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Blackberry polyphenols and heart health (*Cardio-RUBUS*)

Key external stakeholders:

Beverage industries, Food retailers, Food ingredient manufacturers, government authorities/legislators, consumers, food research scientists.

Practical implications for stakeholders:

Blackberries have a favourable nutritional profile; they are low in fat and kilocalories, while rich in dietary fibre, vitamins, folate, and are also a rich source of antioxidant compounds known as polyphenols. Research shows that increased consumption of fruit and vegetables, which are rich in polyphenols, is associated with reduced risk of cardiovascular diseases. However, there is a need for dietary studies to identify levels at which blackberry polyphenols are physiologically effective as findings on health effects associated with blackberry consumption are limited.

Main results:

- A systematic review exclusively focused on food-based berry fruit interventions and health outcomes revealed that two-thirds of high-quality berry-based dietary interventions demonstrated beneficial effects on markers of cardiovascular and metabolic health risk specifically, improvements in vascular function, blood lipid concentrations and fasting glucose concentrations.
- Guided by the findings of the systematic review, a novel polyphenol-rich blackberry beverage was developed and characterized for use in the dietary intervention study. Two blackberry beverages: a high-dose (treatment) and a low-dose (control) blackberry polyphenol beverages were formulated and manufactured at laboratory, pilot and commercial scale. Beverages underwent extensive stability testing and characterized for the main polyphenols present.
- A novel membrane filtration-based process was developed for the first time for the selective enrichment of polyphenols from blackberry puree using ceramic membrane technology.
- The dietary intervention study on 82 participants did not change blood pressure, arterial stiffness, concentrations of circulating glucose and blood lipids post consumption of the polyphenol rich blackberry beverage over a 6-week period. However, in a sub-group analysis showed a significant reduction in arterial stiffness in the hypertensive participants receiving the treatment, which was not observed in participants with a normal blood pressure.
- The findings further support the growing research consensus, which suggests that the large inter-individual variation in the response to polyphenol intakes may obscure beneficial associations between polyphenol-based food intakes and health outcomes in dietary interventions.

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Opportunity / Benefit:

- The survey results indicated that beverages are the predominant source of polyphenol intakes in the Irish population and are a potential means by which to increase polyphenol intakes.
- The novel process developed for selective enrichment of polyphenols from blackberry puree will assist Irish fruit processors and beverage product formulators in developing next-generation polyphenol-enriched beverages
- The fruit beverage industry now has important information on the stability of these polyphenols in commercially relevant beverage formats under typical storage conditions.
- The above findings are highly advantageous to the Irish food industry for the design of future polyphenol based functional foods and will inform policy makers establishing dietary recommendations for polyphenol intakes.

Collaborating Institutions: University College Dublin; Dublin Institute of Technology; Diageo Ireland, Dublin; Largo Foods, Ashbourne, Co. Meath; Monaghan Mushrooms, Tyholland, Co. Monaghan.

Teagasc project team: Dr. Dilip Rai (PI)
Dr. Ciaran Fitzgerald

External collaborators: Prof. Mairead Kiely, UCC (coordinator)
Dr. Alice Lucey, UCC
Dr. Seamus O'Mahony, UCC.
Dr. Jacqueline Lyons, UCC.

1. Project background:

Epidemiological data consistently indicate cardio-protective effects associated with increased berry consumption. Berry fruits are a rich source of bioactive polyphenols, which have well established health benefits. Blackberry is a berry fruit widely available in Ireland (native species *Rubus fruticosus*); interestingly between 2015 and 2017, the purchase of blackberry fruits has increased by 28% in Ireland (Bord Bia). Blackberries are rich micronutrients and contain a myriad of polyphenols including anthocyanins, ellagitannins, flavonols and flavan-3-ols, however, their effects on cardio-metabolic health remain to be established.

2. Questions addressed by the project:

The project addresses the following specific questions:

- What are the sources and level of polyphenol consumption in the diets of Irish adults and children particularly for the development of polyphenol-enriched functional foods?
- What are the main polyphenols and their abundances in the Irish native blackberry? How are the polyphenols affected at different storage temperatures and time?
- What were the implications of consumption of polyphenol-enriched beverage to a cohort of population (with normal blood pressure and hypertensive subject)?

