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Anti-oxidant and anti-microbial compounds from dandelion root, fenugreek and bitter melon

Key external stakeholders:

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

Practical implications for stakeholders:

The bioactive constituents in these species, in particular *Taraxacum officinale* (dandelion) roots, offer promising leads as sources of natural alternatives to synthetic food additives/preservatives.

Main results:

- The ethyl acetate extracts (1 mg/ml) of *Trigonella foenum-graecum* (fenugreek) seeds had the highest antioxidant activity (DPPH IC_{50} = 212 µg/ml) but showed no anti-microbial activity.
- The ethyl acetate extract of *Momordica charantia* (bitter melon) exhibited antimicrobial activity against *S. aureus*, MRSA and *B. cereus* strains (MIC = 62.5 – 93.8 µg/ml) while the *n*-hexane extract and a methanol-hydrophilic dialysed extract of *M. charantia* fruit demonstrated the best antioxidant activity in comparison to all other extracts from this species (DPPH IC_{50} = 575 – 648 µg/ml).
- Dandelion roots (*T. officinale*) contains 1, 5-dicaffeoylquinic acid as a major antioxidant compound while its ethyl acetate extract demonstrated the strongest antimicrobial activity against *S. aureus*, MRSA and *B. cereus* strains (MIC = 250 – 500 µg/ml).
- A number of previously unreported compounds (4-Hydroxyphenylacetic acid derivatives of inositol) were isolated from dandelion root that could have useful biological properties not under investigation here.

Opportunity / Benefit:

Dandelions are under-utilised plants and often considered as weeds. However dandelion roots were shown to have substantial anti-oxidant and anti-microbial properties. The outcomes of the project demonstrated that these under-utilised plants can serve as excellent source of natural anti-oxidant and anti-microbial agents and therefore can be potentially exploited as natural food preservatives and for nutraceutical applications.

Collaborating Institutions:

University College Dublin

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1. Project background:

Since ancient times plants have been exploited by mankind for their associated medicinal properties. As our basic understanding of medicinal plants continued to develop so too did our expertise in successfully isolating their active components. Whilst the use of medicinal remedies gradually began to decline in favour of synthetic alternatives, the use of plants has remained strong in developing countries as an alternative medicine. Today the biological efficacies of plant derived metabolites are again receiving interest as active components in functional foods for general health and also to delay the onset of many diseases such as cancer, diabetes and inflammatory disorders. The development and refinement of biological screening strategies and analytical technologies over time has greatly enhanced the continued identification of bioactive compounds from plant origin. However, the pharmacological benefits of many traditional medicinal plants and the underlying compounds responsible for their purported efficacy remain largely unexplored or poorly understood. To this end the present study aimed to investigate the biological efficacy of three medicinal plants (*Momordica charantia, Trigonella foenum-graecum* and *Taraxacum officinale*) with long histories of use to treat various disorders but with little information on the compounds responsible for these properties.

2. Questions addressed by the project:

The existing literature on the antioxidant and anti-microbial activities of these three species were inconclusive. The project therefore addresses the following questions:

- Do these three species have anti-microbial and anti-oxidant activities and what level of activity do they have?
- What is the identity and chemical structure of the compound(s) responsible for the bioactivity?
- How much of these bioactive compounds are present in the respective species?

3. The experimental studies:

Crude extracts of the samples were prepared using various solvents of varying polarity. Solvent-solvent partitioning and/or molecular weight cut off filtration were employed on the crude extract fractions. Further purification was carried out using normal and reverse phase flash and preparative chromatography. All the fractions were investigated for in-vitro antioxidant activities and anti-microbial activities against a wide range of food-borne pathogens. The fractions that showed the strongest antioxidant and antimicrobial activities were further enriched using a combination of chromatographic techniques. The constituent bioactive compounds were then identified and quantified with hyphenated spectroscopic methods. The LC-NMR facility at TFRCA was particularly useful in this regard.

