



Green chemistry extraction of actives from bio-based waste, and the development of sustainable cosmetic

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Sustainable Cosmetics

- **Source** of raw materials for **ALL** ingredients
 - Agricultural processes?
 - Water use?
 - Impact on habitats and biodiversity?
 - Societal impacts?
- What happens during **manufacture**?
 - Energy and water consumption? Emissions?
- **Green chemistry** approach for developing nature-derived ingredients
- **Impact** when product goes down the drain or into the air?
 - Does it **biodegrade**?
 - Does it go back into nature?



Brand principles and ethos



Made from Nature



- Products that are respectful of **natural** resources
- Where possible, utilise **waste** and resources that do not compete with land for food
- Offer **sustainable** solutions to the manufacturing of personal care & cosmetic products

Designed by Science



- Fundamentally based on **science-led** innovation
- Products with **outstanding performance**
- **Green chemistry** principles in actives extraction and formulation design
- Products that are **safe for the consumer**
- Products that are **safe for the environment**



SUSTAINABLE DEVELOPMENT GOALS



Food waste

- Annually, **one third of global food** produced for human consumption is either **lost or thrown away** (Food and Agriculture Organization of the United Nations)
- **~1.3 billion tonnes** of food goes to waste
- Food waste contributes **~8%** to annual global **GHG emissions** (World Resources Institute)
- **Land, animal habitats, water, agrochemicals, labour** and **energy** used to create the food is **lost**
- Down the **drain, incinerated, landfilled**
- **What about unavoidable food by-products?**



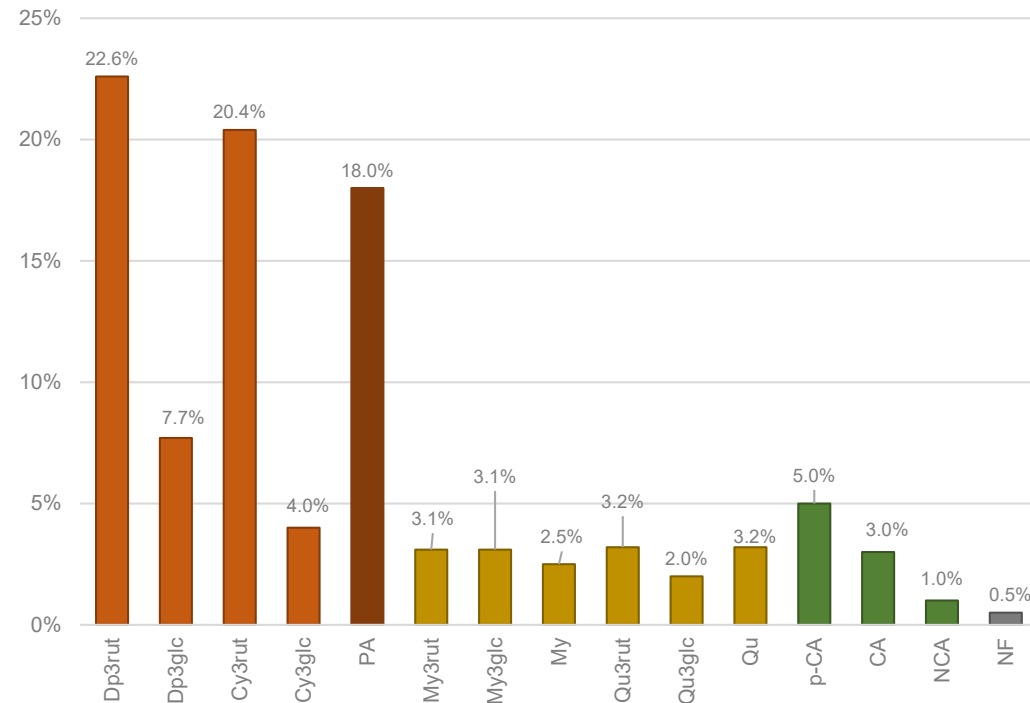
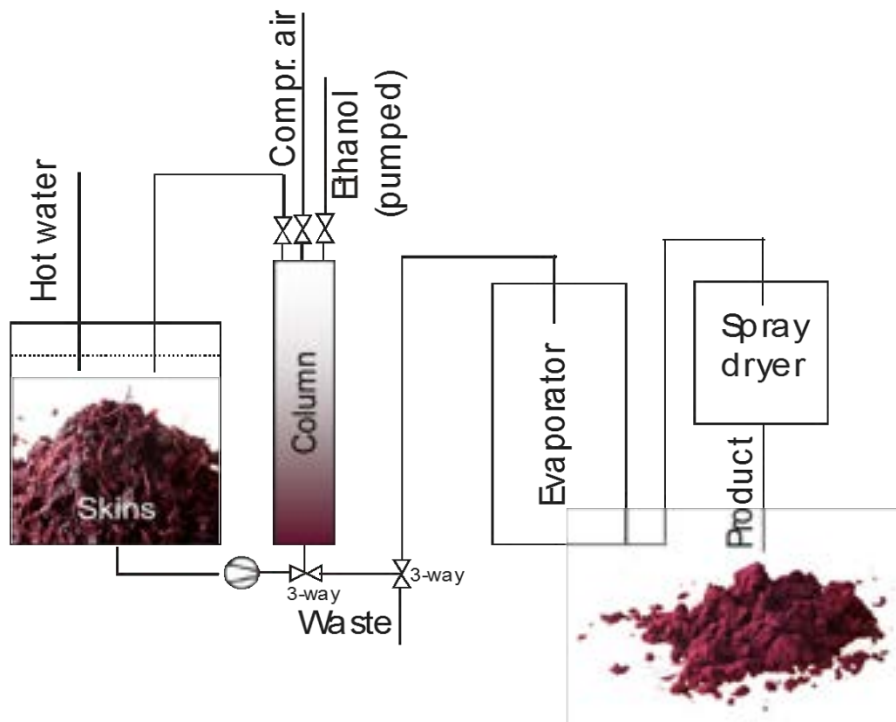
Blackcurrant

