Influence of PLA Film Packaging on the Shelf Life of Soft Cheese *Kleo*

Lija Dukalska, Sandra Muizniece-Brasava, Irisa Murniece, Ilona Dabina-Bicka, Emils Kozlinskis, Svetlana Sarvi

Abstract—Experiments were carried out at the Faculty of Food Technology of Latvia University of Agriculture (LLU). Soft cheese *Kleo* produced in Latvia was packed in a biodegradable PLA without barrierproperties and VC999 BioPack lidding film PLA, coated with a barrier of pure silicon oxide (SiOx) and in combination with modified atmosphere (MAP) the influence on the shelf life was investigated and compared with some conventional (OPP, PE/PA, PE/OPA and Multibarrier 60) polymer film impact. Modified atmosphere consisted of carbon dioxide CO_2 (E 290) 30% and nitrogen N_2 (E 941) 70%. The analyzable samples were stored at the temperature of +4.0±0.5 °C up to 32 days' and analyzed before packaging and in the 0, 5th, 11th, 15th, 18th, 22nd, 25th, 29th and 32nd day of storage. The shelf life was extended along to 32 days, good outside appearance and lactic acid aroma was observed.

Keywords—Soft cheese, modified atmosphere, conventional and biodegradable PLA film, shelf life

I. Introduction

SOFT fresh cheeses are those cheeses that are unripe. White cheese is usually made from row milk without of starter culture [1], souring the milk, either with lemon juice or vinegar. Creamy curds were formed then strained to produce a simple cheese. These cheeses have high moisture content, are usually mild and have a very soft texture. These cheeses are typically the most perishable. Cheeses in the fresh category include Italian Style Mascarpone, and Ricotta, Chevre, Feta, Cream cheese, Quark and Cottage cheese.

Optimal packaging solutions could prevent or minimize quality changes, resulting in increased shelf life as well as quality maintenance. Different types of cheeses have to be packed in different packaging concepts [2]. Most fresh cheeses are packed in air atmosphere due to the short shelf life required. Some experiments proved that chemical composition and sensory characteristics, colour and body of white cheese made from pasteurized cow milk during the storage period of 45 days in vacuum packaging did not significantly change [3]. It was found out that packaging and cold storage of Sudanese white cheese in metal containers is better than in plastic containers as low total bacterial, coli forms, *E.coli* and yeast counts were obtained in cheese packed in metal containers [4].

An established fact is that primary spoilage organisms in cheeses are moulds and MAP could be used to prevent mould growth. Gases with low residual oxygen and high CO_2 levels may be used to ensure microbial stability. (Mortensen, Bertelsen et al., 2005). Sometimes cream cheeses are pasteurized prior to packaging [5].

Texture as well is an important characteristic used to differentiate many cheese varieties [6; 7] and is considered by the consumer as a determinant of overall quality and preference [8], therefore its evaluation is an important step in product development and quality control [9].

For shelf life extension of processing products different packaging materials and technologies can be used. In order to optimize product and packaging compatibility, materials with improved barrier properties should be used. Packaging is an integral and determinant part of the industrial and commercial food supply chain [10]. The potential use of Modified atmosphere packaging (MAP) for extending the shelf life of dairy products, including cheese, has been demonstrated [11]. Limited work has been conducted to date on the use of different gas composition MAP for shelf life extension of soft, creamed-style, and whey cheeses [12]–[14].

Biodegradable polymer market introduction has started successfully all over Europe [15], [2], [10]. Most important application sectors of biodegradable polymers at the present time are mainly for organically produced food packaging, conventional fruit and vegetables as well as bread and bakery products, ready-to-eat foods, service packaging, shopping bags, catering products, bio waste bags, mulch films, horticulture auxiliaries. Nets, trays and flow pack – from PLA, cellulose and starch materials – are being used as well. Not only the range of biodegradable products has widened but the number of those manufacturers, distributors and users has also increased. At present PLA is the most widely used biodegradable polymer for fresh-food applications.

PLA (polylactide) without barrier properties has been approved as a good packaging material for foods having relatively short shelf life. Little information was found on the use of PLA material for food packaging: for fruit juice packaging [16], [17], yogurt pre-packaging [18], salad dressings [19], and sour cream [16], as well as for semi hard cheese packaging [20], [21]. In all occasions the chemical indices of foods as well as fat oxidation was better protected in conventional packaging materials. Nowadays new

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biodegradable materials have been produced with improved barrier properties, for instance VC999 BioPack lidding film PLA, coated with a barrier of pure silicon oxide (SiOx) [22].

The oxygen (O_2) penetrability of PLA materials overall is higher as of conventional polymers usually used for cheese packaging (laminated PET and PE). Nevertheless the barrier properties of PLA films have been appointed at temperature 23 ºC and RH 0%, what are radically different conditions from those usually used for cheese storage. Therefore the influence of PLA materials without as well as with barrier properties on the cheese quality during the storage time should be experimentally verified and specified.

In Latvia University of Agriculture faculty of Food Technology the tasks were carried out to check the published data that biodegradable PLA packaging films offer 10 to 15% longer shelf life of fruits and vegetables. Some in Latvia cultivated fruits were tested [23].

