HDPE POLYMER AND BIODEGRADABLE PACKAGING, EFFECT ON THE SHELF LIFE PASTEURISED EGG WHITE

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Abstract

Biodegradable packaging materials play an important role in maintaining the save of environment. The growing requires for increased fresh food shelf life as well as the need for protection against foodborne diseases urged the development of quality food packaging. Plastic products have become a significant contaminant in environmental ecology due to their recalcitrant biodegradation, poor management, and dangerous disposal. Current and future advances in shelf life estimation have the potential to improve the safety, reliability, and sustainability of the food supply. Selection desired kind of packaging will help to predict the shelf life of the product. The packaging protects the products from shocks, ambient temperature, microbiological deterioration, and other external factors. This manuscript aimed was to analyse the differences between the two types of packaging, the effect of packaging on the shelf life pasteurised egg white. Pasteurised egg white has a shelf life of up to 40 days, which makes it difficult to increase the exportation of this product. The technological process allows the product to be packaged using a polymer can (HDPE), which does not make it possible to obtain stable fulfilment of the requirements or Tetra Rex® Bio-based packaging were used as an alternative. Tetra Rex® Bio-based is produced solely from a combination of plastics derived from sugarcane and paperboard. Shell egg mass was pasteurised with pasteurisation process continuing for 60 minutes, maximum temperature from 55°C to 57°C (holding time: 180 seconds). The changes in qualities of samples during storage were characterised by measuring total bacterial count (CFU/g) at start of shelf life, with method: LVS ISO 4833-1:2014 and pH (pondus Hydrogenii), method: GOST 31469 -2012. Data that was obtained emphasises the importance of packaging type, which could provide a stable quality to use products for a duration up to 60 days.

Keywords: *bio-based packaging, high-density polyethylene, shelf life, pasteurised liquid product*

1. INTRODUCTION

The industrial path of development, which has been the principal for many decades in the world, was based on the intensive use of mainly non-renewable resources. Using this approach has increased productivity and improved food security in many countries. However, this trend has led to several negative issues, such as environmental pollution, reduced food quality, and various regional socio-economic problems. Thus, in 2017, 173 kg of packaging waste per person was produced in the EU (it varies from 64 kg in Bulgaria and 231 kg in Luxembourg respectively) [20; 22]. During the studied decade (2007-2017), paper and cardboard were the main components of all packaging waste (31.2 million tons or 41 % in 2017) ("Packaging Waste Statistics" 2020). Plastic ranks second in the total volume of packaging waste (14.5 million tons or 19% in 2017) [16]. The growth in cardboard and plastic garbage volumes over this period was 12.1% and 1.1%, respectively [15]. The main advantage of cardboard as a packaging material is the possibility of its processing, which explains the increase in its use. At the same time, even though the target of 55% of recycled waste has been achieved by almost all EU member states, reducing the level of plastic waste is still an essential task for the entire region and countries, as well as for an individual producer [17].

In recent decades, meeting environmental requirements have been playing one of the leading roles in the system of human consumer values. Environmental friendliness of products is formed at all stages of the life cycle, is an object of standardization and certification, and also requires proper packaging [19].

Food packaging assists several purposes, allowing food to be transported safely over long distances and stored for long periods. The principal roles of food packaging are to protect food products from outside

influences and damage, to contain the food, and to provide consumers with ingredients and nutritional information [8]. Some of the secondary packaging goals include traceability, convenience, and anti-counterfeiting [7;14].

Reducing the level of food waste and waste from used packaging can be achieved in two ways: by increasing the shelf life of products, as well as replacing plastic packaging with an environmentally friendly counterpart [3;4].

