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Full Length Research Paper

The influence of protective properties of packaging materials and application of modified atmosphere on packed dried apricot

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The influence of protective properties of packaging materials and modified atmosphere on quality changes of dried apricot is shown in this paper. In our investigation, we used four different characteristic combinations of packaging materials with different barrier properties for packaging of dried apricot: polyester-polyethylene (PET/PE), paper-polyethylene (PAP/PE), paper-aluminium-polyethylene (PAP/Al/PE), polyester-aluminium-polyethylene (PET/Al/PE) and two different atmospheric conditions: normal and modified (30% CO_2, 60% N_2). The parameters evaluated in this study were moisture content, the content of the brown component and the hidroxymethilfurfural (HMF) content. During the storage period of 12 months, changes in moisture content, and colour changes of brown component and HMF contents were affected by the type, combination and applied packing conditions. During the investigation period, the moisture content increased, as well as the content of the brown component and the HMF content. The highest changes in moisture content are reported for dried apricot packaged in the PAP-PE under normal atmosperic condition (increased from 31.2 to 39.6%, taking into consideration 100 g of the sample, after 12 months of storage). The highest value of HMF content was recorded for dried aprricot packaged in the PAP-Al-PE with modified atmospheric condition after nine months of storage (0.152 mg/g). The research results indicate that sustainability of dried packaged apricot is affected by the selection of packaging material and the applied atmospheric conditions.

Key words: Packaging, modified atmosphere, dried apricot.

INTRODUCTION

Dried fruit is a substrate susceptible to moisture and oxidation reactions during storing which leads to selection of an appropriate packaging material for such content with characteristics which would help provide long term sustainability of the packed product.

Packing in the modified atmosphere (MAP) improves the dried product technological quality and consequently reduces possible biochemical changes (Exama and Arul, 1993; Mannapperuma and Singh, 1994; Gvozdenovic et al., 2006, Achour, 2005; Shen et al., 2006). Factors which can influence the packed product's quality change during the storage time include: moisture, oxygen, light, packaging material, production quality and packing conditions. The choice of packaging for food products depends on many factors, primarily on the characteristics of products that are packed, the desired term, sustainability of existing packaging line and the properties of packaging materials and packaging. Packaging materials with

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Abbreviations: PET/PE, Polyester-polyethylene; **PAP/PE,** paper-polyethylene; **PAP/Al/PE,** paper-aluminium-polyethylene; **PET/Al/PE,** polyester-aluminium-polyethylene; **HMF,** hidroxymethilfurfural.

optimal barrier properties are selected for delicate foods and are used as monomaterials or in combinations that are optimal for the packed product (Gvozdenovic et al., 2006). Polymer materials allow the gas molecules to pass depending on the material structure and partial pressures. If the packaging unit is poorly made, it will lead to increased diffusion of molecules of gases and water vapour.

Monomaterials, which are the ones most frequently used for forming a packaging material unit for packing food products, are mostly made of polyethylene (PE), polypropylene (PP), polyamides (naylon), polyetylene terephtalate (PET), polyvinyl chloride (PVC), poly-vinylidene chloride (PVdC) and vinyl alcohol ethylene (EVOH). Hard and semi-hard structures are most commonly made of PP, PET, unplasticized PVC and expanded polystyrene (Gordon, 2006).

In order to improve barrier characteristics, thin layer of aluminium can be applied onto polymeric films by metalization. Using this process, metals in thin layers are applied onto surface of polymeric film (10 nm thickness) (Coles et al., 2003). Even at smaller thickness, below 6 to 9 µm, aluminium is still far superior to most polymer materials (Goddarg, 1980). Nonenzymatic darkening is a serious occurence in dried and concetrated food with decreased water content where water activity is 0.6 to 0.7 (Rapusas and Driscoll, 1995).

During the drying process, nonenzymatic darkening reactions can be intensified by decreasing the water content and through chemical processes between carbohydrates and proteins and their decomposing products such as peptides and amino acids. HMF is created as an intermediary product of nonenzymatic decomposing. Normal organoleptic properties (colour, taste and scent) are lost during these reactions while, due to the blocking of amino groups, nutritious value of the product is decreased (Barriero et al., 1997; Labuza and Saltmarch, 1980). According to many researchers' observations, HMF does not occur during heat treatment only, but following prolonged storing (Ilkay and Ustun, 2003).