The objective of this work was to evaluate the application of traditional PLA film without barrier properties and VC999 BioPack lidding film PLA, coated with a barrier of pure silicon oxide (SiOx) for soft cheese *Kleo* produced in Latvia packaging in modified atmosphere (MAP) consisting of carbon dioxide CO_2 (E 290) 30% and nitrogen N_2 (E 941) 70% and compare with some conventional (OPP, PE/PA, PE/OPA and Multibarrier 60) polymer film impact to the cheese quality in MAP packaging, as control selecting at present existing commercial vacuum packaging (VP) of the cheese in PA/PE film.

II. Materials and Methods

A *Experimental Design*

Experiments were carried out at the Department of Food Technology, Latvia University of Agriculture in 2011. The object of the research: cheese *Kleo* – a regional white soft fresh cheese manufactured in local cheese making factory from pasteurized (78–82 °C) and normalized cow milk – for experiments was bought on the local supermarket in Latvia. The albumen from the milk had been set down by addition of acid cheese whey, after than filled in self compressing vats for moulding for 16 to 18 hours. The pressed unripe cheese peaces have a cylindrical shape with rounded off side edges, before packaging they are rubbed with salt (NaCl), salt content – from 0.3% to 0.8%. The consistency of cheese is mild, and has a homogenous slightly grainy texture, with irregular breaks, the surface slightly wet, the colour from white to slightly yellowish. The moisture content of cheese should not be more than 64%, fat content – 35±2%.

B *Packaging and Storage of Samples*

Cheese *Kleo* currently is sold on the market place in a polymer PA/PE pouch vacuum packaging (VP) weight of 0.3 to 0.8 kg in each and its shelf-life is not more than 15 days at a temperature of 0 to +6 °C. Six different polymer films were used for experiments: PA/PE, PE/OPA, Multibarrier 60 and OPP with different water vapor permeability and various thicknesses, as well as biodegradable polymers PLA or polylactide without barrier properties, obtained from Company MaaG and VC999 BioPack lidding film PLA, coated with a barrier of pure silicon oxide (SiOx). The characteristic of materials used in experiments is shown in the Table 1 and structure of performed experiments – in Fig.1.

TABLE I
CHARACTERISTICS OF USED MATERIALS IN EXPERIMENTS

Sample Nr.	Packaging material	Composition	Thickness, μ m
1.	Pouches for vacuum packaging	PA/PE	20/45±2
2.	PE/OPA	PE/OPA	100±2
3	Multibarrier 60 HFP	APA/TIE/PA/EVOH/ PA/TIE?PE/PE	60±2
4.	OPP	With high barrier properties	40±2
5	VC999 BioPack lidding film	PLA coated with SiOx	50±2
6	Polylactid	PLA, without barrier properties	30±2

The manufactured cheese *Kleo* cylindrical peaces were cut into four parts each, packed by 100±10 g in beforehand from roll stocks made polymer pouches size 110 x 120 mm.

Packaging in Vacuum. Cheese samples were packaged in laminated conventional polyamide/polyethylene (PA/PE) pouches (size of 200 mm x 300 mm), and in vacuum conditions hermetically sealed by chamber type machine *MULTIVAC C300*. Vacuum packaging (VP) was selected as a control.

Modified Atmosphere Packaging (MAP). For shelf life extension the use of MAP conditions in the pouches were investigated. Modified atmosphere – mixture of carbon dioxide CO_2 (E 290) and nitrogen N_2 (E 941) – was used for the cheese packaging, gases were delivered from „AGA" Ltd. Modified atmosphere mixture consisting of carbon dioxide CO_2 30% and nitrogen N_2 70% was prepared in laboratory conditions using gas mixer WITT GASETECHNIK KM 100-2 MEM**.** The samples were hermetically sealed by MULTIVAC C300 vacuum chamber machine.

Storage and Analyzes of Samples. Samples were stored in a Commercial Freezer/Cooler „Elcold" at the temperature of +4.0±0.5 °C, controlled by MINILog Gresinger electronic. At the storage time within 32 days under fluorescent light *OSRAM Lumilux De Luxe* with radiant fix at 100–800 lx. Through the storage time, the samples were randomly interchanged to minimize temperature fluctuations and light conditions. Physical and chemical properties: headspace gas composition, pH, moisture content, water activity, colour of cheese samples and hardness were evaluated. Content of micro organisms – moulds, yeasts, lactic acid, and *Escherichia coli* bacteria was pointed. At each time of measurement, two identical packages for each packaging material were randomly selected on sampling days (day 0) and after 5^{th}, 11^{th}, 15^{th}, 18^{th}, 22^{nd}, 25^{th}, 29^{th} and 32^{nd} day of storage; six measurement repetitions of each sample were performed.