- **95%** all blackcurrants grown in UK are for *Ribena*
- In UK, **several hundred tonnes** of blackcurrant skin waste
- Deseeded for blackcurrant seed oil
- Remaining dried skins had no use (ploughed back into land)



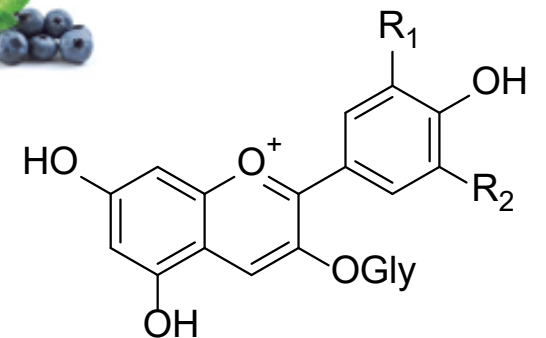
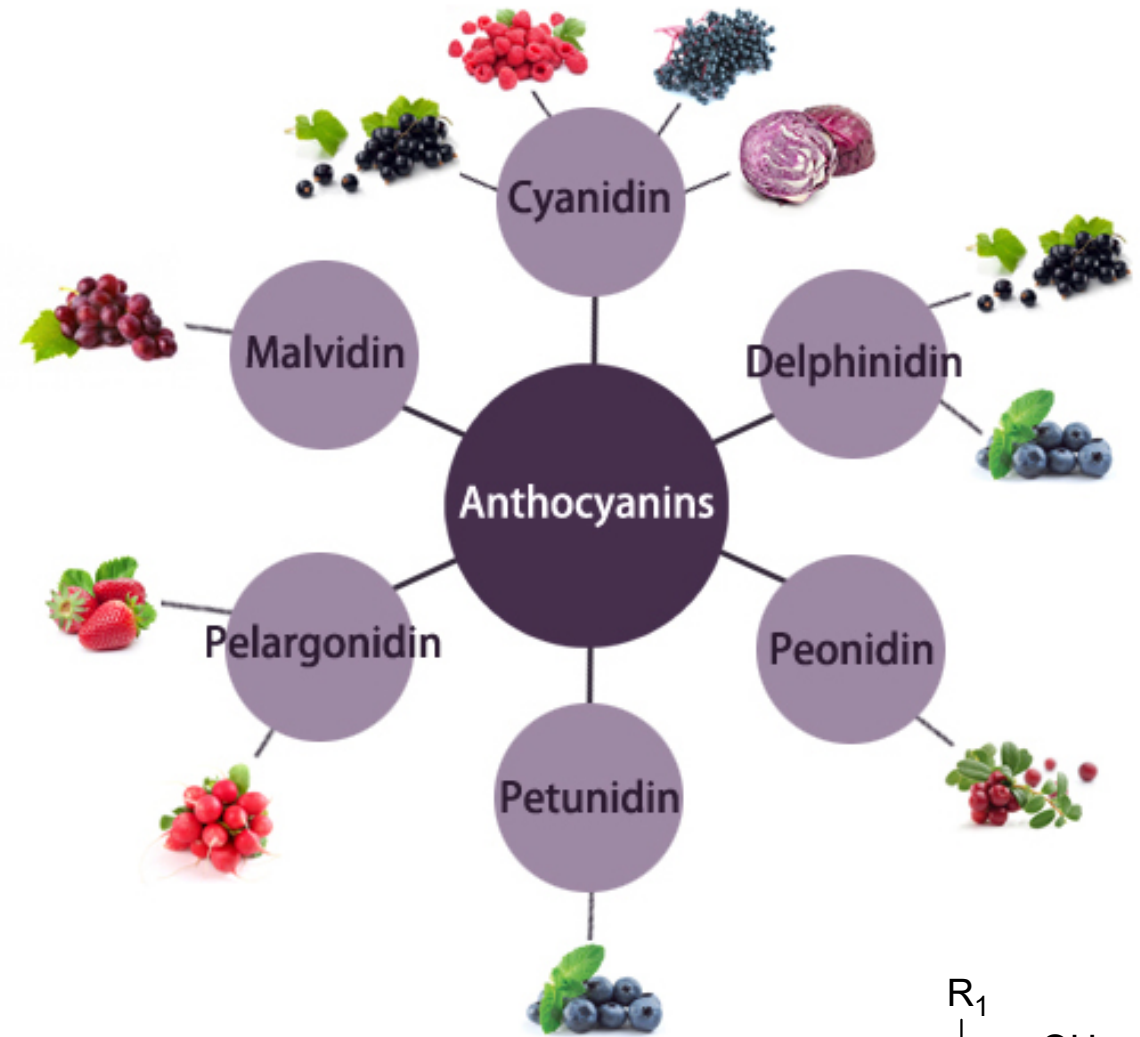
Blackcurrant skin extraction

