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Research Article

Sensory Characteristics and Content of Hydroxymethyl-Furfural and Polyphenols in Dried Apples and Health-Related Considerations

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Abstract: Dried apples improve your health owing to their mineral contents. The main function of packaging dried apples is to protect the packaged product from external factors that may affect the contents' physicochemical, mechanical, and sensory changes during the storage period. The study investigates the sensory characteristics and content of hydroxymethyl-furfural and polyphenols in dried apples and health-related considerations. To gratify that aim, the mixed apple sample was calibrated (precise sorting according to the size and color of the apples), selected, washed, and cut into slices. The product is sulfurized with SO2, the procedure takes several hours, and it is immediately introduced into the dryer. The mass is dried in a dryer "Iverak" (Valjevo, Serbia) with warm air at a temperature of max 65 ° C for 15-18 hours. Packaging materials used in the study are: 1. Monomaterial, polyethylene (PE), thickness 95μ m (PE (95) μ m); 2. Combined packaging material, oriented polypropylene metallized (OPP), thickness 20 μ m (OPPmet (20) μ m); 3.Combined packaging material, oriented polypropylene (OPP) / polyethylene (PE) thickness 20 / 50μ m (OPP / PE (20/50) μ m); 4.Combined packaging material, oriented polypropylene metallized (OPPmet) / polyethylene (PE) thickness 20 / 50μ m (OPPmet / PE (20/50) μ m); 5.Combined packaging materials, polyester (PET) / oriented polypropylene metallized (OPP) met / polyethylene thickness 12/38/30 (PET/OPPmet/PE(12/38/30) μ m). The study presents the results of testing in changes of content of hydroxymethyl-furfural (HMF), polyphenols and sensory properties, dried apples packed in different combinations of packaging materials, including PE (95) μ m, OPP met (20) μ m, OPP / PE (20/50) μ m, OPP met / PE (20/50) μ m, PET / OPP met / PE (12/38/30 μ m), considering health issues. The article's findings can make a notable contribution to the knowledge of the thermal kinetics of antioxidant impacts and phenolic content over the production of apple chips.

Keywords: Packaging Materials, Dried Fruit, Health Issues, Antioxidant Impacts And Sensory Properties.

