

Shelf Life Extension of Milk Pomade Sweet – Sherbet with Crunchy Peanut Chips by MAP in Various Packaging Materials

Eva Vormā, Sandra Muizniece-Brasava, Lija Dukalska, Janis Skalbe

Abstract—The objective of the research was to evaluate the hardness stability of milk pomade sweets packed in several packaging materials (OPP, Multibarrier 60 HFP, BIALON 65 HFP, BIALON 50 HFP, ECOLEAN) by several packaging technologies – modified atmosphere (MAP) (consisting of 30% CO₂+70% N₂; 30% N₂+70% CO₂ and 100% CO₂) and control – in air ambience. Samples were stored at the room temperature +21±1 °C. The studies of the samples were carried out before packaging and after 2, 4, 6, 8, and 10 storage weeks.

Keywords—packaging, shelf life, sherbet with crunchy peanut chips, hardness.

I. 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 [1]. 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 absorption of water from the atmosphere following prolonged exposure to ambient conditions, making the sweets soft and soggy [2], 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.

V. Vormā is with the Faculty of Food Technology, Latvia University of Agriculture, Jelgava, Latvia, LV-3001 (e-mail: vorma@inbox.lv).

S. Muizniece-Brasava is with the Faculty of Food Technology, Latvia University of Agriculture, Jelgava, Latvia, LV-3001 (e-mail: sandra.muizniece@llu.lv).

L. Dukalska is with the Faculty of Food Technology, Latvia University of Agriculture, Jelgava, Latvia, LV-3001 (e-mail: lija.dukalska@llu.lv).

J. Skalbe is with the joint stock company Laima, Riga, Latvia, LV-1145 (e-mail: Janis.Skalbe@Laima.lv).

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 [3]. Laima faces severe competition on the Latvian market – it has to compete with world-famous companies such as Nestle, Fazer, Chupa Chups, and Cadbury'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 behaviour 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 planned to carry out.

Packaging is a medium between product manufacturers and consumers [4], packaging has a significant role in the food supply chain [5]. The main functions of packaging are to extend the shelf life, and maintain the quality and safety of the packed goods [6]. An effective package must prevent the transmission of oxygen, light and water vapour, and microbial growth to retard quality deterioration of packaged goods [7]. 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 Roberto Sablo from Multisorb Technologies [8]. (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 [9; 10].

The main recourse used for food packaging, including sweets, is Plastic materials [11]. 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 [12]. Polyolefin's (PE, PS), polyesters (PS), polyethylene terephthalate (PET) and polycarbonates (PC) are the principal families of thermoplastics in food packaging [13]. 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 [14; 15; 16]. However, these technologies do not always remove oxygen completely. Moreover the O₂ that penetrates through the packaging film cannot be removed by these technologies.

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.

II. MATERIALS AND METHODS

A. Experimental design

Experiments were carried out at the Department of Food Technology, Latvia University of Agriculture in 2009. 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 ± 1 g.

B. Packaging and storage of samples

The study involved preliminary preparation of different polymer pouches from OPP, Multibarrier 60 HFP, BIALON 65 HFP, BIALON 50 HFP and ECOLEAN films, packaging of sherbets in different modified atmosphere (MAP) content (30% CO₂+70% N₂; 30% N₂+70% CO₂ and 100% CO₂) and air ambience as control and storage in room temperature at +21 ± 1 °C (controlled by MINILog, Gresinger electronic) and about 40% RH for 10 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 water vapor transmutation rate and various thicknesses in order to asses whether hardening can be ascribed to water loss

from sherbet sample or from redistribution of the moisture inside the product or by combination of moisture loss and redistribution.

TABLE I
CHARACTERISTICS OF USED MATERIALS IN EXPERIMENTS

Sample Nr.	Packaging material	Composition	Thickness, μm
1.	OPP	Single layer, transparent	40±2
2.	Multibarrier 60 HFP	Laminate, APA/TIE/PA/EVOH/PA/TIE/PE/PE, transparent	60±2
3.	BIALON 50 HFP	Laminate, BOPA / PE, frosty white	50±3
4.	BIALON 65 HFP	Laminate, BOPA / PE, transparent	65±3
5.	ECOLEAN	Single layer, Ca / PE, frosty white	78±4
6.	PP	Single layer, transparent	40±2