- **Green chemistry** alternatives to conventional hair dyes
- Extract **anthocyanins** from blackcurrant fruit waste (*Ribena*)
- Extraction using a **water-based process** and **solid-phase resins**
- **Chemistry** all of natural compounds present **fully characterised**

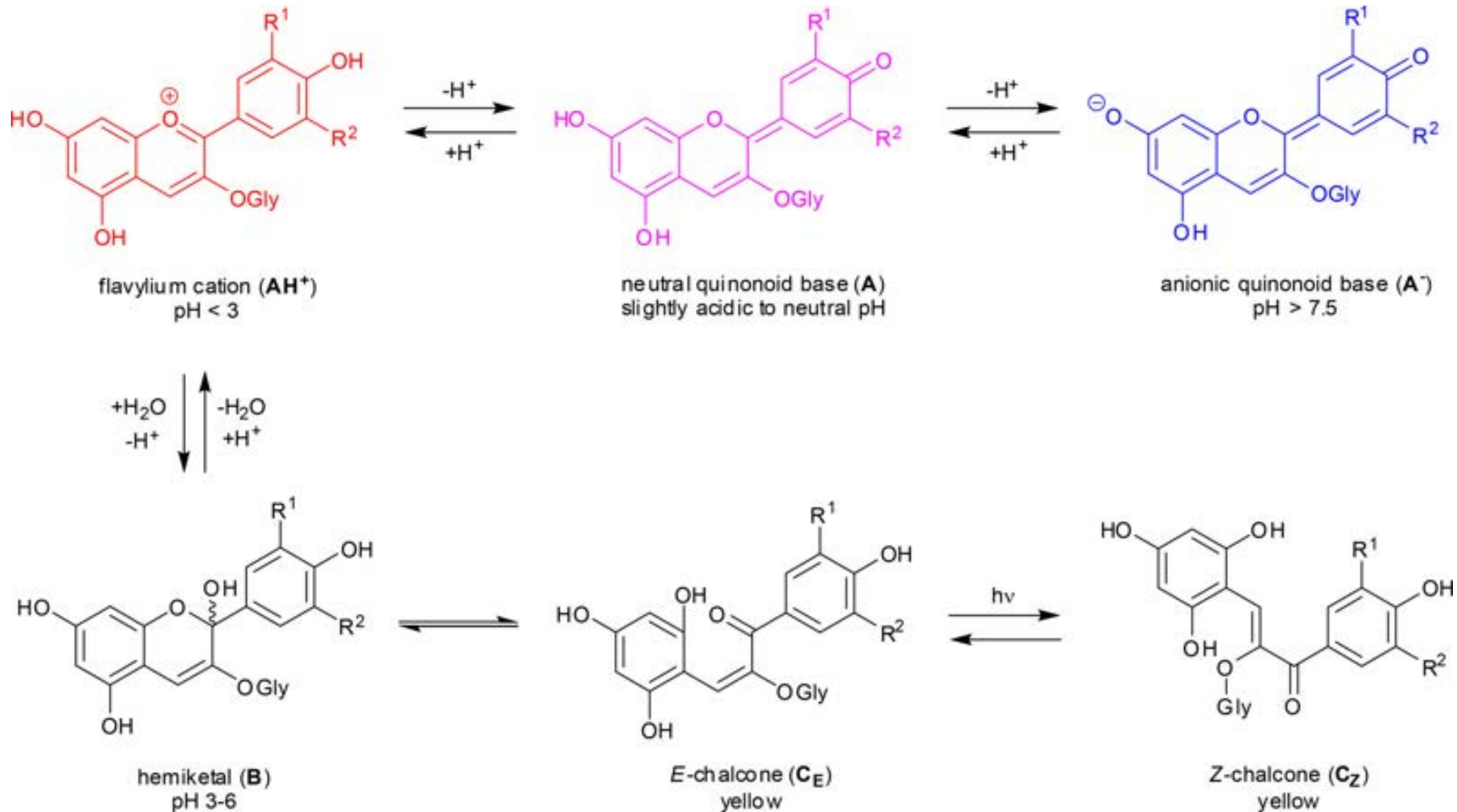


Anthocyanins

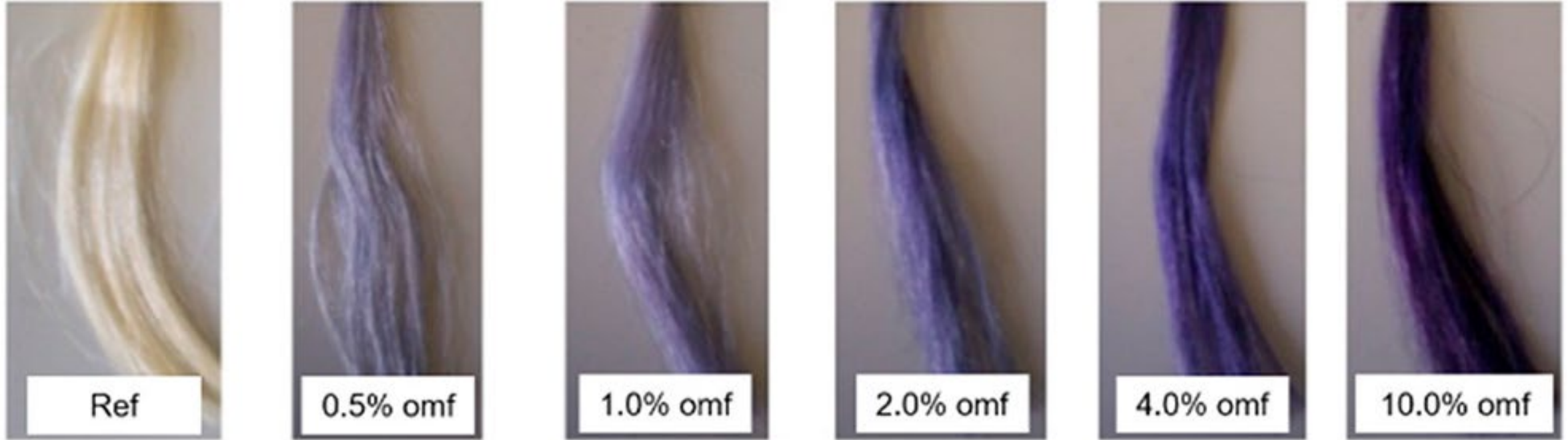
- Largest group of polyphenolic pigments in the plant kingdom
- **Nontoxic**, **water-soluble**, and responsible for **pink**, **red**, **purple**, **violet**, and **blue** colours in fruits, vegetables, and flowers
- Colours / stability determined by:
 - number of **hydroxyl** groups (and degree of methylation)
 - nature, number, and position of sugar moieties (**glycosides**)
 - **acylation** (aliphatic or aromatic) of glycosides