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1. INTRODUCTION

It is established that any thermal processing, including drying, detrimentally impacts the sensory quality and also the bioactive elements of fruit. Despite the fact that light, heat, and oxygen- sensitive phytochemicals degrade over the course of drying, thermal cures are able to enhance the general antioxidant prospect of processed vegetables and fruits in various manners. As a result, various effects are documented for different fruits and drying circumstances or even by several scientists for identical products. For instance, the entire anthocyanin, oxygen extreme absorbance capacity, and whole phenolic content of apple rose with convective drying. Having said that, in another analysis, phenolic combinations and complete antioxidant capacity were reduced with convective and osmotic drying[1-3]. The kinetic measures are employed to reduce the shortage of bioactive elements over the course of storage and processing. Hence, kinetic investigations are performed to boost drying techniques and prerequisites. Multiple investigations have been published on the subject of kinetic changes in antioxidant blends in different fruits in various drying circumstances. Even though apples have been vastly utilized for drying analyses, there exist just a few investigations on the entire phenolic change kinetics and loss of ascorbic acid in apples. Nonetheless, there is no relevant analysis of the kinetic method of antioxidant activity changes in the course of apples' drying[4-6]. Conventional dried fruits are those to which no sugars are included in the course of the process of drying, for instance, peaches, apples, figs, raisins, dates, prunes, and apricots. They are separate from the more newly formed sugar-infused dried fruits, including blueberries, as well as cranberries, candied dried fruits, including pineapple and papaya, and processed fruit snacks like those acquired from fruit purees and the concentrates of fruit juice. Dried fruits include sugars, and even though the procedure of drying eliminates water, the sugar of a particular piece of dried fruit stays the same as for an identical amount of fresh fruit[2,7,8]. Dried apples assist in your health due to their mineral contents. Considering the results of the Linus Pauling Institute, dried apples (half-serving) provide four percent of our daily requirement for potassium. Potassium is regarded as a mineral critical for brain and neuron activities[9,10]. Dried products are primarily very hygroscopic and at the same time subject to oxidative changes, under the action of oxygen and light, so it is necessary to choose the appropriate packaging material, which will protect the packaged dried product from changes during the storage period[1,11]. The main responsibility for the overall quality of dried food products, for their composition, choice of packaging material, design, methods and storage conditions, lies with the food manufacturer[2]. The stability and durability of products, such as minimally processed apples, are significantly affected by numerous parameters: growing conditions, harvesting, storage of raw materials, processing of raw materials in industry, packaging of processed raw materials, storage of the finished product and the path to consumers. Temperature is equally important after fruit picking because the biochemical reactions that occur in the fruit depend on the temperature and the reaction rate increases with increasing temperature. Low relative humidity leads to greater weight loss and changes in the skin of the fruit and affects the speed of transpiration, while the need for a controlled atmosphere is important point in the shelf life of stored apples[12,13]. The carriers of organoleptic properties of fruits are usually colored substances. The greatest color change occurs during the process of dehydration and storage of dehydrated products[14]. Sugar decomposition products affect the processes of changing the composition and color of products. Color of dried fruits mostly comes from hydroxymethyl-furfural(HMF) and polyphenols. HMF is one of the intermediary compounds in non-enzymatic browning reactions, its reacts after formation and gives a brown color of products.[6]This compound is not volatile and has an unpleasant taste[8,15]. HMF is formed not only during heat treatment but also after a long storage time 7. HMF can also be reduced during longer storage, while the product takes on darker color[9]. Polyphenols are an organic compounds characterized by an aromatic structure with hydroxyl substituents. They are contained in the fruits, where during heat treatment (drying, cooking, etc.) or storage, form complexes with low molecular weight proteins giving dark colored polymers of different composition. During long storage time content of polyphenols could be increased[10,16]. Dried fruit is color sensitive product. Colored substances, sugars and fruit acids are the main carriers of the organoleptic characteristics of fruits, and they are also factors that can affect the quality of the packaged product during storage[17]. In order for minimally processed fruit to survive on the market, sensory acceptability is crucial. Sensory analysis is used to assess product quality. In this case, the human organs used for perception are "measuring senses" (eyes, tongue, skin, ear) which in principle react to the intensity of a certain sensory parameter: color, taste, smell, hearing, touch, etc. Sensory analysis is a subjective method, although the procedures and standards used for statistical data processing give a relatively realistic picture of the quality of the product being analyzed[18,19]. Therefore, the main goal of production is to keep the raw material fresh during processing and storage until the product isused[13]. The quality of the packaged product is also affected by the use of packaging material. For sensitive food products such as dried apples, packaging materials with optimal barrier properties are selected, and they are used as monomaterials or in combinations.[20,21]Packaging material and the product packaged in it must not react. Materials that have shown economic justification and quality are: polyethylene, polypropylene, polyester, aluminum foil. Polyethylene was obtained by polymerization of ethane(ethylene). Polyethylene is used for packaging dehydrated products in the form of foils as a monomaterial or in combination with other materials. Polypropylene is produced by polymerization of propylene, in the presence of appropriate catalysts[22,23]. Polypropylene is usually an outer layer of combined food packaging materials. Polyester is a thermoplastic obtained by the reaction between a polybasic acid and a polyvalent alcohol that forms long-chain molecules. In combination with packaging materials, polyester provides good protection and gives strength to the packaging material for packaging dried products. Existing monomaterials often do not have all the necessary physical and chemical properties for food protection, so often packaging materials are combined into combined foils, that is typical for aluminum. Aluminum foil is soft, prone to wear, on the outside it must be protected with a layer of varnish or a combination of other foils with another packaging monomer, which will give the packaged product ideal protection. Characteristic combinations of plastic materials with different barrier properties were selected in the paper[24-26]. Dietary antioxidants with health advantages have raised attention over vegetables and fruits. The process of vegetables and fruits impacts their antioxidant effects and also their quality. Apple chips are dehydrated, ready-to-eat, fruit- based snacks with favorable sensory characteristics. The outcomes of the current study can help the knowledge of the thermal kinetics of antioxidant effects and phenolic content over the course of the production