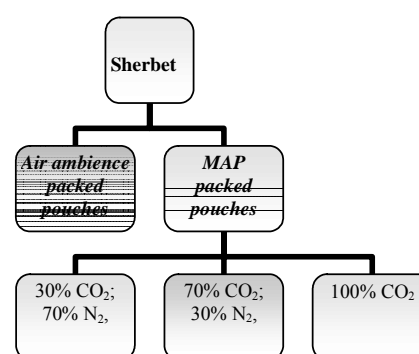


Fig. 1. Structure of performed experiments

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

C. Physical analysis

The following mechanical 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 O₂/CO₂.
- 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;
- Hardness for freshly manufactured sherbet samples were determined as cutting force (in N) by using TA-XTplus Texture Analyser. Cutting force was determined for six small sherbet samples from each it piece. For the sample cutting force determination a special probe with knife edge for a cut test HDP/BSKBLADE SET WITH KNIFE was applied. The maximum cutting force (in N) was detected at the deformation rate 10 mm/s and distance 10 mm. The samples were cut right

through, in order to check whether any different structural characteristics (peanut pieces) were present under the knife inside the product or on the surface. Samples for cutting were placed centrally under the knife edge. Plotting force (in N) versus storage time (in weeks), the hardness change of sherbet stored in each gas composition in the package as well as for each packaging material was calculated. The maximum cutting force (N) was used as an index for the cut test.

At each time of measurement, two identical packages for each treatment were randomly selected on sampling days (day 0) and after 2, 4, 6, 8, and 10 storage weeks; six measurement repetitions of each sample were performed.

E. 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 hardness, moisture and mass losses by different packaging materials.

III. RESULTS AND DISCUSSION

The aim of this work was to assess the effect of MAP composition during the storage time on the hardening of sherbet with crunchy peanut chips samples affected by moisture losses in different polymer packaging and compare with conventional storage conditions in air ambiance. A linear function ($R^2=0.6728$) in increase of CO_2 content inside hermetically sealed packages for all tested packaging materials with air ambiance (Fig. 2), and accordant decrease in O_2 content ($R^2=0.3506$) was observed, accordingly from 1.5%–2.1% on average for CO_2 and from 21.0–19.3 % for O_2 . Presumable it is connected with sucrose crystallisation reactions and respective hardening of sherbet.

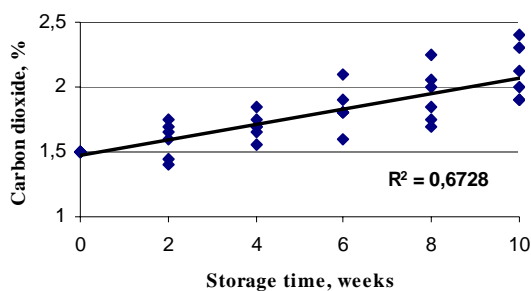


Fig. 2. The dynamics of carbon dioxide (CO_2) content in the headspace of package in air ambiance during storage

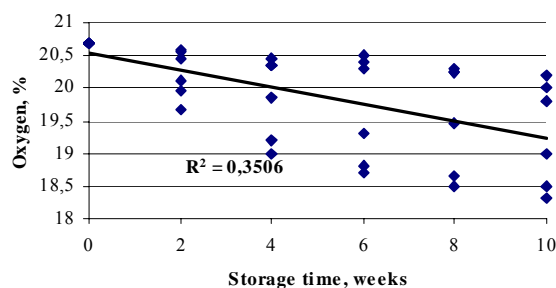


Fig. 3. The dynamics of oxygen (O_2) content in the headspace of package in air ambiance during storage

Maintaining certain gas composition in the package during MAP storage is extremely important and it depends on the barrier film properties. Therefore testing of CO_2 and O_2 percentage was periodically performed.

The monitoring of the change of CO_2 composition is shown in Fig.4., Fig.6. and Fig.8, changes of O_2 – in Fig.5., Fig. 7 and Fig.9.