Eggs are a very nutritious, cheap food product, which is used in the cooking traditions of most nations [3]. At the same time, egg safety has become a global problem with the emergence of pathogens Salmonella Enteritidis as the main danger associated with the consumption of uncooked eggs [5]. By 1993, the prevalence of Salmonella enteritidis has reached epidemic proportions in many countries [11;15]. Unlike the other Salmonella serotypes, this microorganism infects an egg before it is laid, and the bacterium penetrates the egg before an eggshell is formed [9]. Heat treatment and appropriate proper boiling of eggs, thus killing the microorganism, destroy salmonella enteritidis. Nevertheless, the usage of uncooked eggs is still quite common both at home and in some sophisticated recipes. Pasteurization of eggs before the sale excludes or at least decreases the risk of infection of Salmonella enteritidis foods [12]. In addition to providing safe eggs, pasteurization also leads to the possibility of a significant increase in the shelf life of eggs [2].

Thus, pasteurization of liquid egg white and correctly selected packaging allows solving two problems of reducing garbage at once: increasing the shelf life and the use of biodegradable packaging. This study aims to investigate the dynamics of the central chemical indicators in the pasteurized eggs stored under constant environmental conditions and packaged in HDPE and biodegradable pack [14].

2. MATERIALS AND METHODS

The study was conducted at Latvia University of Life Science and Technologies in Jelgava, Latvia,

Study period: This study was carried out during 76 days, the period from November 28st 2019 year to February 12rd 2020 year to estimating some indicators of posteurised liquid egg white.

Sample collection: A total of 55 samples of posterized egg white packaged in biodegradable Tetra Rex® Bio-based and 55 samples of posterized egg white packaged HDPE packaging.

During the storage of food products, including pasteurised egg white due to the physicochemical and microbiological processes occurring in them, not only their quality decreases, but their safety indicators also change. Shelf-life is the period throughout which food has its acceptable or desirable properties under defined storage and handling requirements [4]. These acceptable or desirable attributes can be associated with the safety or quality of the product and can be microbiological, chemical or physical in nature.

Studied samples of pasteurized egg white are considered proper from the moment they were produced until the beginning of the deterioration of microbiological indicators. Based on previous studies, it was found that the main factors affecting the shelf life of eggs are temperature storage conditions, processing methods, and packaging methods. However, for the implementation of the experiment and the subsequent mathematical processing of its results, the factors must be controllable and have a sufficiently high measurement accuracy.

Liquid egg white was pasteurised with the equipment Ovobel AR56SH, with pasteurisation process resuming for 60 minutes, the highest temperature from 55°C to 60°C (holding time: 180 seconds). The indicators studied are the total number of bacteria count (CFU/g), *pH* (pondus Hydrogenii), the solids content in egg white. Measuring of total bacterial count (CFU/g) was providing with method LVS ISO 4833-1:2014 and *pH* (pondus Hydrogenii) was estimated with method GOST 31469 -2012. For the estimations, the instrument pH metrs JENWAY 3510 was used.

The collected results were estimated by the MS Excel program package using the methods of descriptive statistics; arithmetic mean values and standard deviation were determined for each parameter. ANOVA

methods were used for analytical analysis; p-values less than 0.05 were admitted to be statistically meaningful.

3. RESULTS AND DISCUSSION

HDPE is a high molecular weight, high density polyethylene copolymer which has a broad molecular weight distribution. The design of the product, molecular architecture, and density gives it a unique combination of easy extrusion and high melt strength with strong physical properties which makes it suitable for producing thin films with excellent strength and rigidity [1;7]



a) b)

Fig. 1. a. – HDPE row materials, b.- HDPE plastic package.

The Tetra Rex® Bio-based package is a symbol of freshness and convenience. Now, the world's first fully renewable package is available with the Tetra Pak® Craft packaging material effect, further enhancing its distinctiveness on the shelf [21]



a) b)

Fig. 2. a. – Tetra Pak Tetra Rex® Bio-based packaging layers of packaging, b. - Tetra Rex® Bio-based package.