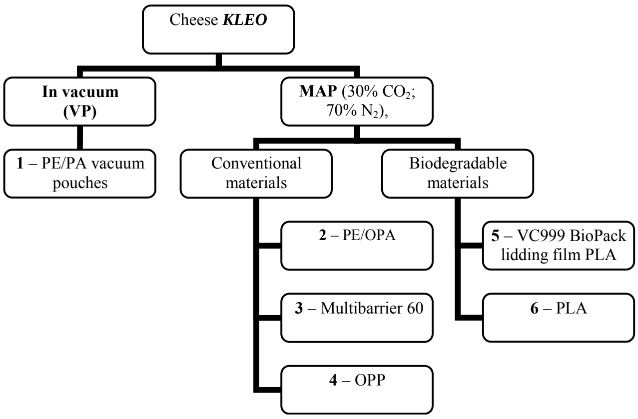

Fig. 1 The Structure of Performed Experiments in Biodegradable PLA and Conventional Packaging

C. Physical and Chemical Analysis

Headspace gas composition – expressed as % oxygen (O_2) and % carbon dioxide (CO_2) was measured using a gas analyser OXYBABY® V O_2/CO_2. **Moisture content** was determined by ISO 6496:1999**. Mass loss** – determined by standard LVS ISO 1442: 1997. **Water activity** – determined by standard ISO 21807:2004, AquaLab LITE device. **pH** – determined by JENWAY 3510 pH-meter, standard method LVS ISO 5542:2010. **Texture analyses** were determined on the Texture Analyzer, TA-XT2i Texture Analyzer; Stable Micro Systems, NY. A spherical probe (P/1S – Ball Stainless) was used measuring the hardness of cheese samples. Test speed, distance and trigger force were 2 mm s^{-1}, 5 mm and 0.0493 N. **Colour** of cheese samples was measured in CIE L*a*b* colour system using Tristimulus Colorimeter, measuring Hunter colour parameters by Colour Tec PCM/PSM. Colour values were recorded as L* (brightness) – the vertical co-ordinate runs from L* = 0 (black) through grey to L* = 100 (white); a* (-a, greenness, +a, redness) – the horizontal co-ordinate, that runs from -a* (green) through grey to +a* (red) and b* (-b, blueness, +b, yellowness) – another horizontal co-ordinate, that runs from -b* (blue) through grey to +b* (yellow) [24]. The measurements were repeated on different randomly selected locations at the surface of each sample. For evaluation of colour change, the total colour difference (TCD), ΔE*, was calculated between measurements before packaging of cheese samples and during the storage time according to equation (1):

$$\Delta E* = \sqrt{\left(L*-L_0^*\right)^2 + \left(a*-a_0^*\right)^2 + \left(b*-b_0^*\right)^2}\ , \qquad (1)$$

Where:

L^*, a^*, b^* – value of cheese sample colour components measured before packaging;

L_0^*, a_0^*, b_0^* – value of cheese sample colour components measured after storage time.

Microbial analyses: The samples for microbial testing were prepared according as LVS EN ISO 6887-5:2011, lactic acid bacteria count – determined by standard method, ISO 9332:2003; yeasts and moulds – determined by LVS ISO 21527-2:2008; *Escherichia coli (E.coli*) – by ISO 16649-1.

D. 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 weight losses, moisture content, hardness, a_w, pH, changes of atmosphere content (CO_2 and O_2) in headspace of packs, and microbial conditions by different packed samples.

III. Results and Discussion

Water vapor permeability of packaging materials is essential for generation of water losses during storage time. In our experiments it was established that in PLA packaging without barrier properties mass losses substantially increased till 5.6±0.1% already during 12 storage days and samples grew moldy. Whereas in packaging made of VC999 BioPack lidding film PLA during 32 storage days, mass losses gained 4.4±0.1% and samples were not spoiled. The mass losses from packages made of conventional polymers during 32 storage days didn't exceed 0.3±0.1% (Fig. 2). Dosebry and Hardy [25] noted that a 2.5% to 5.0% weight loss of cheese due to insufficient barrier properties is normal. They also found that dehydration of fresh cheese should be avoided, because a dehydrated surface is a major quality defect in those products. Moisture loss was the main factor of weight loss from the cheese during the storage time caused by different water vapor barrier properties of packaging materials.

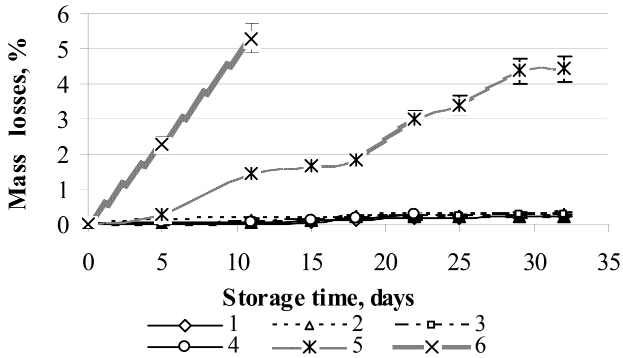

Fig. 2 Mass Losses of Cheese Samples during the Storage Time
1 – vacuum packaging in PA/PE (control); **2** – PE/OPA, MAP; **3** – Multibarrier 60, MAP; **4** – OPP, MAP; **5** – VC999 BioPack lidding film PLA; **6** – PLA without barrier properties.

The mass losses mainly arise due to high water vapour permeability of PLA films. The mass losses influence the changes of moisture content in the cheese samples during storage time as well (Fig. 3). We have already pronounced that in PLA without barrier properties moisture content after 12 storage days decreased till 53±0.1%, the samples got spoiled and therefore the experiments with PLA without barrier properties were not followed up henceforward. Whereas in cheese samples packed in VC999 BioPack lidding film PLA the moisture content during 32 storage days decreased only till 55.4±0.1% and the quality of samples was kept in good condition.