4. Main results:

- The ethyl acetate extracts of *T. foenum-graecum* (fenugreek) seeds at 1 mg/mL demonstrated the strongest antioxidant activity (DPPH IC_{50} = 212 µg/ml) but showed no anti-microbial activity.
- The ethyl acetate extract of *M. charantia* (bitter melon) demonstrated strongest antimicrobial activity against *S. aureus*, MRSA and *B. cereus* strains with (MIC = 62.5 – 93.8 µg/ml while the *n*-hexane extract and a methanol-hydrophilic dialysed extract of *M. charantia* (bitter melon) fruit demonstrated the best antioxidant activity in comparison to all other extracts from this species (DPPH IC_{50} = 575 – 648 µg/ml).
- Dandelion roots (*T. officinale*) contains 1, 5-dicaffeoylquinic acid as a major antioxidant compound while its ethyl acetate extract demonstrated the strongest antimicrobial activity against *S. aureus*, MRSA and *B. cereus* strains (MIC = 250 – 500 µg/ml).
- A number of previously unreported compounds (4-Hydroxyphenylacetic acid derivatives of inositol) were isolated from dandelion root that could have useful biological properties not under investigation here.

In summary, the ethyl acetate extract of *T. officinale* root has demonstrated strong antioxidant and antimicrobial properties which may warrant further investigation in food matrices as a potential functional

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food ingredient.

5. Opportunity/Benefit:

Dandelions are under-utilised plants and often considered as weeds. However dandelion roots were shown to have substantial anti-oxidant and anti-microbial properties. Therefore outcomes of the project demonstrated that these under-utilised plants can serve as excellent source of natural anti-oxidant and anti-microbial agents and therefore can be potentially exploited as natural food preservatives and for nutraceutical applications.

6. Dissemination:

The technology has been transferred in a number of ways, primarily through scientific A1 publications and conferences as outlined below:

Main publications:

1. Kenny, O., Smyth, T.J., Hewage, C.M., & Brunton, N.P. (2014). Quantification of caffeoylquinic acid derivatives in bioactivity-guided fractions of an antioxidant ethyl acetate extract from dandelion (Taraxacum officinale) root. International Journal of Food Science and Technology, DOI: 10.1111/ijfs.12668.
2. Kenny, O., Smyth, T.J., Walsh, D., Kelleher, C.T., Hewage, C.M., & Brunton, N.P. (2014). Investigating the potential of under-utilised plants from the Asteraceae family as a source of natural antimicrobial and antioxidant extracts. Food Chemistry, 161, 79 – 86.
3. Kenny, O., Smyth, T.J., Hewage, C.M., & Brunton, N.P. (2014). Antioxidant properties and quantitative UPLC-MS/MS analysis of phenolic compounds in dandelion (Taraxacum officinale) root extracts. Free Radicals and Antioxidants, 4(1), 55 – 61.
4. Kenny, O., Smyth, T.J., Hewage, C.M., & Brunton, N.P., McLoughlin, P. (2014). 4-hydroxyphenylacetic acid derivatives of inositol from dandelion (Taraxacum officinale) root characterised using LC-SPE-NMR and LC-MS techniques. Phytochemistry, 98, 197 – 203.
5. Kenny, O., Smyth, T.J., Hewage, C.M., & Brunton, N.P. (2013). Antioxidant properties and quantitative UPLC-MS analysis of phenolic compounds from extracts of fenugreek (Trigonella foenum-graecum) seeds and bitter melon (Momordica charantia) fruit. Food Chemistry, 141(4), 4295 – 4302.
6. Kenny, O., Smyth, T.J., McLoughlin, P., Hewage, C.M., Brunton, N.P. & Rai, D.K. (2011). Isolation and Structural Characterisation of a Bioactive compound from Bitter Melon. *Recent Advances in Synthesis and Chemical Biology X Symposium,* University College Dublin, 9th December 2011.

Popular publications:

1. Kenny, O., Smyth, T.J., McLoughlin, P., Walsh, D., Brunton, N.P., Rai, D.K., & Hewage, C.M. (2012). Bioactivity Guided Fractionation, Isolation and Characterisation of Plant Secondary Metabolites from Bitter Melon (*Momordica charantia*) Fruit, Fenugreek (*Trigonella foenum- graecum*) Seeds and Dandelion (*Taraxacum officinale*) Roots. *Teagasc Walsh Fellowships Book of Abstracts,* RDS Hall, Ballsbridge, Dublin 4, 22 November 2012.
2. Kenny, O. (2014). Investigation and characterisation of antioxidant and antibacterial compounds from bitter melon (Momordica charantia) fruit, fenugreek (Trigonella foenum-graecum) seeds and edible Asteraceae species. *PhD Thesis*.

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