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Quality Evaluation of Ready to Eat Potatoes' Produce in Flexible Packaging

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Abstract**—**Experiments have been carried out at the Latvia University of Agriculture Department of Food Technology. The aim of this work was to assess the effect of thermal treatment in flexible retort pouch packaging on the quality of potatoes' produce during the storage time. Samples were evaluated immediately after retort thermal treatment; and following 1; 2; 3 and 4 storage months at the ambient temperature of +18±2ºC in vacuum packaging from polyamide/polyethylene (PA/PE) and aluminum/polyethylene (Al/PE) film pouches with barrier properties. Experimentally the quality of the potatoes' produce in dry butter and mushroom dressings was characterized by measuring pH, hardness, color, microbiological properties and sensory evaluation. The sterilization was effective in protecting the produce from physical, chemical, and microbial quality degradation. According to the study of obtained data, it can be argued that the selected product processing technology and packaging materials could be applied to provide the safety and security during four-month storage period.

Keywords**—**Potatoes' produce, shelf life, retort thermal treatment and packaging.

I. Introduction

ACCELERATED pace of life is becoming pressing need for ready to eat meals, which also would have adequate nutritional value. The cooking method of foods could have a certain impact on their nutrient content. That's because many vitamins are sensitive to heat and air exposure. Loss of nutrients increases as cooking time increases and with higher temperatures. Cooking methods that minimize the time, temperature, and amount of needed water will help to preserve nutrients. The growth of world consumption of ready to eat products is noteworthy, not only for its scale but also for its constancy. Consumption has developed around more elaborate products incorporating two types of service: a saving of preparation time ('*ready-to-eat*' food) and a diversification of places of consumption (catering outside the home), storage [1]. Ready to eat meals can be broadly defined as complex assemblages of precooked foodstuffs, packaged together and sold through the refrigerated retail chain in order to present the consumer with a rapid meal solution [2]. Consumption of *ready-to-eat* meals is limited, because more or less people prefer traditions and could be applied for home consumption or foodservice / catering. Results of some researches show that some preferences are linked with tradition, whereas others are more innovative and typical of modern-time behavior [3]. Ready to eat traditionally cooked dishes cannot be stored for a long time. One of the most effective ways of preparation of such products is heat treatment, followed by storage under reduced temperature. Although currently the world's food sterilization is already well known and popular cooking method, however, each type of product it is applied in the evaluation of the product specificity of the chemical composition. Ready to eat products need a preservatives or mild pasteurization (*Sous-vide* technology) to give them a commercially acceptable shelf life. Nowadays, a perspective method to extend the shelf life of food products is vacuum packaging and packaging in the protective gas mixture or modified atmosphere (MAP) [2], [4]; days or weeks, maintaining food quality, taste, and aroma.

Sous-vide cooking do not always happen at low temperatures. The cooking methods are varied and each way has its own impact on the product. The specific reasons for cooking of foods are as follows: cooking promotes the accessibility of some nutrients such as starch in potatoes (starch granules are available for digestive enzymes), so the food will be more digestible; the food products become tender, so it is easier to eat; cooking eliminates potentially harmful micro-organisms and leaches out some toxins; Heating food launches a series of chemical reactions, breaking down big, tasteless molecules into small molecules detectable by our taste buds [5].

Ready-to-eat (RTE) foods are pre-processed foods that are normally packed and served or consumed when required. Thermal processing of foods is a widely used method for preserving food with extended shelf life, which normally refers to in-containers sterilization process in metal or glass rigid containers. In a still retort maximum temperature used is 121 ºC [6]. Very important is the product compatibility with packaging material, so the correct choice of packaging is one of the ways to maintain maximum product quality, while maintaining the nutritional value of the product [7]. More and more consumers are seeking products with smaller packaging. Re-sealability and cooking flexibility and flexible packaging offer these convenient solutions. In a world with consumers with busy lifestyles and the need for quick-to-eat food products, one packaging type may provide some solutions – it is 'Retort Pouch'. It is a Heat-resistant bag made of laminated plastic films or foil, which after refilling with food is heat-sealed and sterilized by pressure cooking in retort (autoclave) to yield commercially sterile state of food. As a result, the retort pouch contains heat-treated food which is safe from

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micro-organisms [8], [9]. The retort pouch is a packaging type that allows faster heat transfer than the traditional metal and glass containers, owning to their slimmer profile, or more specifically, the higher surface area to volume ratio [9], [10]. Prevention of recontamination of food, convenience and minimization of waste, more storage space and less labor costs are just some of the benefits of packaging [7]. Flexible retort pouch provides same conveniences as cans; in addition, flexible package has great advantages in saving cost and energy. Portability and light weight significantly reduces the storage space, truckload, transportation cost, and labor work. The flexible retort pouch is much easier for disposal after being used compare to cans. Printing on the plastic material provides vivid image and therefore better present the product [11]. Flexible package conform to all FDA features, have reduced cooking time, faster cycle time, improved taste/nutritional value, weight less packaging – increase utilization of warehouse space and reduces transportation costs, packaging differentiation increases sales volume.

