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Sous Vide Packaging Technology Application for Salad with Meat in Mayonnaise Shelf Life Extension

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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 *sous vide* packaging during the storage time of salad with meat in mayonnaise at different storage temperature. Samples were evaluated at 0, 1, 3, 7, 10, 15, 18, 25, 29, 42, and 52 storage days at the storage temperature of +4±0.5 ºC and +10±0.5 ºC. Experimentally the quality of the salad with meat in mayonnaise was characterized by measuring colour, pH and microbiological properties. The *sous vide* packaging was effective in protecting the product from physical, chemical, and microbial quality degradation. The *sous vide* packaging significantly reduces microbial growth at storage temperature of +4±0.5 ºC and +10±0.5 ºC. Moreover, it is possible to extend the product shelf life to 52 days even when stored at +10±0.5 ºC.

***Keywords*—**salad with meat in mayonnaise, shelf life, *sous vide* packaging.

I. INTRODUCTION

SALAD with meat in mayonnaise is perishable food, having a short shelf life. *Sous vide* packaging is successful in extending the shelf life of ready-to-eat foods. This technology has been used for restaurants, catering establishments and industrial processing. Many studies have proved that, *sous vide* packaging is effective particularly for meat and meat products [1]–[5]. Nowadays, it is becoming increasingly popular because it affords convenient, ready-to-eat foods of high sensory quality, prevents evaporative losses of water and flavour volatiles during heat treatment, at the same time as it also maintains nutritional quality by reducing oxidative losses of nutrients during preparation and during storage [6].

Sous vide is an interrupted catering system in which raw or precooked foods are packaged under vacuum in heat stable, high gas barrier packaging materials, and then thermal treated (pasteurized) by controlled cooking in water, hot air or water steam below +100 ºC temperature. Heating is followed by rapid cooling. Then products are stored at 0 to +4 ºC refrigerated temperatures, distributed and retailed under refrigeration so as to inhibit the growth of aerobic microorganisms [7], [8]. The shelf life of *sous vid*es products ranges from 7 to 52 days and depends on the food composition [7]–[10].

Some studies [11], [12] declare results obtained from three-year experimental *sous vide* packed ready-to-eat foods testing, and find that in the *sous vide* packed ready-to-eat products the chances of survival and growth of pathogens seem very low since psychotropic, toxin-producing strains of bacillus or *Clostridium spp.* are rare or nonexistent due to the low oxygen tension produced in foods. Therefore at low storage temperature the health risk of these products seems small; accordingly for microbial testing of the ready-to-eat end products. *Sous vide* packaged food have received a lot of attention by researchers [13], [14].

Sous vide technology could afford a cooked product in better sensory quality that satisfies the consumer demands for foods with reduced or simple culinary preparation and extended shelf life [15].

The aim of this work was to assess the effect of *sous vide* packaging and storage at different temperatures of salad with meat in mayonnaise, as well as to obtain information about physical, chemical and microbial quality changes.

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 salads with meat in mayonnaise. Salads with meat in mayonnaise produced for a local market were used for the experiments. The ingredients in the salads were boiled potatoes and eggs, cooked beef, pickled cucumbers, salt, and mayonnaise Provansa (ingredients: vegetable oil, water, dehydrated eggs, sugar, salt, sourness adjusters (acetic acid, citric acid, sodium bicarbonate) dehydrated yolk, stabilizer (xanthan gum), flavouring (mustard seeds), preservative (potassium sorbate)) purchased on the local market.

B. Production and storage of salads with meat in mayonnaise

The study involved preparation of the precooked materials, vacuum packaging of the products in polyamide / polyethylene (PA/PE) film pouches with barrier properties (size of 200mm x 300 mm, film thickness 20/45 μm), *sous vide* processing and chilling. Mass of each sample was 200±1 g. The product was packaged in vacuum and sealed by

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chamber type machine MULTIVAC C300. The samples were pasteurized by two thermal treatment methods:

a. in a water bath "Clifton Food Range" at the temperature of +65±0.5 ºC. Generally the treatment time was within 50 min, including warming up (15 min), holding time (20 min) while the core temperature of the sample was reached +63±2 ºC. The cooling occurred in two steps: with water from an artesian well at +14±1 ºC temperature for 5 min, which was follow by ice water cooling at +1 to +2 ºC for 5 min [16].
b. in a convection steam oven "FCV10E, Tecnoinox" at temperature +65 ±0.5 ºC. Total thermal treating time within 80 min, including warming up (20 min), holding time (20 min) while the core temperature of the sample was reached +63±2 ºC. The cooling time in the defrosting cabinet (Foster, FXBC 10) was 40 min until the sample reached the temperature +5±1 °C.

