DEVELOPMENT AND TESTING OF INNOVATIVE PROTOCOLS AND TECHNOLOGIES TO ENHANCE THE SAFETY OF FOOD AND TO REDUCE FOOD LOSS

Composition and drying effects on the functional properties of films based on chitosan and pectin: an exploratory data analysis approach

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State of the Art

The main aim of this study was to analyse how the chemical composition and drying conditions affect the technological properties of films based on chitosan (CH) and pectin (P) through a multivariate data analysis approach. Different cross-linkers and plasticizers were tested in order to analyse their effects on the final performances of the films. A prototype was used to create specific drying conditions for each film forming solution (FFS), including infrared heating and ventilation as the drying technologies (Fig. 1). Microstructural, mechanical and barrier (i.e. air; UV-vis light) properties were evaluated in this study.

Petroleum-derived plastics are widely used to produce packages and films for food packaging. Their production requires a large consumption of raw materials and the disposal of waste is going to be more and more difficult because of their resistance to be degraded [1]. The biopolymers represent a sustainable alternative to the conventional plastics for food packaging, e.g. the production of films. The biofilms' technological properties are strictly related with their specific composition and production process [2,4]. In particular, the drying process represents the critical step of the process. In fact, basing on the applied conditions, drying can either enhance or damage the performances of the films [3].

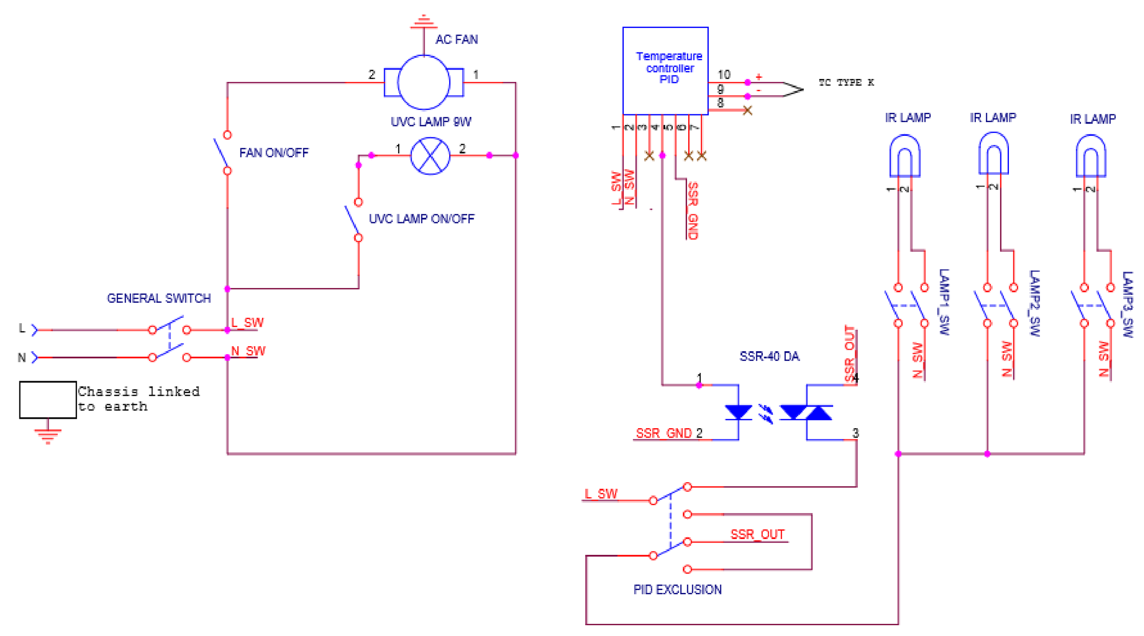

Figure 1: Electrical scheme of the prototype

Materials and Methods

4 combinations of polymer + plasticizer considered:
P + glycerol (GL)
P + propylene glycol (PG)
CH+GL
CH+PG

Each combination was investigated using a Plackett-Burman design to optimise the composition of the FFSs. The experimental factors were: biopolymer concentration; presence/absence of the plasticizer; presence/absence of STMP, $CaCl_2$ and UV-C radiation as cross-linkers; drying temperature (25 °C vs 75 °C) and ventilation.
The response properties were: optical, microstructural, drying time, mechanical, UV- and air-barrier. The optical and microstructural properties of the biofilms were directly evaluated through a visual analysis. The remaining properties were analysed altogether by PCA, to investigate both the correlation between the single properties and the effect of the experimental factors on them.

Results and Discussion

The first PCA model was calculated on the whole dataset, the other 4 models on the single combinations of polymer + plasticizer.
Out of 32 possible FFSs 4 of them did not form films due to the incompatibility of UV-C radiation with STMP. High temperature and UV-C made the films yellowish. STMP made the P films opalescent and developed aggregates in CH films. Scanning electron microscopy (SEM) confirmed the effect of STMP on CH (Fig. 1). P films were smoother than CH ones. However, $CaCl_2$ and high temperature induced bubbles in P films (Fig. 2).