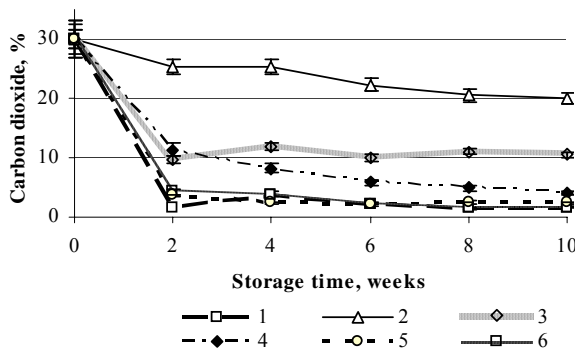


Fig. 4. The dynamics of carbon dioxide (CO_2) content in the headspace of package in MAP (30% CO_2 +70% N_2)

1 – OPP; 2 – Multibarrier 60 HFP; 3 – BIALON 50 HFP; 4 – BIALON 65 HFP; 5 – ECOLEAN; 6 – PP

An interesting phenomenon has been observed analysing experimental data of head space composition changes in modified atmosphere (MAP) with different initial CO_2 composition packages made of all films, with exception of Multibarrier 60 HFP film indicating essentially different results. In Multibarrier 60 HFP pouches, CO_2 content decreased on average for 33% (30% CO_2 +70% N_2) – to 16% (100% CO_2) accordingly to initial CO_2 content increase in head space of package from 30% to 100%. Whereas O_2 content in Multibarrier 60 HFP pouches increased only for 4%, and in pouches from all other materials it slightly increased up to 10% till 20%. Both in BIALON 50 HFP and BIALON 65 HFP pouches after 7-8 storage weeks the pouches collapsed and a perfect vacuum established (Fig.8 and Fig.9) and appearance of packages changed totally. This phenomenon can be explained by carbon dioxide absorption on the sherbet surface. As a result, the pressure decreased in the package and destroyed it.

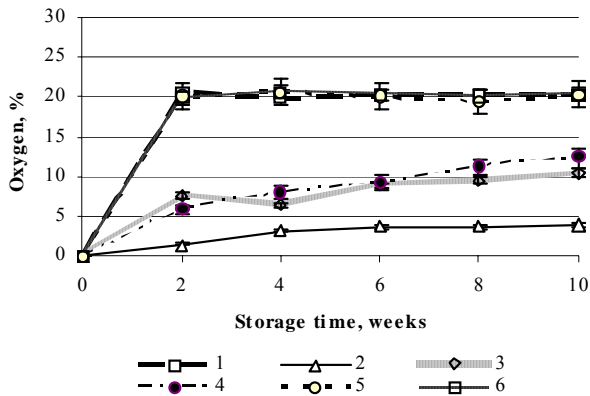


Fig. 5. The dynamics of oxygen (O₂) content in the headspace of package in MAP (30% CO₂+70% N₂)

1 – OPP; 2 – Multibarrier 60 HFP; 3 – BIALON 50 HFP; 4 – BIALON 65 HFP; 5 – ECOLEAN; 6 – PP

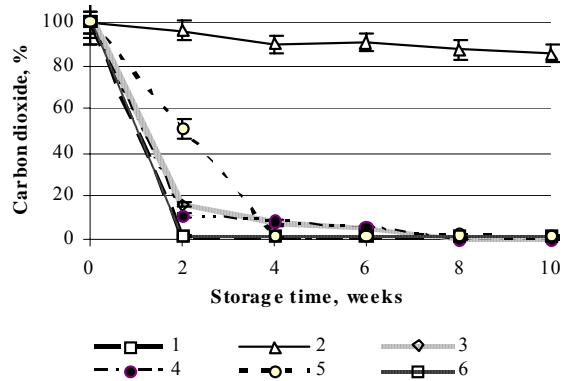


Fig. 8. The dynamics of carbon dioxide (CO₂) content in the headspace of package in MAP (100% CO₂)

1 – OPP; 2 – Multibarrier 60 HFP; 3 – BIALON 50 HFP; 4 – BIALON 65 HFP; 5 – ECOLEAN; 6 – PP

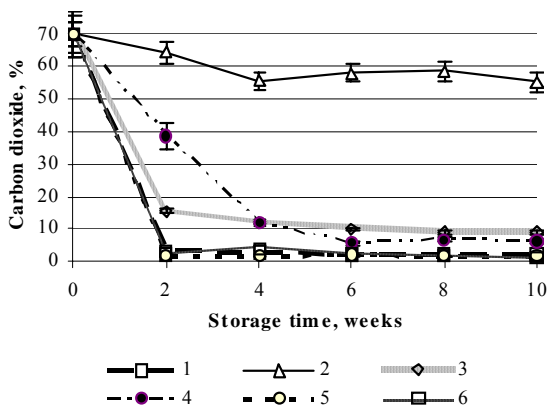


Fig. 6. The dynamics of carbon dioxide (CO₂) content in the headspace of package in MAP (70% CO₂+30% N₂)