As a control the salad with meat in mayonnaise was packed in traditionally used polystyrene (PS) containers (size 100 mm x 80 mm x 25 mm, thickness 30±3 μm) covered with non-hermetical lids, mass of sample 200±1 g. The samples of salad used for experiment are summarized in Fig.1. The experiments were carried out for two storage regimes: +4±0.5 °C (an appropriate storage temperature for *sous vide* products), and +10±0.5 °C (temperature provided in domestic refrigerators and in some retail display cabinets [17]). The samples were stored in Commercial Freezer/ Colder ELCOLD temperature (recorded by MINILog, Gresinger electronic) within 52 days 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 treatment were randomly selected on sampling days 0, 1, 3, 7, 10, 15, 18, 25, 29, 42, and 52 for analysis. To define colour and pH values, all samples of 200 g were homogenised with mixer BOSCH Easy Mix 260.

C. Physical and chemical analysis

Colour changes of salad with meat in mayonnaise samples were measured in CIE L*a*b* colour system using Tristimulus Colorimeter measured Hunter colour parameter changes: by Colour Tec PCM/PSM. Colour values were recorded as L* (brightness), a* (-a, greenness, +a, redness) and b* (-b, blueness, +b, yellowness). Small pouches (20 mm x 20 mm) from transparent polymer film were made for colour measurements. The measurements were repeated on three randomly selected locations at the surface of each sample.

pH values of the salad with meat in mayonnaise 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.

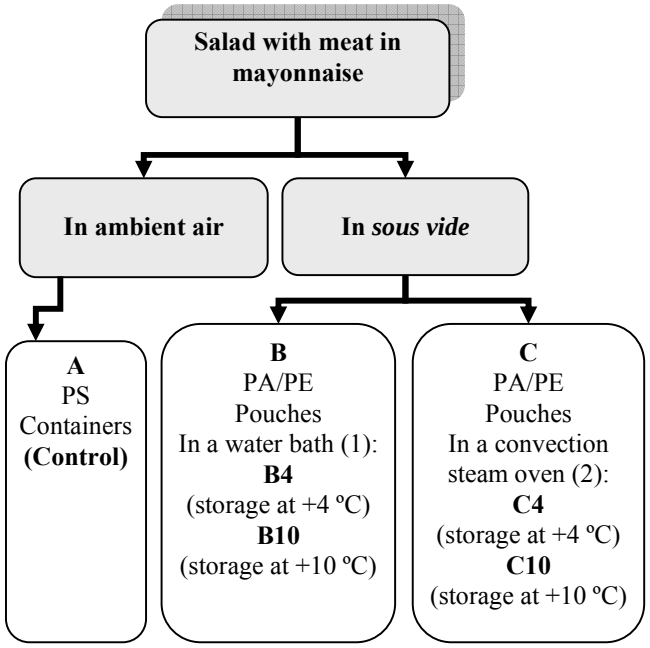

Fig.1. Structure of performed experiments.

D. Microbiological analysis

Microbial analyses was performed to control the shelf life of salads with meat in mayonnaise thermal treated by two heating methods, the total plate count test was performed by the methods of colony count technique at +30 ºC in accordance with International Standard ISO 4833:2003. A salad sample with meat in mayonnaise (amount of each 10 g) was removed from each package, placed in a stomacher bag; 90 ml of 0.1% peptone water were added and then homogenized with a stomacher (Bag Mixer 400) for three seconds. After preparing serial decimal dilutions of the homogenate with 0.1% peptone water, duplicate plates were prepared using pour plate method for enumeration. Total viable counts were determined on Plate Count Agar with incubation at +30±1 ºC for 72±3 h. After the specified period of incubation, each dish containing 15–300 colonies, the total forming units (CFU) was counted and multiplied by the dilution factor to determine CFU $\cdot g^{-1}$ of the salad with meat in mayonnaise. The results were evaluated by Guidance Note No. 3, 2001 Guidelines for the Interpretation of Results of Microbiological Analysis of Some ready-to-eat foods Sampled at Point of Sale [18]. According to the guidelines, salads are adapted to vegetable food group (prepared mixed salads and crudités) and meat food group (meat, sliced (cooked ham, tongue)) which belong to category D, accordingly could be acceptable up to 10^6 - 10^7 cfu $\cdot g^{-1}$. The results are defined like $< 10^6$ cfu $\cdot g^{-1}$ satisfactory (means that the test results indicate good microbiological quality), 10^6 - $<10^7$ cfu $\cdot g^{-1}$ acceptable (is suggested to take account of the limitations in microbiological sampling, handling, testing and wide confidence limits in enumeration - due to these factors, some samples will fall between what is considered satisfactory and

unsatisfactory), and $\geq 10^7$ g^{-1} unsatisfactory (indicates that the acceptability threshold has been exceeded) [18]. All the determinations were made in duplicate.