of apple chips. The kinetic outcomes can be beneficial for the creation of dryers and also optimizing the drying circumstances. The aim of this paper is to monitor changes in some basic quality parameters of dried fruit-apples, depending on the combination of packaging materials used. Monitoring of changes in content of hydroxymethyl-furfural(HMF), polyphenols and sensory changes.

2. MATERIALS AND METHODS

The mixed apple sample was first calibrated (precise sorting according to the size and color of the apples), selected, washed and cut into slices. The product is then sulfurized with SO_2, the procedure takes several hours, and then it is immediately introduced into the dryer. The mass is dried in a dryer "Iverak" (Valjevo, Serbia) with warm air at a temperature of max 65 ° C for 15-18 hours.

Packaging materials used in the work are:

1. Monomaterial, polyethylene (PE), thickness 95µ m (PE (95) µ m);
2. Combined packaging material, oriented polypropylene metallized (OPP), thickness 20 µ m (OPPmet (20) µ m);
3. Combined packaging material, oriented polypropylene (OPP) / polyethylene (PE) thickness 20 / 50µ m (OPP / PE (20/50) µ m);
4. 4.Combined packaging material, oriented polypropylene metallized (OPPmet) / polyethylene (PE) thickness 20 / 50µ m (OPPmet / PE (20/50) µ m);
5. Combined packaging materials, polyester (PET) / oriented polypropylene metallized (OPP) met / polyethylene thickness 12/38/30 (PET/OPPmet/PE(12/38/30) µ m).

Packaging units were formed in which 100g of dried fruit was packed. Packaged samples were stored for 180 days at room temperature of 17-22°C, exposed to light. The test of packaged dried fruit was performed according to the following dynamics: 0, 15, 30, 90, 120 and 180 days. The hydroxymethyl-furfural content was determined by the Winkler method, the original and oldest method, which belongs to spectrophotometric methods[15]. Total polyphenolic compounds were determined by Folin-Ciocalteu reagent, after color development it was measured spectrophotometrically[16].Measurements were performed by Genesys10s UV-Vis spectrophotometer (Thermo Sci., USA). Sensory analysis was performed by the method of analytical descriptive point, scoring system at scale of 1-5[17], during the storage period of 0, 15, 30, 60, 120,180 days. Results were expressed as mean of triple measurements. All measurements were statistically analyzed using ANOVA, followed by multiple comparisons by Tukey test (SPSS). P-values of less than 0.05 were considered significant.

3. STATISTICAL ANALYSIS

Statistical analysis was carried out by SPSS Ver. 21. Comparisons between means conducted by multi- range Duncan test, at level of P value: 5%, as significant difference.

4. RESULTS AND DISCUSSION

The properties of dried apples are used for children, athletes, people who need various vitamins and minerals, etc. The properties of dry apples during pregnancy strengthen the immune system of the mother and fetus. This natural dry fruit prevents the occurrence of various diseases[7]. Dried apple is a useful snack for everyone. This fruit fulfills a large part of the body's daily fiber needs. Benefiting from the properties of dry apples during pregnancy prevents damage to the neural tube of the fetus. This delicious food does not increase blood sugar. It also prevents anemia during this period. Many people use the properties of dry apples for slimming and weight loss. Dried apple accelerates the weight loss process. This dried fruit provides energy to athletes and is helpful for their healthy nutrition[9,11]. Various types of research have been conducted on the properties of dried apples to prevent cancer. This dried fruit reduces the risk of colon and breast cancers. It also fights cancer cells in the lung. Dry apple prevents the progression of lung cancer and plays a vital role in destroying cancer cells. This dry fruit contains antioxidants. Antioxidants destroy free radicals and reduce oxidative stress[5,16]. The properties of dry apples reduce nervous problems and affect brain function. Consuming dried apples prevents brain damage, disorders, Alzheimer's, Parkinson's, and other brain-related diseases. Acetylcholine is a compound in the brain that is essential for enhancing memory, learning power, and concentration. Dried apple increases the amount of acetylcholine in the body. Dried apple prevents damage to the cells that are responsible for the release of dopamine. Their loss provides the basis for Parkinson's disease[10,19]. The results of HMF change in packaged samples of dried apple are shown in Figure 1.

