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Potato peels: a rich source of pharmaceuticals and bioactives

Key external stakeholders:

Potato growers, Potato processors, pharmaceuticals, functional food manufacturers, government authorities/legislators, consumers, food research scientists

Practical implications for stakeholders:

Large volumes of potato peels as by-products are generated as a result of processing of foods. This project highlighted the potential use of this waste as a source of bio-active compounds for bio-pharmaceutical and natural bio-control agents.

Main results:

- A set of optimised methods for the extraction, isolation, purification and characterisation of glycoalkaloids was developed. Optimised large scale solid liquid extraction of glycoalkaloids from potato peels yielded ~90% pure aglycone solanidine (500 mg) following acid hydrolysis and flash chromatography separation.
- The purified aglycone glycoalkaloid, solanidine, had a high potential to synthesize novel anticancer and apoptotic drugs. As many as 29 novel compounds structurally related to glycoalkaloids had been synthesized and tested against a number of cell-line assays.
- None of the 9 different cultivars exceeded the threshold of toxicity of glycoalkaloids content of 1 mg/g. As expected, room temperature storage influenced the greater production of glycoalkaloids in peels when compared to potatoes stored at chilled temperature.
- Glycoalkaloids and potato peel extracts enriched in glycoalkaloids did not possess anticancer potential nor did they induce apoptosis nor showed cardioprotective effects. However, they demonstrated anti-inflammatory and immuno-modulatory potentials. Whilst the potato peel peptides showed anti-inflammatory, anti-hypertensive and modest anti-oxidant activities.
- Pelleted potato peels rich in glycoalkaloids contorlled the level of nematode *Globodera pallida* in conjunction with crop rotation or nematicide and more importantly the light treated pelleted peels had significantly higher ‘suicide hatch’ rate of potato nematodes.

Opportunity / Benefit:

Outcomes of the project will especially be of use to the potato processors as the development of methodologies for the recovery of valuable compounds from their waste stream will allow them to exploit a potentially valuable resource. This strategy also seeks to harness new technologies for use in plant sciences, food innovation and bio-pharmaceutical applications. In addition, levels of toxic glycoalkaloids in the Irish fresh potato cultivars will be determined for the safety of the consumers and also investigate the effect of commercial storage conditions of potatoes used by the processing industries. The outcomes of the project will also indirectly address the call for sustainable agriculture development as it seeks to find an environmentally safe solution for the control of potato nematodes, a major pest of potato crops, which cause significant damage and losses.

Collaborating Institutions: University College Cork; Largo Foods, Ashbourne, Co. Meath; Wilson’s Country, Craigavon, Co. Armagh.

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1. Project background:

Processing of potatoes involves the generation of large amounts of waste especially in the form of peel. However, the potato peel is a rich source of a group of chemical compounds known as glycoalkaloids. These compounds are known toxins to humans at high levels (>200 mg/kg), however, some evidence indicates that they may possess anti-carcinogenic activities and other health benefits when present at lower levels indicating a possible use in the phyto-pharmaceutical industry. In addition glycoalkaloids can act as a hatch agent which may be explored to control nematode infestation in potato crops. This project aims to examine the potential of potato peel waste as a source of glycoalkaloids for the control of nematodes by developing methodologies and schemes for recovery of these potentially valuable compounds. In addition, an in-depth investigation of the bio-activity and toxicity of these agents will be undertaken. After removal of glycoalkaloids the remaining waste will be tested for presence of potential bioactive peptides.

2. Questions addressed by the project:

The project addresses the following specific questions:

- Can extraction methodologies be developed to recover glycoalkaloids in sufficient amount from a potato peel by-product for bio-pharmaceuticals and examine the efficacy of glycoalkaloids enriched peels as nematode control agents?
- What are the levels of glycoalkaloids in Irish whole potato cultivars and how does the commercial storage by the potato processing industry can affect their levels?
- Could the detoxified peels (after removal of toxic glycoalkaloids) serve as source of bio-active peptides?

3. The experimental studies:

A number of extraction technologies from conventional thermal (solid-liquid, pressurized liquid) and novel non-thermal (ultrasonication, pulsed electric field and pulsed light) extraction techniques were employed. Response surface methodology assisted the optimisation of extraction of crude glycoalkaloids in high yield. Further enrichment and isolation of glycoalkaloids were achieved using a combination of flash-chromatography and preparatory chromatography. Synthetic analogues of glycoalkaloids were prepared in Prof. Anita Maguire's lab. Ammonium sulphate was employed to precipitate peel proteins which where hydrolysed using trypsin. Biological assays such as immune-modulatory and against cancer cell-lines were investigated. Identification and quantification of the glycoalkaloids and peptides were carried out on an UPLC-MS/MS systems.

