PACKAGING MATERIAL AND STORAGE-INDUCED QUALITY CHANGES IN FLEXIBLE RETORT POUCH POTATOES' PRODUCE

Aija Ruzaike, Sandra Muizniece-Brasava, Lija Dukalska

Department of Food Technology, Faculty of Food Technology, Latvia University of Agriculture, 2 Liela str., Jelgava, Latvia, e-mail: aija.ruzaike@gmail.com

Abstract

Experiments have been carried out at the Latvia University of Agriculture Department of Food Technology. The aim of this work was to apprize the quality changes of potato produce in dry butter and mushroom dressing which was thermally treated in vacuum packed soft retort pouches and stored for 12 months at ambient temperature +18±2 °C. A retort pouch is a heat-resistant bag made of laminated plastic films or foil. It is then heat-sealed and sterilized by pressure cooking in a retort. Two laminated polymers with barrier properties were used: transparent polyamide/polyethylene (PA/PE) and lightproof polyethylene terephthalate/aluminium/ polyamide/polypropylene (PET/ALU/PA/PP). Samples of potato products in packaging were analysed immediately after retort thermal treatment and after 1, 2, 3, 4, 6, 8, 10 and 12 months of storage. The quality changes of potato produce during storage was characterized by measuring such parameters as structure, pH, colour and microbiological parameters. Data obtained emphasize the importance of selected laminate PET/ALU/PA/PP with aluminium layer preventing light transparency which could provide stable quality of ready to eat potato produce thermally treated in retort pouch for long-duration up to 12 months. The aim of this work was to apprize the quality changes of potato produce in dry butter and mushroom dressing which was thermally treated in vacuum packed soft retort pouches and stored for 12 months at ambient temperature +18±2 °C.

Keywords: retort pouch, quality, storage, potatoes.

Introduction

Nowadays, potatoes are popular for human consumption around the world and in more than 100 countries potatoes are staple food for many (Singh, Kaur, 2009). Raw potatoes are difficult to digest, therefore several types of preparation, such as cooking, baking, braising, grilling, and microwave processing, are used to improve the structure of potatoes and make them more accessible to the diet (Carini et al., 2013). The main factors that affect potato quality among consumers are potato size, colour and texture after cooking. When purchasing processed potato products the focus is on the appearance, taste, texture and nutritional value of the product (Suryawanshi, 2008). Today, food market offers a wide range of potato varieties; most of them are classified according to organoleptic characteristics, quality and end-use (Lopez-Vizcón, Ortega, 2012). The demand for vacuum-packed, healthy, cut potatoes is ever increasing (Lante, Zocca, 2010). With increasing consumer demand for convenience and high quality products, potato processing companies constantly look for new and innovative ways to use potatoes effectively (Abu-Ghannam, Crowley, 2006). Popular processed potato products include potato crisps, French fries (chips), potato powder, potato cubes, slices and potato starch (Suryawanshi, 2008). During the recent years, development of new food products has been receiving increased attention. It is mainly because the demand for safe food with extended shelf life has been increasing in both consumer and merchant groups (Valceschini, 2006). Heat treatment is a common food preservation method. Based on the intensity of the treatment, it can be divided into two main groups' – pasteurization and sterilization. Each of these treatments has its own specific features (intensity, suitability for the type of product), which determined the shelf life of food. Heat treatment can also affect the quality of food. The optimal treatment regime needs to be selected for each type of food in order to minimize unwanted quality losses and increase the desired quality, while ensuring microbiological safety (Lammens et al., 2013). Sterilization is one of the most important processes to maintain packaged food quality (Marra, Romano, 2003). Currently, treatment of products in packaging is one of the leading processing technologies that impart long-term storage at room temperatures (Ito et al., 2014).