Brown component repesents a way of measuring characteristic colour of the product. Next to HMF content, brown color intensity is regarded as an indicator of nonenzymatic darkening process.

The goal of this research was to determine a quality packaging material that would optimally protect the product, by means of monitoring the packed dried apricots quality changes.

MATERIALS AND METHODS

Chemicals

Barbituric acid, p-toluidine, isopropanol, glacial acetic acid, Carrez I($K_4Fe(CN)_6 \cdot 3H_2O$), Carrez II ($Zn(CH_3COOO)_2 \cdot 3H_2O$) and $K_2Cr_2O_7$ were purchased from Merck® (KGaA, Darmstadt, Germany).

Sample

Dried apricot was packed under normal atmospheric pressure and in the modified atmosphere (30% CO_2, 60% N_2). The air was taken out from the sample and the gas mixture injected into the obtained vacuum. The sample was hermetically closed. 100 g of dried apricot was packed into formed packaging material units. Dried apricot was packaged in four characteristic combinations of packaging materilas with different barrier properties: polyester-polyethylene (PET/PE), paper-polyethylene (PAP/PE), paper-aluminium-polyethylene (PAP/Al/PE) and polyester-aluminium-polyethylene (PET/Al/PE). Packaging 12 µm material in the case of PET/PE i PAP/PE and 15 µm material for PAP/Al/PE and PET/Al/PE was used. Packed samples were kept at room temperatures (17 to 22°C), and were exposed to the influence of light for 12 months.

Packaging materials barrier properties testing

Modified atmosphere sustainability was monitored by OXY-BABY device (Witt Gasetechik, Germany).

Dried packed apricot analyses

Moisture content was determined after drying samples at 103 ± 2°C to constant mass (Laboratory dryer, Termodry, Raypa, Spain).

Determination of HMF

Hidroxymethilfurfural content was determined by the Winkler method (Zappalà et al., 2005).

Determination of brown component content

Brown component content was determined spectrophotometrically by measuring absorbance maximum at 420 nm (Erlandson and Wrolstad, 1972; Abramovic et al., 1985). The measurement was compared to a calibration line (4 to 160 mg/L) of prepared $K_2Cr_2O_7$ solution using redistilled water as a blank. All measurements were performed in triplicates.

Instruments

A PG Instrument LDt T80+ ultraviolet-visible (UV-Vis) spectro-photometer (Wibfost, England) was used for all measurements.

RESULTS AND DISCUSSION

Modified atmosphere with 30% of CO_2 and 60% of N_2 was used in the experiment. The rest of the modified atmosphere contained O_2. The measurement results are given in Figures 1 to 3. The most significant changes were observed after the first month in PAP/PE. In this package, the percentage of O_2 increased from the initial 1.43 to 17.53%, the percentage of CO_2 changed from the initial 31.53 to 1.53%, while the percentage of N_2 starting from 67.03% reached the value of 80.93%. The PET/Al/PE showed the smallest change in CO_2 concen-tration, where the concentration of this gas was 28.84% at the beginning, 27.94% at the end of the first month,

