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EFFECT OF PACKAGING MATERIALS AND TECHNOLOGIES ON THE MILK POMADE SWEET *SHERBET* WITH CRUNCHY *PEANUT* CHIP'S COLOUR AT THE SHELF LIFE

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Abstract

The objective of the research was to evaluate the colour stability of milk pomade sweet – sherbet *with crunchy* peanut *chips. The product was packed in several packaging materials (OPP, EVOH, BIALON 65, BIALON 50, ECOLEAN, cellophane based biodegradable NVS film and PP) by several packaging technologies vacuum, modified atmosphere (30% CO_2+70% N_2; 30% CO_2+70% CO_2 and 100% CO_2) and control – in air ambiance and stored at room temperature +21±1 °C RH 40±5% in daylight for 12 weeks. At the beginning of the experiment, the sherbet was in the category of excellent quality in terms of taste, smell, colour, moisture content and hardness expressed by cutting force. During the storage, these properties changed and there was observed the product quality decrease because of moisture content reduction in some of packaging material's packed samples and connected with it product hardening, in the turn having influence on the colour stability, which have been expressed by total colour difference* ΔE^*. *The studies of the sample colour measurement were carried out before packaging and after 2, 4, 6, 8, 10 and 12 storage weeks. Colour was measured in the CIE L*a*b* system by Colour Tec PCM/PSM.*

Key words: *colour, milk pomade sweets, packaging technologies, shelf life*

1. INTRODUCTION

The confectionary market consists of cereal bars, chocolate, gum and sugar confectionary. One of delicious sugar confectionary kinds is Oriental sweets – sherbet, which could be classified as milk pomade sweet. Milk pomade sweets could be characterised by moisture below 5% and water activity (a_w) around 0.2 respectively (Labuza et al, 2004). Milk sweets are usually a mixture of several ingredients, made according to a fairly complex recipe and in a short time. This may lead down to absorbtion of water from the atmosphere following prolonged exposure to ambient conditions, making the sweets soft and soggy (Manley, 1998), in that way packaging films with a high moisture barrier properties could be a common practice. In the second place, hardening is the main cause of quality deterioration cookies and biscuits, included of milk pomade sweets, which change from soft and pliable to firm and crumbly within a few days or even hours after their manufacturing. While study of biscuit and cookies physical properties has been widely studied, little research has been found on milk sweets and candies shelf life. A very extensive study on the texture evaluation of dry food systems during storage has been carried out by Labuza, 2004. The authors concluded that a strong correlation exists between cookie hardening and sucrose crystallisation; for all that it is supposed that sucrose crystallization is probably not the only cause of texture deterioration of cookies. Presumably, hardening is a consequence of water loss from the cookie surface.

Sherbet with crunchy ***peanut*** chips could be classified as milk pomade sweet. It is one of quite popular delicious sweets in Latvia produced by Joint stock Company Laima, which is one of the oldest producers of sweets in the Baltic States, offers one of sweets. Its ***confectionary*** is also highly recognized abroad. Laima is the sweet legend since 1870 (Laima, 2006) Laima faces severe competition on the Latvian market – it has to compete with world-famous companies such as Nestle, Fazer, Chupa Chups, and Cadburry's. Laima also exports products to Germany, Israel, USA, Canada, and Czech Republic. The exceptional sweet – sherbet belongs to Oriental sweets with main ingredients sugar and glucose syrup as well as condensed milk. All those ingredients are cooked as jelly and afterwards whipped, so obtaining milk fondant. Peanuts are added to fondant and this substance is formed in tablets and chilled, afterwards cut in pieces. Sherbet is recommended to keep cool and dry (+18±3 °C). On the market place peanut sherbet for the time being could be found only in bulk carton transport packaging boxes by 5 to 10 kg in each.

Freshly made sherbet is soft and savoury but after several days' storage at the open air gradually hardens, as it has been observed at the market place and laboratories, product loses eye appeal, taste and become not marketable. This problem limits the shelf life, so sherbet with crunchy ***peanut*** chips can be marketed only at the local market. As there are not knowledge about behavior of this unique product sherbet at the storage time, a preliminary investigations on the evolution of texture of freshly manufactured sherbet, packed in various plastic films with several barrier properties was planed to carry out.