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

III. RESULTS AND DISCUSSION

The aim of this work was to assess the effect of *sous vide* packaging during the storage time of salad with meat in mayonnaise at two different storage temperatures +4±0.5 ºC and +10±0.5 ºC at the same time to determine the salad's quality during the storage.

The influence of storage temperature and *sous vide* thermal treatment methods on the total colour difference (Δ E*) has been calculated by equation (1) to describe the product overall colour change during the storage time (Fig.2.).

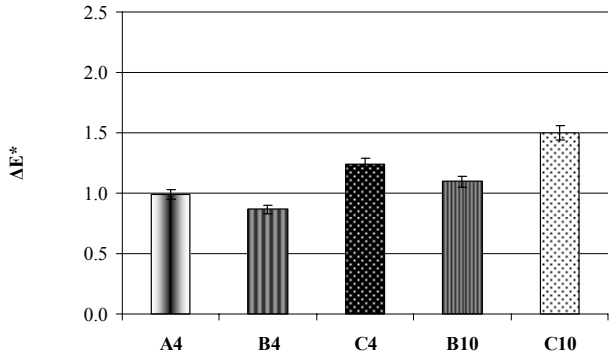

Fig. 2. The influence of storage temperature and thermal treating methods of *sous vide* technology on the total colour difference ΔE^*. **A4** – in ambient air (control), at +4 ºC; **B4** – *sous vide* (1), at +4 ºC; **C4** – *sous vide* (2), at +4 ºC; **B10** – *sous vide* (1), at +10 ºC; **C10** – *sous vide* (2), at +10 ºC

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

where

ΔE^* : total color difference
$L^* - L^*_{day0}$: difference of lightness
$a^* - a^*_{day0}$: difference of green and red colour
$b^* - b^*_{day0}$: difference of blue and yellow colour

The calculated total colour difference (Δ E*) of examined samples has been observed notable. Comparing the control sample, and samples processed by *sous vide* technology two thermal treating methods (in water bath and in a convection steam oven "FCV10E, Tecnoinox") stored at +4 ºC (B4; C4), as well as samples stored at +10 ºC (B10; C10), it is found that disparity in colour difference does not exist ($p>0.05$). *Sous vide* technology sample C10 due of storage at +10 ºC temperature increased the difference value more then 1.5 times and for sample C4 storage at +4 º C temperature increased the difference value 1.25 times compare with control sample.

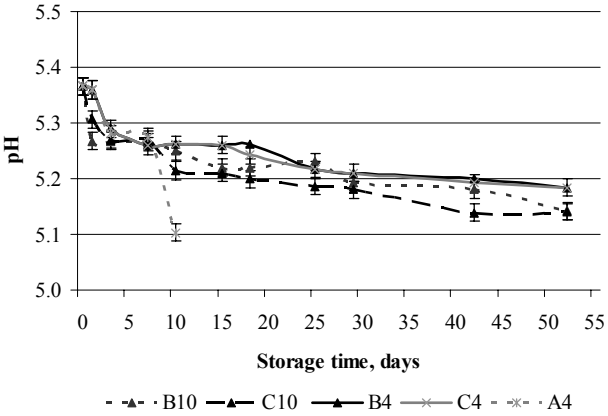

Fig. 3. Dynamics of pH values during storage time at temperature +4±0.5 ºC and +10±0.5 ºC

A4 – in ambient air (control), at +4 ºC; **B4** – *sous vide* (1), at +4 ºC; **C4** – *sous vide* (2), at +4 ºC; **B10** – *sous vide* (1), at +10 ºC; **C10** – *sous vide* (2), at +10 ºC

At the beginning of storage experiments pH value of salad was 5.37, but during storage time it slightly decreased (Fig.3.). pH values of all samples after storage time for 52 days achieved 5.15 in average. Difference between *sous vide* technology (1) and (2) processed samples and stored at +4 ºC as well as at +10 ºC during storage time was not significant ($p>0.05$).

According to the standards for the microbiological quality of ready-to-eat foods indicated by Food Safety Authority of Ireland, mixed salads have been considered unsatisfactory when their total count of microorganisms surpass 10^7 cfu $\cdot g^{-1}$.