1 – OPP; 2 – Multibarrier 60 HFP; 3 – BIALON 50 HFP; 4 – BIALON 65 HFP; 5 – ECOLEAN; 6 – PP

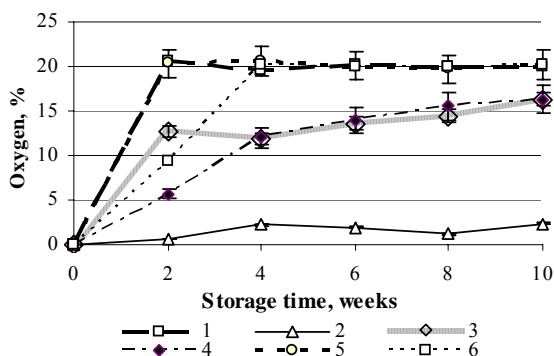


Fig. 7. The dynamics of oxygen (O₂) content in the headspace of package in MAP (70% CO₂+30% N₂)

1 – OPP; 2 – Multibarrier 60 HFP; 3 – BIALON 50 HFP; 4 – BIALON 65 HFP; 5 – ECOLEAN; 6 – PP

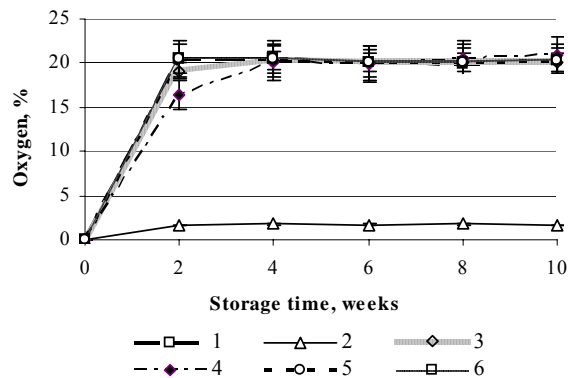


Fig. 9. The dynamics of oxygen (O₂) content in the headspace of package in MAP (100% CO₂)

1 – OPP; 2 – Multibarrier 60 HFP; 3 – BIALON 50 HFP; 4 – BIALON 65 HFP; 5 – ECOLEAN; 6 – PP

Initial moisture of samples was 3. 21±0.01 %. As can be seen (Table 2) the moisture content during 10 weeks storage decreased. The different moisture content decrease of samples is influenced by various water vapour permeation of packaging material (p<0.05). Significant differences in moisture content values during the 10 weeks storage among all sherbet samples packed in different kinds of materials and various MAP gas mixture content were not found (p>0.05). Mass losses at the storage time are presented in Table 3. Experimentally it was established that mass losses of the product packed in Ecolean and BIALON 65 HFP films in all investigated conditions differed (p<0.05) from those packed in four other kinds of materials – 3.05 to 3.24%. On the contrary mass losses from the sherbet packed in OPP and PP films within 10 storage weeks were considerably smaller – 1.74 to 1.94%. To follow these results, PP and OPP films could be adequate for sherbet packaging.

TABLE II

MOISTURE OF SAMPLES AFTER STORAGE 10 WEEKS, % *					
Sam-ple Nr.	Materials	Air ambience	MAP		
			30% CO ₂ +70%N ₂	70% CO ₂ +30% N ₂	100% CO ₂
1.	OPP	2.58±0.02	2.76±0.01	2.45±0.01	2.36±0.01
2.	Multibarrier 60 HFP	2.51±0.01	2.54±0.01	2.63±0.01	3.00±0.02
3.	BIALON 50 HFP	2.01±0.01	2.37±0.02	2.55±0.02	2.71±0.01
4.	BIALON 65 HFP	2.45±0.01	2.41±0.01	2.34±0.02	2.60±0.01
5.	ECOLEAN	2.91±0.02	2.92±0.02	2.51±0.01	2.68±0.02
6.	PP	2.50±0.02	2.73±0.02	2.60±0.01	2.16±0.02

* Initial moisture of samples was 3. 21±0.01 %

TABLE III

MASS LOSSES OF SAMPLES AFTER 10 WEEKS STORAGE, %					
Sam-ple Nr.	Materials	Air ambience	MAP		
			30%CO ₂ +70%N ₂	70% CO ₂ + 30%N ₂	100% CO ₂
1.	OPP	1.94±0.01	1.83±0.01	1.83±0.01	1.86±0.01
2.	Multibarrier 60 HFP	2.36±0.01	2.35±0.02	2.47±0.01	2.47±0.02
3.	BIALON 50 HFP	2.71±0.02	2.97±0.01	2.63±0.02	2.43±0.02
4.	BIALON 65 HFP	3.05±0.01	3.16±0.02	3.26±0.01	3.02±0.02
5.	ECOLEAN	3.25±0.03	2.96±0.01	2.85±0.01	3.49±0.02
6.	PP	1.75±0.01	1.78±0.01	1.74±0.02	1.74±0.01

