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Retaining health promoting polyacetylenes in fully processed vegetables

Key external stakeholders:

Vegetable processors, government authorities/legislators, consumers

Practical implications for stakeholders:

Technologies for the maximum retention of biologically active polyacetylenes in carrot, parsnips and fennel products were developed in this project and these have been formulated and disseminated to industry stakeholders, especially as recommendations to processors.
Results from the project have been formulated into a series of blueprints and fact sheets for end-users. Knowledge gained from the project can be used to formulate processing strategies which will maximize the retention of polyacetylenes in processed foods.

Polyacetylenes are a group of bioactive compounds present in carrots and other vegetables which have recently gained scientific attention due to their ability to inhibit cancer development in rats. Carrots contain three polyacetylenes; falcarinol (FaOH), falacrindiol (FaDOH) and falcarindiol-3-actetate (FaDOAc). The present project sought to examine effective processing strategies for retaining these compounds in vegetables and facilitated key recommendations to be made to processors and consumers.

Main results:

- During minimal processing, abrasive peeling accounts for most of the losses in polyacetylene levels, when compared to other minimal processing treatments such as cutting and washing. Therefore, to maximise polyacetylene contents in minimally processed carrot products less severe methods of peeling are recommended.
- The inclusion of a blanching step prior to sous-vide processing resulted in a significant decrease in levels of FaOH and FaDOH in parsnip disks. Subsequent sous-vide processing had little effect on levels of polyacetylene; however, chill storage for up 20 days did result in significant decreases in these compounds. Roasting results in significant losses of polyacetylenes from fennel bulb.
- Ultrasound assisted hot air drying (UAHD) resulted in higher retention of polyacetylenes in dried carrot disks than blanching followed by hot air drying. Given the minimal impact of ultrasound on polyacetylene content and the general negative impact of blanching, ultrasound could be considered as a replacement for blanching.

Opportunity / Benefit:

Opportunities arising from the outputs of the project derive from the ability of vegetable processors to optimise processing protocols for the retention of polyacetylenes. A series of recommendations have been made with regard to traditional and novel processing techniques and these can be used to produce premium products with optimal health promoting properties.

Collaborating Institutions:

NUIG, Natures Best Ltd, Drogheda, Co. Louth

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1. Project background:

A large number of epidemiological studies have associated consumption of fruits and vegetables with decreased risks of development of diseases such as cancer and coronary heart disease. Despite this, it is unclear which components are responsible for the health promoting properties of fruits and vegetables. C_{17} polyacetylenes are a group of bioactive compounds present in carrots which have recently gained scientific attention due to their cytotoxicity against cancer cells. In comparison to other compounds with cancer protective effects, relatively little is known about the occurrence of these compounds in plant foods or the effect of industrial or domestic processing on their retention. To date only a small number of studies have been published regarding the effect of processing on levels of polyacetylenes in vegetables. The aforementioned studies were limited in scope since they deal with one type of vegetable (carrot) and small number of processing protocols (steam blanching and boiling). Polyacetylenes have been shown to occur in other vegetables including parsnips and fennel; however, no information is available as to the effect of processing on the levels of these compounds in these vegetables. Little is known also about the relative contents of polyacetylenes in different vegetable varieties.

2. Questions addressed by the project:

The project asks:

- How do various processing methodologies affect the levels of polyacetylenes in carrots, parsnips and lettuce?
- What are the optimum processing parameters to retain falcarinol and falcarinol-type polyacetylenes in these vegetables?

3. The experimental studies:

Retention of polyacetylenes in a selection of vegetables (carrots, parsnips and fennel) following full scale processing and typical domestic cooking protocols was determined. Pilot-scale facilities were used to develop processing protocols which mimic those used for industrial full scale processing. Samples were subjected to industrial processing protocols i.e., conventional canning, sous-vide processing and high pressure processing and the retention of polyacetylenes determined immediately after processing and following storage. Losses of polyacetylenes following common domestic practices such as boiling, blanching steam cooking and roasting and after short defined refrigerated storage periods were also determined. Data garnered from the effect of full scale processing on polyacetylenes retention in will be used to formulate optimised processing protocols for maximum retention of the compounds.