Using this method, the product can maintain most of its original texture, as well as minimal loss of nutrients can be ensured, in addition to obtaining a longer shelf life. This technology provides a number of advantages; it allows to effectively managing the heat from the steam or water to the product through the packaging, preventing recontamination of the product. It also excludes off-flavour formation and oxidation of the product, preventing moisture and nutrient losses during evaporation and loss of volatile compounds during cooking, as well as preventing development of aerobic microorganisms in the product. Heat treatment of vegetables and fruits in packing is recognized as an excellent way to maintain their structure without losing such valuable nutrients as vitamins and minerals, which can significantly decrease when vegetables and fruits are boiled in water. This high nutrient retention contributes to the persistence of flavour and colour in such vegetables as turnips, swedes, carrots etc. (Sansone et al., 2012).

Packaging is essential for products intended for long-term storage because storage time and temperature significantly affect the appearance, aroma, taste and structure (Clark et al., 2002). Thermal treatment of food products in soft packaging is becoming more widely used and it serves as an alternative to metal cans. Packaging bags intended for heat treatment usually consist of up to three layers: polypropylene (PP), aluminium foil and polyethylene terephthalate (PET). Aluminium foil and polyethylene terephthalate are primarily used to provide the desired barrier properties. Polypropylene provides an excellent sealing of packaging. Polypropylene layer protects aluminium foil from the inside and promotes overall strength (Byun et al., 2010, Srinivasa Gopal et al., 2001).

Suitable and qualitative packaging has a major role in maintaining the quality of the product and also in the convenience of customer use (Ahvenainen, 2003). The quality of products must be maintained during storage; therefore food companies need to constantly work on improving recipes, readjusting packaging materials and technology in order to reduce the initial product quality changes during storage. In turn, scientists need to look for more innovative ideas to provide entrepreneur, producer, and customer satisfaction (Puligundla et al., 2012).

Materials and Methods

Research was carried out during the period from November 2011 to January 2014. Product samples were prepared at vegetable processing company in Latvia. Physical and chemical analysis (colour, hardness, pH) were performed at the Packaging material property testing laboratory at the Department of Food Technology (Latvia University of Agriculture). Microbiological and nutrition analyses and corresponding to them expiry date were defined at the laboratory of Food and Environmental Investigations at Institute of Food Safety, Animal Health and Environment *BIOR*.

In total, three different types of samples were prepared: control sample of cut potatoes without dressing, and two samples of potatoes with butter and mushroom *(Agaricus bisporus)* dressing. Raw potatoes were pealed and cut into equal-sized 8 mm wide slices. After dressing addition, potato products were dosed in soft retort pouches made out of two different packaging materials, portion mass in each pouch was 500±0.05 g. Two laminated polymers with barrier properties were used: transparent polyamide/polyethylene (PA/PE) and lightproof polyethylenetereftalate/aluminium/polyamide/polypropylene (PET/ALU/PA/PP) films. Size of each pouch was 200×250 mm, thickness of film 80 μm. Potato products were placed in soft retort pouches, vacuum-sealed using a two-chamber vacuum packaging machine Falcon 2-70; hermetic sealing mode – vacuum, 20 MPa, sealing time 3.8 s for PE/PA pouches and 5.3 s for PET/ALU/PA/PP pouches. A retort pouch is a heat-resistant bag made of laminated plastic films or foil. It is then heat-sealed and sterilized by pressure cooking in a retort "Lagarde", sterilizing temperature +121±2 °C, cooling temperature +20±2 °C. Samples were stored for 12 months at ambient temperature +18±2 °C. Physical and chemical properties as well as microbiological testing of products were carried out on the production day (day 0) and after 1, 2, 3, 4, 6, 8, 10 and 12 months of storage. Samples were encrypted with letters and numbers (Fig. 1), samples in PE/PA packaging were marked as P1 (control sample), P2 (sample with butter dressing) and P3 (sample with mushroom dressing), while samples in PET/ALU/PA/PP packaging were marked as A1 (control sample), A2 (sample with butter dressing) and A3 (sample with mushroom dressing).