Hardness changes in sherbet samples stored in various packaging materials and applying different composition of MAP are presented in Figs 10–13. Sherbet texture becomes harder irrespective of used packaging technology or material type. The major reason can be water vapour migration through the packaging material and subsequent sucrose crystallisation, which promotes hardening. The initial cutting force of all samples determined at the beginning of the experiment was 56.2±5.0 N. Mouth feel, texture and eating qualities are adversely affected by the loss of moisture [8]. For our tested sherbet samples, mouth feel of all samples in the investigated storage time was acceptable. At the same time it was observed that the best films for air packaging were transparent Multibarrier 60 HFP, ECOLEAN as well as OPP – after 10 storage weeks they showed increase in the cutting force till 240±5.0 to 300±5.0 N. On the contrary analysing the results of MAP packed samples the data were as follows: in 30%CO₂ +70%N₂ – the best films were recognized PP, OPP and ECOLEAN showing increase in cutting force from 190±5.0 to 285±5.0 N, in 70%CO₂ + 30%N₂ maximal cutting force substantially differed (p<0.05) of transparent BIALON 65 HFP (395±5.0N), all other samples does not have essential difference (258±5.0 to 300±5.0 N), and in 100% CO₂ – as the best materials have been accepted OPP, BIALON 50 HFP – frosty white laminate, BOPA / PE and ECOLEAN (250±5.0 to 300±5.0 N).

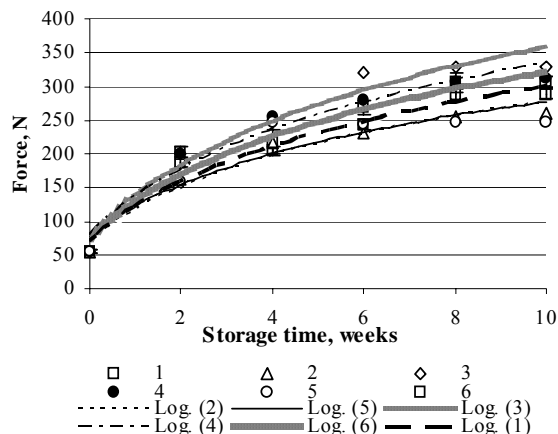


Fig. 10. The dynamics of texture changes of milk pomade sweets during storage in air ambience

1 – OPP; 2 – Multibarrier 60 HFP; 3 – BIALON 50 HFP; 4 – BIALON 65 HFP; 5 – ECOLEAN; 6 – PP

The cutting force curves were mathematically processed by log function with high determination coefficient R² values, shown in the Table 4.

TABLE IV

DETERMINATION COEFFICIENTS, R ²					
Sam-ple Nr.	Materials	Air ambience	MAP		
			30%CO ₂ +70%N ₂	70% CO ₂ + 30%N ₂	100% CO ₂
1.	OPP	0.9655	0.8918	0.9121	0.9294
2.	Multibarrier 60 HFP	0.9677	0.9662	0.9619	0.8855
3.	BIALON 50 HFP	0.9648	0.9779	0.9725	0.9899
4.	BIALON 65 HFP	0.9561	0.9565	0.9706	0.9830
5.	ECOLEAN	0.8768	0.9238	0.8252	0.8690
6.	PP	0.9575	0.8704	0.9919	0.9721

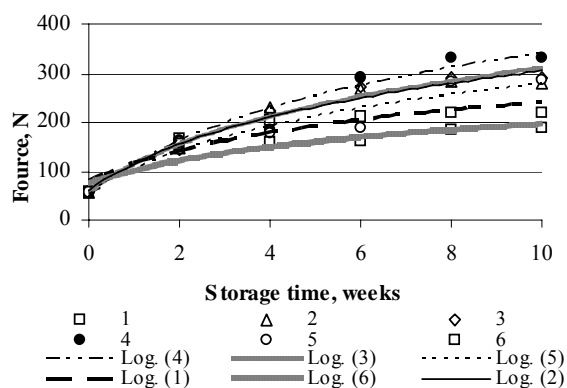


Fig. 11. The dynamics of texture changes of milk pomade sweets during storage in MAP 30% CO₂+70% N₂