Packaging is a medium between product manufacturers and consumers (Meroni, 2000), packaging has a significant role in the food supply chain (Ahvenainen, 2003). The main functions of packaging are to extend the shelf life, and maintain the quality and safety of the packed goods (Lopez-Rubino et al, 2004). An effective package must prevent the transmission of oxygen, light and water vapour, and microbial growth to retard quality deterioration of packaged goods (Singh and Singh, 2005). Mouth feel, texture and eating qualities are adversely affected by loss of moisture. As all packaging materials are permeable to moisture to some extent, active packaging can balance moisture and compensate for moisture loss, suggests Rberto Sablo from Multisorb Technologies (Sabdo, 2009). (Active packaging includes concepts that will absorb oxygen, moisture or remove compounds that may cause taints. Other systems of active packaging release antimicrobial agents, antioxidants, flavours and/or colours (Rooney, 1995; Vermeiren at el, 1999).

The main recourse used for food packaging, including sweets, is Plastic materials (Baner et al, 1999). The shelf life of foods packed in plastics depends on the permeation of gas and water vapour through the packages. This is because a significant amount of food deterioration results from oxidation and changes in the water content (Varsanyi, 1986). Polyolefin's (PE, PS), polyesters (PS), polyethylene terephtalate (PET) and polycarbonates (PC) are the principal families of thermoplastics in food packaging (Brown, 1992). Those materials need to be examined for their suitability for use as various sweet and candy's packaging materials.

At the time being the application of vacuum and modified atmosphere packaging technologies appeared successful in extending the shelf-life and quality of the food (Siverstvik at al, 2002; Devlieghere and Debevere, 2003; Spencer, 2005). However, these technologies do not always remove oxygen completely. Moreover the O_2 that penetrates through the packaging film cannot be removed by these technologies.

The row materials such as fossil fuel and gas for conventional polymer production could be partially replaced by greener agricultural sources, which should also participate to the reduction of CO_2 emissions (Narayan, 2001). Over the past five years packaging suppliers have been introducing various forms of biodegradable plastics. The market of biodegradable polymers at the present is

growing based on considerations that consumers and recycling regulations will drive demand for environmentally-friendly packaging.

NatureFlex™ NVS is a transparent heat-sealable compostable cellulose film, have a good barrier to gases and aromas, they are a relatively recent introduction to overall product range. These films are based strongly on renewable resources and are fully certified to the European (EN13432) and American (ASTM D6400) norms for compostable packaging. In addition they have been proven to be suitable for Home Composting and will also biodegrade in a waste-water environment. NVS film has been specifically formulated to offer improved stiffness under chill cabinet conditions and a controlled level of moisture permeability with a heat-sealable conversion-friendly coating on both sides. Target applications include the flow packing of fresh produce, window bags and bakery. The barrier properties of NVS are as follows (NatureFlex™ NVS, 2009): WTR - 360 g/m^2 d ±10% at +38 °C and HR 90% (ASTM E96) and OTR – OTR: 3 cm^3/m^2 d bar at +23 °C and HR 0-5%: (ASTM F 1927). This film was selected to test in our experiments for sherbet packaging in air ambiance.

The objective of this study was to determine physical parameters and respective shelf-life extension of a delicious sweet – ***sherbet*** with crunchy ***peanut*** chips by packaging in different packaging materials with diverse barrier properties using various gas compositions in packages.

2. MATERIALS AND METHODS

2.1. Experimental design

Experiments were carried out at the Department of Food Technology, Latvia University of Agriculture. The object of the research was milk pomade sweet ***sherbet*** with crunchy ***peanut*** chips, produced by stockholder *Laima*, Latvia. Ingredients of sherbet: sugar, peanuts (24%), condensed milk with sugar, water, glucose syrup, wafers (wheat flour, egg mass, baking agent (E500), emulsifier (soya lecithin), salt. Dimensions of one piece of sherbet in average was 40 x 40 x 8 mm, mass 30±1g.

