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Mechanical properties of dried fruit packaging materials

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ABSTRACT

One of the important mechanical properties of packaging materials is its tensile strength. The good tensile strength is essential for materials and their mobility, packaging and for correctness when forming packing units. In this paper, stability of mechanical properties (tensile strength and elongation) was tested, for five types of plastics used as packaging material. The tested materials are made of single and combined packaging materials: PE 95 μm, OPP 20 μm, PE/OPP 20/50 μm, OPPmet 20 μm and PET/PE/OPP 12/38/30 μm. Testing of tensile strength and elongation of the material during tearing of the packaging material was performed with the following dynamics: 0, 30, 60, 120 and 180 days. The packed contents were dried apples. All materials showed good insulating properties and stability of the welding site. The quality of packaged dried apples, based on the test results, was assessed as good for the technology and product characteristics. In terms of strength PET/OPPmet/PE, OPPmet and OPP proved to be the best materials. In case of exposure of the package to mechanical loads it is recommended to use some of these three materials.

Keywords: Packaging material, Tensile strength, Elongation, Dried fruit

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1. Introduction

Packaging means accepting the product and protection them until use and some period during use if it is required. The main purpose of food packaging is to keep food contents from contaminants and damage caused by exposure to the outside world [1]. Together with the product, the packaging forms a unique whole that is presented to the customer which means that it is an integral part, protects and present of product, thus providing the necessary information about the content. The task of the packaging is to protect the product from mechanical, physical, chemical and biological changes caused by the action of the external environment and storage time, in all conditions of packaging and storage [2].

Related to packaging of dried product, one of the basic requirements that packaging materials must have is to protect the packaged product from the effects of external factors, e.g. moisture. Usual materials for this type of packaging are plastics: polyethylene, polypropylene, polyester, solo or in combination, and sometimes in combination with aluminum foil.

Polyethylene has good thermal properties. It is used in the structure of multilayer materials, as a layer that makes it easy to form packaging units on packaging machines. Due to its good chemical properties, it is used as a layer

that is in direct contact with the packaged product [3]. It is combined with polyester, polypropylene and other packaging materials [4].
Polypropylene is one of the lightest polymers but combination with other mono materials under high pressure (1215 bar), it could achieve a higher density of 0.92 - 0.94 g/mm^3. Usually, in dehydrated products, it forms an outer layer of combined packaging materials.
Polyester foils are characterized by less water vapour permeability than other plastic foils. Due to its low light transmittance, good mechanical and chemical properties, polyester plays a large role in food packaging [5]. In combination, polyester provides good protection and strength to the packaging material, while polypropylene and polyethylene give the weld-ability.
These multilayer packaging materials sometimes are used for better food storage results. Which combination will be used depends on the type of content that is packing [4]. Metalized foils are polymeric films coated with a thin layer of metal, mostly aluminum [6]. This combined multilayer packaging material contributes to aesthetics and usually carries the product declaration, which is significant as marketing function [4]. Technological process of dried fruits production consists: calibration, cleaning, washing, cutting, treatment with sulfur dioxide, drying, packing. Packing, exactly packaging material, is last process/choice in production but maybe most important for placement of product [7].
One of the important mechanical properties of packaging materials is its tensile strength. The good tensile strength is essential for materials and their mobility, packaging and for correctness when forming packing units. Packaging made up of multiple layers of polymer can reduce its mechanical properties over time, which can lead to loss of function of the packaging – penetration of external influences [8]. Checking the tensile strength of the packaging material over time is important as a measure of the quality of the packaging [8,9]. In this paper, stability of mechanical properties (tensile strength and elongation) in period of 6 months was tested, for five types of plastics (single and combined) used as packaging material: polyethylene (PE), polypropylene (OPP), combination PE and OPP, metalized polypropylene (OPPmet), polyester (PET) in combination with PE and OPPmet. The packed contents were dried apples.

