes (thickness: δ=35±1 μm; size: 80×120×42 mm; capacity: 400 mL; barrier properties: not known) were placed in prepared pouches (size 255×245 mm) made of biodegradable *NatureFlex™ NVS INNOVIA* material (thickness: δ=35±1 μm; barrier properties: OTR (oxygen transmission rate): 3000 cm^3 m^{-2} 24 h^{-1}; CO_2TR (carbon dioxide permeability tester through films): 12000 cm^3 m^{-2} 24 h^{-1} and hermetically sealed using the packaging equipment (EUROMATIC, Italia). Packaging boxes *DuniForm PP* were hermetically thawed with *BOPP PropafilmTM P2GAF* "breathable" conventional polymer film covered with an anti-dewing coating (thickness: δ=38±1 μm; barrier properties: OTR (oxygen transmission rate): 3000 cm^3 m^{-2} 24 h^{-1}; CO_2TR (carbon dioxide permeability tester through films): 12000 cm^3 m^{-2} 24 h by means of SEAL 300 Faverani (Italia) equipment. *Nature Works® PLA P–360* boxes with non–hermetically sealed PLA cover (thickness: δ=30.0 μm; barrier properties: WVTR (water vapour transmission rate): 55 g (m^{-2} 24 h^{-1}±10% at 23±2 °C and HR (relative humidity) 85% (ASTM F 1249), OTR (oxygen transmission rate): 500 cm^3 m^{-2} 24 h at 23±2 °C and RH (relative humidity) 50%: (DIN 53380-3). Samples were stored for 12 days in a Commercial Freezer-Cooler "Elcold" at the temperature 4±1 °C.

The headspace gas composition and the content of microorganisms – mesophilic aerobic and facultative anaerobic (total bacteria), yeasts at each time of measurement were tested on sampling day and 3rd, 5th, 8th, 10th, and 12th day of storage. Four identical packs for each packaging mode were randomly selected for testing. Oxygen (O_2) and carbon dioxide (CO_2) was measured using a gas O_2 and CO_2 analyser OXYBABY®V.

Microbiological analysis

Microorganisms in treaded shredded carrots were tested according to the standard method LVS EN ISO 6887-1:1999 and 6887-4:2004. Total plate count (TPC) was determined in conformity standard LVS EN ISO 4833A. Yeast plate count determined in conformity with standard method LVS ISO 21527-2:2008. Microbiological data were expressed as log colony forming units per gram of product (log CFU g^{-1}).

Statistical analyses

The investigation results were processed by statistical and mathematical methods. Two-way analyses of variance ($p \leq 0.05$) were used to determine the significance of differences between various parameters. Statistics of a completely randomized desing were determined using the GLM (General Linear Model) and SPSS 21 (Statistical Package for Social Sciences).

Results and Discussion

Microbiological quality is the main quality parameter of food. Microbiological parameters determining shelf-life of shredded carrots were evaluated as the main quality parameters. Carrots washing, peeling and shredding damages tissue results in the growth of microorganisms. In the present research 2.5% *NatureSeal® AS5* was used as the agent for the processing of fresh shredded carrots. The results demonstrated that treatment was an effective method to hinder microbiological growth during storage and improving the shelf life of products (Fig.1.). Treatment of shredded carrots with 2.5% *NatureSeal® AS5* water solution had a positive effect on total plate count; after treatment it was possible to significantly

($p<0.05$) decrease TPC count by 1.34 log CFU g^{-1} compared to untreated shredded carrots.

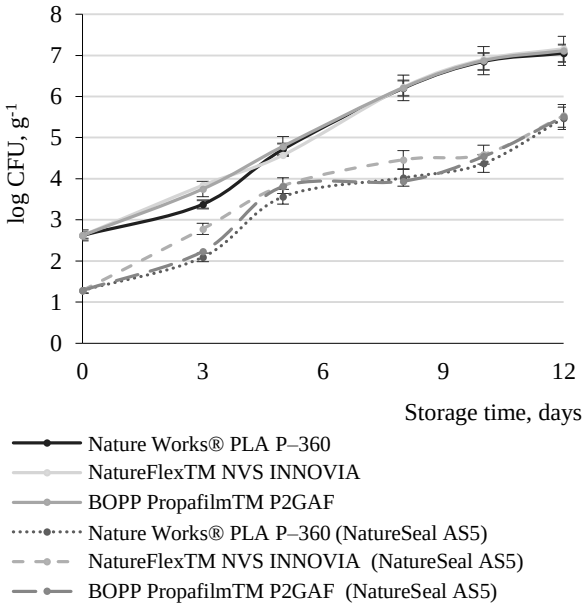

Figure 1. Dynamics of TPC count in shredded carrots treated with *NatureSeal® AS5*