2.2. Packaging and storage of samples

The study involved preliminary preparation of different polymer pouches from OPP, MULTIBARRIER 60**,** BIALON 65, BIALON 50, cellophane based biodegradable NVS film, ECOLEAN and PP films, packaging of sherbets in vacuum and different modified atmosphere (MAP) content (30% CO_2+70% N_2; 70% CO_2+30% N_2 and 100% CO_2) and air ambiance as control and storage in room temperature at +21±1 ºC (controlled by MINILog, Gresinger electronic) and about 40% RH for 12 weeks under day and night conditions. A characteristic of materials used in experiments is shown in the Table 1 and structure of performed experiments – in Fig.1. The materials for experiments were selected with different transparency, water vapor transmutation rate and various thicknesses.

Table 1. Characteristics of materials used in experiments.

Sample Nr.	Packaging material	Composition	Thickness, μm
1.	OPP	Single layer, transparent	40±2
2.	MULTIBARRIER 60	Laminate, APA/TIE/PA/EVOH/PA/TIE/PE/PE, transparent	60±2
3.	BIALON 50	Laminate, BOPA / PE, frosty white	50±3
4.	BIALON 65	Laminate, BOPA / PE, transparent	65±3
5.	ECOLEAN	Single layer, Ca / PE, frosty white	78±4
6.	BIO NVS	Single layer, transparent, Cellophane based biodegradable NVS film	25±1
7.	PP	Single layer, transparent	40±2

Two pieces of sherbets were placed in each package. Size of each pouch was 80 x 120 mm, the total mass in each package – 60 ±1.0 g. The results were reported as averages of those two determinations. Samples were analyzed before packaging (day 0) and after 2, 4, 6, 8, and 10 storage weeks.

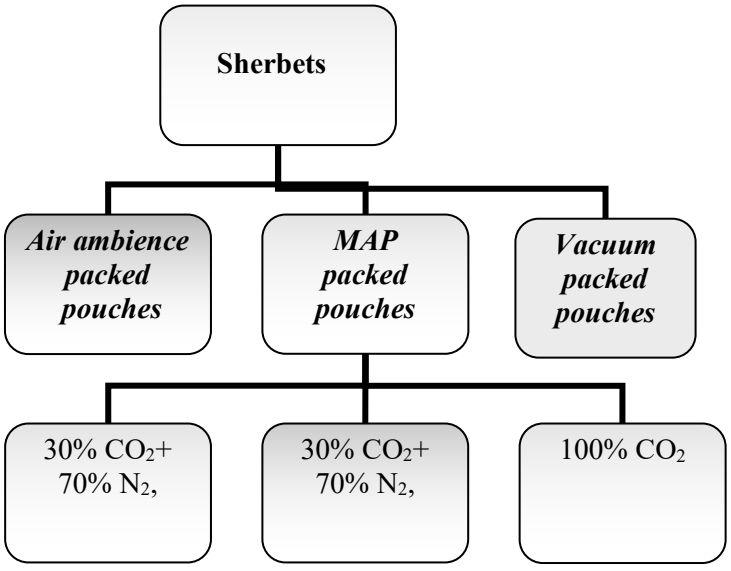

Fig.1. Structure of performed experiments

2.3 Physical analysis

The following chemical and physical characteristics were analyzed:

- The dynamics of gas composition in a hermetically sealed package headspace at the storage time was measured as a percentage of oxygen and carbon dioxide by a gas analyser OXYBABY® V O_2/CO_2.
- Moisture content and accordant at the storage time was determined by using verified balance KERN (Germany) with precision ±0.001g ; mass loss calculation (%) – were determined by weighing on the electronic scales;
- The colour of sherbet samples was measured in CIE L*a*b* colour system using Tristimulus Colorimeter measured Hunter colour parameter changes: by Colour Tec PCM/PSM. Samples for colour measurement were placed in PP bag. Colour values were recorded as L* (lightness, 0 = black, 100 = white), a* (-a, greenness, +a, redness) and b* (-b, blueness, +b, yellowness) are two chromatic components which range from -120 to +120 (Papadakis et al., 2000). The measurements were repeated on five randomly selected locations on each sample. Total colour difference (ΔE^*) of sherbets between initial value and after storage was calculated using the following equation 1:

$$\Delta E^* = \left[\left(L^* - L^*_{day0}\right)^2 + \left(a^* - a^*_{day0}\right)^2 + \left(b^* - b^*_{dayo}\right)^2\right]^{1/2} \quad (1)$$

Where ΔE^* – total colour difference; L*, a* and b* are the lightness (L), greenness and (a) and blueness (b) values for the stored sherbet samples; and L_{day0}, a_{day0} and b_{day0} are the corresponding color values for sherbet samples at the beginning of experiment. The difference $L^* - L^*_{day0}$ is difference of lightness, $a^* - a^*_{day0}$ – difference of green and red colour and $b^* - b^*_{day0}$ – difference of blue and yellow colour.