4. Main results:

The objective of this project was to provide recommendations to processors of vegetables for maximum retention of polyacetylenes following full scale processing by assessing the effect of same on levels of polyacetylenes. The project involved developing industrially relevant protocols for a selection of vegetables (carrots, parsnips and fennel) which also incorporated pre-processing steps such as blanching. Both thermal (water immersion, sous-vide and canning) and non-thermal methods (high pressure processing) were developed as well as combinations of same (for example thermal high pressure treatments). A number of industrially relevant outcomes resulted from this work:

- During minimal processing, abrasive peeling accounts for most of the losses in polyacetylene levels, when compared to other minimal processing treatments such as cutting and washing. Therefore, to maximise polyacetylene contents in minimally processed carrot products less severe methods of peeling are recommended.
- Water immersion cooking of carrot disks resulted in losses of all three polyacetylenes both following storage and during subsequent chill storage. However, the degree of loss was not as marked as for more severe processing method such as canning.
- Canning resulted in severe losses of polyacetylenes in carrots following storage at room temperature for 12 months.
- In general high pressure processing resulted in increases in levels of polyacetylenes in comparison

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to fresh samples for both carrot and parsnip slices. However, the level of decrease was not dependent on magnitude of pressure applied. The reason for this effect is unclear but may be related to increases in their extractability. This will be investigated further as part of the IPFN (RMIS 5864).

- The use of high pressure in combination with temperatures from 50-70°C did result in losses of polyacetylenes and this effect was greatest at 70°C.
- The inclusion of a blanching step prior to sous-vide processing results in a significant decrease in levels of FaOH and FaDOH in parsnip disks. Subsequent sous-vide processing had little effect on levels of polyacetylene; however, chill storage for up 20 days did result in significant decreases in these compounds.
- Roasting results in significant losses of polyacetylenes from fennel bulb. Losses are less dramatic when the bulbs are boiled; however, levels in boiled bulbs are much lower than for fresh.
- Ultrasound assisted hot air drying (UAHD) resulted in higher retention of polyacetylenes in dried carrot discs than blanching followed by hot air drying.

5. Opportunity/Benefit:

Fruit and vegetable processing companies will be interested as the study points out various strategies that can be used to reduce the losses of bioactive compounds during processing with the health-benefit aspects to the consumers in consideration.
Teagasc can also provide the information/ technology as a service from the capacity and skill developed from this project. Teagasc has in fact disseminated the outcomes through symposiums mainly aimed at the food industry in Ireland. www.ipfn.ie

6. Dissemination:

The technology has been transferred in a number of ways, a sample is outlined below:

Main publications:

Rawson, A., Brunton, N., and Tuohy, M. (2012). Degradation kinetics of polyacetylenes in carrots as affected by combined treatment of pressure and temperature compared to sous-vide processing *Food Chemistry* 133: 15-20.

Rawson, A., Hossain, M. B., Patras, A., Tuohy, M., and Brunton, N (2011). Effect of Boiling and roasting on the levels of polyacetylenes and polyphenols in fennel bulb. *Food Research International* doi:10.1016/j.foodres.2011.01.009.

Rawson, A., Tiwari, B.K., Tuohy, M., O'Donnell, C.P., and Brunton, N (2011). Effect of ultrasound on polyacetylenes in carrot. *Ultrasonics Sonochemistry* 18: 1172 -1179.

Popular publications:

Rawson, A., Koidis, A., Rai, D.K., Tuohy, M., and Brunton, N (2010). Effect of sous-vide processing on the levels of polyacetylenes in parsnips. *Journal of Agricultural and Food Chemistry* 58: 7740-7747.

Koidis, A., Rawson, A., Tuohy, M., and Brunton, N. (2012). Influence of unit operations on the levels of polyacetylenes in minimally processed carrots and parsnips: An Industrial Trial. *Food Chemistry* 32: 1406-1412.

Rawson, A., Tiwari, B. K., Tuohy, M., Brunton, N., (2012). Impact of freezing and frozen storage on the levels of polyacetylene content, colour and texture of carrot disks. *Journal of Food Engineering* 108: 563-569.

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