Final report

Smart pack/ coatings design to optimise meat quality (Monash GRIP Program)

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Abstract

Over the years, food packaging has grown from being solely used as a simple barrier function protecting the food, to oxygen-scavenging and intelligent functions such as antimicrobial activity control, atmosphere control, edibility, biodegradability etc., which extend the shelf life of red meat. Many technologies have risen to prolong meat shelf life, but for solutions with minimal food processing, Modified Atmosphere Packaging (MAP)/vacuum packaging (VP) are the most attractive solutions. In this project, a dynamic meat packaging technology was discovered. In a nutshell, a novel silicone-based polymer was designed, synthesised and fabricated as a thin film coated onto LDPE. The oxygen permeability of the film was controlled by UV irradiation. Under 365 nm, the film crosslinked and displayed a low oxygen permeability, and conversely, under 254 nm, the film decrosslinked and displayed a high oxygen permeability. This method of photoreversible oxygen permeability control was exhibited for at least 4 cycles. The results indicated that this technology could be used either as a VP in the crosslinked state, or a MAP in the de-crosslinked state. The control could allow meat suppliers to optimise the shelf-life and colour of the meat throughout the supply chain from cold storage to the point-of-sale

Executive summary

Background

Food packaging materials are membranes, materials that act as a barrier, controlling the permeation of molecules into the packaged food. There are numerous definitions of membranes depending on their composition, geometry and application, but the most general definition is that a membrane separates two different phases, allowing the mass transfer from one phase to another by use of a driving force such as diffusion. For food packaging, the membrane must be deemed safe to use for this application. The membrane must be well-engineered to mitigate the permeation of undesirable materials into the food product, must be chemically inert, and can uphold mechanical integrity protecting the meat from the environment. It should also control the rate of permeation of oxygen, moisture, carbon dioxide and others materials which affect the quality of meat and its shelf-life. For VP, having a high barrier packaging system is essential. However, during the sale, the meat will no longer need to be vacuum-sealed as the shelf life at the retailer is not very long.

There has been an increasing interest in smart polymers over the years. Mainly used in the biotechnology field, smart polymers undergo physical or chemical changes in their properties based on their surrounding environment. As a material, smart polymers promise a wide variety of applications, where stimuli such as light, temperature, pH, magnetic field, etc., can be utilized to induce a change in the material to obtain a material with different properties. The challenge with meat packaging is that storage and sale on the shelves require different environments around the meat, as well as different characteristics for the meat itself. Therefore, having a dynamic packaging material that can be optimal for both, storage and sale, is of utmost importance, and that can be achieved using smart polymers. This would allow for optimal storage conditions provided by a VP technology, and optimal sale conditions such as meat colour. What is also important is to choose the right stimulus; one which is practical for retailers to induce themselves without much knowledge about polymeric materials, does not self-induce during storage and transportation, does not require high capital and operating costs for the retailer, and does not directly affect the quality of meat. A good candidate for such a stimulus is ultra violet (UV) light. With the right material of choice, this stimulus would be practical for creating a packaging material that is non-porous during storage, and is porous during the sale to negate the negative effects of VP.

Objectives

A photoresponsive, and highly efficient polymer was designed, synthesised and fabricated as a ‘smart’ polymer coating. The objective was to create a polymer membrane that can show efficient regulation of the oxygen transport by UV irradiation. This was achieved, and the material exhibited reversible control of the oxygen permeability for at least 4 cycles without loss of photocontrol performance.

Methodology

- Design of a highly efficient photo-responsive monomer, including synthesis and characterisation.
- Fabrication of the monomer as a thin-film onto porous LDPE.

- Testing the oxygen permeability of the now composite membrane after different UV irradiation conditions (365 nm or 254 nm).
- Optimisation of the film’s thickness and investigation of other materials that are more efficient.

Results/key findings

The results indicated that this method of oxygen permeability control is highly applicable in the packaging field, as it required a small amount of the high-value coating, is very efficient (requiring small UV irradiation doses), and can tune the oxygen permeability for at least 4 cycles without loss of photo-control performance.

For in-depth key research findings please follow the denoted publication:

A. Alrayyes, Z. Low, H. Wang, K. Saito, Multi-cycle reversible control of gas permeability in thin film composite membranes via efficient UV-induced reactions. *Chem. Commun.*, **2021**, Advance Article. https://doi.org/10.1039/D0CC08238D

Benefits to industry

The techonology can be used in conjunction with very cheap LDPE, making it fiscally viable. In addition, the techonology uses only 3 polymer layers, 2 of which are ultra-thin, while industry standards require 4-7 layers, which further increases its fiscal applicability while reducing plastic waste. Finally, the ability to modify the oxygen permeability throughout the supply chain will allow suppliers to optimise the quality and colour of the meat as it passes through the storage and sale processes.

Future research and recommendations

- Investigating other permeability properties of the coating such as the WVTR.
- Prototyping the technology and testing its effect on packaged meat.
- Investigating the biocompatibility of the novel polymer.
- Working with suppliers on ways to integrate the technology within their production processes.