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Future Plastics from Potato and Wheat: Let the Chemistry "Play"

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Introduction

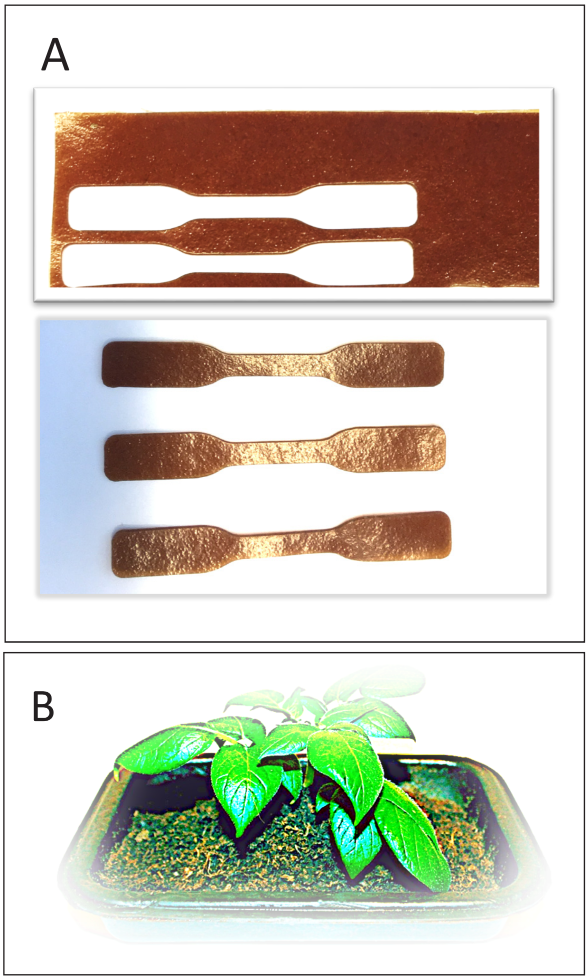
What would it be like if we could convert potato and wheat residuals into green composites for an interior panel of an electric vehicle? Or from the potato and wheat residual components we could design a flower pot that self-provides nutrients for a plant? These futuristic ideas for using potato and wheat residuals might be a reality rather soon and that could potentially fulfil our sustainable future needs.

In Southern Sweden potato and wheat, two main crops are primarily grown for food purposes e.g. potatoes for the table, and production of potato starch and wheat flour. But if potato and wheat could serve for a dual purpose e.g. food/feed and bio-based materials, it would be an excellent gain for Swedish sustainable agriculture and the overall bio-economy. Gluten proteins (originating from animal feed quality wheat) and potato proteins are residuals after starch extraction from wheat and potato, respectively, and are both attractive components for making resilient or "rubber" like plastics. So, one of our research questions was if we combine these two protein residuals into a blend with the help of chemical additives, can we produce plastics with valuable and unique properties, such as high resilience and rubbery behaviour?

In this fact-sheet we show our recent promising findings on fabrication of few green composites from potato and wheat residual components made with the help of chemical aids to have diverse properties and colours. With the interplay of chemistry between the potato and wheat components, and chemical aids, we show an ability to produce few green plastic materials with improved mechanical properties and lower processing temperatures in comparison to chemical aid-free materials.

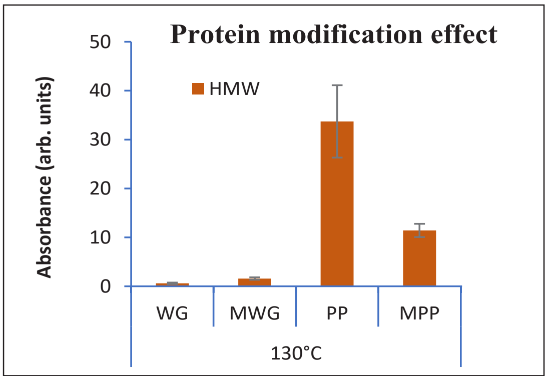
As indicated in the picture above, composites varied in colour from light yellowish-brown of more gluten protein containing composite (a top sample with punched holes, Picture 1A) to dark brown (a bottom sample of a dog bone shape, Picture 1A) or dark brown composites with more potato protein versus gluten protein. The important finding was related to the use of chemical aids prior to wheat and potato protein processing, which means that adjusting the protein components and processing aid chemistry helped to create composites with improved functional properties, such as increased ability to stretch and resilience to damage. We looked closer at wheat and potato protein chemistry and tried to answer the question of what happens to the protein components when they are mixed with the chemical aid or are modified (M letter indicates modified protein) before they are turned into a composite (Figure 1). We observed two different behaviours of the protein components studied: wheat gluten protein had more chemical interplays within itself then with the chemical aid, while potato protein showed a good

Picture 1.



