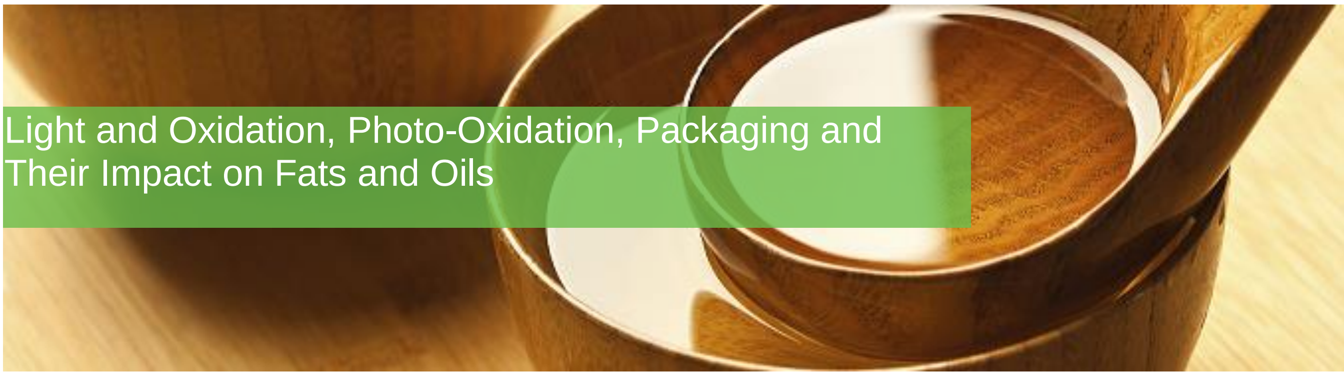

Light and Oxidation, Photo-Oxidation, Packaging and Their Impact on Fats and Oils

Introduction

- Fats and oils (Lipids) tend to deteriorate through several degradation reactions and can develop oxidative rancidity through a variety of pathways and conditions. Oxidation may be accelerated by a variety of factors including the presence of oxygen, oxidizing agents (metal catalysts), enzymes (iron-centered atom lipoxygenase), photo-oxidation, heat and more.
- This paper quotes and compiles some academic and lab research work that was conducted on a specific oil by researchers according to their published journal.
- This paper will focus on only photo-oxidation, which is an issue in all finished foods no matter their ingredient declaration or industry. All products benefit from the inclusion of antioxidants as the nutritional profile, flavor, color and shelf life are all impacted by oxidation.
- Research paper1 and text book2 may not quantify the rate of oxidation through light, but this may provide sufficient evidence that light plays a significant role in the oxidative instability of fat containing foods.

Theory

- Photo-oxidation is an alternative mechanism that leads to formation of hydroperoxides as a result of excitation state of lipid electrons (**type I photo-oxidation**) or excitation state of oxygen electrons (**type II photo-oxidation**).

- **Type I photo-oxidation** – The reaction starts in the presence of light and some sensitizers, such as riboflavin. It is a process by which a hydrogen atom or an electron, transfer between an excited triplet sensitizer and a substrate, such as PUFA, producing free radicals or free radical ions.

- **Type II photo-oxidation** – Under this mechanism, environmental oxygen is normally in the triplet electronic state, $^3O_2$. It can be excited by light to singlet oxygen in presence of a sensitizer, such as chlorophyll. Singlet oxygen is1,500 times faster in reacting with unsaturated lipids than triplet oxygen, which ultimately leads to forming hydroperoxides.

- Another important way in which unsaturated lipids can be oxidized involves exposure to light and a sensitizer such as methylene blue (Frankel, 1998). Through this non free radical process, oxygen becomes activated to the singlet state by transfer of energy from the photosensitizer.

Results and discussion

- The purpose of this research was to design a suitable color package hydroxypropyl methylcellulose (HPMC) to avoid photo-oxidation of food grade Salmon oil.

- Salmon oil was extracted from head of salmon by means of enzymatic extraction under low processing temperature.

- Salmon oil samples were placed on petri dishes and covered with different colored HPMC films of thickness 40 mm and placed under fluorescent light at 20°C for 8 days. A duplicate set of samples were stored in darkness as control.

Methods of conditioning the samples

Salmon oil samples were analyzed to study the light induced oxidation of salmon oil kept under the colored films. These analyses were conducted at 2nd, 4th and 8th day of storage.

The analyses:

- Color measurement of HPMC films – No significant difference was found in color of HPMC films at 2nd, 4th and 8th days during the phenomena of photo-oxidation.

