# BIODEGRADABLE PACKAGING IMPACT ON SHELF LIFE OF PASTEURISED EGG WHITE

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**Abstract.** The growing requirements for increased fresh food shelf life, as well as the need of protection against foodborne diseases urged the development of quality food packaging. Current and future advances in shelf life estimation have the potential to improve the safety, reliability, and sustainability of the food supply. Selection of desired kind of packaging will help predict shelf life of products. The newly designed active and intelligent packaging is a packing technology, which allows for such product safety and quality demands to be achieved. The aim of this work was to analyse the differences between two types of packaging, the effect of packaging on shelf life of pasteurized egg white. Pasteurized egg white has a shelf life of up to forty days, which makes it difficult to increase the exportation of this product. The technological process allows the finished 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 was used as an alternative. Tetra Rex® Bio-based is produced solely from a combination of plastics derived from sugarcane and paperboard. Samples of pasteurized egg white in an HDPE package showed a critical norm of Total bacteria max $\leq 1 \times 10^5$ (CFU·g$^{-1}$) by the thirtieth day of the expiration date. However, the samples in the Tetra Pak® Bio-based package showed the criteria of Total bacteria max $\leq 1 \times 10^5$ (CFU·g$^{-1}$) growth indicators on the forty-eighth day. The changes in qualities of samples during storage were characterized by measuring total bacterial count (CFU·g$^{-1}$) at start of the shelf life, with the method: LVS ISO 4833-1:2014 and *pH* (*pondus Hydrogenii*), method: GOST 31469-2012. As a result of the tests, pasteurized liquid egg white samples sixty units of samples in HDPE package and sixty units in Tetra Rex® Bio-based package were analysed. The data that were obtained emphasize the importance of the packaging type, which could provide stable quality of ready to use products for duration of up to 60 days.

**Keywords:** egg white, shelf life, packaging, tetra pack, HDPE, pasteurised.

## Introduction

With the increase in population during the last decennary, an increasing problem of pollution due to the huge use of plastics and their deletion has been observed around the world, having serious problems to the environment. Large quantity of investigations focuses on the study of combination of materials of natural origin for the generation of plastics with short degradation time, or for their incorporation into existing ones and modification of the degradation times. Within the total production of plastics in the world amounting to 140 million tons, those that are used in the food industry makeup two-thirds of the total volume and the difficulty in achieving their recycling and avoiding their use is still a challenge today. Biodegradable packaging forms a great vitality alternative for this sector of the industry, due to the multiple varieties of materials used in its manufacture [1].

Shell eggs are a perishable product and are consumed in large quantities in plastic packaging or moulded fibre egg packaging. According to the EU regulation No. 589/2008, the shelf-life of an egg allowing the product to be used in ambient temperature is at least 28 days. In the event of a decrease in sales of shell eggs, farmers need to process a fresh egg for further purchases – this product is whole shell egg liquid mass, liquid egg white and liquid egg yolk. These products can be implemented with an expiration date from thirty until forty days. For these products the shelf life is a significant criterion and correct choice of packaging is priority [2].

Over the past few decades, the production of egg products has been constantly increasing. In the period 2018-2019, total in European countries egg production increased more than 20 %, with approximately 290000 tons in liquid equivalent [3; 4].

The food product is packaged for storage, preservation, and protection traditionally for a long time. These three criteria are the essential functions of food packaging that are still required today for better maintenance of quality and handling of foods. In addition to these primary functions of food packaging, more superficial features are required for food marketing, distribution, and consumer-related issues, which are to provide the required information, handling and dispensing convenience, sales promotion, and stock management. No matter what new fancy function of packaging is explored, the first priority should be serving the essential functions of food packaging [5].

Consumers await from food packaging are protected food products from outside influences and damage, to support the food, and to provide consumers with ingredients and nutritional information. Traceability, convenience, and tamper indication are secondary functions of increasing importance. The goal of food packaging is to contain food in a cost-effective way that satisfies industry requirements and consumer desires, maintains food safety, and minimizes environmental impact [6].

The various materials used in the manufacture of food packaging provide physical protection, as well as the necessary physicochemical conditions for the maintenance of food quality. Besides the protection of food, it is increasing the interest of the industry for the so-called intelligent and active food packaging, which can monitor and change the environmental conditions of packaging in real-time. Intelligent and active food packaging can be developed using biodegradable or non-biodegradable polymers or a combination of both. Among the biodegradable polymers, most, such as carbohydrates (starch, chitosan and alginate) and gelatine (proteins) are obtained from renewable sources, and since they are biodegradable, they have a clear environmental advantage [7].