The current state of the art in retort pouch processing has increased commercial value, and level of quality, safety, and convenience not realized by other means [9].

Innovation include faster and better preparation methods, improved temperature control, even heating, energy and labor savings, less waste, better sanitation, faster service and flexibility. Novel food service processes can evolve as a result of adoption of technological breakthroughs in “high tech” fields of the economy. This justifies investments in offensive research and highlights the importance of technical competencies for a food service professional [12]. Foods contained in a retort pouch taste better, consumers prefer the taste, texture, and nutritional benefits of foods packed in flexible packaging [13]. A sensory aspect of consumer choice ready to eat products is still highly influenced by the perception of its healthiness, safety, tenderness, juiciness and aroma or flavor [14]. The retort pouch is a fast-growing packaging technology in today's consumer world. Retort pouches generally give a better product quality thanks to a shorter processing time. One example of it is the study of Mohan et al., founding that prawn kuruma packed in retort pouches was superior to canned product regarding to color, firmness, chewing and overall acceptability [15]. Vacuum packaging prevents evaporative losses of flavor volatiles and moisture during cooking and inhibits off-flavors from oxidation [16]. Heat treated food to reduce both the vegetative microorganisms and the spores to a safe level are called sterilization. [Sterilization is typically achieved by using a pressure cooker to heat the center of the food to +250°F (+121 °C) for 2.4 minutes [17]. Sterilized foods are shelf stable, but are grossly overcooked and taste similar to canned foods [18]. Consumer demand for flexible pouches and plastic containers is rising, due to the growing preference for ready to eat meals and semi-cooked food products. Thus, while the market for retort pouches is currently only a niche one, it holds immense potential and opportunities for growth [19]. The retortable pouch has re-emerged as a packaging alternative for both conventional and aseptically processed foods [20]. Deterioration of foods during storage is dependent from 4 general factors: enzymatic, microbial, chemical and physical processes, which could be initiated in retort processing and expand throughout storage. Several processing and storage-induced quality changes in retort pouched foods have been studied and stated in the literature [21]–[23]. The sensory quality of food comes from the combination of a set of parameters concerning all the steps of product life, from the raw materials to the conditions of preparation [24]. Sensory analysis is one of the main quality indices in shelf-life and storage studies for foods, especially for products which are microbiologically stable such as heat stable meals [25]. Quality assessments including sensory evaluation, nutritive value, organoleptic properties, processing and product traceability; and quality indicators that may be useful to the consumers when buying food products [26].

Par-cooked in the packaging pouches fresh pasteurized baby whole potatoes; potato slices and cubes can be stored up to 5 weeks at the fridge. They retain all the nutritional goodness (mineral, fiber and vitamins) and flavor that they had before packaging [27]. Project of the National Aeronautics and space Administration (NASA) Human Research program is currently working to design a stable and nutritious food supply with acceptable quality for a minimum 3 to 5 years at ambient temperature [28].

The aim of this work was to assess the effect of retort thermal treatment of potatoes’ produce in vacuum pouch packaging made from polyamide / polyethylene (PA/PE) and aluminum / polyethylene (Al/PE) films with barrier properties and to evaluate the quality parameters during the storage time at ambient temperature.

II. Materials and Methods

A. Experimental Design

Experiments were carried out in the laboratories of Department of Food Technology, Latvia University of Agriculture. The object of the research was sliced potatoes ′Laura′, produced by stockholder Paplate 1, Latvia.

B. Packaging and Storage of Samples

The study involved preparation of raw material – potato peeling and cutting in slices, mixing with powdery butter and mushroom dressings (10% from the product mass), vacuum packaging of the products in polyamide / polyethylene (PA/PE) and aluminum / polyethylene (Al/PE) film pouches with barrier properties (size of 200mm x 2500mm, film thickness 80μm and 90μm), retort thermal treatment and following chilling. Control sample was selected sliced potatoes without dressings. Product mass in each pouch was 500±5g. The fresh product was packaged in vacuum and sealed by chamber type machine Falcon 2-70. The sterilization process was carried out in the conditions of production in French company’s "Lagard" Pārbaudīt rakstību horizontal autoclave

"Sterinover." Sterilization mode selected on the basis of the manufacturer's recommended processing parameters – sterilization temperature +121±2°C, cooling temperature +20±2°C. After The potatoes' produce samples used for experiment are summarized in Fig. 1.