2. Materials and methods

A sample of various apple varieties was used for drying, totally about 100 kg. Drying process was performed in the industrial mini dryer Iverak (Valjevo, Serbia), used for drying fruits, vegetables, forest fruits, mushrooms, and medicinal herbs, has a drying capacity of 1000-1300 kg. The mixed fruit sample was previously washed and cut into pieces in the same size and shape (calibrated). Prepared fruit was dried at a temperature of max 65°C for 15-18 hours. 100 g of dried fruit was packaged unit in tested packing material. After filling, the contents were closed with a laboratory closing machine. The samples of fruit, in formed bags, were stored under normal conditions, at room temperature of 17-22 °C for six months, exposed to the influence of daylight.
The tested materials are made of mentioned single and combined packaging materials: PE 95 μm, OPP 20 μm, PE/OPP 20/50 μm, OPPmet 20 μm and PET/PE/OPP 12/38/30 μm. The unit pack made of combined materials is formed by a heat seal. Testing of tensile strength and elongation of the material during tearing of the packaging material was performed with the following dynamics: 0, 30, 60, 120 and 180 days. Every result is given as the average of five measures.
The longitudinally and transversely cut tubes were in dimensions 15x15 mm, the displacement rate was 400 mm/min, and the distance between terminals 100 mm [8,10]. The graph of the test tube is given in Figure 1.

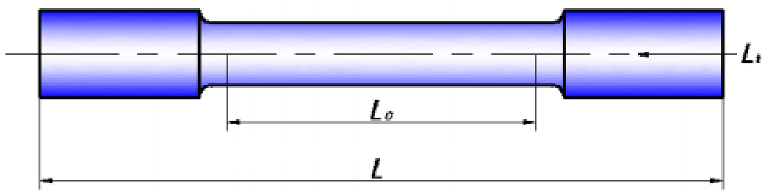


Figure 1. Test tube: L_o – measuring part of tube, L_t – part of tube that is in the tearing machine, L – length of tube

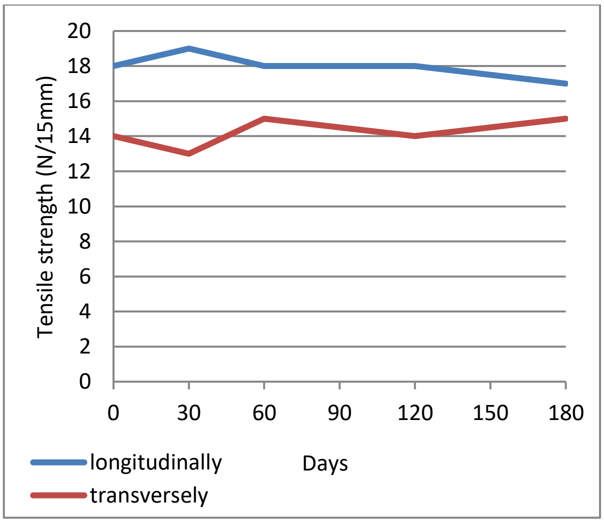
The tensile strength and elongation of the material during tearing of the specimen was measured by the SRPS method [10], on INSTRON 4301 (Buckinghamshire, UK) testing machine, Figure 2.

Figure 2. INSTRON 4301 testing machine (Buckinghamshire, UK)

3. Results and discussion

The most important mechanical characteristics of the packaging materials are the tensile strength (TS) and elongation (E) of the material. The results show the maximum tearing forces during the test (tensile strength – TS), and the stretching at that force (elongation – E) for five materials that are usually use for packaging of dried fruit. These parameters are determined for both directions of material, longitudinal and transverse. The results for all five tested materials are given in Figures 3-7.

According to Figure 3, it is evident that the tearing forces and elongation were greater in the longitudinal than in the transverse direction, for PE material. The percent elongation values are quite large indicating the nature of the PE material [10]. Relatively low fluctuations of results show the mechanical stability of PE material over time, in both directions of testing. There is no continuous decline or increase of results over time.