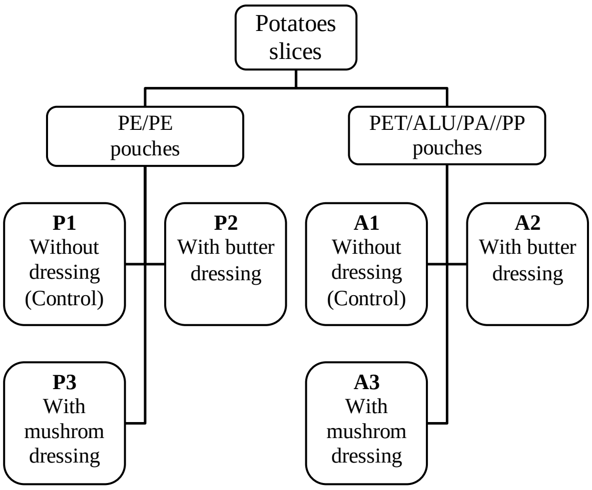

Figure 1. Research structure

Colour analysis

Colour of potato product samples were determined using *Colour Tec PCM / PSM* with CIE L* a* b* colour system. Measurements were completed in tenfold repetition for each sample for more precise calculations of the mean value and standard deviation. Measurements were recorded using data program *Colour Soft QCW*. Total colour difference (ΔE*) of potatoes' products between initial value and after storage was calculated using the following equation 1: (MacDougall, 2002).

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

where ΔE* – total colour difference of the product during storage, L* – colour intensity value at the final product storage day, L_0* – colour intensity value at day 0, a* – value of colour component green – red at the final product storage day, a_0* – value of colour component green – red at day 0, b* – value of colour component blue – yellow at the final product storage day, b_0* – value of colour component blue – yellow at day 0.

Determination of nutritional value

Nutritional value of developed products was determined using the following methods: protein content (BS EN 12135:2001 standard), carbohydrates were determined by difference, fat content (GOST 8756.21-89 p.2 method), crude fibre content (ISO 5498:1981), ash content (GOST 25555.4-91 p.2 method), moisture content (GOST 28561-90 p.2

method). Energy value was calculated according to the results of analysis above. Nutritional values testing of products were carried out on the production day.

Determination of hardness

The hardness of potato products was determined with *TA.XT. Plus Texture Analyser, Blade set with knife (Stable Microsystems, UK*). Data collection and analysis was carried out with program *Texture EXPONENT 32*. Blade movement speed during the test mode was 1 mm s^{-1} (forwards) and 10 mm s^{-1} (backwards). The force at which data collecting started was 0.04903 N. Measurements were completed tenfold for each sample for more precise calculations of the mean value and standard deviation.

Determination of pH

pH of potato products was determined using pH-meter *JENWAY 3510* with electrodes *JENWAY 3 mol / KCl* (standard method ISO 1132:2001).

Microbiological analysis

Total plate count (TPC) was determined according to the standard LVS EN ISO 4833:2003. To determine sulphite-reducing *Clostridia* in the product (*Clostridium* spp.), GOST 29185-91*, standard method was used.

Data analysis

The obtained data were processed using SPSS 16.0 software package; arithmetic mean value and standard deviation were calculated. The results were analysed using univariate analysis of variance (ANOVA). Factors were rated as significant if p-value< $\alpha_{0.05}$. For the interpretation of the results it was assumed that α=0.05 with 95% confidence.

Results and Discussion

Nutrition is an important factor for consumers when making a food choice. More attention is paid to the composition of ingredients and nutritional value of products because the number of food-related diseases is ever increasing (Patras et al., 2009). Therefore, nutritional value of potato products was determined and the results are given in Table 1.

The results show the energy value of control sample – 301 kJ 100 g^{-1}, which mainly constitutes of potato carbohydrates (15.7%), followed by protein (1.8%) and a small proportion of total fat (0.1%).

Potatoes contain about 20% of dry matter; the rest is water (Ek et al., 2012). Total water content in the control sample is 81%. The addition of dressing mixtures to potatoes changes and affects their nutritional value. Nutrition changes are mainly related to the dressing mixture composition. Energy value of potatoes with butter dressing is 346 kJ 100 g^{-1}, which is by 45 kJ more than of the control sample. The sample with butter dressing contains 16.8% carbohydrates, which is 1.1% more than in the control sample. Potatoes with butter dressing contain about 0.2% more protein and 0.9% more fats than the control sample; moisture content is for 2% lower.