The samples were stored in room temperature at +18±1ºC (controlled by MINILog, Gresinger electronic) and about 40% RH for 4 month under fluorescent light (OSRAM Lumilux De Luxe) with radiant fix at 100–800 lux (measured by Light meter LX-107). Throughout the storage period, the samples were randomly interchanged to minimize temperature fluctuations and light conditions.

At each time of measurement, two identical packages for each kind were randomly selected. The results were reported as averages of all determinations. Samples were analyzed after thermal treatment (day 0) and following 1, 2, 3, and 4 storage months.

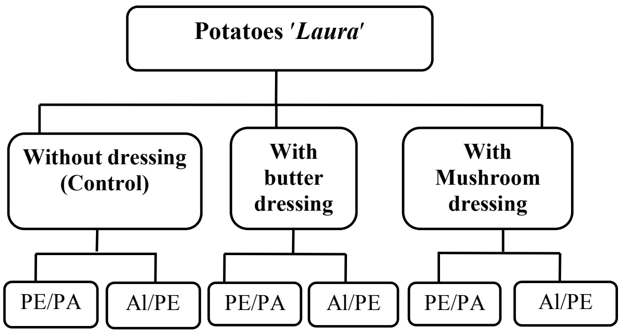

Fig. 1 Structure of performed experiments

C. Physical and Chemical Analysis

To define color and pH values, all samples of 200g were homogenised with mixer BOSCH Easy Mix 260.

- **Microbial analyses**: samples for microbiological testing were prepared by dilution method in conformity with standard LVS EN ISO 6887-1:1999 and 6887-4:2044. TPC (total plate count) – determined in conformity with standard LVS EN ISO 4833:2003 A; TPC was expressed as decimal logarithm of colony forming units per gram of a product (log10 $TPC \cdot g^{-1}$).
- **Color** changes of potatoes' produce samples were measured in CIE L*a*b* color system using Tristimulus Colorimeter measured Hunter color parameter changes: by Colour Tec PCM/PSM. Color values were recorded as L* (brightness), a* (-a, greenness, +a, redness) and b* (-b, blueness, +b, yellowness) [29]. Small pouches (20 x 20 mm) from transparent polypropylene (PP) polymer film were made for color measurements. The measurements were repeated on three randomly selected locations at the surface of each sample.

Total color difference (ΔE*), was calculated between color component measurements before packaging of samples and after the storage time according to (1):

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

where

L^*, a^*, b^* – value of potatoes' produce sample color components measured after thermal treatment;

L_0^*, a_0^*, b_0^* – value of potatoes' produce sample color components measured after storage time.

- **pH** values of the potatoes' produce samples were determined by JENWAY 3510 pH-meter using an electrode JENWAY (3 mol/KCl). Two identical packages were analyzed on three randomly selected locations on each sample.
- **Hardness** of potatoes' produce was determined as cutting force (in N) by using TA-XTplus Texture Analyser. Cutting force was determined for ten small potato 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 10mm/s and distance 10mm. At each time of measurement, two identical packages for each kind were randomly selected on sampling (day 0) and following 1, 2, 3, and 4 storage months; ten measurement repetitions of each sample were performed.
- **The liking degree** potatoes without and with dressings was evaluated immediately after thermal treatment and following 1, 2 and 3 months storage, the liking degree of potatoes products were characterized using a Hedonic scale ISO 4121:2003 [30]. The Hedonic scale was used to carry out the sensory evaluation of the samples; it helps to evaluate the liking degree of potato products. The analysis of variance ANOVA and Tukey's test were used to analyze the results of sensory evaluation ($p \leq 0.05$). Altogether 35 panelists – 28 females, 7 males (mean age 22), took part in the evaluation.

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 means of pH, color, hardness and microbiological properties. Compare Means, One Way ANOVA ($p \leq 0.05$) were used to determine significance of differences between means of the total color difference.

III. Results and Discussion

Initial pH of potatoes' produce without dressings (control samples – V1; and F-1) was 5.84±0.03, as we can see in Fig. 2. While the addition of dressings somewhat reduced the initial pH value from 5.84±0.03 to 5.74±0.02 ($p > 0.05$).