2.4. Statistical analysis

The results were processed by mathematical and statistical methods. Statistics on completely randomized design were determined using the General Linear Model (GLM) procedure SPSS, version 16.00. Two-way analyses of variance ($p \leq 0.05$) were used to determine significance of differences between means of oxygen, carbon dioxide, colour and mass loses. Compare Means, One Way Anova ($p \leq 0.05$) were used to determine significance of differences between means of the total colour difference.

3. RESULTS AND DISCUSSION

The aim of this work was to assess the influence of vacuum and MAP gas composition on the colour changes of ***sherbet*** with crunchy ***peanut*** chips samples during the storage time affected by moisture losses in different polymer packaging and compare with conventional storage conditions when samples were hermetically packet in air ambiance.

The changes of carbon dioxide (CO_2) content in the headspace of package after storage within 12 weeks are presented in the Table 2.

There was not found significant difference in carbon dioxide content values among all sherbet samples packed in different kinds of materials in air ambiance and stored within 12 weeks ($p>0.05$). Experimental data showed a significant figure of decrease in CO_2 content just about in all packages An interesting phenomenon has been observed analysing experimental data of gas composition changes in the head space of all packages made from different polymers with essentially different initial CO_2 composition only present Multibarrier 60 film excepted indicating essentially different results ($p<0.05$).

Table 2. Carbon dioxide (CO_2) content in the headspace of each package after 12 weeks storage, %.

Smple Nr.	Materials	Air ambiance (1.5% CO_2)	Composition of MAP		
			30%CO_2 +70%N_2	70% CO_2 + 30%N_2	100% CO_2
1.	OPP	1.61±0.01	1.52±0.01	1.32±0.01	1.95±0.01
2.	MULTIBARRIER 60	1.65±0.02	19.90±0.03	56.35±0.02	93.85±0.03
3.	BIALON 50	1.55±0.01	3.25±0.01	4.65±0.01	1.83±0.01
4.	BIALON 65	1.70±0.02	3.05±0.01	3.45±0.02	3.60±0.02
5.	ECOLEAN	1.62±0.01	1.35±0.01	1.45±0.01	2.35±0.01
6.	BIO NVS	1.50±0.01	1.30±0.01	1.60±0.01	1.70±0.01
7.	PP	1.75±0.02	1.30±0.01	1.35±0.01	1.45±0.01

The changes of Oxygen (O_2) content in the headspace of package after storage 12 weeks are presented in the Table 3.

Significant differences in changes of oxygen content values during 12 storage weeks among all sherbet samples packed in air ambiance and different materials were not found ($p>0.05$), it was similar to air composition. Only insignificant rise in O_2 content in head space of pouches made of Multibarrier 60 film was observed when modified atmosphere with different initial CO_2 concentration applied – the rise in O_2 content was from 1.65% till 2.55%, explained as a result of excellent barrier properties. On the contrary in pouches made from all other in experiments used packaging films the O_2 content slightly increased even to 20.75% similar that in surrounding ambiance. At the same time the carbon dioxide (CO_2) content in all MA packages dramatically deceased till 1.35% to 4.65% (Table 2). This phenomenon can be explained by carbon dioxide absorbcion on the sherbet surface.

Table 3. Oxygen (O_2) content in the headspace of each package after 12 weeks storage, %.