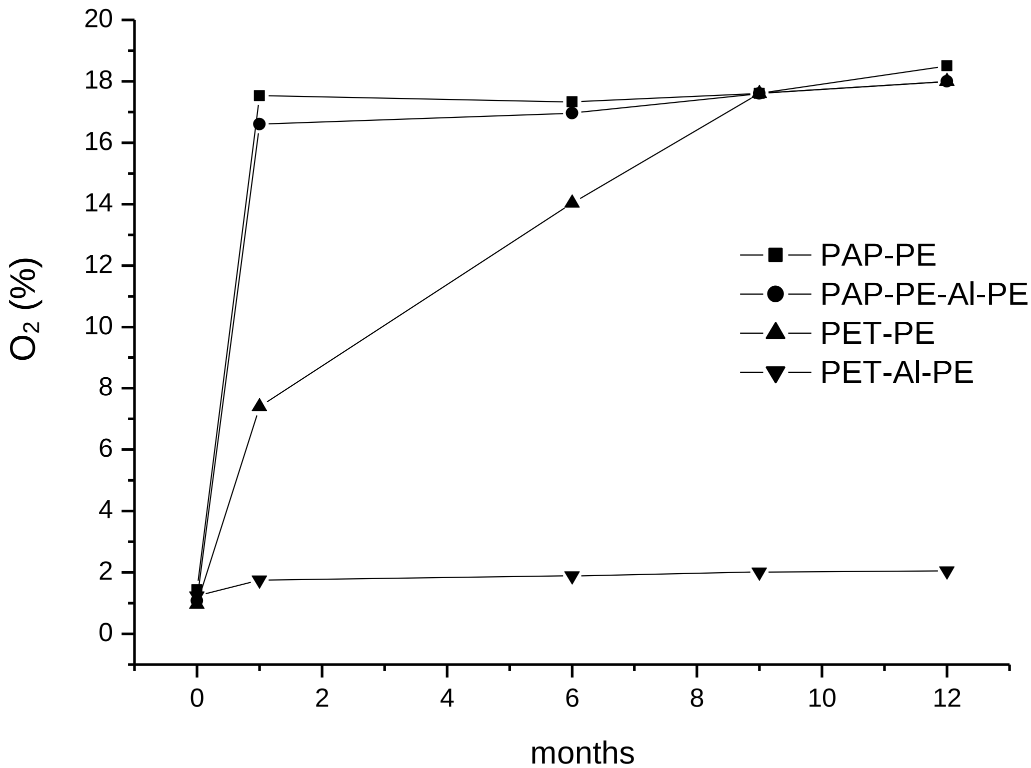

Figure 1. Changing the concentration of oxygen in modified atmospheric conditions.

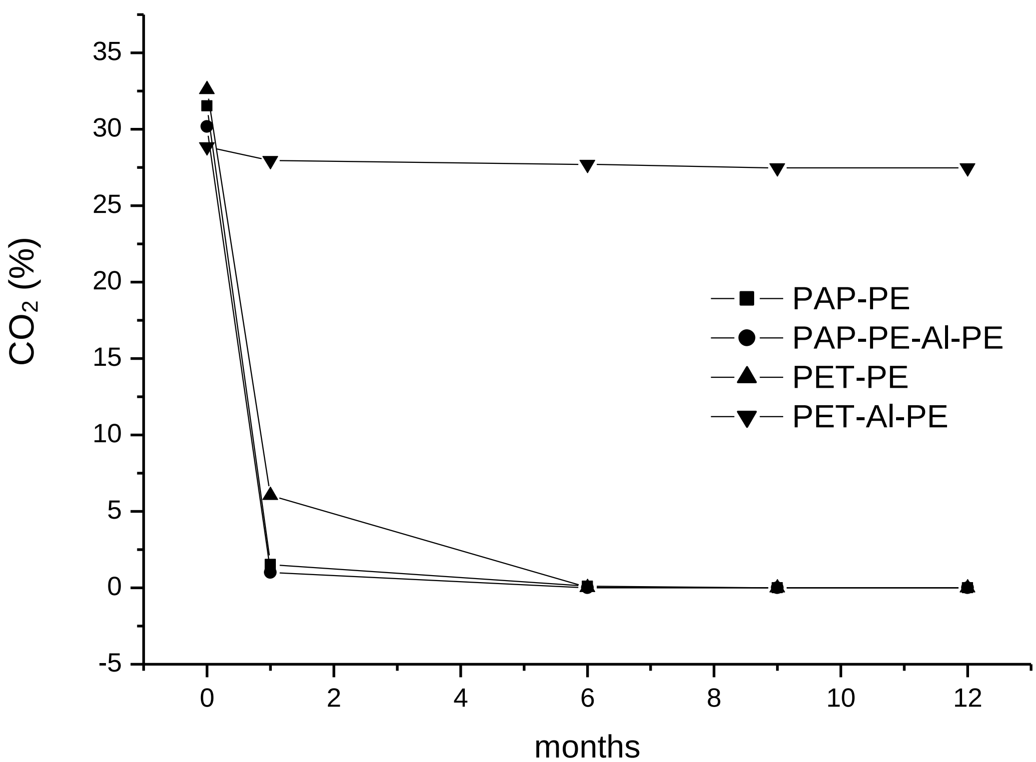

Figure 2. Changing the concentration of carbon dioxide in modified atmospheric conditions.