Energy value of potatoes with mushroom dressing is 341 kJ 100 g^{-1}. This sample contains fewer kJ than potatoes with butter dressing. Total carbohydrate content in potatoes with mushroom dressing is 17.7%, which is by 2.0% and 0.9% more than in the control sample and potatoes with butter dressing, respectively. Protein content in potatoes with mushroom dressing is 2.4%, which is by 0.6% higher and 0.4% lower than in the control sample and potatoes with butter dressing, respectively. Moisture content in potatoes with mushroom dressing is 78.2%, which is by 3.2% and 0.8% lower than in the control sample and potatoes with butter dressing, respectively. The results show that addition of dry dressing mixtures does not significantly change energy value of potato products.

Table 1

Nutritional value of potato products

Parameters	Content per 100 g of product		
	control sample	**sample with butter dressing**	**sample with mushroom dressing**
Energy value	71 kcal / 301 kJ	82 kcal / 346 kJ	80 kcal / 341 kJ
Protein, %	1.8	2.0	2.4
Carbohydrates, %	15.7	16.8	17.7
Fat, %	0.1	1.0	0.3
Crude fibre,%	0.6	0.6	0.7
Moisture, %	81.0	79.0	78.2
Ash content, %	0.8	1.2	1.4

Colour is one of the main factors which the consumer perceives as the quality indicator of the product (Suryawanshi, 2008). Generally, the colour may be affected by genetic factors and technological parameters of production process. Technological parameters include packaging material, light exposure during storage and the type of preparation (Murcia et al., 2003). Total colour changes of potato products during the storage are characterized by the total colour difference ΔE* which is calculated from measured L*, a* and b* values.

There are significant disparity (p<0.05) between the total colour difference ΔE* of potato products arising during storage in studied PE/PA pouches (p<0.05) and PET/ALU/PA/PP packaging (Fig. 2), which can be explained by light transmission of packaging material. After the comparison of the samples packaged and stored in both packaging materials for 12 months, it can be concluded that PET/ALU/PA/PP packaging ensures a significantly (p<0.05) lower product colour changes than PE/PA packaging.

There are significant disparity (p<0.05) between the total colour difference ΔE* of potato products arising during storage in studied PE/PA pouches (p<0.05) and PET/ALU/PA/PP packaging (Fig. 2), which can be explained by light transmission of packaging material. After the comparison of the samples packaged and stored in both packaging materials for 12 months, it can be concluded that PET/ALU/PA/PP packaging ensures a significantly ($p<0.05$) lower product colour changes than PE/PA packaging.

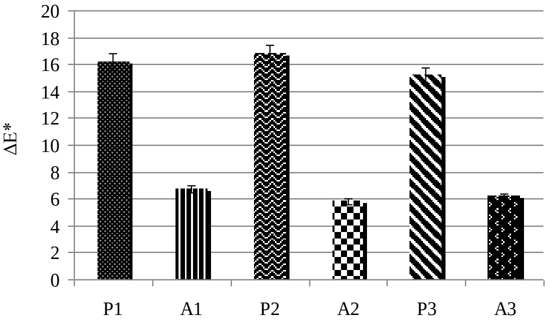

Figure 2. The total colour difference ΔE* of potato products after 12 months of storage

P1 – control sample in PE/PA packaging, A1 – control sample in PET/ALU/PA/PP packaging, P2 – potatoes with butter dressing in PE/PA packaging, A2 – potatoes with butter dressing in PET/ALU/PA/PP packaging, P3 – potatoes with mushroom dressing in PE/PA packaging, A3 – potatoes with mushroom dressing in PET/ALU/PA/PP packaging

An important quality indicator of thermally-treated potatoes in packaging is structure which indicates the hardness of the product; therefore changes in potato hardness after thermal treatment are mainly due to the changes in the structure and chemical composition (Abu- Ghannam, Crowley, 2006).