Smple Nr.	Materials	Air ambiance (20.70% O_2)	Composition of MAP		
			30%CO_2 +70%N_2 (0% O_2)	70% CO_2 + 30%N_2 (0% O_2)	100% CO_2 (0% O_2)
1.	OPP	20.15±0.02	20.75±0.02	20.60±0.01	20.15±0.02
2.	MULTIBARRIER 60	19.45±0.02	2.05±0.01	1.65±0.01	2.55±0.01
3.	BIALON 50	19.00±0.01	15.50±0.02	16.95±0.02	20.25±0.01
4.	BIALON 65	19.76±0.02	13.20±0.01	17.55±0.02	19.90±0.02
5.	ECOLEAN	20.10±0.01	20.55±0.02	16.95±0.02	20.12±0.01
6.	BIO NVS	19.70±0.03	20.50±0.02	20.45±0.01	20.25±0.02
7.	PP	19.75±0.01	20.40±0.01	20.50±0.03	20.50±0.02

During the 12 weeks of storage, product moisture content decreased slightly and differs influenced by different packaging materials. Also it can be noticed that this change of moisture content was very small, which means that the used packaging materials protected the sherbet from water transmission through the packaging films to ambiance. Changes in moisture content of the savoury sherbet based on nuts addition depend on initial moisture content of the product and storage conditions and used packaging materials. It is clear that the transparent biodegradable NVS film due to its high water vapour permeability did not give satisfactory results in keeping the product in a longer period of storage, after several days the product became very hard and unusable for eating. Mass losses at the storage time mean evaporated water and are interlinked with the moisture changes; they have been presented in the Figure 2. Experimentally it was established that mass losses of the product within 12 storage weeks packed in Ecolean, Bio NVS and BIALON 65 films in all investigated conditions differ ($p<0.05$) from those packed in four other polymer materials – they was in the highest level and sometimes run into 4.0 to 4.5%. On the contrary mass losses from sherbet packed in OPP and PP films within 12 storage weeks were considerably insignificant – 1.74 to 1.94%. To follow these results, PP and OPP films could be adequate for sherbet packaging providing moisture and acceptable quality after 12 weeks storage in room temperature.

Colour is an important attribute because it is usually the first property the consumer observes. The Hunter (L, a, b) values were measured in order to describe the colour changes of fresh and stored sherbet. The initial Hunter L, a, b values of sherbet samples were determined to be 68.5, 2.75 and 16.1, respectively. The total color difference (Δ E*) has been calculated using equation (1). The influence of packaging material on the total colour difference Δ E^* of ***sherbet*** with crunchy ***peanut*** chips is shown on the Fig. 3. As can be seen from the figure, during storage a complete colour change ΔE^* occurs because of influence of light on the product packed in packaging films with different gas permeability.