4. Main results:

- A set of optimised methods for the extraction, isolation, purification and characterisation of glycoalkaloids was developed. Optimised large scale solid liquid extraction of glycoalkaloids from potato peels yielded ~90% pure aglycone solanidine (500 mg) following acid hydrolysis and flash chromatography separation.
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5. Opportunity/Benefit:

Development of anti-carcinogenic and anti-inflammatory drug from a cheap and easily accessible source will be useful for pharmaceutical industries. A number of compounds synthesised in this project had shown very good anti-cancer activity with excellent IC_{50} values and could have potential in the future as possible target candidates for the pharmaceutical industry. The light treated pelleted peels have potential for acceptance by the organic certification bodies, thus opening up a new market for PCN control products.

6. Dissemination: The technology has been transferred in a number of ways, primarily through scientific A1 publications, conferences and an industry workshop as outlined below:

Main publications:

- Sinead E. Milner, Nigel P. Brunton, Peter W. Jones, Nora M. O' Brien, Stuart G. Collins and Anita R. Maguire. (2011). Bioactivities of Glycoalkaloids and their Aglycones from Solanum species. *Journal of Agriculture and Food Chemistry*, 59 (8), 3454-3484.
- Kenny, O.M., Brunton, N.P., Rai, D.K., Collins, S.G., Maguire, A.R., Jones, P.W. and O'Brien, N.M. (2013). Cytotoxic and apoptotic potential of potato glycoalkaloids in a number of cancer cell lines. *Journal of Agricultural Science and Applications,* 2(4): 184-192.
- Kenny, O.M., Brunton, N.P., Hossain, M.B., Rai, D.K., Collins, S.G., Maguire, A.R., Jones, P.W. and O'Brien, N.M. (2013). Anti-inflammatory properties of potato glycoalkaloids in stimulated Jurkat and Raw 264.7 macrophages. *Life Sciences,* 92(13), 775-782.
- Hossain, M. B., Tiwari, B. K., Gangopadhyay, N., O'Donnell, C., Brunton, N. P. and Rai, D. K. (2014). Ultrasonic extraction of steroidal alkaloids from potato peel waste. *Ultrasonics Sonochemistry*, 21(4), 1470-1476.
- Hossain, M., Aguiló-Aguayo, I, Lyng J.L, Brunton, N.P. and Rai, D.K. (2014). Effect of pulsed electric field and pulsed light pre-treatment on the extraction of steroidal alkaloids from potato peel Innovative Food Science and Emerging Technologies*. Innovative Food Science and Emerging Technologies*, *In Press.* DOI: 10.1016/j.ifset.2014.10.014.

Conference Abstracts

- O'Brien, NM, O'Callaghan YC, Foley DA, McCarthy FO, Maguire AR (2010). Cytotoxic and apoptotic effects of stigmasterol oxides in U937 cells. Proceeding of the 8th Euro Fed Lipid Congress, Munich, Germany. 21-24 November 2010.
- Hossain M.B., Brunton N.P., Smyth T., Rai D.K. (2012). Response surface optimization of solid-liquid extraction condition for the extraction of glycoalkaloids from potato peel. International Conference on Food safety, Quality and Nutrition: Greening the Food Industry. Manchester Metropolitan University, UK. 11-13th April 2012. Page 15.
- Hossain M.B., Brunton N.P., Smyth T., Rai D.K. (2012). Effect of drying methods on the glycoalkaloids content of potato. International Conference on Food safety, Quality and Nutrition: Greening the Food Industry. Manchester Metropolitan University, UK. 11-13th April 2012. Page 90.
- Hossain M.B., Tiwari B.K., O'Donnell C., Rai D.K., Brunton N.P. (2012). Extraction of glycoalkaloids from potato peel waste. IFT Conference, Las Vegas, USA.June 25-June 28, 2012.
- Hossain. M.B., Aguiló-Aguayo. A., Brunton. N.P., Rai. D.K. (2013). Optimization of pressurized liquid extraction of glycoalkaloids from potato peel using response surface methodology. EUROFOODCHEM XVII, Istanbul, Turkey, May 7-10, 2013.

Industry Workshop: Waste not Want not – Recovering value from Food Waste, 7th February 2014 – A book of abstracts.

Popular publications:

- Hossain. M.B. and Rai, D.K. (2014). Storage conditions and potato glycoalkaloids. *TResearch,* Summer edition, pages 16-17.
- Potatoes appeal to our health' in *The Irish Times,* July 16, 2009 under Science section.

7. Compiled by: Dr. Dilip Rai

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