There are few of raw materials that can be employed for packaging production. For the liquid egg mass, either a polymer (HDPE) or Tetra Rex® Bio-based packaging is preferred [8].

HDPE is a high-density high-pressure polyethylene (HDPE plastic). It is a very safe plastic, which does not emit almost any harmful substances. Specialists recommend, if possible, buying water in these bottles. This is a hard type of plastic, which is most often used for storing milk, food products, detergents and is utilised in the production of a certain kind of plastic bags. This is the kind of material, from which the majority of sports and reusable tourist bottles are made [6].

Tetra Rex® Bio-based packaging is a modern, complicated, yet effective method for storing various foods. The primary material in all Tetra pack packages is paperboard. The Tetra pack packaging material structure from the inside package is as follows: two layers of polyethylene, aluminium, polyethylene, paperboard and more polyethylene on the outside of the package. Tetra Pack Tetra Rex® Bio-based from the inside package is as follows: two layers of polyethylene, paperboard and one-layer polyethylene on the outside of the package [9].

The aim of this study was to analyse the differences between two types of packaging effects on pasteurized liquid egg mass shelf-life.

## Materials and methods

Liquid egg white from company Balticovo JSC was used in the research. Liquid egg white was pasteurized using the plate pasteuriser Ovobel AR56SH. The conventional pasteurization method lasted from 55 ℃ to 60 ℃ for 6 minutes. After pasteurization the liquid product was packed in two kinds of packaging: the first samples were packed in HDPE bottles 1L, 60 units of samples with code OB1428-1B. The second samples were packed in Tetra Rex® Bio-based package 1L, 60 units of samples with code OB1428-1T. The first samples of OB1428-1B were packed using equipment Gercini, the second samples OB1428-1T were packed using equipment Galdi RG50UCS. Pasteurized egg white was stored at temperature +2 to +6 ℃ for sixty days at two types of packaging.

Total bacterial count ($CFU \cdot g^{-1}$) was established according to the standard LVS ISO 4833-1:2014. pH value determined according to the standard GOST 31469-2012,14 and ISO 1842:1991, using equipment Jenway 3510 Benchtop PH Meter.

For data analysis arithmetical values and standard deviations in Microsoft Excel v16 software were used. The impact of factors and their interaction, the significance effect (p-value) were explored with Anova: Single Factor statistical model.

## Results and discussion

HDPE is high molecular weight, high density polyethylene copolymer, which has a broad molecular weight distribution. The design of the product, molecular architecture, and density give 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 [10].

a) b)

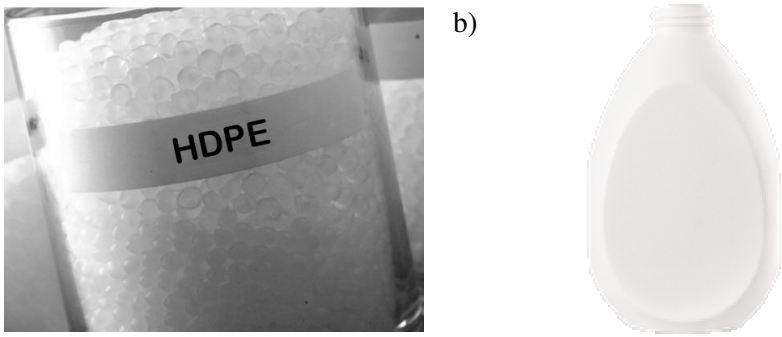


Fig. 1. **HDPE row materials (a), HDPE plastic package (b)**

Tetra Rex® Bio-based is manufactured solely from a combination of plastics derived from sugar cane and paperboard. The bio-based plastics used by Tetra Pak are produced by Brazilian chemical company, Braskem, which sources all its feedstock from sugar cane.

a) b)