The basic functions of food packaging [5, 9, 13] are:

- Containment of the product
- Protection of the product
- Communication with the consumer
- Convenience to the consumer

These are often interdependent. The fulfilment of the four functions must be combined with the minimum possible cost. Since the cost of packaging for food products is usually a significant proportion of the total cost, the use of the least expensive, but appropriate for the food, packaging is preferred. Thus, an ideal package delivers to the consumer a safe, quality food in a convenient way and at minimum cost. In addition to the four basic functions, three other functions have been introduced [9] placing more requirements on food packaging:

- Production efficiency (or machinability)
- Minimal environmental impact
- Package safety

With the increase in population during the last decade, an increasing problem of contamination due to the indiscriminate use of plastics and their disposal has been observed around the world, causing serious problems to the environment. For this reason, a large number of investigations focus on the study of compounds and materials of natural origin for the generation of plastics with short degradation time or for their incorporation into existing ones and modify the degradation times [1;10].

First criteria which describe product quality on the first day after production is Total bacterial count (CFUg1). These criteria allowed max. ≤1×105 (CFUg1) method LVS ISO 4833-1:2014. Pasteurized egg white issued in practical laboratories showed different measure of criteria – total bacterial count. The results of the experiment can be analysed using a graphical interpretation of the values of total bacterial count (Figure 3).

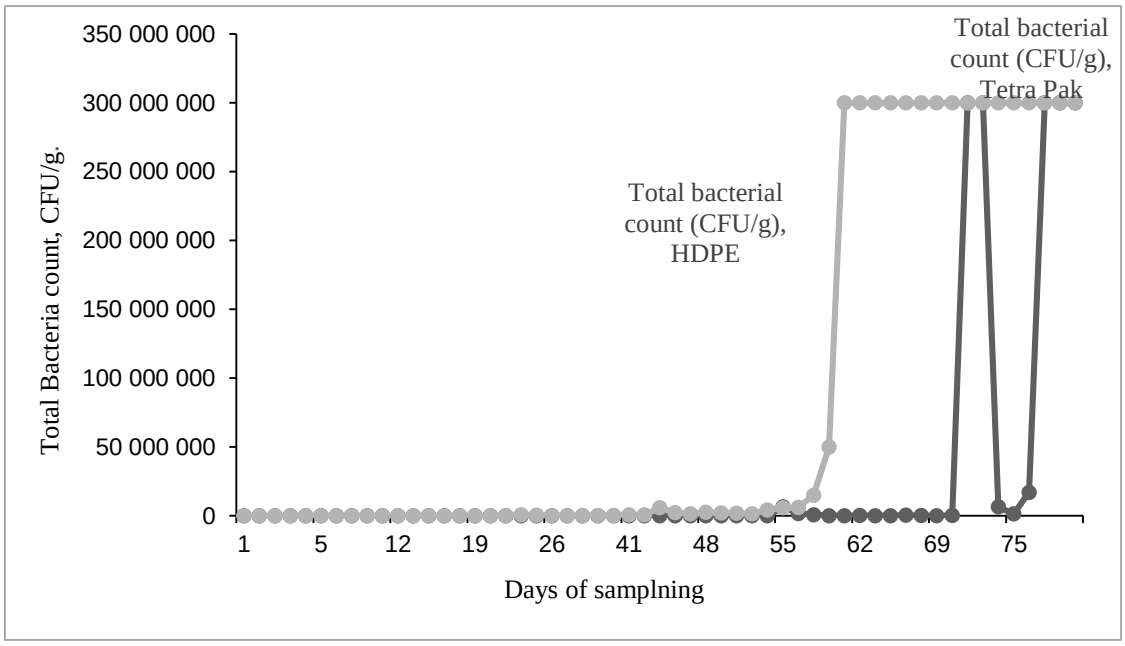


Fig. 3. Variation during the period of seventy six days of shelf life: grey line is Total Bacterial count (CFU/g) HDPE plastic packaging and black line is Total Bacterial count (CFU/g) Tetra Pak Tetra Rex® Bio-based.

Based on the study of the total number of bacteria in pasteurized egg white both in biodegradable and in plastic packaging, it was determined that the number of bacteria varies and depends not only on time but also on the type of packaging materials.

The total mean can be obtained as the arithmetic mean of group means. Group averages of the total number of bacteria in each type of packaging are presented in Table 1.