Initial moisture content of samples was 56.0±0.1%. The moister content different decrease of samples are dependent on the packaging material various water vapor permeation through the material ($p<0.05$). Obviously in the Fig. 3, during the first five storage days the moisture content of cheese samples in all packaging materials decreased on average from 56±0.1% to 53±0.1% till 55.0±0.1%. Apparently it is connected wit RH increase in the surrounding of packaging. When maximum of RH 100% was attained, and CO_2 content as a result of fermentation of cheese increased, filling up the free space in the packaging, the sweated moisture of cheese again was adsorbed and as a result the moisture content of cheese samples step by step raised and during 32 storage days achieved the initial level. Significant differences in moisture content values during the 32 days storage among all cheese samples packed in different kinds of materials were not found ($p>0.05$). In cheese packed in VC999 BioPack lidding film PLA packs it was 55.3±0.1%, somewhat less then initial (56.0±0.1%).

Water activity a_w of cheese *Kleo* at the beginning of experiment was 0.98, during the storage time it increased till 0.99. The intensity of water activity a_w increases in samples packed in VC999 BioPack lidding film PLA has been observed higher, compare with those cheese samples packed in conventional polymer packaging, what could be explained with a higher water vapour permeability of biomaterials.

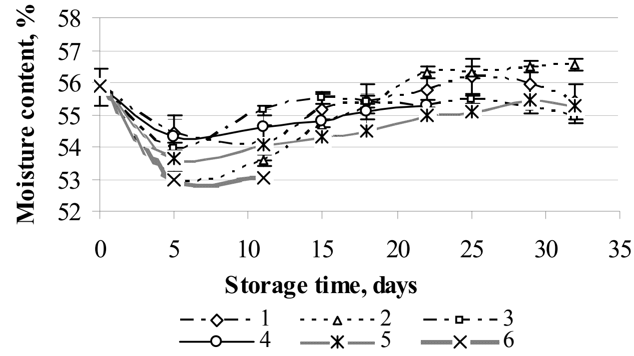

Fig. 3 The Dynamics of Moisture Content in Cheese Samples during the Storage Time

1 – vacuum packaging in PA/PE (control); **2** – PE/OPA, MAP; **3** – Multibarrier 60, MAP; **4** – OPP, MAP; **5** – VC999 BioPack lidding film PLA; **6** – PLA without barrier properties.

The protective gas composition in the headspace of packs during storage time changed substantially. Carbon dioxide content decreased in all packages during the first 5 days of storage approximately till 10.0±0.5% to 20.0±0.5% due to partial dissolution in the cheese mass having high moisture content (64.0±0.5%) (Fig. 4).

Following the storage along to 32 days CO_2 content in MAP Multibarrier 60 packages as a result of lactic acid bacteria growth and high gas barrier properties of mentioned polymer film significantly increased till 55.0±0.5%.Though the least increase in CO_2 concentration was observed in VC999 BioPack lidding film PLA packaging (till 38±0.5%), what could be explained by higher CO_2 permeability of used material. In vacuum packaging the CO_2 content increased only till 5.0±0.5%.

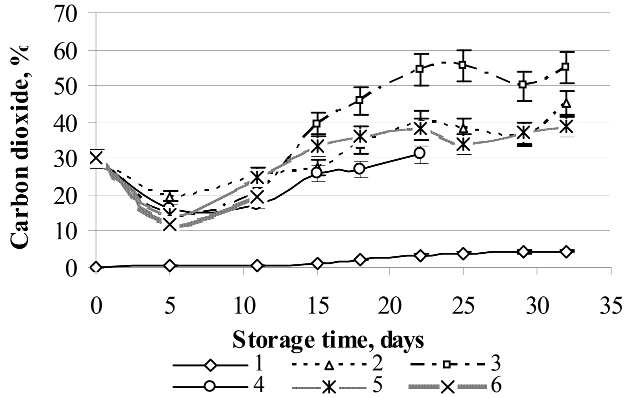

Fig. 4. The Dynamics of Carbon Dioxide (CO_2) Content in the Headspace of Packages in MAP (30% CO_2+70% N_2) and Vacuum (VP)

1 – vacuum packaging in PA/PE (control); **2** – PE/OPA, MAP; **3** – Multibarrier 60, MAP; **4** – OPP, MAP; **5** – VC999 BioPack lidding film PLA; **6** – PLA without barrier properties.

The oxygen content (O_2) in the packages made of Multibarrier 60, VC999 BioPack lidding film PLA, PE/OPA as well as in vacuum packaging increased in average till 4.5±0.5% (Fig.5).