Chemistry of anthocyanins



Anthocyanin sorption



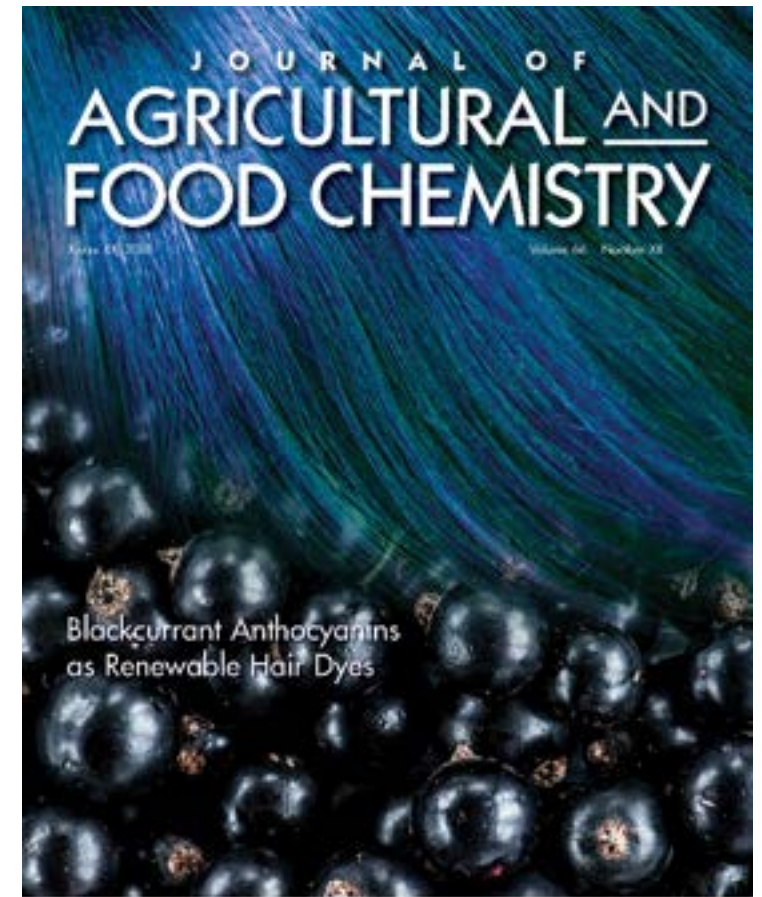
- Hair dyeings were **intensely blue coloured**, and a **surprising level of build-up** was achieved
- Semi-permanent hair colorants
- Colour range by modifying formulation pH using one dye

A range of colours...



- intense pinks, reds, purples and blues on hair
- browns possible when mixed with a natural yellow

Rose et al., *J. Agric. Food Chem.* **2018**, 66, 6790



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THE HUFFINGTON POST

A range of colours...