Treated shredded carrots were microbial spoiled by mesopholic aerobic and facultative anaerobic microorganisms after 12 day. Microbial growth increased due to the increase in surface by cutting and peeling. The effect of shelf-life on the TPC was significant ($p<0.05$). Different packaging materials didn't significantly ($p=0.131$) influence changes of microbial results (TPC) in shredded carrots during storage. Researcher Karabagias (2018) reported that yeasts are able to grow in vegetables with a neutral or slightly acid pH environment and in the presence of organic acids, carbohydrates and other easily metabolized carbon sources. He explain that during their growth, yeasts metabolize some produce metabolic end-products and food components. This causes chemical and physical properties of a vegetable to change and the food is spoiled. Literature data suggest that *NatureSeal™* commercial product used by vegetables and fruits industry according to the technology to achieve effective preservation of fresh-cut vegetables. Good microbial quality (microbial loads <5 log CFU g^{-1}) of all processed carrot during 10 day storage, low storage temperature may be connected to the combination of antimicrobial compounds calcium and ascorbic acid (Giacalone, Chiabrando, 2013). In the present research (Fig. 2) from the beginning in the treated carrots yeasts count was 1.31 log CFU g^{-1} and in the non-treated carrots was 2.59 log CFU g^{-1}. However, independently form packaging material, yeast count of treated carrots increased 2.2 times after 8 day, which was significant ($p=0.023$). The results showed that it was possible to ensure microbial quality of carrots by preservation with 2.5% *NatureSeal® AS5* and reduce yeast count by 1.28 log CFU g^{-1} ($p<0.05$) compared to untreated shredded carrots. The current research showed that all used pacing materials didn't significantly ($p=0.158$) affect changes of yeast count in shredded carrots 12 days during storage.

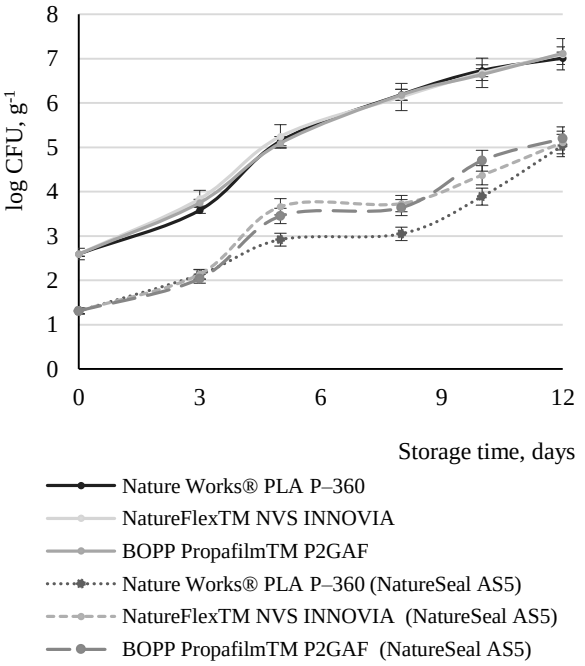

Figure 2. Dynamics of yeast count in shredded carrots treated with *NatureSeal® AS5*

Packaging containers *Nature Works® PPLA P-360* with non-hermetically sealed conditions and conventional breathable *BOPP Propafresh™ P2GAF*, conventional *NatureFlex™ NVS INNOVIA* film and *BOPP Propafilm™ P2GAF* film packing could be characterized as the best environment for respiration and quality maintenance of minimally processed (fresh-cut) produce (Dukalska et al., 2013). One of the tasks of this work was to assess O_2 and CO_2 composition dynamics in packaging with carrots treated with 2.5% *NatureSeal® AS5* (Fig. 3).