	Total bacterial count (CFU g^1), Tetra Pak	**Total bacterial count (CFU g^1), HDPE**
Total bacterial count sum	1 534 687 040	4 902 034 790
The arithmetic mean	27903400,73	89127905,27

Table 1. Total bacterial count analysis

The total mean:

$$\bar{x} = \frac{117031306}{2} = 58515653$$

The total sum of the squared deviations of the options from the total average:

$$S_t = \sum\sum\left(x_{ij} - \bar{x}\right) = 1.51659947988\text{E} + 18$$

The factor sums of squared deviations of group averages from the total average, which characterizes the influence of this factor:

$$S_f = q\sum(\overline{x_{ij}} - \bar{x}) = 1.413517381075E + 18$$

The factor variance:

$$S_f^2 = \frac{S_f}{p-1} = \frac{1.03082098813E + 17}{2-1} = 1.03082098813E + 17$$

Residual variance:

$$s^2 = \frac{S_f}{p(q-1)} = \frac{1.413517381075E + 18}{2(55-1)} = 0$$

A comparison of the estimates of these variances by the Fisher criterion showed that result values do not differ significantly.

pH levels and the percentage of the solids content in eggs do not differ depending on the type of packaging. The arithmetic mean for pH is

$$\bar{x} = \frac{\sum x_i}{n} = \frac{399.77}{2} = 7.27$$

The average linear deviation is calculated in order to take into account the differences of all units of the studied population.

$$\text{d} = \frac{\sum|x_i - \bar{x}|}{f} = \frac{10.397}{55} = 0.19$$

Each value of the series differs from the other by an average of 0.19.

Dispersion - characterizes the measure of dispersion (deviation from the average) around its average value (measure of dispersion, i.e. deviation from the average):

$$D = \frac{\sum(x_i - \bar{x})^2}{n} = \frac{4.687}{55} = 0.0852$$

Standard deviation.

$$\sigma = \sqrt{D} = \sqrt{0.0852} = 0.292$$

Each value of the series differs from the average value of 7.27 by an average of 0.292.

The arithmetic mean for the percentage of the solids content in eggs is:

$$\bar{x} = \frac{\sum x_i}{n} = \frac{609.75}{55} = 11.09$$

The average linear deviation:

$$d = \frac{\sum|x_i - \bar{x}|}{f} = \frac{5.713}{55} = 0.1$$

Each value of the series differs from the other by an average of 0.1.

Dispersion:

$$D = \frac{\sum(x_i - \bar{x})^2}{n} = \frac{0.947}{55} = 0.0172$$

Standard deviation.

$$\sigma = \sqrt{D} = \sqrt{0.0172} = 0.131$$

Each value of the series differs from the average value of 11.09 by an average of 0.131.

Food packaging is denoted as a coordinated system of preparing food for transport, distribution, storage, retailing, and end-use to satisfy the ultimate consumer with optimal cost [6]. Food packaging is an essential part of modern society; commercially processed food could not be handled and distributed safely and efficiently without packaging. The World Packaging Organization (WPO) estimates that more than 25% of food is wasted because of poor packaging [19].

Thus, it is clear that optimal packaging can reduce a large amount of food waste. Moreover, the current consumer demand for convenient and high-quality food products has increased the impact of food packaging [1; 12].

Protection of food packaging / materials in contact food during storing or handling food and prevention of migration of any unwanted non-food components to food are main tasks of food packaging [8; 18].

4. CONCLUSIONS

The results of this study indicated the follows: Evaluation of the entire change in the criterion, reflecting the total number of bacteria, demonstrated a different speed in reaching its maximum value, which directly affects the shelf life of the product. Nevertheless, its maximum value does not depend on the type of packaging. Some changes in the pH criterion are observed, but they are comparable in both packages, are reasonable, and do not affect the shelf life of the product. The percentage of solids is similar in both packages, is healthy, and does not affect the shelf life of the product. Pasteurized egg white in both packages according to test results did not withstand a shelf life of sixty days.

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