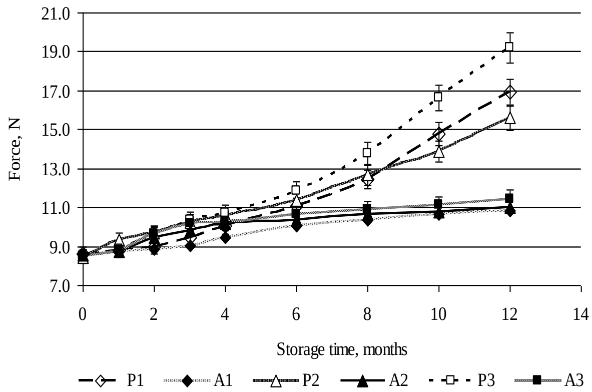

Figure 3. Changes in hardness of potato products during storage

P1 – control sample in PE/PA packaging, A1 – control sample in PET/ALU/PA/PP packaging, P2 – potatoes with butter dressing in PE/PA packaging, A2 – potatoes with butter dressing in PET/ALU/PA/PP packaging, P3 – potatoes with mushroom dressing in PE/PA packaging, A3 – potatoes with mushroom dressing in PET/ALU/PA/PP packaging

In order to evaluate potato hardness during 12 month storage period, samples of potato products in both packaging materials, which were stored at a constant temperature +18±2 °C, were compared (Fig. 3).

During the six month period of storage, hardness of potato products has risen evenly in both packaging materials from 8.5 to 10.8–11.8 N; during the first half of storage (6 months) the studied packaging materials evenly affected the changes in potato hardness. However, a significant increase in hardness ($p<0.05$) was observed after 12 months of storage in PE/PA packaged potato products from 11.8 to 15.6–19.2 N. These significant changes occurred because PE/PA packaging has higher water vapour permeability; hence it cannot maintain initial quality of potato products during storage. Changes in structure of heat-treated products in packaging are usually caused by water loss during storage (Alonso et al., 2013).

pH is an important factor as it determines which microorganisms can proliferate in the product (Suryawanshi, 2008). Initial pH for potatoes without dressing was 5.84, for potato products with dressing – 5.75 (Fig. 4).

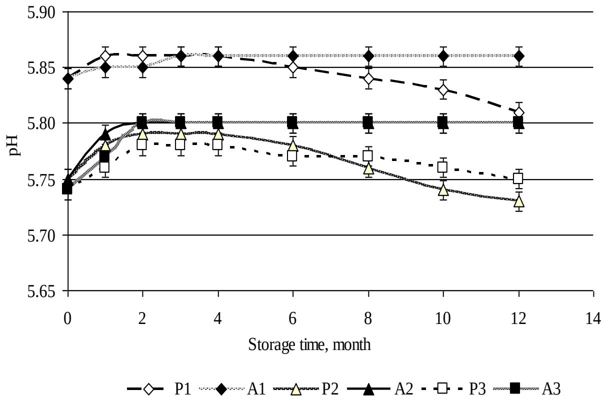

Figure 4. Changes in pH of potato products during storage

P1 – control sample in PE/PA packaging, A1 – control sample in PET/ALU/PA/PP packaging, P2 – potatoes with butter dressing in PE/PA packaging, A2 – potatoes with butter dressing in PET/ALU/PA/PP packaging, P3 – potatoes with mushroom dressing in PE/PA packaging, A3 – potatoes with mushroom dressing in PET/ALU/PA/PP packaging

Stability in pH during storage of heat-treated products in packaging is an important quality indicator. Potato products in PE/PA packaging presented slight decrease in pH during storage; pH in the control sample reduced to 5.81, in the sample with butter dressing to 5.73 and in the sample with mushroom dressing till 5.75, these changes were not significant ($p>0.05$).