3. The experimental studies:

These research activities adopted a stepwise approach to produce robust scientific data to substantiate the effect of blackberry polyphenols on cardio-metabolic health outcomes. First, the estimate dietary intakes of polyphenols and their predominant food sources in the Irish population using nationally representative data from recent food surveys were determined. Second, a novel functional polyphenol-enriched blackberry beverage was developed and characterized in terms of stability, polyphenol composition, nutritional profiling and sensory evaluation. Final step was the dietary intervention study on a cohort of participants and carried out the effects of blackberry-derived polyphenols on cardiovascular markers.

- **Main results:**
- A systematic review exclusively focused on food-based berry fruit interventions and health outcomes revealed that two-thirds of high-quality berry-based dietary interventions demonstrated beneficial effects on markers of cardiovascular and metabolic health risk specifically, improvements in vascular function, blood lipid concentrations and fasting glucose concentrations.
- Guided by the findings of this systematic review, a novel polyphenol-rich blackberry beverage was developed and characterized for use in the dietary intervention. Two blackberry beverages: a high-

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- A novel membrane filtration-based process was developed for the first time for the selective enrichment of polyphenols from blackberry puree using ceramic membrane technology.
- The dietary intervention study on 82 participants did not change blood pressure, arterial stiffness, concentrations of circulating glucose and blood lipids post consumption of the polyphenol rich blackberry beverage over a 6-week period. However, in a sub-group analysis showed a significant reduction in arterial stiffness in the hypertensive participants receiving the treatment, which was not observed in participants with a normal blood pressure.
- The findings further support the growing research consensus, which suggests that the large inter-individual variation in the response to polyphenol intakes may obscure beneficial associations between polyphenol-based food intakes and health outcomes in dietary interventions.
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4. Opportunity/Benefit:

Food-based dietary interventions are central to healthy aging, indicating a clear need and market opportunity to develop novel foods with proven benefits for cardiovascular and metabolic health.

Cardio-RUBUS undertook a 'farm to fork' approach integrating food research and enterprise to enable the development and characterisation of a functional blackberry beverage. This beverage was tested for physiological efficacy in Irish adults and provided scientific evidence on the effects of blackberry polyphenols on cardio-metabolic health. Thus, the outcomes open up a substantial market opportunity to develop novel functional foods with proven health benefits using one of Ireland's native fruits.

- **Dissemination:**

The Cardio-Rubus team have addressed several research objectives, resulting in the delivery of two MSc and one PhD theses. Findings had also been published in notable food science and nutrition journals, and raised awareness about the project both nationally and internationally as well as to the Irish food industry.

Main publications:

- Henegan C. (2017). Dietary bioactives and cardiovascular disease. PhD Thesis.
- Kelly N.P. (2017). Formulation of nutritional beverages and development of polyphenol-enriched ingredients from blackberry puree. MSc Thesis.
- Fitzgerald, S. (2015). Contribution of berries to cardio-protective bioactive intakes. MSc Thesis.
- Kelly, N.P.; Kelly, A.L.; O'Mahony, J.A. (2019). Strategies for enrichment and purification of polyphenols from fruit-based materials. Trends in Food Science & Technology 83, 248-258.
- García-Conesa, M.-T.; Chambers, K.; Combet, E.; Pinto, P.; Garcia-Aloy, M.; Andrés-Lacueva, C.; de Pascual Teresa, S.; Mena, P.; Konic Ristic, A.; Hollands, W., et al. (2018). Meta-analysis of the effects of foods and derived products containing ellagitannins and anthocyanins on cardiometabolic biomarkers: Analysis of factors influencing variability of the individual responses. International Journal of Molecular Sciences 19, 694.
- Heneghan, C.; Kiely, M.; Lyons, J.; Lucey, A. (2018). The effect of berry-based food interventions on markers of cardiovascular and metabolic health: A systematic review of randomized controlled trials. Molecular Nutrition & Food Research 62, 1700645.
- Heneghan, C.; Kiely, M.; Lyons, J.; Lucey, A. The effect of berry-based food interventions on markers of cardiovascular and metabolic health: A systematic review of randomized controlled trials. Molecular Nutrition & Food Research 2018, 62, 1700645.
- Heneghan, C.; Kiely, M.; Lyons, J.; Singh, T.; Lucey, A. (2016). Dietary intakes of polyphenols and food sources in ireland. Proceedings of the Nutrition Society 75, E127.
- Heneghan, C.; Lyons, J.; Lucey, A.; Kiely, M. (2015).Food-based berry intervention studies and blood pressure: A systematic review of randomised controlled trials. Proceedings of the Nutrition Society 74, E227.

