LWT - Food Science and Technology 45 (2012) 191–197

Contents lists available at SciVerse ScienceDirect

LWT - Food Science and Technology

journal homepage: www.elsevier.com/locate/lwt

Quality of olive oil reformulated MRE entrée packaged in oxygen-absorbing film

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ARTICLE INFO

Article history:
Received 12 January 2011
Received in revised form
2 September 2011
Accepted 8 September 2011

Keywords:
Oxygen absorber
Copolymer film
Active packaging
Shelf life
Meal ready-to-eat

ABSTRACT

An iron-based oxygen absorber (ABSO$_2$RB®) activated by moisture was incorporated into a retort laminate and used to package chicken pesto with noodles. The effect of packaging material (regular MRE and oxygen-absorbing pouches) and reformulation with olive oil on the quality and shelf life of the entrée were investigated. Physical properties (color, texture, moisture, water activity), chemical properties (pH, TBARS), and microbiological quality (Total aerobic, coliforms, *Escherichia coli*, Yeast and Molds, Anaerobic plate counts) were measured in triplicates in an accelerated shelf-life study for 6 months at 37.8 °C. Samples stored at 26.7 °C for 12 months served as calibrated controls. Consumer and trained panel tests were carried out using a 9-point hedonic scale. The ABSO$_2$RB® pouches performed well in terms of seal integrity and strength and limited the formation of rancid fatty acids in olive oil throughout the shelf-life study. Soybean formulations in ABSO$_2$RB® pouches had the lowest ($p < 0.05$) Thiobarbituric Acid Reactive Substances (TBARS) value. Consumer and trained panelists accepted the olive oil formulations, in both packages. Results from this study will help MRE developers to expand the number of items using healthier oils. If future considerations to replace MRE packaging are needed, the ABSO$_2$RB® film will be a suitable alternative.

1. Introduction

US military Meal Ready-to-Eat (MRE) menus are constantly changing to accommodate dietary needs of the soldiers and quality improvements. Incorporation of Mediterranean items is currently under consideration. It has been a long-standing goal to enhance the nutrition of MREs and Unitized Group Rations (UGRs) by replacing the hydrogenated oils in these rations, which contain trans fats, with non-hydrogenated oils. Olive oil promotes cardiovascular health due to its high content of monounsaturated fat and low content of saturated fat. In general, olive oil contains 55 g/100 oleic acid compared to 25 g/100 in soybean oil (Morales & Przybylski, 2000). The FDA (2008) allows food products containing olive oil to display a health claim on the label when olive oil replaces a similar amount of saturated fat.

The long-term health benefits of MRE reformulation with olive oil could be substantial. There is a large body of clinical data to show that consumption of olive oil can provide heart health benefits such as favorable effects on cholesterol regulation and LDL cholesterol oxidation, and that it exerts anti-inflammatory, antithrombotic and antihypertensive effects (Lairon, 2007; Perez-Jimenez, Ruano, Perez-Martinez, Lopez-Segura, & Lopez-Miranda, 2007). In addition, olive oil contains substantial amounts of compounds deemed anticancer agents (e.g. squalene and terpenoids) (Owen et al., 2004). However, olive oil is not used in most military ration formulations due to concerns about general consumer attitude toward the oil in terms of flavor, mouth feel, and overall acceptability. Furthermore, healthy oils tend to become rancid over prolonged storage. The military requirements are a shelf life of 3 years and 18 months at 26.7 °C for MREs and UGRs, respectively.

Rancidity of oil is caused when oxygen combines with essential fatty acids such as linoleic and linolenic (Morales & Przybylski, 2000). The access of oxygen to the food product influences the deterioration of pigments, lipids, proteins and the overall sensory quality thus affecting shelf life. The task of packaging technology is to develop the type of packaging that will maintain the low level of oxygen inside the package at a given time. Removal of oxygen, both

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doi:10.1016/j.lwt.2011.09.005

residual and that entering through the plastic package walls or seals, may be achieved by affixing an oxygen scavenger sachet to the interior of the package wall to extend the quality of the product and suppress aerobic microorganisms. Oxygen scavengers can reduce the amount of oxygen in a package to less than 0.1 g/kg, as compared to traditional preservation methods such as gas flushing and vacuum packing, which reduce headspace oxygen to only about 5 g/kg (Brady, Strupinsky, & Kline, 2001).

Oxygen scavenger sachets were introduced in Japan in and are currently available in a wide variety of sizes and fills to ensure adequate oxygen absorber capacity. The sachets are made entirely from food grade materials and can be used by themselves or in conjunction with vacuum/gas flushed packaging to reduce ambient oxygen present at the time of packaging (Brady et al., 2001). This approach of inserting a sachet into the package is effective but meets with resistance among food packers. The active ingredients in most systems consist of a non-toxic brown/black powder or aggregate which is visually unappealing if the sachet is broken. A much more attractive approach would be the use of a packaging plastic as the scavenging medium. By incorporating a desiccant in the product contact layer, contamination of a product by leakage from a sachet will not occur. This approach also eliminates the risk of ingestion. Oxygen-scavenging films also offer potential cost savings due to increased production efficiency and convenience. The quality of the packaged food is preserved by modifying the inner atmosphere to very low residual oxygen retarding the growth of spoilage bacteria and mold, biochemical and enzymatic degradation, while minimizing the need for butylated hydroxyanisole (BHA), butylated hydroxytoluene (BHT), sulfur dioxide, sorbates, benzoates, and other food additives.