Changes in pH of potato products in PET/ALU/PA/PP packaging were not significant ($p>0.05$) as well, while pH in the control sample rose to 5.86 and in samples with dressing pH rose or dropped to a small extent.

It can be concluded that both PE/PA packaging and PET/ALU/PA/PP packaging are able to provide practically constant pH during storage. This is an important indicator when assessing the possible development of microorganisms in thermally treated products in packing during storage.

Consumer demand for food depends on the quality of the product, convenience of use, and safety of the product (Chen et al., 2012). One of the most common types of food contamination is biological contamination. It is relevant to emphasize the importance microbiological contamination has on public health, because direct contact and other transfer factors help microorganisms to get and proliferate in a variety of foodstuffs and the digestive tract of animals and humans. Microbiological contamination of food is one of the most common types of food contamination not only in countries where there are problems with provision of food hygiene requirements, but also in the European Union countries and the United States where a high level of consumer protection is ensured (Food and Veterinary Service Research Centre, 2004).

Total plate count and the presence of sulphite-reducing Clostridia were determined immediately after thermal treatment and during 12 month storage period. The total plate count (number of microorganisms) in potato products in both types of packaging materials during storage did not exceed 10 CFU g^{-1}. It clearly demonstrates that the selected treatment regime and the choice of packaging material can ensure product safety. Potatoes and potato products are recognized as one of the main foods that may cause a significant risk of becoming infected with *Clostridium* species bacteria (Barker et al., 2005). *Clostridium* species are anaerobic spore-producing bacteria, so it is necessary to ensure effective heat treatment process to eliminate the risk of infection. Sulphite-reducing *Clostridia* were not present in any of the samples during storage which indicates the effectiveness of the technology used and the ability to ensure the security and safety of the product during storage.

Microbiological indicators are one of the main criteria that determine shelf life of the product and its safe use in the diet. According to the results of the total plate count, absence of sulphite-reducing *Clostridia*, as well as such quality characteristics as colour, hardness and pH of potato products, the optimal shelf life for thermally treated potato products in PE/PA packing stored at the temperature of +18±2 °C could be three months but thermally treated potato products in PET/ALU/PA/PP pouches can be used up to 12 months.

Conclusions

Changes in the total colour difference ΔE* of potato products during 12 month storage packed in PET/ALU/PA/PP are not significant ($p>0.05$), while significant colour changes have been observed in potato products packed in PE/PA ($p<0.05$).

A steady increase in potato hardness from 8.5 N to 10.8–11.8 N was observed during the six month storage in both packaging materials. After 12 month storage, a significant ($p<0.05$) increase in hardness was observed in potato products stored in PE/PA packages (from 11.8 N to 15.6–19.2 N).

The selected thermal treatment in vacuum packed soft retort pouches and both types of packaging materials provide microbiological safety of potato products during 12 month storage at +18±2 °C temperature, but only laminated lightproof PET/ALU/PA/PP film provides constant product quality during storage. Potato products in PET/ALU/PA/PP packaging are safe for human consumption up to 12 months of storage.