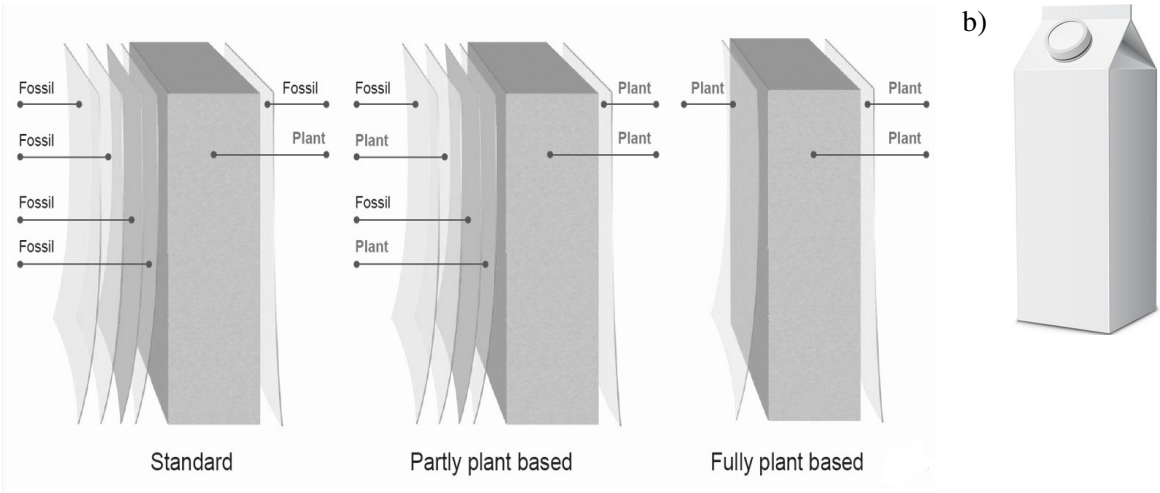


Fig. 2. **Tetra Pak packaging differences per kind of packaging (a), Tetra Rex® Bio-based package (b)**

The environment where food is produced and sealed must also be free of potentially contaminating bacteria. That means the filling and sealing equipment must be sterile before packaging and during the whole process. This can be realised using hot air and steam, or by combining heat treatment with hydrogen peroxide chemical sterilisation [11].

A large part of each individual's ecological footprint stems from their consumption of products. The production and consumption of more environmentally friendly products is an essential step towards achieving more sustainable lifestyles. At present, however, environmentally friendly, or 'green' products are still a niche market, estimating the global market share for green products at less than 4 %. The green economy accounts for 6 % of the market capitalization of globally listed companies [12].

The first criterion, which describes the product quality on the first day after production, is Total bacterial count ($CFU \cdot g^{-1}$). This criterion is allowed max. $\leq 1 \times 10^5$ ($CFU \cdot g^{-1}$) method LVS ISO 4833-1:2014. Pasteurized egg white issued in practical laboratories showed different measure of the criterion – total bacterial count. Test results are transformed by applying the natural logarithm to the criterion Total bacteria count for both samples of packaging. Criteria ln12 satisfy Total bacteria count max. $\leq 1 \times 10^5$ ($CFU \cdot g^{-1}$), Figure 3.

In the period from the first day of packaging until the sixteenth day the samples have an identical test result of product safety. Paper and paperboard are sheet materials comprising an interlaced network of cellulose fibres, intensely vulnerable to water or moisture owing to the hydrophilic nature. In many cases, an additional barrier material is used, such as aluminium, plastic, or without any of these elements [13]. Plastics are used in food packaging because they offer a wide range of appearance

and performance properties, which are derived from the inherent features of the individual material and how it is processed and used [14].

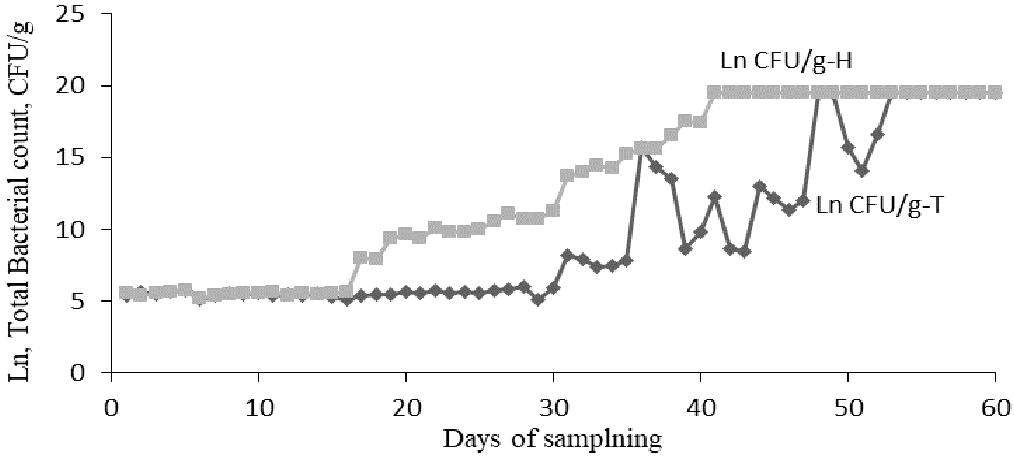


Fig. 3. **Variation during the period of sixty days of shelf life: grey line is Total Bacterial count** (Ln CFU·g$^{-1}$, -H) **HDPE plastic packaging and black line is Total Bacterial count** (Ln CFU·g$^{-1}$, -T) **Tetra Pak Tetra Rex® Bio-based**

