Journal of Cleaner Production xxx (2017) 1–10

Contents lists available at ScienceDirect

Journal of Cleaner Production

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

# Developing a bio-based packaging film from soya by-products incorporated with valonea tannin

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ARTICLE INFO

*Article history:*
Received 29 September 2016
Received in revised form
11 December 2016
Accepted 13 December 2016
Available online xxx

*Keywords:*
Packaging films
Soya by-product
Valonea tannin
Antioxidant

ABSTRACT

The waste production from plastic packaging causes serious environmental problems and resource issues. The most effective way to solve these problems is to develop eco-friendly packaging. In this work, soy protein isolate (SPI) films were developed incorporated with 0%, 5%, 10%, 15% (w/w, based on SPI) valonea tannin at pH 8 and 10. Valonea tannins increased protection against UV light and decreased the transparency of SPI films ($p < 0.05$). Antioxidant properties of SPI films improved as determined by 2, 2-diphenylpicrylhydrazyl (DPPH) radical scavenging activity. The addition of valonea tannins increased tensile strength (TS) and decreased percentage of elongation at break (% E) of SPI films ($p < 0.05$). The SPI films with 10 w/w% valonea tannin at pH 8 and 10 had the highest TS. Due to the highly hydrophilic nature of valonea tannins, the water vapor permeability (WVP) of SPI films was increased; however, oxygen permeability (OP) reduced ($p < 0.05$). Compared to SPI films at pH 8, films at pH 10 had higher transparency, TS, and % E and lower OP, WVP, and DPPH radical scavenging activities. The results revealed that SPI films show a great potential to be used as antioxidant packaging films for food.



## 1. Introduction

Plastics are unique materials that fulfill a huge range of functions in society, but contribute to environmental impacts related to the consumption of resources. Almost all consumer goods purchased in everyday life come with packaging, which provides goods protection from physical damage, contamination and deterioration. In 2011, the average citizen generated 159.4 kg of packaging waste (around 31% of the municipal solid waste) in the European countries. In other industrialized countries such as US, Australia or Canada, packaging waste is in the similar trend and represents around 30–35% of municipal solid waste yearly generated (Tencati et al., 2016). Considering that packaging materials represent a major source of solid waste, eco-friendly packaging's are necessary for the success of the overall environmental program. In recent years, development of biodegradable packaging materials from renewable natural resources has received widespread attentions. Bio-based polymers such as polysaccharides, proteins, lipids, and their composites are considered to be the most promising alternatives to synthetic packaging materials due to their biodegradability and availability from reproducible resources (Li et al., 2008). Soy protein is extracted from the by-product of soy oil production. During this process, soy flour is obtained as a secondary product and it can be purified to obtain soy protein concentrate (SPC) and soy protein isolate (SPI), adding value to agricultural by-products (Garrido et al., 2014). SPI films have excellent oxygen barrier properties and moderate mechanical properties, but high water vapor permeability (WVP) due to their hydrophilic nature (Wang et al., 2012). Therefore, SPI film is considered to be used as food packaging films.

Tannins are complex and heterogeneous group of polyphenolic secondary metabolites of higher plants with molecular weights between 500 and 20,000 Da and soluble in water and polar organic solvents (Onem et al., 2014). Tannins can be classified into hydrolysable tannins and condensed tannins. Hydrolysable tannins are obtained from chestnuts (*Castanea sativa*), myrabolans (Terminalia and Phyllantus), divi–divi (*Caesalpina coraria*), tara, algarobilla, and valonea (Yang et al., 2016).

The Chinese oak, is one of the major treespecies in warm-temperate deciduous broad-leaved forests and subtropical evergreen broad-leaved forests, which is also widely distributed in Asia. The acorn cups and beards of Chinese oak (Quercus variabilis) containing high percentage of hydrolysable (pyrogallol) group of

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http://dx.doi.org/10.1016/j.jclepro.2016.12.064
0959-6526/© 2016 Published by Elsevier Ltd.

tannin are internationally called as “Valonea”. Valonea, contains approximately 28.45% tannin with a purity of 77.64%, which is obtained by conventional hot water extraction (Yang et al., 2016). The MALDI-TOF (Matrix-Assisted Laser Desorption/Ionisation Time-of-Flight) spectrum of valonea tannins reveals the presence of low molecular weight hydrolysable tannins including nonahydroxytriphnoic, flavogallonic acid, ellagic, and gallic acid and of large molecular weight fractions such as castalagin/vescalagin and vescavaloneic/castavaloneic acids as shown in Figs. 1 and 2 (Ozgunay et al., 2007).