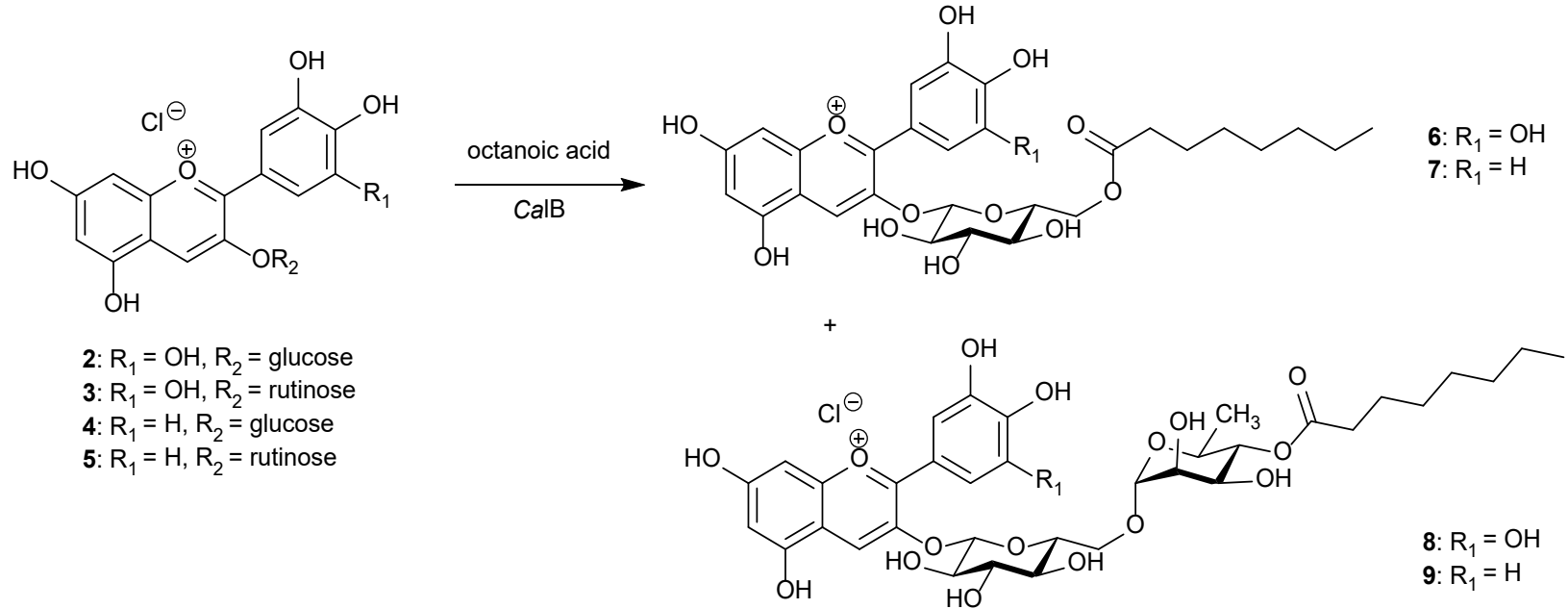


Utilising the variation in anthocyanin profile between species to **expand the colour palette**



Enzymatic esterification of anthocyanins (AnthoLip)

- **Complex mixtures** of anthocyanins **successfully esterified** with enzymes
- Esterification with *Candida antarctica* lipase B (CalB) is chemo- and regioselective
- **Lipophilicity increases** with esterification and chain length added
- **Antioxidant capacity and colour unchanged** with esterification
- **Increased application possibilities** in cosmetic formulations
- **Increased stability**
- Esterification acceptable within organic certification
- Issues with enzymes from GMOs?
- Acceptance by consumers?

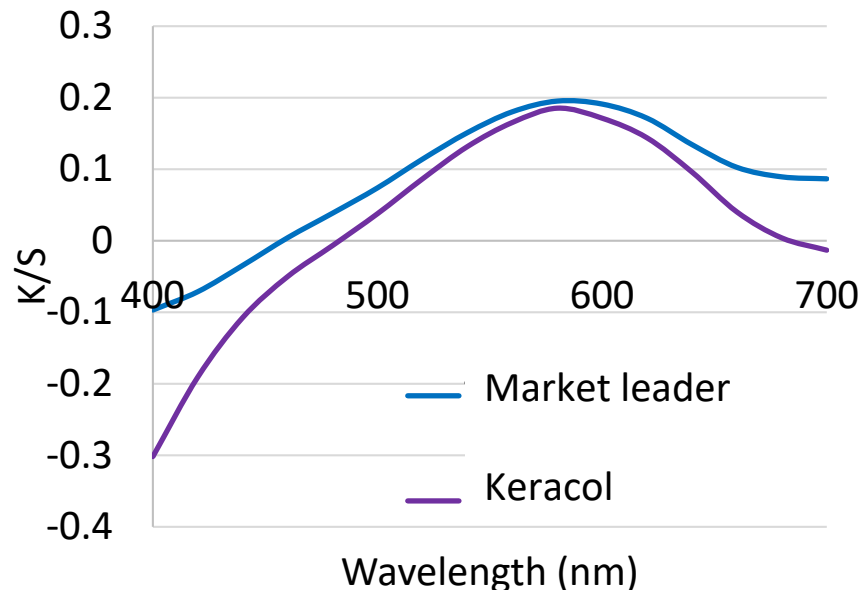


L. Cruz et al., *Food Chem.* **2018**, 266, 415.

- Lipophilisation of anthocyanin-rich extract with octanoic acid (C₈) is successful (shown)
- Laureate (C₁₂), palmitate (C₁₆), stearate (C₁₈) and oleate (C_{18:1}) esters can also be formed

Natural Purple Berry Brightening Serum

- World's first **natural purple hair treatment**
- Counteracts yellow and brassy tones in blonde, silver and grey hair
- Works just as well as (if not **better than**) synthetic technologies based on Acid Violet 43 and HC Blue No 2
- Five ingredients only in formulation
- **99.5% natural or naturally-derived**
(0.5% is a thickener – not yet found a natural that can achieve this functionality for our formulation, but working on it!)