However, pasteurized egg white in HDPE packaging from the seventeenth day until the 40$^{th}$ day shows gradual growth in change of total bacterial count. After the 40$^{th}$ day the product in HDPE packaging is not suitable for consumption, but Tetra Rex® Bio-based shows stable product quality until the 50$^{th}$ day. On the thirty-eighth day, one of the samples in Tetra pack packaging showed elevated criteria of Total bacteria count. After visual analyses the closure defect of the lid was fixed, which entailed non-tightness and the flow of oxygen into the package. This led to accelerated growth of bacteria in the specific sample.

Statistical calculation method shows the advantages of packaging Tetra Rex® Bio-based over HDPE packaging. Values of criteria: Total bacterial count ($p < 0.005$) has essential difference between the two kinds of packages with a probability of 99 %, Table 1, Table 2.

Table 1

**Comparison of criteria Tetra Rex® Bio-based and HDPE packaging, Anova: Single Factor, Summary**

| Groups | Count | Sum | Average | Variance |
|---|---|---|---|---|
| Ln CFU·g$^{-1}$, -T | 60 | 586.0827613 | 9.768046022 | 29.10032808 |
| Ln CFU·g$^{-1}$, -H | 60 | 771.2748326 | 12.85458054 | 33.40684196 |

Table 2

**Anova: Tetra Rex® Bio-based and HDPE packaging**

| Source of Variation | *SS* | *df* | *MS* | *F* | *P*-value | *F*-crit |
|---|---|---|---|---|---|---|
| Between Groups | 285.8008606 | 1 | 285.8008606 | 9.144578469 | 0.003061351 | 3.921478181 |
| Within Groups | 3687.923032 | 118 | 31.25358502 | - | - | - |
| Total | 3973.723893 | 119 | - | - | - | - |

Food packages are wrappers that maintain the quality of food during transportation and storage. In this way, the packaging increases the half-life of foods, avoiding contact with oxidizing substances, microorganisms, contaminating chemicals, light and other conditions that interfere with their shelf-life [7]. By combining polymeric support and other substances, such as essential oil from spices [15], lactic acid produced by bacteria [16] and plant extracts [17], active packaging is being developed to

reduce, inhibit or cease the development of superficial microorganisms in food. Several studies are carried out, focusing on carbohydrate materials that are biocompatible, non-toxic and biodegradable and have suitable film-forming property, such as starch and chitosan, which also have the characteristics of having antimicrobial properties [9].

The most widely used biopolymers for food packaging are natural biopolymers, such as cellulose, chitosan, starch and protein derivatives, although they have poor mechanical and barrier properties. Tetra Rex Bio-based offers for clients a fully renewable package made from materials that can be traced back to their plant-based source. It is a good decision for the environment, and it is excellent for communicating with consumers [11]. Technological advances are currently prompting researchers to invent synthetic biopolymers with improved mechanical and barrier properties that not only overcome the disadvantages of natural polymers, but also include other properties that help improve food safety, quality and shelf life [18].

Antimicrobial packaging is a form of active packaging. Active packaging interacts with the product or the headspace between the package and the food system to obtain a desired outcome [19]. The packaging with which the tests were carried out will subsequently be the basic material for research, the creation of active and intelligent types of packaging for perishable products, such as pasteurized egg white.

## Conclusions

1. Pasteurized egg white is a perishable product that requires the observance of clear technological processes during production, such as: quality of raw materials, compliance with sanitary standards, step-by-step compliance with the pasteurization process.
2. HDPE is the most widely used type of plastic, which has good chemical resistance. This packaging protects the product from external damages, such as light, moisture, but cannot guarantee the constant state of microbiology, which shortens the shelf life of the final product.
3. Tetra Rex® Bio-based packaging for food can be a versatile and low-cost approach to control and preserve the quality of a food product. The test results showed additional eight days, compared to HDPE packaging. Values of criteria: Total bacterial count ($p < 0.005$) has essential difference between the two kinds of packages with a probability of 99 %.
4. Pasteurized egg white in both packages according to the test results did not withstand the shelf life of sixty days. The maximum result of the shelf life of forty-eight days was provided by the packaging Tetra Rex® Bio-based.

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