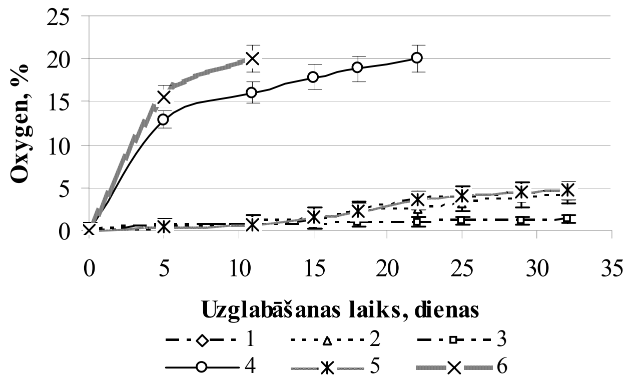

Fig. 5 The Dynamics of Oxygen (O_2) Content in the Headspace of Packages in MAP (30% CO_2+70% N_2) and Vacuum (VP)

1 – vacuum packaging in PA/PE (control); **2** – PE/OPA, MAP; **3** – Multibarrier 60, MAP; **4** – OPP, MAP; **5** – VC999 BioPack lidding film PLA; **6** – PLA without barrier properties.

The phenomena showed MAP, OPP packaging increasing the O_2 content in packages till 20.0±0.5%, similarly like in air conditions. Obviously the polymer OPP has a good water vapour barrier, what couldn't be told about oxygen permeability. Consequently all samples in OPP packaging after 22 storage days spoiled and turn mouldy. The same could be told about packaging in PLA without barrier properties, where the oxygen content already during 12 storage days increased till 20.0±0.5%, similarly like in air conditions, what caused the previously mentioned spoilage of cheese samples in this packaging.

The hardness changes of cheese *Kleo* samples stored in various packaging materials in MAP and vacuum packaging are presented in Fig. 6. The hardness of all investigated cheese *Kleo* samples during storage time of 32 days slowly step by step went down.

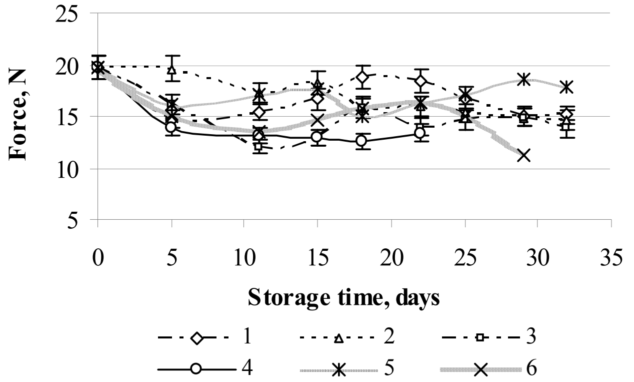

Fig. 6 The Dynamics of Cheese *Kleo* Sample Hardness (N) during the Storage Time

1 – vacuum packaging in PA/PE (control); **2** – PE/OPA, MAP; **3** – Multibarrier 60, MAP; **4** – OPP, MAP; **5** – VC999 BioPack lidding film PLA; **6** – PLA without barrier properties.

Before packaging the hardness was 20±2 N, which of samples packed in conventional polymer packaging by influence of milk acid bacteria gradually reduced till 15±2 N, however the difference between samples was not substantial (p>0.05), though in VC999 BioPack lidding film PLA packaging the hardness decreased least – only till 17±2 N, which, evaluating from this position, approve the advantage of the biodegradable polymer material with barrier properties. Some samples in PLA film packaging, which were not yet mouldy, were analysed after 28 storage days and found that their hardness were comparatively low – 12 N±2 N, and the samples got slimy with loosed quality, approving the previously validated results, that PLA film without barrier properties is not recommendable for soft cheese packaging and shelf life extension.

The relationship between changes of hardness and moisture content during the storage was found in those cheese samples which were packed in the PE/OPA and OPP (r=0.700), as well as in samples packed in biodegradable VC999 BioPack lidding film PLA – r=0.684.

The initial pH value of cheese *Kleo* was 5.8±0.1, which during 32 storage days gradually decreased in all packaging types (p>0.05) – in control sample on average till 5.0±0.1 (Fig. 7).

The least pH value decrease was observed in Multibarrier 60 film packaging – till 5.3±0.1, and in VC999 BioPack lidding film PLA packaging – till 5.2±0.1. The pH value of samples packed in OPP film already after 22 storage days decreased most of all – till 4.9±0.1, and cheese sample in this packaging, as it vas previously told, grew mouldy, wherewith a conclusion could be drawn that OPP film as well is not useful for soft cheese packaging.

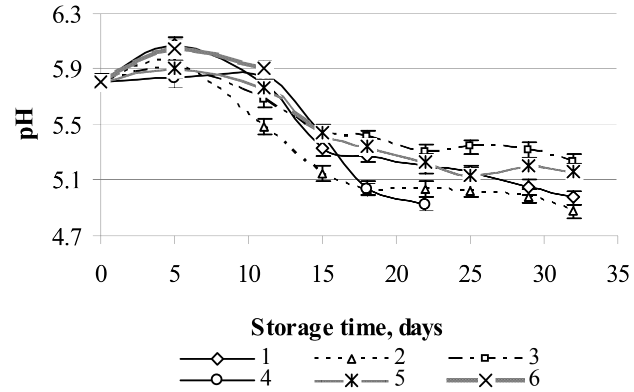

Fig. 7 The Dynamics of Cheese *Kleo* pH Values during the Storage Time

1 – vacuum packaging in PA/PE (control); **2** – PE/OPA, MAP; **3** – Multibarrier 60, MAP; **4** – OPP, MAP; **5** – VC999 BioPack lidding film PLA; **6** – PLA without barrier properties.