itrusafe

UK-China Agritech Challenge

Citrus waste valorization for improved food safety and human health



Innovate
UK



**Newton
Fund**

citrusafe.leeds.ac.uk



Mandarin peel waste

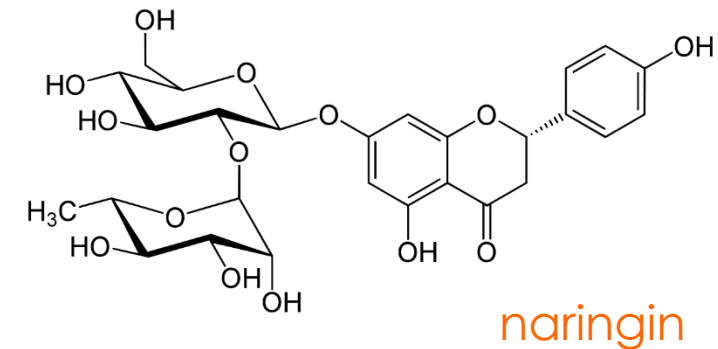
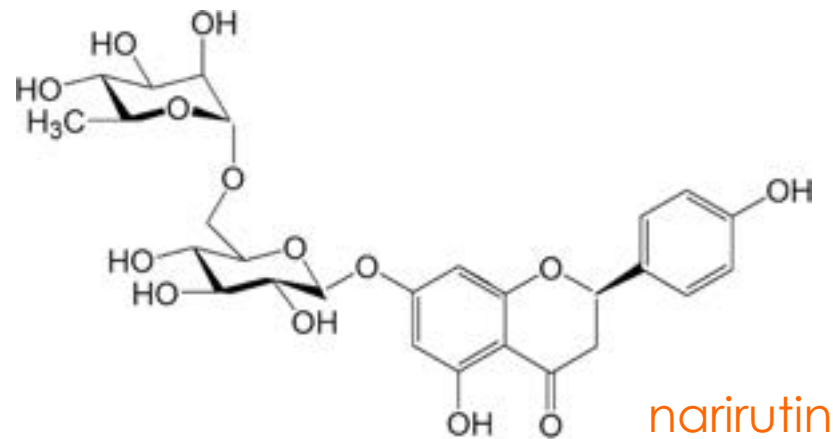
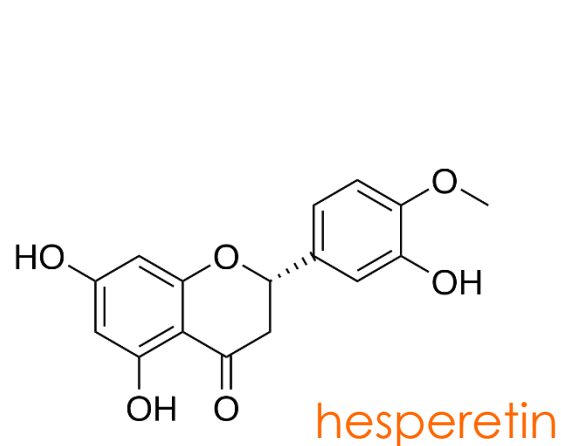
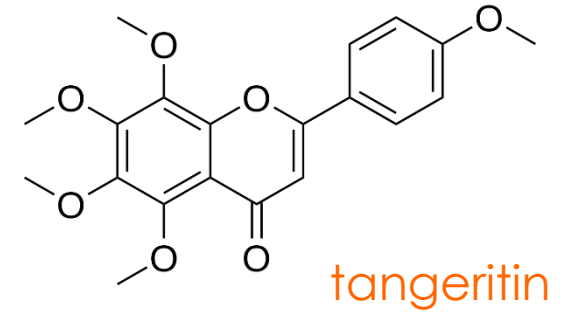
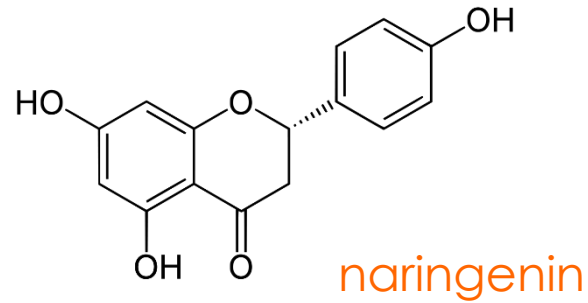
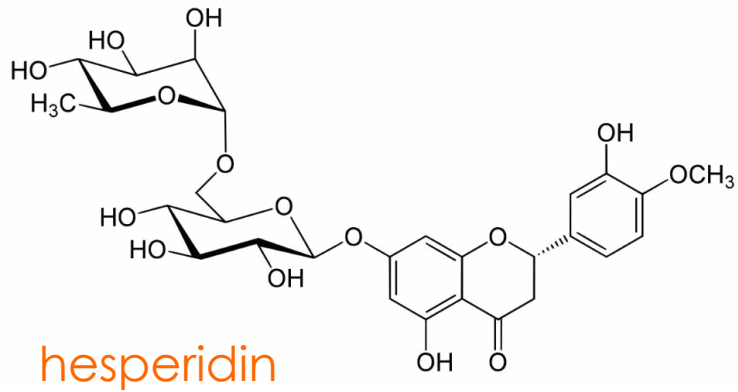
- China's development priorities to eliminate waste and improve food safety
- Valorise **large scale waste** (>10 million tpa) from Chinese mandarin canning manufacturing
- Green extraction technologies to extract and refine **food-grade hydrocolloids and citrus bioactives**