The total count of microorganisms in *sous vide* (1), (2) packaged salads stored at +4 ºC and +10 ºC temperature generally rapidly decreased at the thermal treatment and cooling processes, whereas considerably increased for the control sample packaged at air ambience and stored at +4 ºC (Fig.4). The thermal treatment at ambient temperature +65±0.5 ºC, core temperature of sample +63±2 ºC after about 15 min (B samples), and 20 min (C samples) rapidly destroyed the total count of microorganisms. Taking into account that our accepted temperature regime usually is considered being a mild thermal treatment [1], and in this case complete bacterial inactivation cannot be achieved. Initially, the average value of microorganisms in tested samples was 4.0 log cfu $\cdot g^{-1}$. This value increased after the first day of storage for control sample (till 4.1 log cfu $\cdot g^{-1}$), but considerably decreased till 2.3 log cfu $\cdot g^{-1}$ for sample B10, till 2.4 log cfu $\cdot g^{-1}$ for sample C10, and till 2.2 log cfu $\cdot g^{-1}$ for samples B4 and C4. Assuming that 10^7 log cfu $\cdot g^{-1}$ of total count of microorganisms is allowed to be the total viable count limit of acceptance, after ten days the salad with meat in mayonnaise of the control sample was considered to be spoiled, were still acceptable in *sous vide* technology (1), (2) at +4 ºC and +10 ºC temperature.

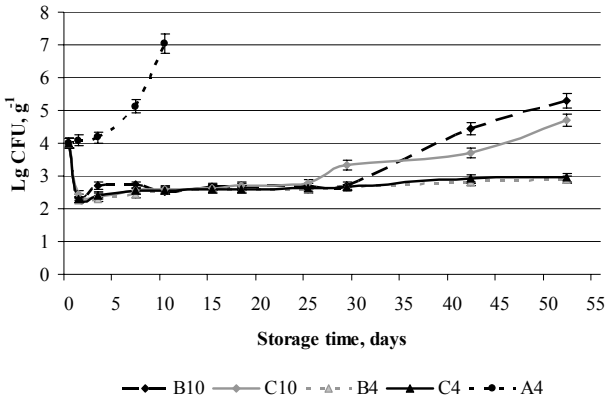

Fig..4. Microbiological indices of salad with meat in mayonnaise at storage temperature +4 ºC and +10 ºC.
B10 – *sous vide* (1), at +10 ºC; **C10** – *sous vide* (2), at +10 ºC; **B4** – *sous vide* (1), at +4 ºC; **C4** – *sous vide* (2), at +4 ºC; **A4** – in ambient air (control), at +4 ºC

The microbiological pollution of of *sous vide* (1), (2) technology packed and thermal treated salads stored for 52 days at +4 ºC temperature was in sample B4 – 2.8 log cfu·g^{-1}, in C4 – 2.9 log cfu·g^{-1}, in B10 – 5.2 log cfu·g^{-1}, and in sample C10 – 4.6 log cfu·g^{-1}. The numbers of microorganisms presented were significantly different ($p \leq 0.05$) between the control and *sous vide* technology samples stored at +4 ºC and +10 ºC temperature. The microorganisms of *sous vide* treated salad did not increase significantly ($p > 0.05$) during the storage time when stored at +4 ±0.5 ºC and +10 ±0.5 ºC for 52 days. However, a small difference in total count of microorganisms was obtained at +10 ±0.5 ºC after 25 days of storage in sample C10 (2.7 log cfu·g^{-1}) and after 29 days of storage in sample B10 (2.7 log cfu·g^{-1}), increasing in sample B10 till 4.6 log cfu·g^{-1} and sample C10 till 5.2 log cfu·g^{-1} after 52 days of storage. The sample's storage temperature was important preservation factor.

Sous vide (by thermal treatment method in water and in steam) technology delayed any microbiological activity in salad samples the storage conditions at +4±0.5 ºC and +10±0.5 ºC. Before salad's commercialization necessary condition is to perform challenge test with pathogenic microorganisms to determine the safety of the product, as has been suggested in the guidelines for the development of *sous vide* products [19].

IV. CONCLUSIONS

The *sous vide* packaging technology of salad with meat in mayonnaise (thermal treatment method in water bath and steam) significantly reduces the microbial growth at storage temperature of +4±0.5 ºC and +10±0.5 ºC, and it is possible to extend the product shelf life till 52 days even at the storage temperature +10±0.5 ºC. On the contrary, control sample (salad with meat in mayonnaise packaged in air ambience) showed considerable spoilage and became microbiologically spoiled after 7 days of storage at +4±0.5 ºC.

Sous vide technology was found effective in extending the shelf life of salads with meat in mayonnaise at storage temperature +4±0.5 ºC and +10±0.5 ºC.

The shelf life testing of the *sous vide* technology packed samples indicate that both the thermal treatment methods – in water bath as well as in the steam provide successful extending of salad shelf life at storage conditions +4±0.5 ºC and +10±0.5 ºC temperature.

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