The pH value of samples packed in PE/OPA film during storage time of 32 days also reached low level – 4.9, for all that the quality of cheese was acceptable.

In the correlation analysis we have found that strong correlation between pH and hardness exists in cheese samples which were packed in the PE/OPA.

The colour values recorded as L* – brightness, are represented in the Fig. 8.

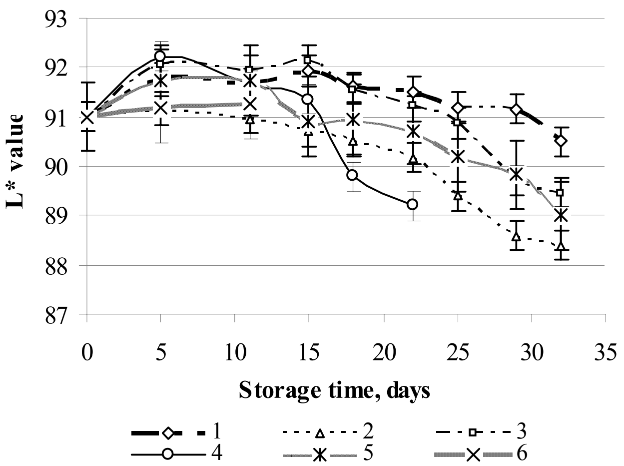

Fig. 8 The Changes of Cheese *Kleo* L* Values During the Storage Time

1 – vacuum packaging in PA/PE (control); **2** – PE/OPA, MAP; **3** – Multibarrier 60, MAP; **4** – OPP, MAP; **5** – VC999 BioPack lidding film PLA; **6** – PLA without barrier properties.

As we have already described previously, the OPP film is useful for the cheese quality maintenance only along 22 storage days, this material as well most of all influenced the changes of L* value during the mentioned period of storage – along the first five storage days the L* value increased from 91±0.2 till 92.2±0.2 units, henceforward till 22 storage days – step by step decreasing till 89.2±0.2 units. The cheese brightness in PE/OPA film packaging during 32 storage days as well decreased till 88.4 unites, showing a major change in brightness. The least influence on the brightness of cheese showed PA/PE film packaging in vacuum – from 91.0±0.2 till 90.6±0.2 units, supposedly the oxygen less ambient and good packaging film barrier properties assist to keep colour of product during storage. The changes in L* value of cheese samples packed in Multibarrier 60 were till 89.6±0.2 and in VC999 BioPack lidding film PLA packaging – till 89.0±0.2. The difference between mentioned two packaging materials influence on the L* value is non-essential (p>0.05).

The values of a* meaning (-a) – greenness, (+) – redness, are graphically represented in Fig. 9. The initial a* value of cheese sample was (-2.6±0.1), gradually decreasing in average till (-3.5±0.1) units in VC999 BioPack lidding film PLA, PE/OPA and Multibarrier 60 packaging (p>0.05). Most of the entire cheese sample component a* change was observed in vacuum packaging – till (-3.7±0.1), which disparate from other investigated material's influence (p<0.05).

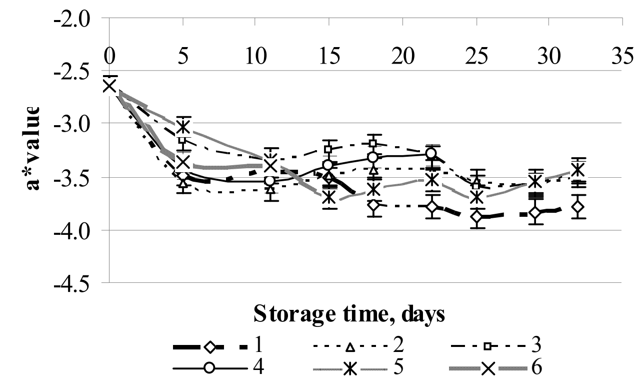

Fig. 9 The Changes of Cheese *Kleo* a* Values during the Storage Time

1 – vacuum packaging in PA/PE (control); **2** – PE/OPA, MAP; **3** – Multibarrier 60, MAP; **4** – OPP, MAP; **5** – VC999 BioPack lidding film PLA; **6** – PLA without barrier properties.

The values of b* meaning (-b) – blueness, (+b) – yellowness, are graphically represented in Fig. 9. The initial b* value of cheese sample was 17.2±0.4 units, gradually increasing in VC999 BioPack lidding film PLA – till 19.6±0.4, in PE/OPA – till 19.2±0.4 units. Somewhat little influence on cheese sample b* value was observed in Multibarrier 60 packaging – till 18.4±0.4 and in PA/PE vacuum packaging – till 18.6±0.4 units. We have to admit that the influence of OPP film packaging on the b* value after 22 days storage was the same that of VC999 BioPack lidding film PLA film – increase till 19.6±0.4, only in OPP packaging the cheese samples turned moldy after 22 storage days, however in biodegradable packaging after 32 days storage the cheese quality was good and acceptable and moulds were not observed.