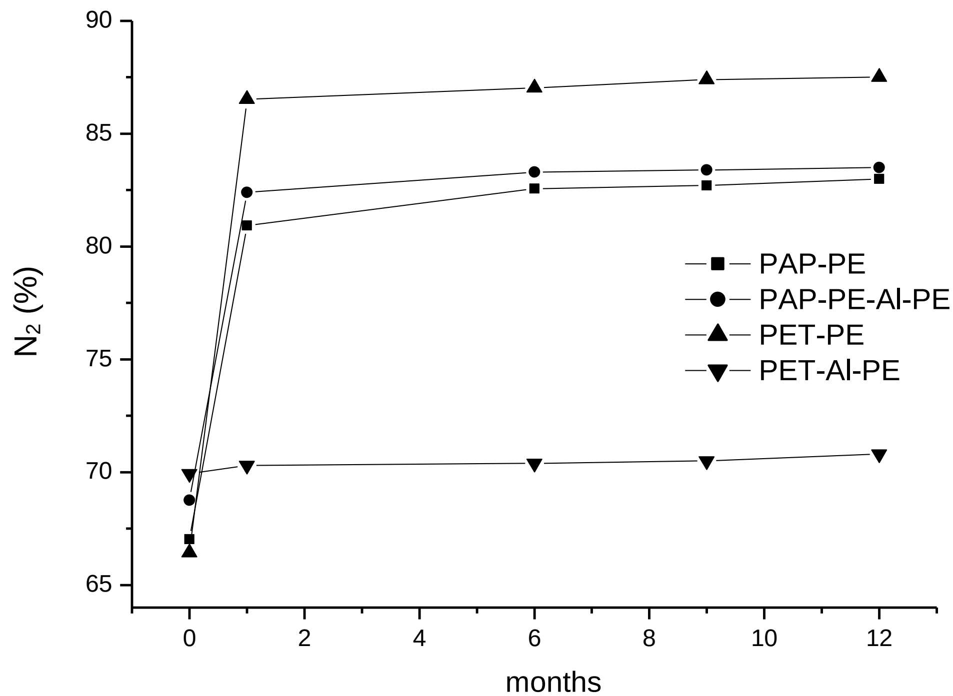

Figure 3. Changing the concentration of nitrogen in modified atmospheric conditions.

Table 1. Changes of the moisture content of packed dried apricots during storage under the normal atmospheric conditions.

Time (month)	Moisture content (%)			
	PAP/PE	**PAP/Al/PE**	**PET/PE**	**PET/AL/PE**
0	31.2	31.2	31.2	31.2
1	35.4	33.8	33.1	31.3
9	39.6	36.8	35.4	32.5
12	39.6	36.8	35.4	32.5

and 27.48% after 12 months. These further support good barrier characteristics of this packaging material.

Other combinations showed more significant changes in CO_2 concentration after the first month.

The smallest changes in nitrogen concentration were measured in PET/Al/PE, whereas other combinations showed insignificant increase in nitrogen concentration in MAP.

Moisture content change

Dried product had 31.2% of moisture at the beginning, taking 100 g of sample into consideration.

Following the humidity values during the storage of the samples packed under the atmospheric pressure in combination with PET/PE, PAP/PE, PAP/Al/PE, PET/Al/PE materials and according to Table 1, we can conclude that more changes occurred after 12 months, especially with samples packed in PAP/PE where the humidity concentration increased from 31.2 to 39.6%. Somewhat lower values were detected in PET/PE packed samples where, after 12 months, the humidity concentration reached 35.4%, while with PAP/Al/PE combination, the humidity concentration increased to 36.8%. PET/Al/PE showed the best moisture protection. In this package, the humidity concentration after 12 months reaches 32.5%, which is 1.3% more than the initial value.

Modified atmospere packaging showed the same tendencies as the corresponding packaging in atomspheric conditions (Table 2). The best protection from humidity showed the PET/Al/PE material combination sample in modified atmospheric conditions. In this package, the humidity concentration increased by 0.8%. PAP/PE combination turned out to be inadequate, even in modified atmospheric conditions, as the humidity

Table 2. Changes of the moisture content of packed dried apricots during storage under the modified atmospheric conditions (30% CO_2, 60% N_2).