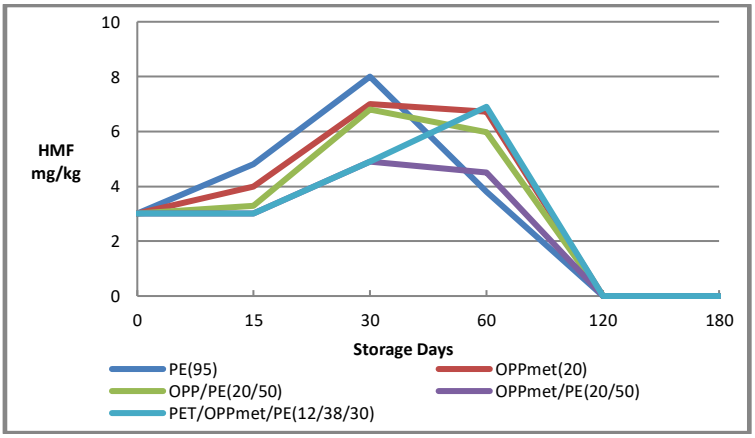

Fig 1: HMF content during storage

During the first period the most pronounced changes were noted in samples dried apples packed in PE (95) and OPP met (20). The maximum concentration of HMF were ascertained after 30 days in the samples packed in these 3 types of packaging materials. Somewhat slower and later occurrence of HMF growth intensification, in samples packed in OPP met / PE (20/50) and PET/OPPmet/PE (12/38/30) indicate better protective properties of the applied combination of packaging materials (figure 1). In all samples, after 120 days of storage, HMF could no longer be detected. Dried apples, depending on applied packaging materials, had the values of polyphenols shown in Figure 2. The results are mean value of triple measurement.