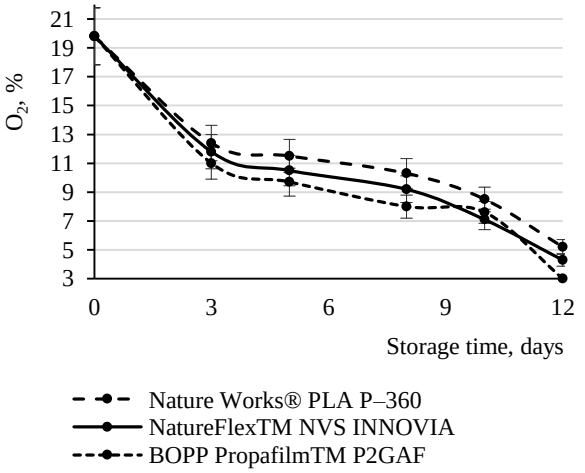

Figure 3. Oxygen content in the packages of shredded carrots treated with *NatureSeal® AS5*

During 12 days of storage an increase of CO_2 and decrease of O_2 was observed depending on the barrier properties of used lidding films. Oxygen content decreased by 19.8% during storage. The decrease of O_2 in different packaging was not significantly different ($p=0.153$). The obtained results showed that observed analysing content of O_2 inside packing with treated carrots. In BIO PLA non-hermetically sealed containers the decrease of O_2 was significant ($p<0.05$) – on the 3rd, 5th and 8th day of storage by 11.6, 4.3 and 11.3%, respectively (fig. 3). Oxygen content inside PLA containers after 10 day storage decreased from 12.7 to 11.3%. The content of oxygen after 12 days inside packaging decreased to 3% on average.

Researcher Augspole et al. (2014) in her study noticed that the increase of CO_2 inside packaging could indicate the beginning of spoilage process and elevated amounts of CO_2 indicate non acceptable quality of packaged shredded carrots. The amount of CO_2 increased 11.3 to 15.8 times (Fig. 4) after 12 day storage.

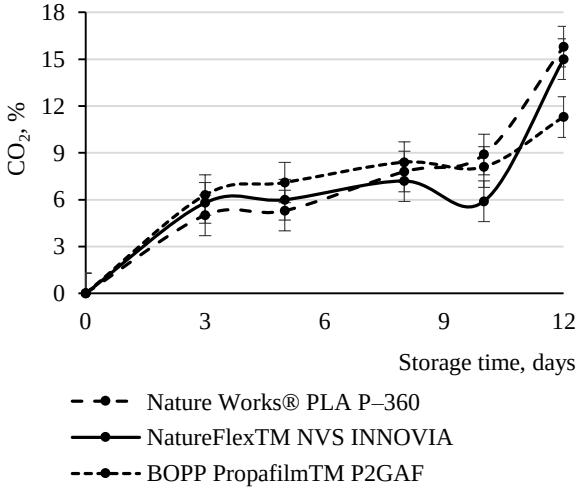

Figure 4. Carbon dioxide content in the packages of shredded carrots treated with *NatureSeal® AS5*

Food scientists have proved that observations prove that both conventional breathable and biodegradable packaging films with an appropriate O_2 transmission rate play an important role in development of equilibrium modified atmosphere and in quality in packages of fresh shredded carrots during storage (Dukalska et al., 2013; Augspole et al., 2012).

Conclusions

Biodegradable packaging materials help to protect microbiological quality of shredded carrots during storage due to their specific barrier properties. During storage, the increase of CO_2 and decrease O_2 was depended on barrier properties of used packaging. The treatment of shredded carrots with 2.5% *NatureSeal® AS5* water solution negatively influenced microbial growth. The results obtained in the current study that cellulose based biodegradable packaging materials can be an alternative to the conventional polymer films for treated fresh shredded carrots.