Popular publications:

- García-Conesa, M.-T.; Chambers, K.; Combet, E.; Pinto, P.; Garcia-Aloy, M.; Andrés-Lacueva, C.; de Pascual Teresa, S.; Mena, P.; Konic Ristic, A.; Hollands, W., et al. Meta-analysis of the effects of

foods and derived products containing ellagitannins and anthocyanins on cardiometabolic biomarkers: Analysis of factors influencing variability of the individual responses. International Journal of Molecular Sciences 2018, 19, 694.
- Fitzgerald C., Rai D.K.,Lucey A., and Keily M. (2015). Linking Blackberry Polyphenols to Heart Health. TResearch 10(3): 16-17.

Conferences

- Henegan C. (2017). Can a polyphenol-enriched beverage increase polyphenol intakes in the Irish Population? Results of a scenario modelling assessment? New Horizons in Medical Research, conference hosted by UCC, Dec 7, 2017. (oral)
- Henegan C. (2017). Effect of a blackberry-derived polyphenol enriched beverage on blood pressure: A randomized controlled crossover trial. The Nutrition Society Irish Section Summer Conference, hosted at Queens University, Belfast, Jun 21-23rd, 2017.(Best oral presentation)
- Lucey, A. (2017). Effect of a blackberry-derived polyphenol enriched beverage on blood pressure: A randomized controlled crossover trial.11th World Congress on Polyphenol Applications, hosted at the University of Vienna, Austria Jun 20-21st, 2017 (oral)
- Henegan C. (2016). Dietary exposure of polyphenol-containing foods within the Irish population (New Horizons in Medical Research, conference hosted by UCC. Dec 8th, 2016. (poster)
- Lucey, A. (2016). Dietary exposure of polyphenol-containing foods within the Irish population. The 1st International Food Bioactives & Health Conference, Institute of Food Research, Norwich, UK, Sept 13-15th, 2016 (poster)
- Henegan C. (2016). Dietary exposure of polyphenol-containing foods within the Irish population. The Nutrition Society Irish Section Summer Conference, hosted at UCD, Dublin, Ireland. July 7-10th, 2016.(oral)
- Kelly N. (2015). Development of a polyphenol-enriched blackberry extract. The 44th Annual Food Research Conference hosted by Teagasc, Moorepark. Dec 14, 2015 (2nd best oral presentation)
- A Summary update of Blackberry studies added to the eBASIS database" (Oral Presentation) Heneghan C. (2015). Presented as part of the Extending eBASIS to study habitual intakes of bioactive compounds in the diet workshop, at the 4th BACCHUS Consortium Meeting, Bratislava, Slovakia. Nov 24th, 2015. "
- Fitzgerald C. and Rai. D.K. (2015). Dipeptidyl peptidase-4 Inhibitory polyphenolic fractions from Irish and international blackberries. International Conference on Polyphenols and Health, Tours, France. Oct 27-30th, 2015. (poster).
- Henegan C. (2015). Dietary exposure of polyphenol-containing foods within the Irish population. International Conference on Polyphenols and Health, Tours, France. Oct 27-30th, 2015. (poster).
- Kelly N. (2015). Development of polyphenol-enriched blackberry based ingredients.) 9th ISANH Congress on Polyphenol Applications at St. Julian's in Malta June 3-5th, 2015. (poster)
- Fitzgerald C. and Rai, Di.K. (2014). The effect of various drying methods on the antioxidant capacity of blackberries (Rubus sp.)43rd Annual Food Research Conference organised by the Institute of Food Science and Technology Ireland (IFSTI) at UCD Dublin Dec 10-14th, 2014. (poster)

Industry Workshops

Rai D.K. (2015). Chemical characterisation of Phytochemicals. Irish Phytochemical Food Network (IPFN) Symposium. Teagasc Ashtown on Sept 30, 2015 (oral presentation).

5. Compiled by: Dilip Rai