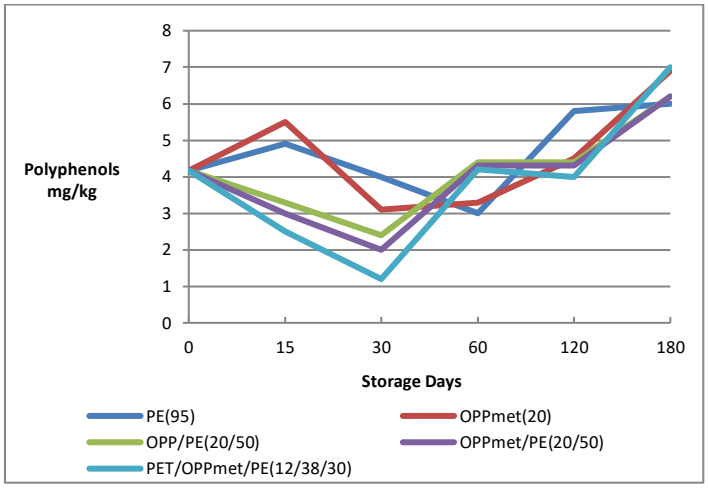

Fig 2: Polyphenols content during storage

Test for the change of polyphenols content in packed dried fruit indicate that up to thirty days is accompanied by more or less pronounced decrease in values, depending on the packaging materials used, and after that there was a trend of increasing the values of polyphenols (Figure 2). It was previously reported that content of polyphenols, in dried fruit products, may decrease but also increase during storage[18,10]. This research showed both trends in different periods of storage but it's generally increasing. This increasing could be results of the release of bound phenolic substances and also hydrolysis of complex phenols (tannins and lignins) that leads to the arising of lower molecular weight phenolic compounds[19,20].However, it wasn't evident significant effect of different packaging material on that process (Figure 2).During storage, various changes in quality occur in the packaged product, which can first be evident through sensory characteristics - changes in color, taste, smell and consistency[12].Sensory evaluation of dried apple samples was performed at the beginning of the experiment according to the point system. Appearance, color, smell, taste, consistency was evaluated (Table 1.) In relation to the quality of drying and calibration of the apple, as a note, it can be stated that the apple after drying had a rather uneven shape and size of slices. The smell and taste decreased by about 10% after 30 days and remained so until the end of the study. The consistency dropped by about 15% after 30 days and remained so until the end of study. The color remained almost the same during the research, even in the HMF degradation phase after 60 days. The darker color of dried fruit products is often caused by the degradation of HMF[7],however in apples the high presence of pectin probably prevented this change[21].The influence of the packaging material on all the mentioned sensory changes, as well as the data given in Table 1, was not clearly noticeable.

Table1. Sensory evaluation based on analytical descriptive point;numbers are mean values of 5 assessors for the entire research period.

packaging materials, (thicknessμ m)	mean value of five measurement 0 - 180 days					
	appearance	color	smell	taste	consistence	descriptive property
PE (95)	4.7	4.7	5.0	4.7	5.0	very good sensory characteristic color
OPPmet (20)	4.7	4.7	4.7	5.0	4.7	very good sensory characteristic color
OPP/PE (20/50)	4.7	4.7	5.0	4.7	4.9	very good sensory characteristic color
OPPmet/PE (20/50)	4.7	4.7	4.7	5.0	4.9	very good sensory characteristic color
PET/OPPmet/PE (12/38/30)	4.6	4.7	4.6	5.0	4.8	very good sensory characteristic color

SD= 4.7±0.01

Sensory characteristics give us an insight into the quality of the dried product (Table 1). For consumers, the sensory characteristic is crucial when choosing a product[17].Onthe base of evaluation: appearance, color, smell, taste, consistency and descriptive properties, quality of the dried apple used in this experiment was mostly very good, for all packaging materials used. HMF is considered harmful to health, although it is normally present in many natural products (e.g. honey), its toxicity and probable carcinogenic properties are stated[22]. Contrary, it is generally known that the consumption of

polyphenols has a positive effect on health condition[23]. Considering the results of this research, a strange conclusion is drawn, that the consumption of dried fruit with a longer storage has a less harmful or more beneficial effect on health, regardless of the packaging material. This is of course only in the context of HMF and polyphenols, with remark that the effect of HMF degradation products is unknown (perhaps the new formed substances are even more harmful than HMF) because it is not known with certainty, which compounds are exclusively derived from HMF due to the complex biochemical composition of fruit[24].The effect of polyphenols can be treated in the same context, it is less known, but it has been reported that some polyphenols have a negative effect on health[25].Considering stated that even different drying techniques can produce different content of HMF and polyphenols in dried fruit[26], it can be assumed that dried fruit, during production and storage, is a dynamic chemical system and that the positive and negative effects of its consumption on health have not been sufficiently researched and determined. Thus the possibility of assessing the impact of packaging material on the quality of dried fruit is limited, only to certain parameters in some of storage periods.

5. CONCLUSION

Based on the results of the evaluation of sensory properties, it can be concluded that the quality of dried apples used in this experiment was rated very good, during whole storage period and for all used packaging materials. There is no clear effect of the packaging material on the content and trend of growth and decline of polyphenolsin packed dried apples, differences between the used packaging materials are minor. There is a partial influence of the packaging material on the HMF content, but it is limited to a period of up to 3-4 months after packaging.

6. AUTHOR CONTRIBUTION STATEMENT

Ajka Aljilji, and Omer Mahmutović devised the project, the main conceptual ideas and proof outline. Nedzad Prazina, SejfoPapić, and Safet Velic were involved in planning and supervised the work. All authors discussed the results and commented on the manuscript.

7. ACKNOWLEDGMENT

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8. CONFLICT OF INTEREST

Conflict of interest declared none.

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