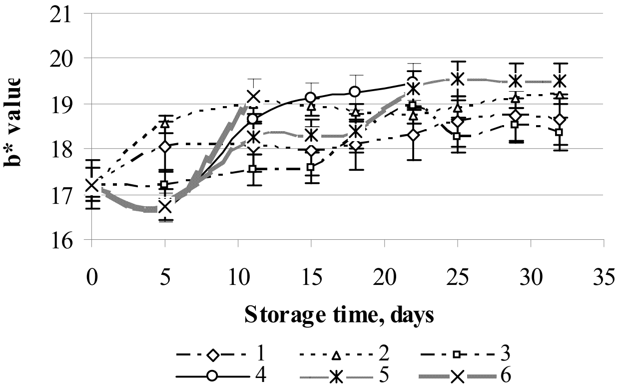

Fig. 10 The Changes of Cheese *Kleo* b* Values during the Storage Time

1 – vacuum packaging in PA/PE (control); **2** – PE/OPA, MAP; **3** – Multibarrier 60, MAP; **4** – OPP, MAP; **5** – VC999 BioPack lidding film PLA; **6** – PLA without barrier properties.

The total color difference (ΔE) of cheese *Kleo* samples in investigated conventional and biodegradable VC999 BioPack lidding film PLA packaging during storage till 32 days was calculated by using equation (1), the results are graphically represented in Fig. 11.

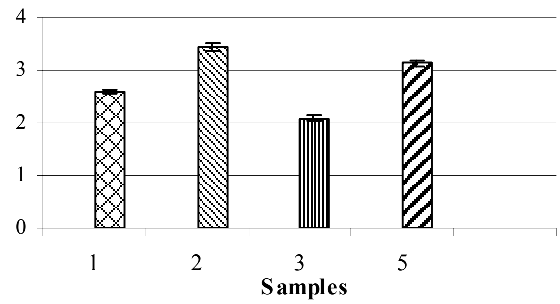

Fig. 11 The Total Colour Difference (ΔE*) of Cheese Samples during the Storage Time

1 – vacuum packaging in PA/PE (control); **2** – PE/OPA, MAP; **3** – Multibarrier 60, MAP; **5** – VC999 BioPack lidding film PLA;

The total colour difference of cheese samples (ΔE*) most of all was influenced by PE/OPA polymer packaging – the changes of 3.45±0.1 units after storage of 32 days were observed and by VC999 BioPack lidding film PLA packaging – of 3.0±0.1 units during the same storage time, although the difference of those two packaging materials on the colour changes was not substantial (p>0.05). The total colour changes in PA/PE vacuum packaging were 2.6±0.1, and in the least changes of ΔE* were influenced by Multibarrier 60 film packaging – only of 2.1±0.1 unit.

Regarding lactic acid bacteria (LAB) all samples showed similar growth rate and after 10 storage days presented the value 7 log cfu g^{-1}, after 32 days of storage – on average 9 log cfu g^{-1}. Similar results were found by Dermiki, Ntzimani et al. (2008) [14] in experiments with MAP packed whey cheese. Lactic acid bacteria may spoil soft cheeses in modified atmosphere, because the bacteria are facultative anaerobic, which implies that they cannot be controlled by modified atmosphere packaging [26]. Not any mould growth in all in MAP packaged cheese samples was observed, excepting OPP and PLA without barrier properties. In cheese packed in PLA without barrier properties the moulds appeared jet on the 12th storage day, and in high moisture barrier property OPP film the samples got spoiled and moulded after 22 days. The yeast grows in all packaging conditions was equal – after 32 storage days on average 9 log cfu g^{-1} was observed. The presence of enterobacteria *Escherichia coli (E. coli)* in the tested cheese samples was not found.

IV. Conclusion

Considering all experimentally obtained results, we have recognized that the shelf life of cheese *Kleo* could be acceptable along 30 days in conventional packaging materials PE/OPA and Multibarrier 60, as well as the biodegradable VC999 BioPack lidding film PLA packaging could be suggested for soft cheese *Kleo* packaging and shelf life extension till 30 days.

