GREEN TEA AS A PROMISING EXTRACT OF ACTIVE FOOD PACKAGING

MATBIM2017 – 4th international meeting on Material/Bioproduct Interaction

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Introduction

Tea is one of the most popular and frequently consumed beverages in the world and its consumption dates back to more than 2000 years in China and then spread to other areas including Japan and later on to Europe (Zhao *et al.*, 2014). Green tea is produced from *Camellia sinensis* (L.) Kuntze leaf infusion and is well known for its pleasant flavour and is associated with positive health effects (Figures 1 and 2).

Fig. 1 – *Camellia sinensis* (L.) Kuntze Shimizu

Fig. 2 – Leaf infusion of *Camellia sinensis* (L.) Kuntze

The biological activity of green tea is related with the considerable amount of catechins and other phenolic compounds, in particular flavonols and phenolic acids, present in its composition (Zhao *et al.*, 2014) (Figure 3). These phenolic compounds prevent the oxidative damage through their antioxidant capacity and also reduce the risk of cancer, cardiovascular and neurodegenerative diseases (Lorenzo *et al.*, 2014).

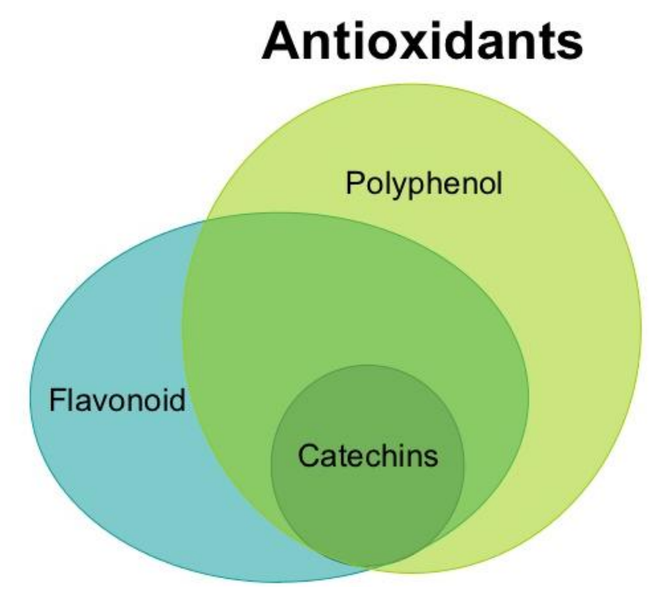

Fig. 3 – Catechins and phenolic compounds.

Active Packaging

The process of oxidation is one of the most common mechanisms of degradation of foodstuffs and it can alter food texture and colour, decrease nutritional quality, develop off-odours and also produce possible toxic compounds. As a consequence, the shelf-life and commercial acceptability of the food products decrease. Currently, one of the major concerns of the consumers is the impact of food on health. In line with this, food industry is trying to substitute synthetic additives by natural compounds. These can be directly added to food or incorporated in food packaging (Figure 4) with the aim of being controlled released throughout the product shelf life.

This concept is so-called **Active packaging** and allows the packaging to positively interact with foods to increase food shelf-life. This interaction can be due to the intended release of compounds from packaging to the foods or to their headspace, or due to the scavenging of compounds by the packaging from the packaged foods. Due to the antioxidant capacity of green tea, its extract can be proposed as an alternative to synthetic antioxidants (Giménez *et al.*, 2013). In fact, it has already been applied in active food packaging.

Fig. 4 – Food Packaging

Material and Methods

The present review focuses on the application of green tea extract in active packaging. In this regard, an extensive bibliographic research was carried out in order to evaluate the polymers already used to incorporate green tea extract, as well as the mechanical and barrier properties and efficiency of these packaging systems in contact with foods.

Results and Discussion

Bioactive constituents of the tea leaves include catechin gallates such as epigallocatechin gallate and gallocatechin gallate (Gramza *et al*., 2005). However the levels of these compounds depend on many factors, such as the edaphoclimatic conditions and drying conditions of the *Camellia sinensis* leaves. Moreover, the extraction and analysis methods can also have a great influence in their content.

Table 1 – Application of green tea extract (GTE) in active food packaging.