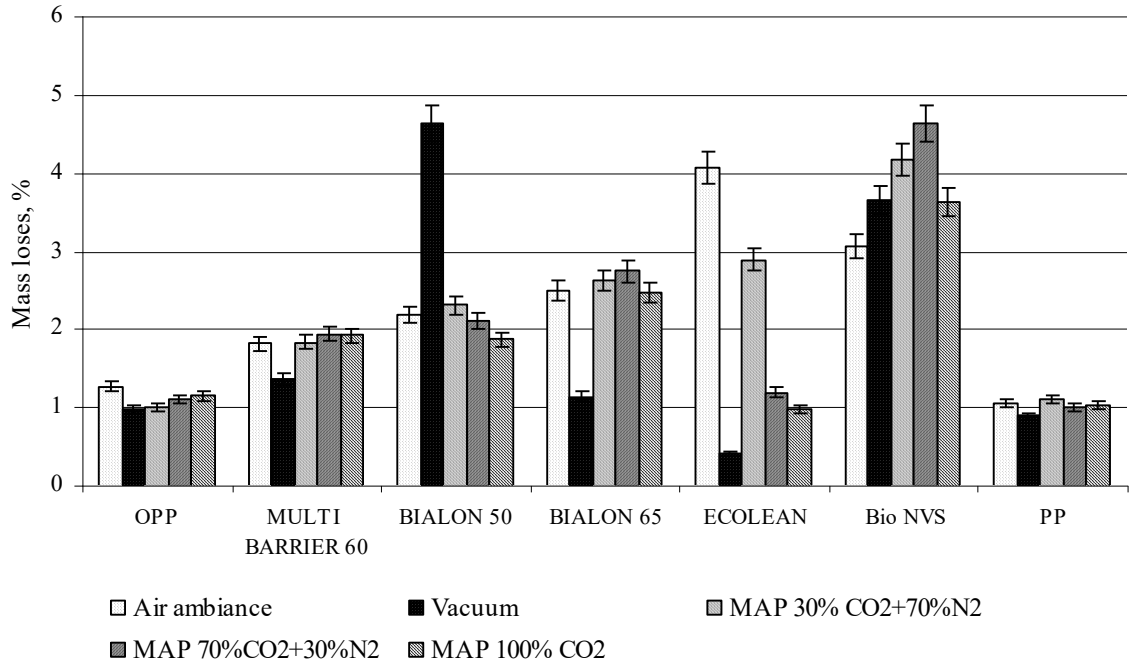

Fig.2. Influence of packaging materials on the mass loses of sherbet samples after 12 weeks storage in different gas compositions, %.

Non-enzymatic browning (NEB) might have influence the variations in the colour (L, a, b). As it has been observed, several factors like temperature, moisture, carbonyl compounds, fatty acids, O_2 presence and sugars have been reported to be a responsible for causing non-enzymatic browning in stored foods (Muralikrishna et al, 1969). Non-enzymatic, or oxidative, browning is a chemical process that produces a brown color in foods without the activity of enzymes. One of two main forms of non-enzymatic browning is caramelize of sugars, what is a function of water activity. Studies improve the NEB increase in the stored dry papaya-cereal flakes influenced by elevated storage temperature (Rai and Chauhan, 2008). During storage, there was observed an insignificant increase in lightness of sherbet samples stored in various packaging materials using several gas compositions, probably caused by sugar crystallization as a result of moisture loss within 12 weeks storage period. Satisfactory retention of sherbet colour was observed for samples packed in most of investigated packaging materials – PP, MULTIBARRIER 60, OPP, milk white BIALON 50 and ECOLEAN – the calculated total colour differences in all investigated packaging gas compositions (including air and besides vacuum packaging) Δ E* has been found notable ($p>0.05$). Exclusion is vacuum packaging showing the highest Δ E* in MULTIBARRIER 60, transparent BIALON 65, ECOLEAN and PP film packed sherbet samples, making possible to conclude that vacuum packaging is not useful for sherbet long term storage. Similarly, transparent BIALON 65 using high CO_2 concentration in gas mixture as well as transparent biodegradable NVS films in all investigated packaging gas compositions due to highest impact on the total colour Δ E* change of sherbet could not be recommendable for its packaging.

In the experiments the effect of various gas compositions on the colour stability was examined, and the influence of gas composition on the total colour difference Δ E^* of sherbet samples after 12 weeks storage in different packaging materials has been represented on the Fig. 4. The results demonstrate the preferential use of all examined packaging materials excepting BIO NVA and transparent BIALON 65 for air packaging and MAP with gas composition of 30% CO_2 + 70% N_2 ($p>0.05$). The amount of CO_2 in used gas composition gradually generate the increase in Δ E^*.