The first PCA model demonstrated that STMP increased UV absorbance of all the FFSs (Fig. 4). $CaCl_2$ caused reduction in the UV absorbance of P films. The PCA model of P+GL demonstrated that high temperature reduced the drying time, with a synergic effect of ventilation (the same effect was observed for each formulation). The model of P+GL highlighted that the UV-C radiation enhanced the mechanical properties of the P+GL films. The GL was confirmed to be a good plasticizer for films' production. The PCA model of P+PG described that $CaCl_2$ enhanced the thickness and decreased the air permeability in P+GP films. The bad performances of PG as a plasticizer were demonstrated. The model CH+GL confirmed the relation between STMP and UV absorbance. STMP enhanced both thickness and permeability in CH. The concentration of the polymer increased the UV-vis absorbance. The variance of CH+PG depended on STMP and temperature, with similar results to those described for CH+GL (Fig. 5).

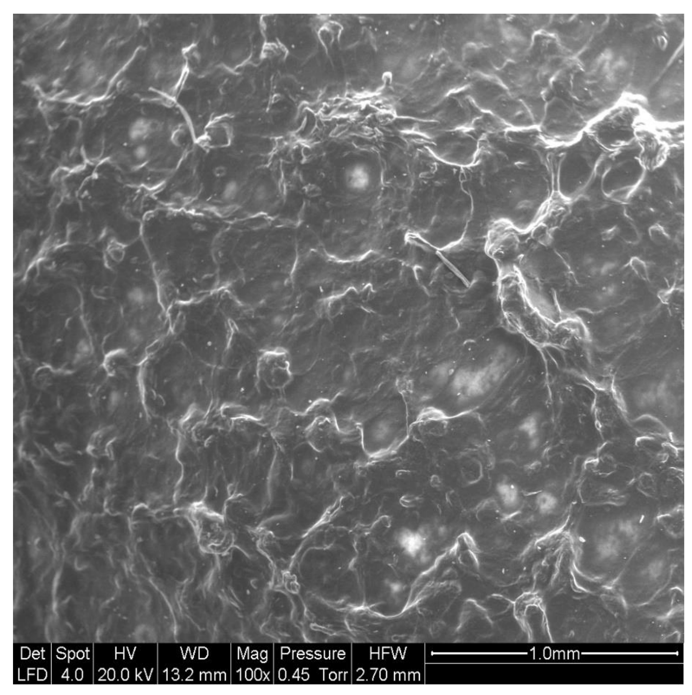

Figure 2: SEM image of CH film treated with STMP.

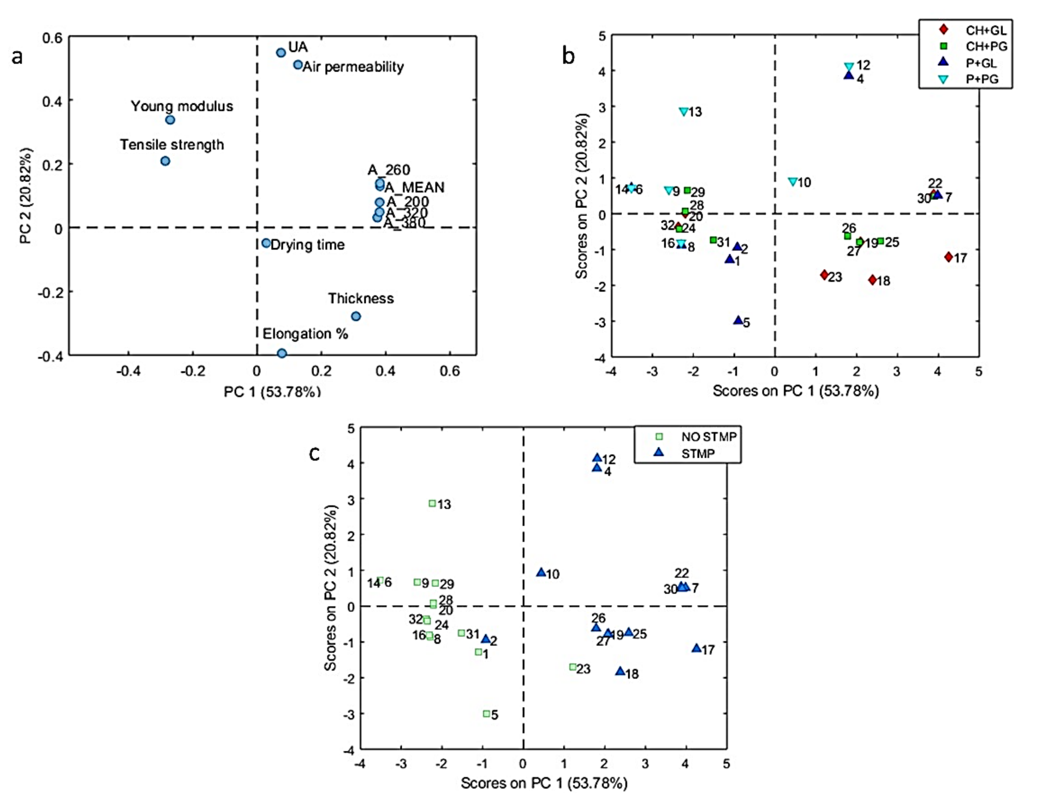

Figure 4: PCA model of the whole dataset: loading plot (a) and PC1-PC2 score plots according to polymer/plasticizer combination (b) and to presence of STMP (c).