Two different interactions exist between protein and tannin including hydrogen bonds between hydroxyl groups of tannin and amide carbonyl of the peptide backbone of protein and hydrophobic interactions which are important for stabilizing tannin—-protein complexes. Tannin with high molecular weight and the conformational flexibility can interact with proteins more effectively (Le Bourvellec and Renard, 2012). The higher molecular weight structures have been detected in commercial valonea tannin, especially pentagalloylglucose, and the increased number of galloyl ester groups in its degradation and oxidation products increases the binding capacity with protein molecules (Ozgunay et al., 2007). Valonea tannins tend to have a strong affinity to proteins. To date, few studies have evaluated the use of valonea tannins as modifiers of SPI for packaging films. The objectives of this study were to develop an antioxidant and flexible packaging film by incorporating valonea tannins into SPI films and to elucidate the effect of valonea tannins on the color, light barrier, physico-mechanical, and antioxidant properties of SPI films.

## 2. Materials and method

### 2.1. Materials

SPI powder (protein content 90%) was provided by Harbin High-Technology Soy Protein Co., Ltd, China. Valonea Tannin was supplied by Guangxi WuMing Extract Company, at 68% purity. Calcium chloride anhydrous ($CaCl_2$) and Sodium chloride (NaCl) were obtained from Tianjin BoDi Chemical Co., LTD. Glycerol (1,2,3-propanetriol) with 99% purity, sodium hydroxide (NaOH), sodium carbonate ($Na_2CO_3$), ethanol and potassium carbonate ($K_2CO_3$) were obtained from Tianjin YongDa Chemical Reagent Co., Ltd. Gallic acid was supplied from Tianjin Kemiou Chemical Reagent Co., Ltd. The saturated salt solutions $K_2CO_3$ were used to control the water humidity at 43% relative humidity at room temperature (Su

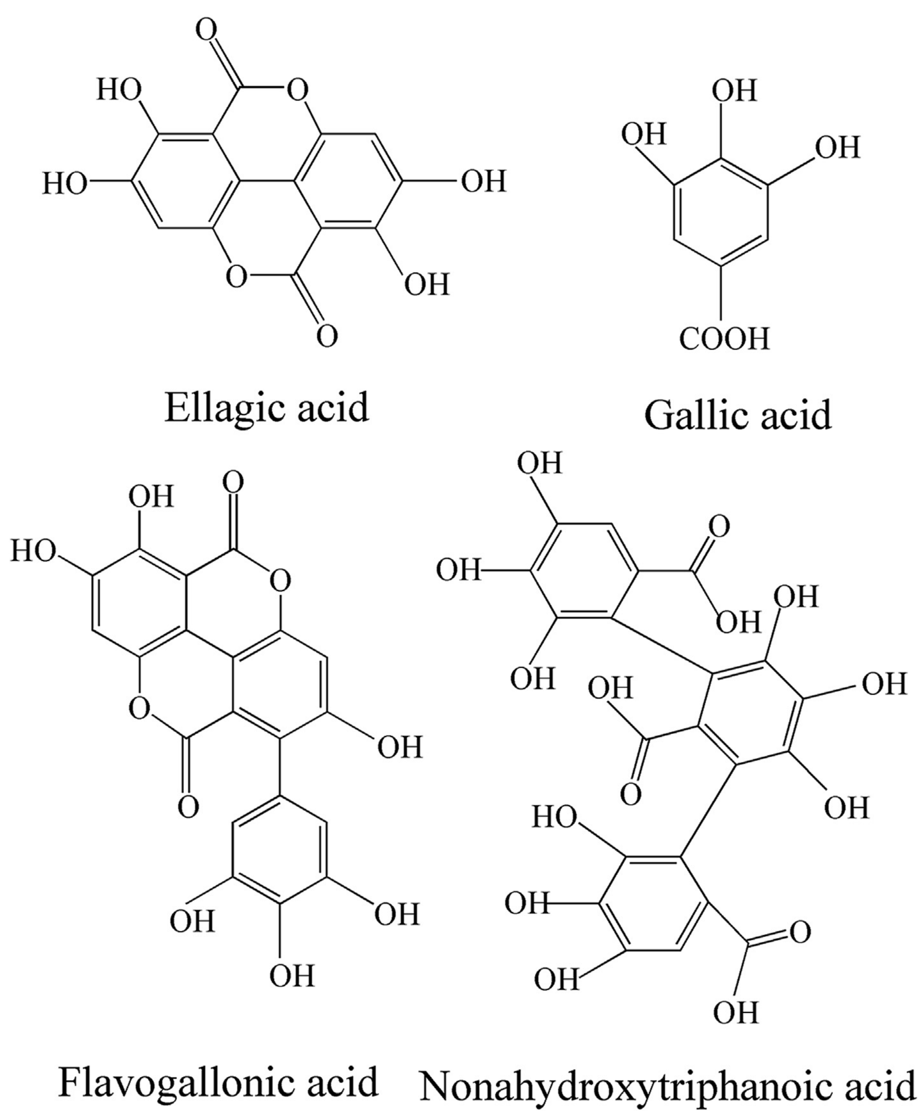


**Fig. 1.** Low molecular weight fragments of valonea tannins.