Significant difference in pH values among investigated potatoes' produce samples after 4 months storage was not found ($p>0.05$), and the increase of pH was not notable. Experimentally found that the packaging material does not affect the product pH changes during 4 months of storage.

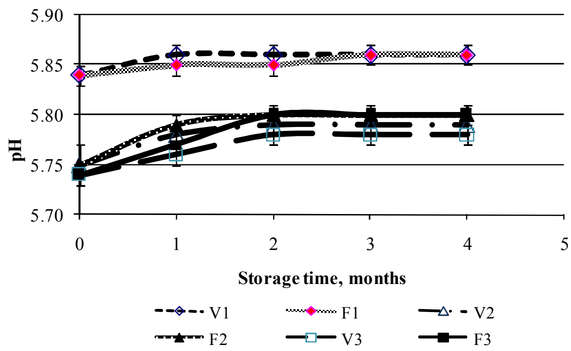

Fig. 2 The dynamics of pH value of potatoes product during storage time **V-1** – potatoes without sauce (control), PE/PA pouches; **F-1** – potatoes without sauce (control) Al/PE pouches; **V-2** – potatoes with butter sauce (control), PE/PA pouches; **F-2** – potatoes with butter sauce (control) Al/PE pouches; **V-3** – potatoes with mushroom sauce (control), PE/PA pouches; **F-3** – potatoes with mushroom sauce (control) Al/PE pouches

The dynamics of potatoes' produce hardness without and with dressings during the storage in both packaging materials are presented in Fig. 3. The observed hardness changes of potatoes has been various dependent from kind of dressings and used packaging materials, for all that after 4 month of storage it was not relevant among tested samples ($p>0.05$). The major reason can be water vapor migration during storage from product through the packaging material, which promotes hardness changes. The initial cutting force of all samples at the beginning of experiment was determined 8.5±0.3 N. Mouth feel, texture and eating qualities are adversely affected by loss of moisture. The mouth feel of all tested samples during investigated storage time was observed as acceptable.

Experimentally was observed that all the investigated samples are microbiologically safe because TPC both initially and throughout the studied samples during storage is less than 10cfu g^{-1}.

The influence of added dressings and packaging material type on the total color difference (ΔE*) has been calculated by (1) to describe the product overall color change during the storage time (Fig. 4).

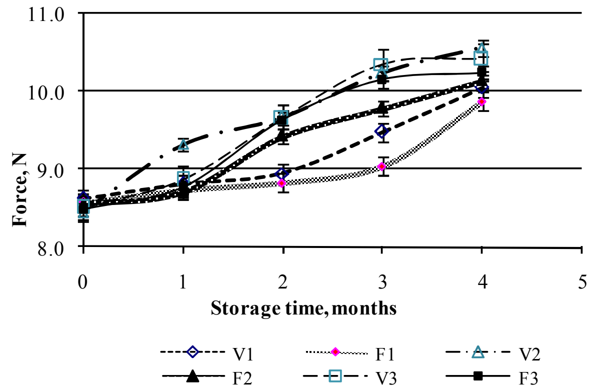

Fig. 3 The dynamics of potatoes' produce hardness during storage **V-1** – potatoes without sauce (control), PE/PA pouches; **F-1** – potatoes without sauce (control) Al/PE pouches; **V-2** – potatoes with butter sauce (control), PE/PA pouches; **F-2** – potatoes with butter sauce (control) Al/PE pouches; **V-3** – potatoes with mushroom sauce (control), PE/PA pouches; **F-3** – potatoes with mushroom sauce (control) Al/PE pouches.

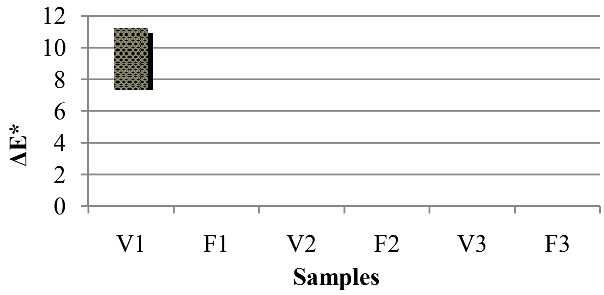

Fig. 4 The total colour difference (ΔE) of potatoes product samples during the storage time **V-1** – potatoes without sauce (control), PE/PA pouches; **F-1** – potatoes without sauce (control) Al/PE pouches; **V-2** – potatoes with butter sauce (control), PE/PA pouches; **F-2** – potatoes with butter sauce (control) Al/PE pouches; **V-3** – potatoes with mushroom sauce (control), PE/PA pouches; **F-3** – potatoes with mushroom sauce (control) Al/PE pouches

Total color difference (ΔE*) substantially differed of those samples packed in different packaging materials during storage time, what could be explained by influence of light and moisture loss during storage ($p<0.05$).