Time (month)	Moisture content (%)			
	PAP/PE	PAP/Al/PE	PET/PE	PET/AL/PE
0	31.2	31.2	31.2	31.2
1	34.5	33.0	32.0	31.3
9	38.0	35.0	34.0	32.0
12	38.0	35.0	34.0	32.0

Table 3. Changes of the HMF content (mg/g) in the packed dried apricots during storage under the normal atmospheric conditions.

Time (month)	HMF (mg/g)			
	PAP/PE	PAP/Al/PE	PET/PE	PET/AL/PE
0	0.051	0.051	0.051	0.051
1	0.058	0.065	0.060	0.053
6	0.067	0.069	0.074	0.069
9	0.137	0.150	0.130	0.077
12	0.045	0.035	0.030	0.050

Table 4. Changes of the HMF cotent (mg/g) in the packed dried apricots during storage in the modified atmospheric conditions (30% CO_2, 60% N_2).

Time (month)	HMF (mg/g)			
	PAP/PE	PAP/Al/PE	PET/PE	PET/AL/PE
0	0.051	0.051	0.051	0.051
1	0.050	0.065	0.065	0.053
6	0.065	0.070	0.074	0.069
9	0.130	0.152	0.130	0.770
12	0.045	0.035	0.030	0.060

concentration increased by 1.3 times, as compared to the initial value.

HMF changes

The HMF changes in the packed dried apricot during the storage is given in Tables 3 and 4. HMF is a very reactive compound which comes into existence as an inter-mediary product of nonenzymatic decomposition. Depending on a combination of materials applied, HMF value during the first three months abruptly increseas only to decrease after nine months in all the samples during the storage. During the whole storage time, the smallest changes of HMF values were observed in samples packed under modified atmospheric conditions in PET/Al/PE packaging material where the initial HMF concentration value was 0.051 mg/g, after nine months it was 0.077 mg/g, whereas after 12 months, it was 0.06 mg/g.

However, the biggest changes were noticed in samples packed under normal atmospheric pressure, especially in samples packed in PAP/Al/PE combination, whereas in nine months, the concentration incresed from the initial 0.051 to 0.137 mg/g.

Brown component changes

The brown component changes in the packed dried apricot during storage is shown in Tables 5 and 6. Brown component represents the measure of a product's characteristic color darkening. During the research, it was determined that the changes of the brown component occur when the content increased, as compared to the initial values after packing. The smallest changes were observed in the samples packed in the PET/Al/PE material, while the greatest changes were noticed in the samples packed in the PAP/PE material which correlates with barrier properties of the applied combinations.

Table 5. Changes of the brown component content (mg/g) of packed dried apricots during storage under the normal atmospheric conditions.

Time (month)	Brown component content (mg/g)			
	PAP/PE	PAP/Al/PE	PET/PE	PET/AL/PE
0	0.041	0.041	0.041	0.041
1	0.060	0.050	0.050	0.053
6	0.085	0.070	0.074	0.069
9	0.130	0.120	0.100	0.077
12	0.150	0.130	0.120	0.080

Table 6. Changes of the brown component content (mg/g) of packed dried apricots during storage in the modified atmospheric conditions (30% CO_2, 60% N_2).

Time (month)	Brown component content (mg/g)			
	PAP/PE	PAP/Al/PE	PET/PE	PET/AL/PE
0	0.041	0.041	0.041	0.041
1	0.070	0.050	0.050	0.053
6	0.080	0.070	0.074	0.059
9	0.120	0.100	0.100	0.067
12	0.130	0.120	0.110	0.070

The greatest changes relating to brown component increase were detected in the samples packed under normal atmospheric pressure in the PAP/PE material, whereas after 12 months, the brown component content reached the value of 0.15 mg/g which is 3.7 times more than the initial value

However, the smallest ones were observed in the samples packed in the modified atmospheric conditions in the PET/Al/PE material which correlates with barrier properties of the applied combinations where the increase of the brown component content was detected and it was 1.7 times more than the initial value.

Conclusion

Moisture content, HMF and brown component content changes are conditioned by the type, combination, barrier properties of the materials used and packaging conditions applied. From the tests, it can be concluded that adequately applied modified atmospheric combination, choice of packaging materials, their combinations and barrier characteristics all have great significance and influence on the sustainability of packed dried apricots. The PET/Al/PE combination provides the best protection to packed dried apricots.

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