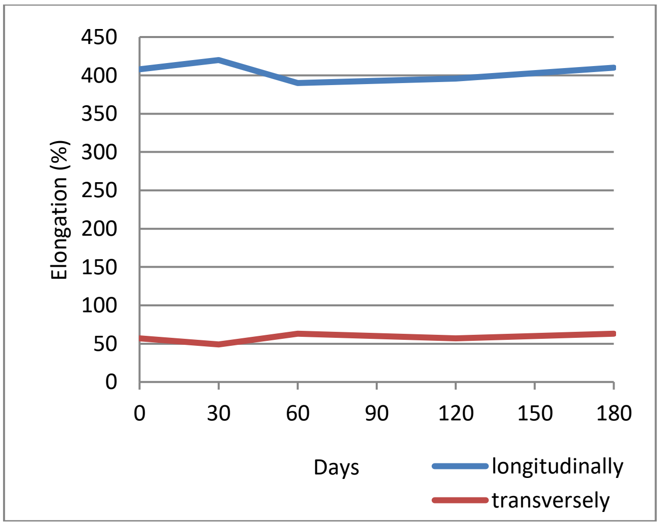


Figure 3. Tensile strength and elongation for packaging material PE (95) over time of testing

Figure 4 shows that tearing forces of OPP material in the longitudinal direction were rather uneven and greater than in the transverse direction. The results in the longitudinal direction cannot be characterized by changing over time of investigation, regardless of significant fluctuations of the results. The transverse direction could be characterized by an increase in force and the percentage of elongation during the first period of testing. It is certain that elongation in the longitudinal direction was smaller than in the transverse direction, which is understandable given the orientation of the OPP polymer chains [11].

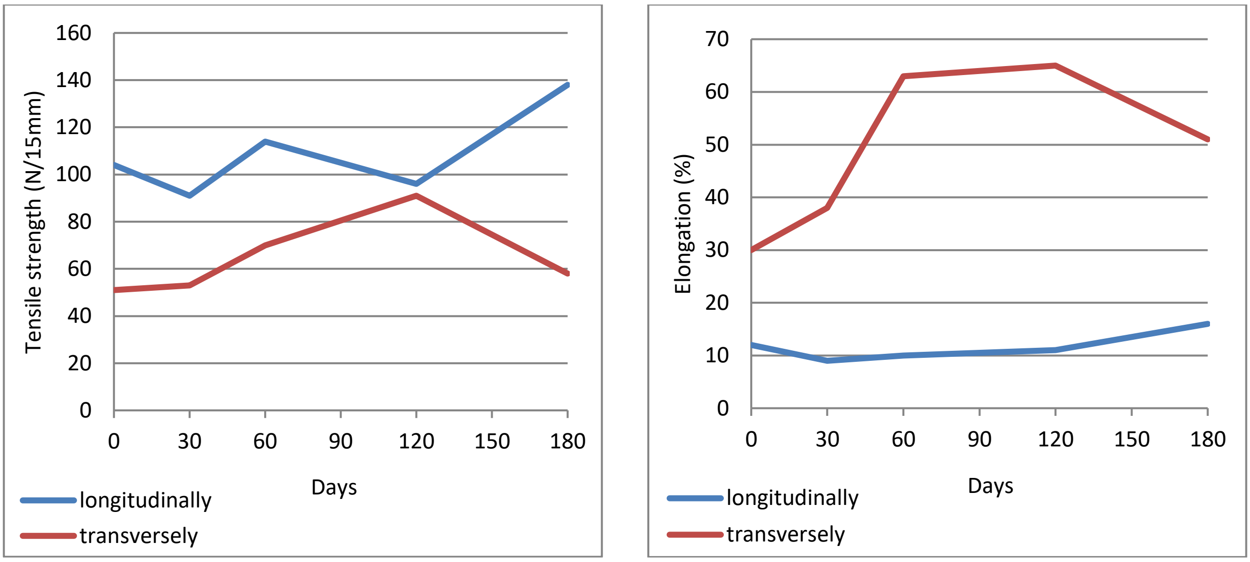


Figure 4. Tensile strength and elongation for packaging material OPP (20) over time of testing

Considering results of OPPmet material, given in the Figure 5, it is clear that the tearing forces in the longitudinal direction were smaller than in the transverse direction, while the elongation in the longitudinal direction was greater than in the transverse direction. The results are quite uniform – OPPmet material did not show a continuous change of the results over the testing period.