To describe the product overall color change during the four month storage time, the influence of packaging materials on the potatoes' produce (control) color is presented in Fig. 5. The packaging materials during 4 storage month substantially influence the color difference of potatoes' produce samples ($p<0.05$). Control samples packed in PE/PA after four months storage changes from intense yellow to light gray color (Fig. 5) indicating to significant decline in the quality of the product.

Fig. 5 The influence of packaging material on the potatoes (control) samples color after 4 storage months

Color and product liking degree are an important attributes because they are usually the first properties the consumer observes. The evolution results of liking degree of potatoes' produce without and with dressings are summarized in Figs. 6 – 8.

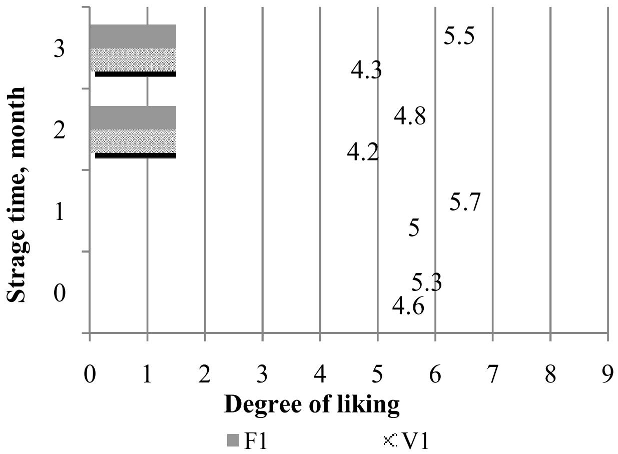

Fig. 6 Hedonic evaluation of potatoes' produce without dressings (control) packed in the PE/PA and Al/PA materials

In assessing the degree of liking of potato samples found that there is a difference between the two packages types of the packed products, but it is not essential ($p>0.05$), recognized as a more enjoyable samples packaged in Al/PA packs.

Mutually compared samples with and without sauces found pleasant samples with added sauces.

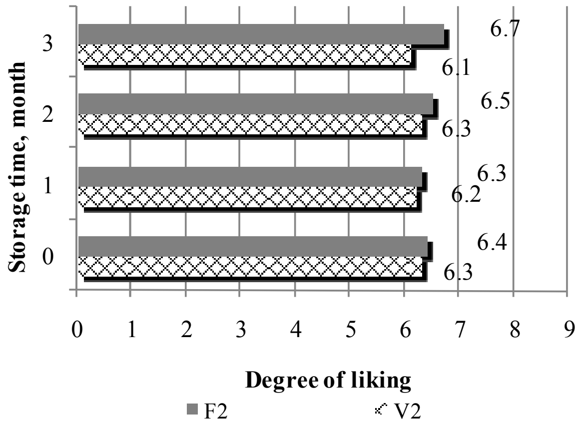

Fig. 7 Hedonic evaluation of potatoes' produce with butter dressings packaged in the PE/PA and Al/PA materials

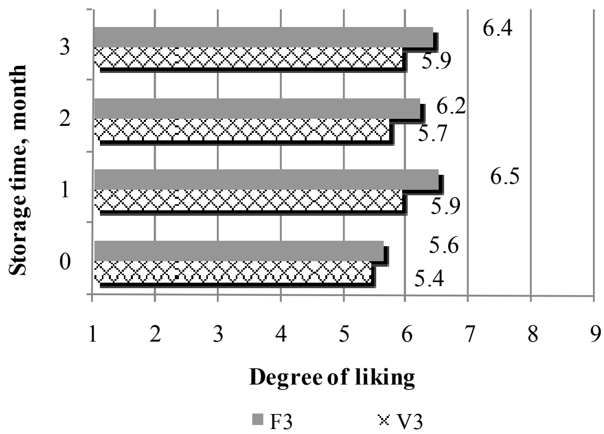

Fig. 8 Hedonic evaluation of potatoes' produce with mushroom dressings packaged in the PE/PA and Al/PA materials

IV. Conclusions

The obtained results can be summarized that Al/PA investigated packaging material is applicable for potatoes products packaging.

Thermal treatment was found effective in extending the shelf life of ready to eat retort sterilized potatoes' produce in flexible pouch packaging and storage at ambient temperature +18±2 °C.

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