References

[1] O. M. Abdalla, A. K. Sbdel Razig, “Effect of type of milk on the quality of white soft cheese”, U. K. Journal of Agriculture Science, pp. 147–157, 1997.
[2] G. Mortensen, G. Bertelsen,, P.V. Nielsen, “Packaging of cheese”. (Book style with paper title and editor) in: Handbook of food and beverage fermentation technology, Y.H. Hui, L. Meunier-Goddik, A.S. Hansen, J. Josephsen, Nip Wai-Kit, P.S. Stanfield, J. F. Toldra, Ed. Taylor & Francis e-library, 2005. pp. 381–399.
[3] M. Osman, M. Abdalla, S.N Mohamed, “Effect of Storage Period on Chemical Composition and Sensory Characteristic of Vacuum Packaged White Soft Cheese”, Pakistan Journal of Nutrition, vol. 8, pp. 145–147, 2009.
[4] Y.M. Ahmed, and I.H Alhassan, “Effect of Packaging materials on Microbiological Properties of Sudanese White Cheese”, International Journal of Dairy Science, vol. 593, pp. 128–134, 2010.
[5] E. Gonzales-Fandos, S. Sanz, C. Olarte, “Microbiological, physicochemical and sensory characteristics of Camerous cheese packaged under modified atmosphere”, Food Microbiology, vol. 16, pp. 351–364, 2000.
[6] K.D. Antoniou, D..Petridis, S. Raphaelides, Z.B. Omar R. Kesteloot, “Texture assessment of French cheese”, Journal Food Science, vol. 65, pp. 168–172, 2000.
[7] K. Wendin, M. Langton, L. Caous, C. Hall, “Dynamic analyses of sensory and microstructural properties of cream cheese”, Food Chemistry, vol. 71. pp. 363–378, 2000. J.X. Guinard, R. Mazzucchelli, “The sensory perception of texture and mouth feel”, Trends in Food Science and Technology, vol. 7,
[8] pp. 213–219,1996.
[9] J.-F. Meullenet, R.K. Gandhapuneni,. ” Development of the BITE Master II and its application to the study of cheese hardness”, Physiology & Behaviour, vol. 89 (1), pp. 39–43, 2006.
[10] D. K. Platt, “Biodegradable polymers”, Market report, RAPRA technologies. A Smithers group Company. 2006.
[11] J.D. Floros, P.V. Nielsen, J.K. Frankas “Advances in modified atmosphere and active packaging with application in the dairy industry”, Packaging of Milk Products, Bulletin of the IDF, 346, Brussels, Belgium, International Dairy Federation, pp. 22–28, 2000.
[12] M. E. Pintado, A. C. Macedo, F. X. Malcasa, “Review, technology. Chemistry and Microbiology of whey cheese”, Food Science and Technology International, vol. 7, pp. 105–116, 2001.
[13] G. Papaioannou, I. Chouliara, E. Andreas, A. E. Karatapanis, M. G. Kontominas, I. N. Savvaidis, “Shelf-life of a Greeke whey cheese under modified atmosphere packaging”, International Dairy Journal, vol. 17, pp. 358–364, 2007. Source: www.sciencedirect.com; resource used on 25.06.2011.
[14] M. Dermiki, A. Ntzimani, A. Badeka, I. N. Savvaidis, M. G. “Shelf-life extension and quality attributes of the whey cheese Myzithra Kalathaki using modified atmosphere packaging”, LWT vol. 41, pp. 284–294, 2008. Source: www.sciencedirect.com; resource used on 25.06.2011.
[15] R. Narayan, „Drivers for biodegradble/compostable plastics and role of composting in waste management and sustainable agriculture”, Orbit Journal, vol. 1(1), pp. 1–9, 2001.
[16] V.K. Haugard, B. Danielsen & G.Bertelsen,” Impact of polylactate and poly(hydroxybutyrate) on food quality”, European Food research and Technology, vol. 216, pp. 253–240, 2003.
[17] V.K. Haugard, C.J. Weber, B. Danielsen & G. Bertelsen, “Quality chanages in orange juice packaged in materials based on polylactate”, European Food research and Technology, vol. 214, pp. 423–428, 2002.
[18] C. S. Frederiksen, V.K. Haugard, L. Poll, & E. M. Becker, “Light-induced quality changes in plain yoghurt packed in polylactat and polystyrene”, European Food research and Technology, vol. 217, pp. 61–69, 2003.
[19] V.K. Haugard and G. Martensen “Biobased food packaging” (Book style with paper title and editor) in: Environmentally-friendly food processing, B. Mattsson and U. Sonesson Ed. Woodhead publishing Limited, 2003. pp. 182-204.
[20] V. K. Holm, G. Mortensen,. & J. Risbo, “Quality changes in semi-hard cheese packaged in a poly(lactice acid) material”, Food Chemistr, vol. 97, pp. 401–410, 2006. Source: www.sciencedirect.com; resource used on 25.06.2011.
[21] V. K. Holm, G. Mortensen, M. Vishart, A. Petersen, “Impact of ply-lactic acid packaging material on semi-hard cheese”, International dairy Journal, vol. 16, pp. 931–939, 2006. Source: www.sciencedirect.com; resource used on 25.06.2011.
[22] New VC999 BioPack Bioplastic Packaging System: Fully Biodegradable, CO2 Neutral & Energy Saving, http://www.packaging-int.com/article/new-vc999-biopack-packaging-system-fully-biodegradable-co2-neutral-energy-saving.html. Resource used on 25.06.2011
[23] L.Dukalska, S. Muizniece-Beasava, D. Seglina, E. Straumite, R. Galoburda., V. Levkane, “Studies of Biodegradable Polymer Material Suitability for Food Packaging Applications (Published ConferenceProceedings style, ” in Proc. 3rd Baltic Conference on Food Science and Technology “FOODBALT-2008”, Jelgava, Latvia,2008, pp. 64–68.
[24] T. P. Coultate, “Food: the chemistry of its components”, Cambridge, UK: RSC Paperbackspp, pp. 213–217, 2002.
[25] S. Dosebry, J. Hardy, “Packaging and wrapping materials” (Book style with paper title and editor) in: Cheese Making, A. Eck, J.C. Gillis, Ed. From science to quality assurance, 2nd ed., Paris, Lavoisier, 2000. pp. 513–528.
[26] S. Westall and O. Filtenborg, “Spoilage yeasts of decorated soft cheese packed in modified atmosphere”, Food Microbiol., vol. 15, pp. 243–249, 1998.