1 – OPP; 2 – Multibarrier 60 HFP; 3 – BIALON 50 HFP; 4 – BIALON 65 HFP; 5 – ECOLEAN; 6 – PP

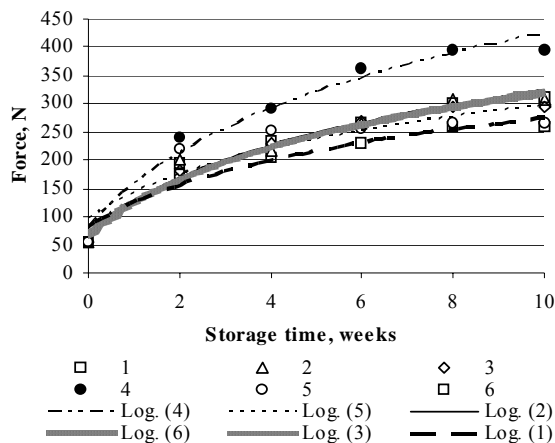


Fig. 12. The dynamics of texture changes of milk pomade sweets during storage in MAP 70% CO₂+30% N₂

1 – OPP; 2 – Multibarrier 60 HFP; 3 – BIALON 50 HFP; 4 – BIALON 65 HFP; 5 – ECOLEAN; 6 – PP

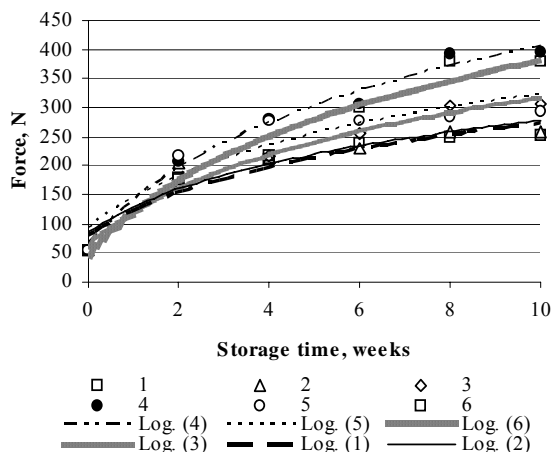


Fig. 13. The dynamics of texture changes of milk pomade sweets during storage in MAP 100% CO₂

1 – OPP; 2 – Multibarrier 60 HFP; 3 – BIALON 50 HFP; 4 – BIALON 65 HFP; 5 – ECOLEAN; 6 – PP

IV CONCLUSIONS

As a conclusion the obtained results can be summarized that all investigated packaging materials are applicable for sherbet packaging, among them OPP with might water vapour barrier properties and ECOLEAN with can be characterized as particularly environmentally friendly material considered as the best.

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Eva Vormā, was born in Riga in 1984. She received her M.S. degree in Food Technology from Latvia University of Agriculture in 2009. She is presently first course student of Ph.D program of Food science in Latvia University of Agriculture. Thesis of PhD studies is “Sugar confectionery shelf-life extension using active packaging”. Scientific direction is to find a suitable packaging type for sugar confectionery packaging using the conventional materials and technologies.

Sandra Muizniece-Brasava, Dr.sc.ing., assistant of professor was born in Latvia, Gulbene at 1977. She has defended her Dr. degree in Food Science in Latvia University of Agriculture at 2006. Thesis of PhD degree was “Poly-b-hydroxybuturate composite materials as environmentally friendly food packaging”. Scientific direction is estimation of the novel and environment friendly food product packaging materials and packaging technologies. She has 24 scientific publications.

Lija Dukalska, Dr, habilit, sc, ing, professor was born in Riga district at 1934. She has received her Dr. degree in Food science and technology at 1972, Dr habilit. Sc. Ing at 1997 and elected in professor's post in Latvia University of Agriculture at 1998. Scientific direction is studies of the novel and environmentally friendly biodegradable food packaging materials and packaging technologies. She has about 140 published scientific articles, and 3 published books, EC expert in Brussels, reg. N°EE19981A03785. Participated in EU financed International projects EcoPac, QLRT-2001-01823 and PackTeck, N G1RTC-CT-2002-05068.

Janis Skalbe, production director of joint stock company Laima, was born in Riga in 1967. He received his M.S. degree in Food Technology from Latvia University of Agriculture in 2007.