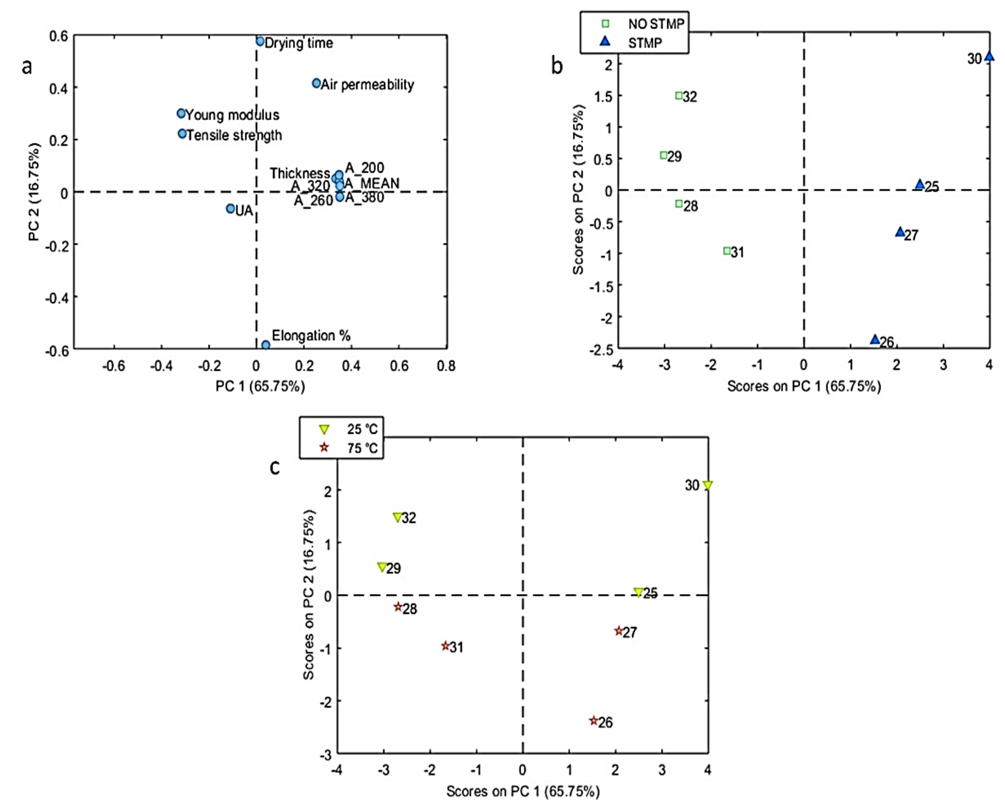

Figure 5: PCA model of CH+PG: PC1-PC2 loading plot (a) and PC1-PC2 score plots according to presence of STMP (b) and to drying temperature (c).

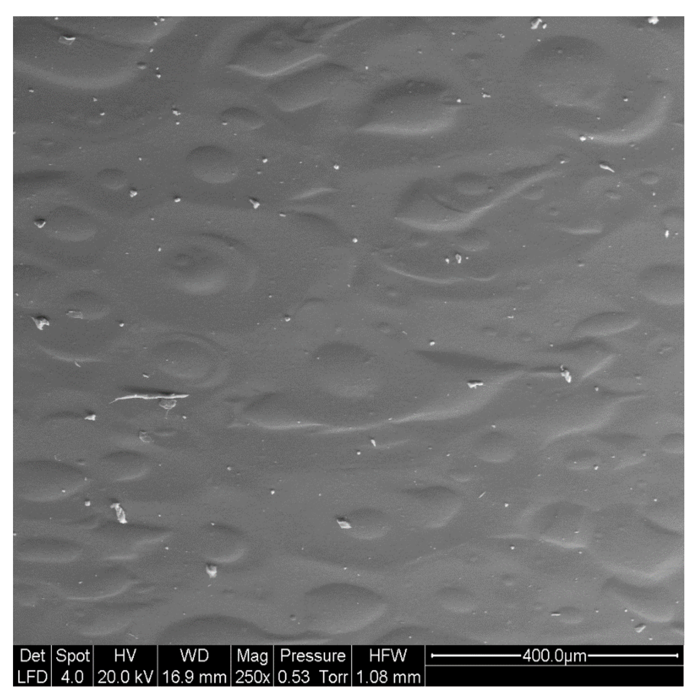

Figure 3: SEM image of P film dried at 75 º C and treated with $CaCl_2$.

Conclusions

The study provided a first insight into the parameters that mostly affected the films' properties. Further films' characteristics such as WVP and colorimetry profile might be considered in future. In any case, the data collected are strongly important to select the manufacture conditions leading to the optimal properties for each biopolymer.

References

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