References

1. Abu-Ghannam N., Crowley H. (2006) The effect of low temperature blanching on the texture of whole processed new potatoes. *Journal of Food Engineering,* Vol. 74, p. 335–344.
2. Ahvendinen R. (2003) Novel *Food Packaging Techniques.* Cambridge England: CRC Press Woodhead publishing limited. 590 p.
3. Alonso A.A., Méndez A.A., Balsa-Canto E., García M., Molina J., Vilas C., Villafín M. (2013) Real time optimization for quality control of batch thermal sterilization of prepackaged food. *Food Control,* Vol. 32, p. 392–403.
4. Barker G.C., Malakar P.K., Torre M.D., Stecchini M.L., Peck M.W. (2005) Probabilistic representation of the exposure of consumers to *Clostridium botulinum* neurotoxin in a minimally processed potato product. *International Journal of Food Microbiology,* Vol. 100, p. 345–357.
5. Byun Y., Hong S.I., Mangalassary S., Bae H.J., Cooksey K., Park H.J., Whiteside S. (2010) The performance of organic and inorganic coated retort pouch materials on the shelf life of ready-to-eat rice products. *LWT – Food Science and Technology,* Vol. 43, p. 862–866.
6. Carini E., Curti E., Littardi P., Luzzini M., Vittadini E. (2013) Water Dynamics of ready to eat shelf stabule pasta meals during storage. *Innovative Food Science & Emerging Technologies*, Vol. 17, p. 163–168.
7. Chen Q., Anders S., An H. (2013) Measuring Consumer Resistance to New food technology. *Food Quality and Preference,* Vol. 28, p. 419–428.
8. Clark S., Warner H., Rodríguez J.J., Olivas G.I., Sepúlveda D., Bruins R., Barbosa-Cánovas G.V. (2002) Residual gas and storage conditions affect sensory quality of diced pears in flexible retortable pouches. *Food Quality and Preference,* Vol. 13, p. 153–162.
9. Ek K. L., Brand-Miller J., Copeland L. (2012) Glycemic effect of potatoes. *Food Chemistry,* No.133, p. 1230–1240.
10. Ito R., Fukuoka M., Hamada-Sato N. (2014) Innovative food processing technology using ohmic heating and aseptic packaging for meat. *Meat Science,* Vol. 96, p. 675–681.
11. Lante A., Zocca F. (2010) Effect of β-cyclodextrin addition on quality of precooked vacuum packed potatoes. *LWT – Food Science and technology,* Vol. 43, p. 409–414.
12. Lemmens L., Colle I., Knockaert G., Buggenhout S.V., Loey A.V., Hendrickx M. (2013) Influence of pilot scale in pack pasteurization and sterilization treatments on nutritional and textural characteristics of carrot pieces. *Food Research International,* Vol. 50, p. 526–533.
13. Lopez-Vizcón C., Ortega F. (2012) Detection of mislabeling in the fresh potato retail market employing microsatellite markers. *Food Control,* Vol. 26, p. 575–579.
14. Marra F., Romano V. (2003) A mathematical model to study the influence of wireless temperature sensor during assessment of canned food sterilization. *Journal of Food Engineering*, Vol. 59, p. 245–252.

15. Murcia M.A., Martínez-Tomé M., Nicolás M.C., Vera A.M. (2003) Extending the shelf-life and proximate compositions stability of ready to eat foods in vacuum or modified atmosphere packaging. *Food Microbiology*, Vol. 20, p. 671–679.
16. Patras A., Tiwari B.K., Brunton N.P., Butler F. (2009) Modelling the effect of different sterilisation treatments on antioxidants activity and colour of carrot slices during storage. *Food Chemistry*, Vol. 114, p. 484–491.
17. Pārtikas un veterinārā dienesta Pētniec. centrs, Pārtikas piesārņojums. Rīga: 2004, 64 lpp.
18. Puligundla P., Jung J., Ko S. (2012) Carbon dioxide sensors for intelligent food packaging applications. *Food Control,* Vol. 25, p. 328–333.
19. Sansone L., Aldi A., Musto E.D., Amendola E., Mensitieri G. (2012) Assesing the suitability of polylactic acid flexible films for high pressure pasteurization and sterilization of packaged foodstuff. *Journal of Food Engineering*, Vol. 111, p. 34–45.
20. Singh J., Kaur L. (2009) *Advances in Potato Chemistry and Technology*. Academic Press, Chapter 7, p. 163–219.
21. Srinivasa Gopal T.K., Vijayan P.K, Balachandran K.K, Madhavan P., Iyer T.S.G (2001) Traditional Kerala style fish curry in indigenous retort pouch. *Food Control,* Vol. 12, p. 523–527.
22. Suryawanshi M.V. (2008) Minimal processing and packaging studies in potato. Departament of horticulture. College of Agriculture, Dharwad University of Agricultural Sciences Dharwad, p. 82.
23. Valceschini E. (2006) Poultry meat trends and consumer attitudes, *Report of National Institute of Agronomic Research (France)*, p. 1–10.