Gomes et al. (2009) evaluated the suitability of a new oxygen-absorbing packaging technology in modifying the inner atmosphere to very low residual oxygen so that microbial spoilage and biochemical reactions were slowed down to maintain the shelf-life of a high-fat moist MRE item (cheese spread). The oxygen-absorbing laminate effectively reduced oxygen concentration in the package by 67.44% within a 24 h period. Product shelf life requirements were met and sensory attributes were highly acceptable to a trained panel.

The objectives of this study were to (1) evaluate whether use of the oxygen-absorbing laminate in retort MRE pouches ensures packaging integrity, and (2) demonstrate that hydrogenated oils of MREs can be replaced with the healthier olive oil without detriment to microbiological, physico-chemical, and sensory quality attributes. Our thesis was that this reaction will not occur if the oxygen within the sealed package is absorbed by the packaging material, thus allowing the use of healthy oils in these rations and also providing a three-year shelf life.

2. Materials and methods

2.1. Food material

The MRE chicken pesto with noodles is an entrée item first introduced in Menu 28 in 2008 and it has since been a part of the new menus (MREInfo, 2011). The entrees were formulated, packaged, and retorted in accordance with PCR-C-067 (2007) at a plant in Indiana. A total of twelve hundred (1200) samples (227 g each) for each treatment were shipped to Texas A&M University for testing based on the performance requirements following the specifications of the Packaging Requirements and Quality Assurance Provisions documents for chicken, noodles and vegetables in sauce: (1) Shelf-life of 36 months (UGRs and MRES) at 26.7 °C; and (2) Palatability and general acceptance must meet approved product standard characteristics (PCR-C-021, 1998). Reformulations replaced the soybean oil with olive oil. Thus, the study evaluated four treatments: soybean oil formulations on two types of packages (regular MRE pouches and oxygen-absorbing pouches) and olive oil formulations on two types of packages (regular MRE pouches and oxygen-absorbing pouches).

2.2. Oxygen-absorbing packaging material

The $ABSO_2RB^{®}$ sealant is made of polypropylene (PP) containing an iron-based oxygen absorber that is water-activated. The $ABSO_2RB^{®}$ sealant was manufactured by Cadillac Products Packaging Company (Troy, Michigan). This material was then shipped to a company that manufactures retort pouches, which laminated the sealant onto the retort structure rather than the regular sealant. The pouches meet the specifications in accordance with MIL-PRF-44073, Packaging of Food in Flexible Pouches, Type I (DOD, 2010). The structure of both oxygen-absorbing and standard MRE retort pouches was the same, outside to inside, specifically polyester/bi-axially oriented nylon/foil/polypropylene sealant (0.00127 cm polyester/0.001524 cm bi-axially oriented nylon/0.001778 cm foil/ 0.00762 cm polypropylene). The standard MRE retort pouch (control) did not contain the oxygen-absorbing sealant. It should be noted the presence of tie-layers between the films. Oxygen concentration inside the pouches was below 0.5% after 24 h as determined by the pouch manufacturer.

2.3. Optical microscopy investigation of laminate material

A laser-scanning microscope (VK-9700, Keyence) was used to characterize the laminate structure of the packaging films. The film specimen for investigation was cleaned, cut, and then mounted by a room-temperature cured epoxy resin (EpoxiCure, Buehler). In order to represent the film structures, the specimens were carefully grinding and polishing before examining.

2.4. Pouch T-peel testing

To determine the pouch-seal integrity, a modified T-peel test, was performed following the ASTM D1876-08 protocol. The specimens were cut from the reference and oxygen absorber-containing pouches into 0.1143 m long and 0.0254 m wide strips consisting of a sealed region with a nominal bonded length 0.01041 m. It should be noted that food inside the pouches was removed and cleaned before sample preparation. There were five samples taken from one package for each material, and a single sample taken from a second. The samples were taken from the centers of the sides of the pouch on both sides. There were no observable differences in samples taken at different locations or different packages. The T-Peel tests were performed on fresh pouches before aging and aged for 6 months at 37.8 °C. The oxygen absorber-containing pouches were also aged for 6 and 12 months at 26.7 °C to confirm the integrity of the structure. This was requested by Natick since it is a standard protocol for their aging conditions. The tests were conducted using an Instron machine (Model 4411) at 23.9 °C at a testing rate of 0.508 cm/min.

2.5. Shelf-life studies

Quality attributes (color, texture, moisture content, Aw, pH, net weight), microbiological and overall quality (sensory), and rancidity were monitored at fixed time intervals throughout the accelerated shelf-life study, which consisted of six months at 37.8 °C. Samples stored for twelve months at 26.7 °C served as calibrated controls (for rancidity and sensory evaluation). All samples were kept at a constant relative humidity (65%–75%). Each