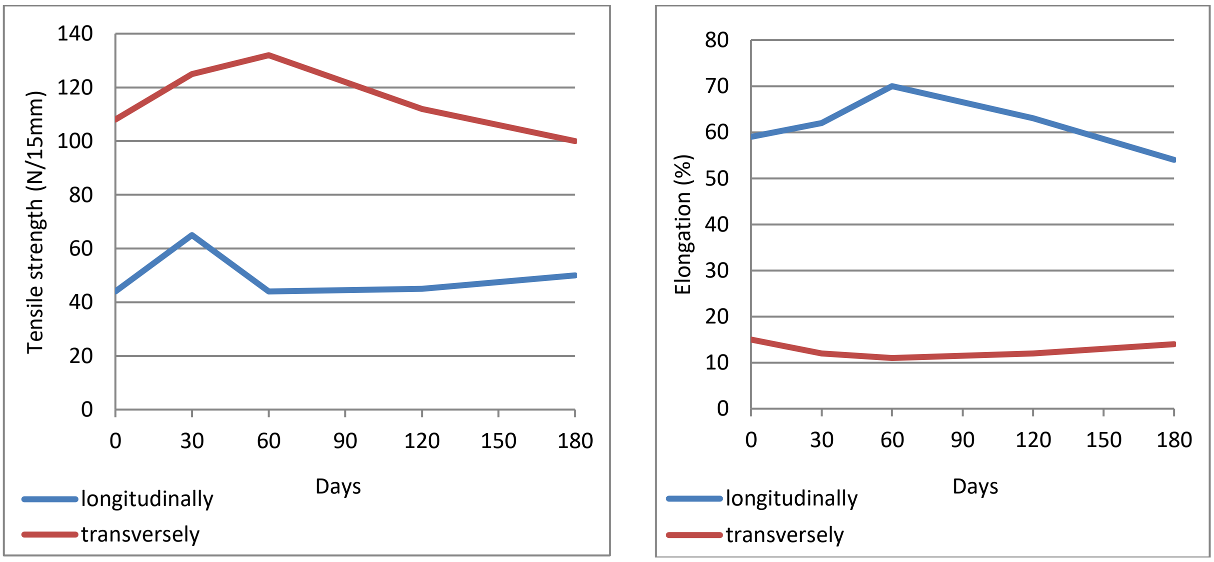


Figure 5. Tensile strength and elongation for packaging material OPPmet (20) over time of testing

Based on the test results, shown in Figure 6, could be concluded that the average values of the tearing force in the longitudinal and transverse directions are almost the same, for OPP/PE material. Very stable results, for both tested mechanical properties, were for the transversely direction, over time of testing.

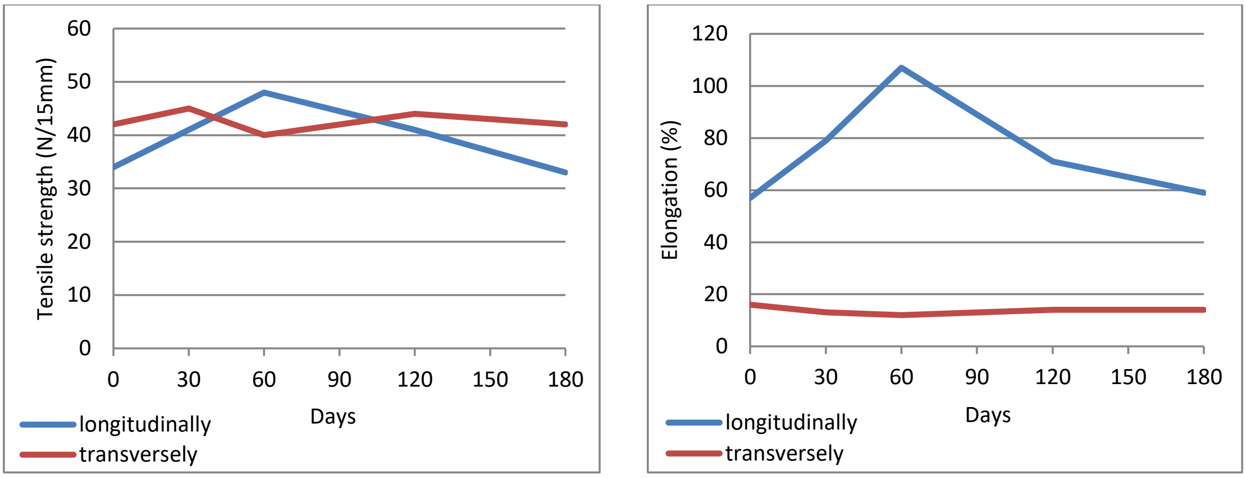


Figure 6. Tensile strength and elongation for packaging material OPP/PE (20/50) over time of testing