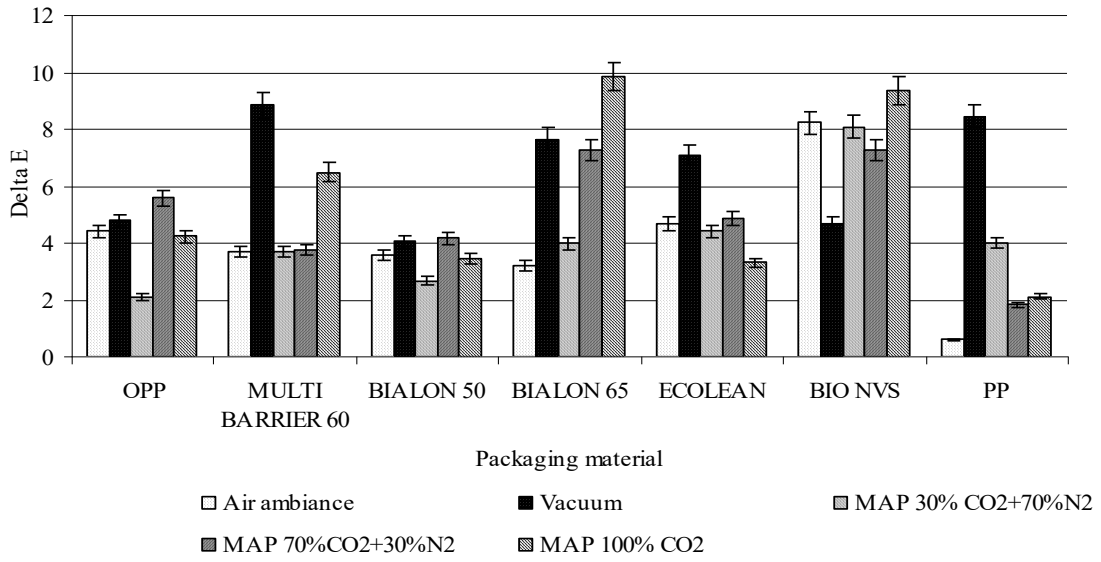

Fig.3. The influence of packaging material on the total colour difference Δ E^* of sherbet samples after 12 weeks storage in different gas compositions, %.

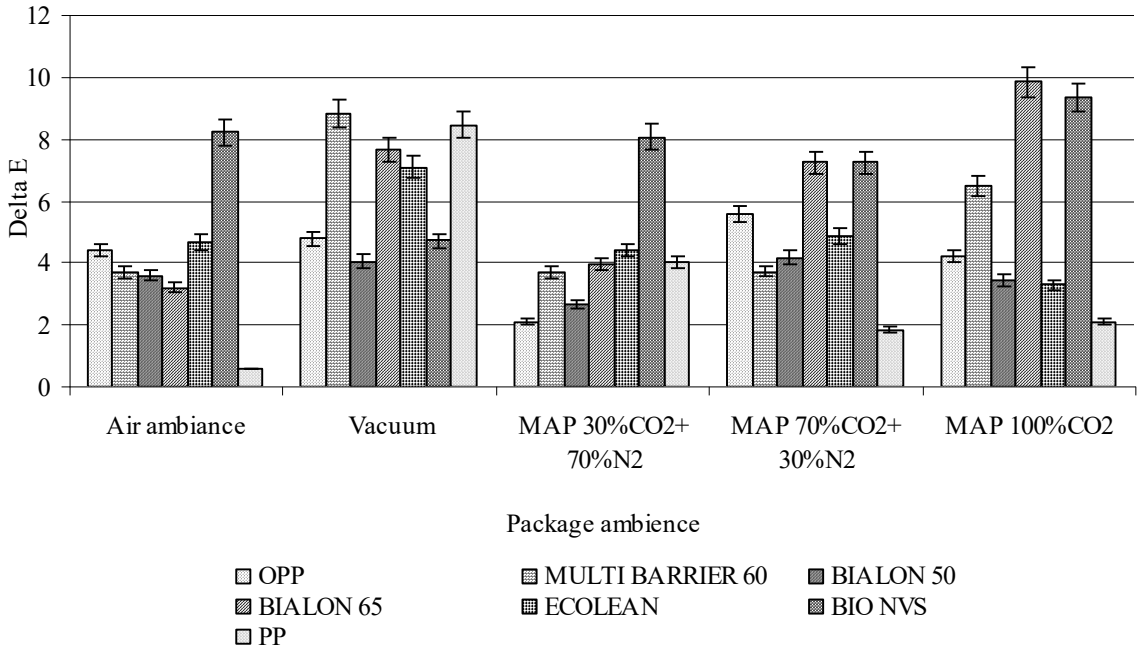

Fig.4. Influence of gas composition on the total colour difference Δ E^* of sherbet samples after 12 weeks storage in different packaging materials, %.

4. CONCLUSIONS

The used packaging material does not fully protect the product from the colour changes. The results demonstrate satisfactory use for sherbet packaging of all examined packaging materials excepting BIO NVA. Among them the smallest impact on total Δ E* change showed OPP, PP and environmentally friendly ECOLEAN films. Evaluating all investigated materials and gas compositions, packaging in air and MAP with gas composition of 30% CO_2 + 70% N_2 could be suggested. Vacuum packaging due to high impact on total Δ E* change is not useful for sherbet long term storage.

As a conclusion the obtained results can be summarized that all investigated packaging materials without BIO NVS are applicable for sherbet packaging, among them OPP and PP and ECOLEAN with can be characterized as particularly environmentally friendly material considered as the best.

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