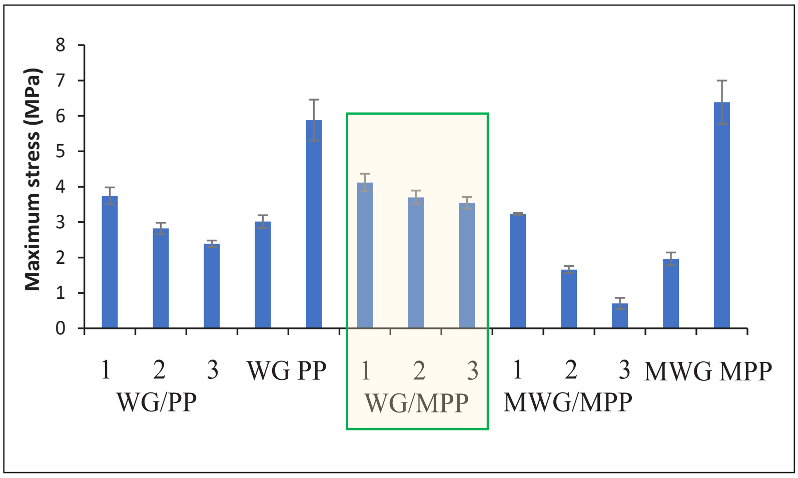
A) an example of a potato protein and wheat gluten composite (more gluten in the blend than potato protein); B) An example of an item resembling a flower pot entirely made of plant protein components and chemical aids; pictures taken by F. Muneer.

Figure 1.



Protein solubility and cross-linking illustrating chemical interplay studied by SE-HPLC. WG- wheat gluten protein, PP- potato protein; MWG- modified wheat gluten protein, MPP- modified potato protein; HMW- high molecular weight protein complex.

Figure 2.



Ultimate strength when material is stretched to breaking.

interplay with the chemical aid (MPP bar is higher than MGP) (Figure 1). A combination of non-modified wheat gluten protein with chemically modified potato protein in a composite gave materials with good resilience that could withstand the highest maximum stresses among the composites produced in this study and also showed attractive "rubber" like properties (Figure 2). In summary, a good chemical interplay between the potato protein and the chemical aid was needed to create green composite materials from wheat gluten and modified potato protein with promising functional characteristics and versatile uses.

Possible uses of the potato and gluten protein composites

Our investigation shows that the chemical modification of potato protein created a green composite material that can withstand higher so called maximum stress, a property referring to the ultimate strength when material is stretched/pulled to breaking, when compared to the non-modified composite (Figure 2; improvement is indicated for the samples in the green square). This property might be of high interest for plastic materials, that can be used for applications such as, flower pots (illustrated in Figure 2) or garden edges. Beside the mentioned applications, our produced composite material might also serve as a good nutrient source for the plant or soil, although a good control-release function and degradation properties of these protein composite materials should be further investigated and optimized.

Summary

Can we design future plants, potato and wheat, that could serve us for a dual purpose as food/feed and green materials? In this fact-sheet we show promising possibilities on creating green composites from the potato and wheat residual proteins with the help of chemical aids. With the interplay of chemistry between the potato and wheat proteins, and chemical aids, we show an ability to produce several composites with good resilience and rubber-like composite materials for various purposes. Our findings point out that in order to produce a green and good resilient composite from the potato protein and wheat gluten, a chemical aid is needed to modify the potato protein and improve the properties of a composite. The most promising green composites from this study can be a potential alternative for further eventual design of for example, flower pots with the function of providing nutrients. With this study, we demonstrate a successful collaboration between the researchers at SLU and Lyckeby Stärkelsen AB, that provided potato protein and in this way contributed to design of new green composites and novel end-uses of potato protein. The futuristic ideas of using the potato and wheat residuals for making green composites might be a reality rather soon…if you let the chemistry "play".

- Faktabladet är utarbetat inom LTV-fakultetens Institutionen av Växtförädling, http://www.slu.se/sv/institutioner/vaxtforadling-bioteknik/
- Projektet är samfinansierat av Lyckeby Stärkelsen AB, Trees and Crops for the Future (TC4F) och Partnerskap Alnarp
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