References

1. Abubakr M.A.S. (2016) Antibrowning activity of bioactive peptides from lab-cultured skim milk hydrolysate. *International Journal of Current Microbiology and Applied Sciences*, Vol. 5(10), p. 212–228.
2. Asrey R., Sasikala C., Barman K., Koley T.K. (2008) Advances in post-harvest treatments of fruits – A review. *Annals of Horticulture*, Vol. 1(1), p. 1–10.
3. Augspole I., Kince T., Skudra L., Dukalska L. (2017) The effect of hydrogen peroxide, ozonised water and Natureseal AS5 solution on the microbiological parameters of fresh-cut carrots. **In:** *FoodBalt 2017: 11th Baltic conference on food science and technology in a changing world": conference proceedings,* Jelgava, p. 112–116.
4. Augspole I., Rakcejeva T., Dukalska L., Skudra L. (2014) Providing quality of shredded carrots during storage by treatment with ozonated water. *Material Science and Applied Chemistry*, Vol. 30, p. 10–17.
5. Augspole I., Dukalska L., Rakcejeva T., Muizniece-Brasava S., Sabovics, M. (2012). Physicochemical quality evalution of feesh-cut carrots packed and stored in biodegradable film packaging. **In:** *Proceedings of 18th International Conference for Renewable Resources and Plant Biotechnology*, NAROSSA, Magdeburg, Germany, in CD.
6. Dukalska L., Ungure E, Augspole I., Muizniece-Brasava S., Levkane V., Rakcejeva T., Krasnova I. (2013) Evaluation of the influence of various biodegradable packaging materials on the quality and shelf life of different food products. *Proceedings of the Latvia* University *of Agriculture*, Vol. 30(325), p. 20–34.
7. Gamboa-Santos J., Soria A.C., Perez-Mateos M., Carrasco J.A., Montilla A., Villamiel M. (2012) Vitamin C content and sensorial properties of dehydrated carrots blanched conventionally or by ultrasound. *Food Chemistry*, Vol. 136(2), p.782–788.
8. Giacalone G., Chiabrando V., (2013) Effect of different treatments with calcium salts on sensory quality of fresh-cut apple. *Food and Nutrition Research*, Vol. 52(2), p. 79–86.
9. Hag R., Prasad K. (2018) Role of various coloring pigments within different varieties of carrot (*Daucus carota*). *Advances in Plants & Agriculture Research*, Vol. 8(5), p. 386–387.
10. Islam S., Hasan M., Salahuddin, Hafiz A.R., Rana S., Sultana R., Mahdi A.A., Mohammed J.K., Begum R., Haque A., Wang H. (2018) Effect of packaging materials & vitamin-C on various storage condition of fresh cut carrot. *International Journal of Life Science and Engineering*, Vol. 3(3), p. 46–58.
11. Karabagias I.K. (2018) Investigation of yeast and mould growth rate in chopped lamb meat packaged under different systems during refrigerated storage. *Acta Scientific Nutritional Health*, Vol. 2(8), p. 47–50.
12. Krasnova I., Dukalska L., Seglina D., Juhnevica K., Sne E., Karklina D. (2012) Effect of passive modified atmosphere in different packaging materials on fresh-cut mixed fruit salad quality during storage. *World Academy of Science, Engineering and Technology*, Vol. 6, p. 7–22.
13. Oliveira A.C.F. (2017) *Effect of abiotic stresses on bioactive contents of vegetables and high-pressure technology in related functional beverages. Doctoral Thesis*, Department of Food Engineering at Universidad Politécnica de Cartagena, 204 p.

14. Rahman S.M.E., Jin Y.G., Oh D.H. (2011) Combination treatment of alkaline electrolyzed water and citric acid with mild heat to ensure microbial safety, shelf life and sensory quality of shredded carrots. *Food Microbiology*, Vol. 28, p. 484–491.
15. Rößle C., Gormley T.R., Butler F. (2009) Efficacy of Natureseal® AS1 browning inhibitor in fresh–cut fruit salads applications, with emphasis on apple wedges. *Horticultural Science and Biotechnology*, Vol. 84(6), p. 62–67.
16. Saha K., Paulsingh S., Harte B. (2009) Effect of transport vibration on quality of minimally processed and packaged fresh-cut cantaloupe. *Applied Packaging Research*, Vol. 3(1), p. 15–26.
17. Saranraj P., Sivasakthivelan P., Sivasakthi S., Kavi Karunya S. (2016) Microbial spoilage and pathogens in vegetables collected from vegetable market. *Weekly Science International Journal*, Vol. 4(3), p. 1–9.
18. Scarano A., Gerardi C., D'Amico L., Accogli R., Santino A. (2018) Phytochemical analysis and antioxidant properties in colored Tiggiano carrots. *Agriculture*, Vol. 8 p. 1–8.
19. Wang X., Kong D., Ma Z., Zhao R. (2015) Effect of carrot puree edible films on quality preservation of fresh-cut carrots. *Irish Journal of Agricultural and Food Research*, Vol. 54(1), p. 64–71.
20. Yu Y., Jiang X., Ramaswamy H.S., Zhu S., Li H. (2018) High pressure processing treatment of fresh-cut carrots: Effect of presoaking in calcium salts on quality parameters. *Journal of Food Quality*, Vol. 4, p. 1–9.