Polymer used	Amount of GTE incorporated	Technique of incorporation used	Results of the study	Reference
GCG	0.5%, 1.4%,2.8% and 4.2%	Added to 100 ml of film-forming solution	- The samples packed with the GCG film containing GTE (2.80%) had a decrease in the populations of *E. coli* O157:H7 and *L. monocytogenes* of 1.05 to 1.14 log CFU/g. - Application of the GCG film to pork loins was successful in inhibiting microbial growth during storage.	Hong *et al.* (2009)
Chitosan	2%, 5%, 10% and 20%	Mixture in chitosan solution	- The incorporation of GTE into chitosan films improved the mechanical and water vapour barrier properties and increased the polyphenolic content and antioxidant activity of the films. - Potential to use developed film as an active packaging.	Siripatrawan *et al.* (2010)
EVOH	5%	Flat extrusion	- Exposure of the films to various food simulants showed that the liquid simulants increased their capacity to reduce DPPH• and ABTS•+ radicals. - The materials developed with the cocktail of antioxidant substances that constitute the GTE could be used in the design of active antioxidant packages for all types of food, from aqueous to fatty products.	Dicastillo *et al.* (2011)
Chitosan	20%	The aqueous solution of GTE was mixed with the chitosan solution	- Lower changes in colour, texture, TBARS value, microbial growth and sensory characteristics - Lipid oxidation and microbial growth were reduced, prolonging the shelf life of commercial pork sausages.	Siripatrawan *et al.* (2012)
EVOH	5%	Solution-extension-evaporation process (casting)	- Films with GTE offered the best protection against lipid oxidation.	Dicastillo *et al.* (2012)
Chitosan	0.5%, 1% and 2%	Mixture in chitosan solution	- The addition of tea extracts significantly decreased water vapour permeability and increased the antioxidant ability of films. - The DPPH radical scavenging ability of GTE films was stronger than that of black tea extracts films in all food simulants (0%, 20%, 75% and 95% ethanol).	Peng *et al.* (2013)
Agar	*No information*	Solution-extension-evaporation process (casting)	- The green tea and/or probiotic film yielded a reduction, particularly of H_2S-producing bacteria counts and total viable bacteria throughout the storage period. - Bioactive films caused a decrease in the biochemical indexes of fish. - Bioactive films with green tea and probiotics extended the shelf-life of hake.	Lacey *et al.* (2014)
Multilayer structure	*No information*	Catechins were incorporated in the adhesive used for building the laminates	- Sensory analysis demonstrated that the packaged food was not affected by GTE, but it was well protected against oxidation, significantly reducing the rancidity and this way extending the shelf life of packaged food.	Carrizo *et al.* (2016)
Sorbitol (protein films)	0.1%, 0.3%, and 0.5%	Mixture in the film-forming solution	- Among the tea extracts, the protein film containing GTE had the highest antioxidant activity. - These results indicate that protein films containing GTE can be used as antioxidant packaging material for pork.	Yang *et al.* (2016)

EVOH – Ethylene Vinyl Alcohol Copolymer; GTE – Green tea extract; GCG – Gelidium Corneum-Gelatin

Green tea extract has already been incorporated into different polymers. In fact, most of them are edible such as proteic films from distilled dry beans (Yang *et al.*, 2016), agar (Lacey *et al.*, 2014), chitosan (Siripatrawan *et al.*, 2010; Siripatrawan *et al.*, 2012) and gelatine (Hong *et al*., 2009).

Green tea extract (GTE) can offers protection against oxidation, significantly reducing rancidity and thereby extending the shelf-life of packaged foods. Moreover the sensory analysis also demonstrated that packaged food was unaffected by GTE (Carrizo *et al.*, 2016).

According to the study carried out by Yang *et al.* (2016), the incorporation of the GTE did not alter the physical properties of the films. Siripatrawan *et al.* (2010) reported the incorporation of GTE improved the mechanical and water vapour barrier properties.

Conclusions

Green tea has great potential of application in active food packaging due to its antioxidant capacity. Therefore, in the near future, is it possible that new food packaging based on green tea extract (GTE) will arise in the market. However, more studies are require to elucidate about the concentrations of GTE that do not affect or affect positively the mechanical or barrier properties of the packaging and that are effective as oxidation inhibitors of packaged foods.

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Acknowledgement

This work was supported by the research project "Development of methodologies for the evaluation of polymeric food packaging components and determination of their structural and mechanical properties" (2016DAN 1289) funded by the National Institute of Health Dr Ricardo Jorge, I.P., Lisbon, Portugal.