Results obtained from the Figure 7 show that tearing forces in the longitudinal direction are higher than in the transverse direction, while in measure of the elongation, it is opposite. Low discontinuous increase in the tearing force in the transversely direction and the same decrease in the longitudinally direction during the test time were observed. Generally PET/OPPmet/PE material showed the best results of tearing force, more exactly showed greatest resistant against tearing.

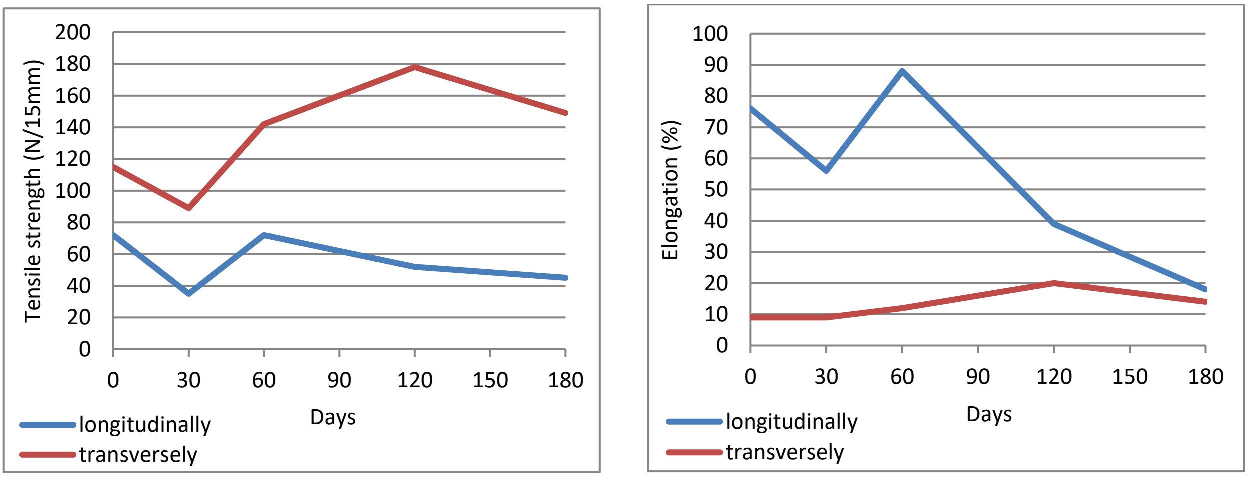


Figure 7. Tensile strength and elongation for packaging material PET/OPPmet/PE (12/38/30) over time of testing

Test results of the packaging unit, for all tested materials, indicate that all packaging units are properly and hermetically sealed and that there has been no change in the sealing quality during the test time. Dried apples did not have a change in taste and appearance, which implies the absence of its reaction with all tested packaging material and environment.

4. Conclusion

In terms of strength, PET/OPPmet/PE proved to be the best material, regardless of significant fluctuation of results. However, if the multilayer material is a problem from an economic or technological point of view, it is not necessary, because other materials have shown good characteristics, especially OPPmet and OPP whose results were close to PET/OPPmet/PE material. PE showed the greatest elongation, which is in line with its nature, but its tensile strength is significantly less than three mentioned materials. Otherwise all materials showed good insulating properties and stability of the welding site. The quality of packaged dried apples, based on the test results, was assessed as good for the technology and product characteristics. There were no biological changes in the content of the packaged material in any of the packaging materials. Also no chemical interaction of the packaging material and the contents of the package were recorded by any material. However, in case of exposure of the package to mechanical loads, it is recommended to use PET/OPPmet/PE material, OPPmet or OPP. These three have shown the best characteristics in terms of strength and can be used as a quality packaging material for packaging dried fruit.

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