- Light transmission and transparency of film – The study has shown that the light transparency of the film and the photo-oxidation of the oil are directly related. Salmon oil packaged in a white film showed minimal light transparency as was very close to that of samples stored in the dark. The study results show that not only the transparency but also color of the film plays a very significant role in the protection of a stored product from photo-oxidation. It can then be concluded that photo-oxidation is a wavelength dependent phenomenon.

- Similarly, red and white edible HPMC films showed no more transmission in the visible region of 400-700nm. It can be concluded that these colors are more protective against light oxidation.

- In another study, Sattar, Tavanger and Ahmad (1983), studied homogenized milk samples packaged with clear, green, amber glass bottles and Tetra Pack waxed packaging at 16-24°C. They statistically showed that amber glass bottles gave the best protection to milk from flavor changes. Tetra pack and green glass bottles were intermediate in performance and the clear glass bottles was the least effective, equally performing as exposed control.

- Oxygen content – The initial dissolved oxygen concentration in each sample dish was almost similar. Upon continuous light exposure, the oxygen concentration was measured and noted to decline remarkably with green, blue and transparent packaging in respective order.

- The difference in dissolved oxygen concentration between petri dishes can be considered as a measure for the O2 consumption in light induced oxidation that differs in different colored edible films. See below figure.

- The results show that the light passes easily through transparent HPMC film and causes photo-oxidation indicating that more oxygen has been consumed with the passage of time. With the blue film, there was gradual oxygen consumption. Green film showed a sudden decrease in oxygen content. Samples covered with other colored films like red, yellow and white showed a very slight decrease in oxygen content. These colors helped block the light transmission through the package. Blue was the least effective in preventing photo-oxidation; causing more oxygen to be consumed.

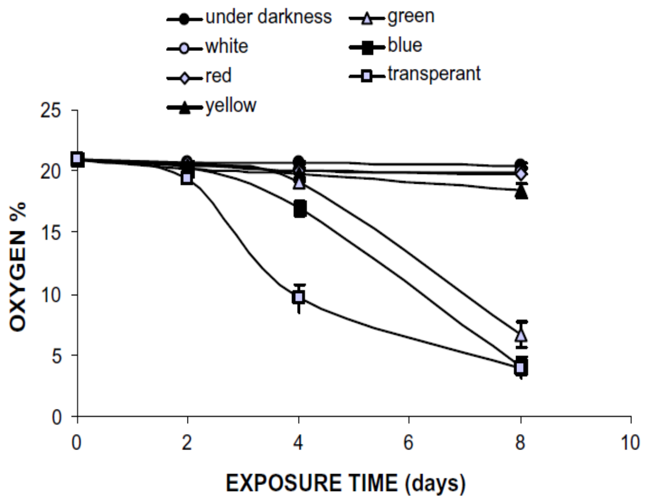

Fig. 4. Quantity of oxygen in petri-dishes covered with HPMC films of different colours and kept under light.

- Fatty acid composition – A gradual increase in photo-oxidation led to an increase in PUFA oxidation. This test was demonstrated by measuring the Polyene Index at the end of the storage period. The Polyene Index was reported as an excellent tool monitoring PUFA degradation during storage time. Although this test may not show significant decomposition of polyunsaturated fat, it provided sufficient evidence that transparent, blue and green colored HPMC films showed the most polyene reduction during storage. The red, yellow and white HPMC films performed much better and showed very little polyene reduction during storage.

Methods of conditioning the samples

- Based on previous research and studies, it is concluded that in addition to other oxidizing factors, light has a major effect in oxidizing lipids and fats under certain packaging and storage conditions. This is termed Photo-oxidation.

- Photo-oxidation had a dramatic impact in the reduction of shelf life of salmon oil when it was packaged in transparent, blue and green HPMC films. This was due to light transmission through the packaging material, causing oxidation of the oil.

- The study showed increased oxygen consumption, increased fatty acid degradation and decreased polyene index in salmon oil. It also showed the altered the flavor profile of milk when packaged in transparent, blue or green HPMC films.

- On the contrary, white, red and yellow offered protection against photo-oxidation in salmon oil.

- Overall, the study has clearly demonstrated the importance in selecting the proper colored-film of HPMC. The colors white, red and yellow are preferred for the protection of the food product from photo-oxidation. It also illustrates the need for antioxidant presence in packaged oils and food as many variables impact their quality, shelf life and nutritional profile.

References

- 1Journal – “control of salmon oil photo-oxidation during storage HPMC packaging film Influence of film color” Muhammad Javeed Akhtar, Muriel Jacquot, Elmira Arab-Tehrany*, Claire Gaiani.
- 2Text book – “Antioxidants in food” – edited by Jan Pokorny, Nedyalka Yanishlieva and Michael Gordon

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