- **Environmental** benefits by reducing or eliminating unavoidable waste from food processing streams
- Significant potential for **commercial** exploitation
- **Social** benefits by increasing employment and source of income for rural populations in China



Ethanolic extract

- Novel extraction process in ethanol
- Solvent completely recycled
- Range of flavones, flavanones and flavanone glycosides extracted



Mandarin cleansing

- **Novel green extraction process** with bioethanol
 - Solvent completely recycled
- Range of flavones, flavanones and flavanone glycosides **extracted from waste mandarin peel**
- **Hesperidin** and **narirutin**
 - Antioxidant, skin soothing, wound healing, anti-inflammatory
- **Between 98% and 100% natural or naturally-derived ingredients**
- Non-naturals are preservatives
- Our by-product post-extraction is **biodegradable** (Original peel waste is not)
- Other **actives from repurposed food waste+** (hemp seed fibre for exfoliator)



Grape waste skincare

- world's largest fruit crop (>60 million tpa)
- >250 billion litres of wine
- ~10 million tpa waste pomace (skins, seeds, stems)



Exploitation of **grape pomace** for high value products as **novel actives** in cosmetics products

Grape pomace



Fresh grape composition:

70-80% water

15-25% carbohydrates

3-5% phenolic compounds

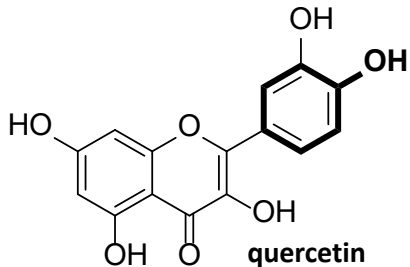
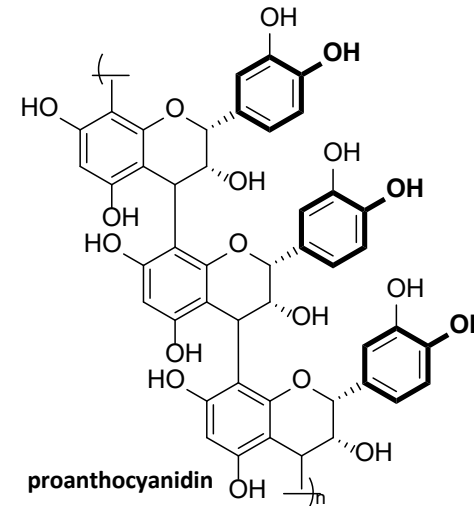
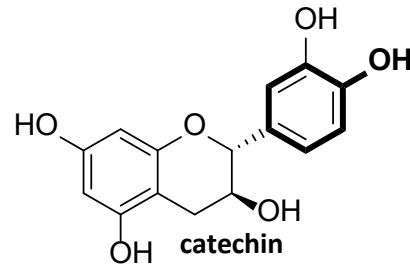
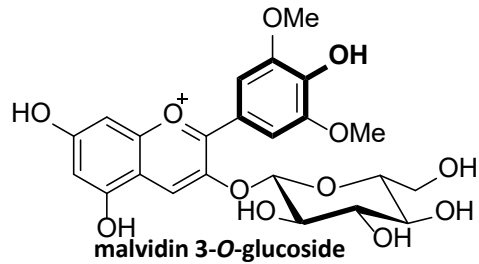
0.3-1.5% organic acids

0.3-0.6% minerals

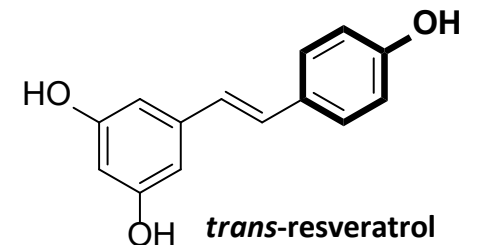
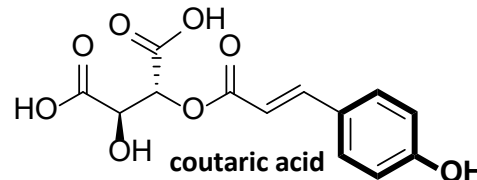
juice

skin

**Efficient
extraction using
green processes
developed**

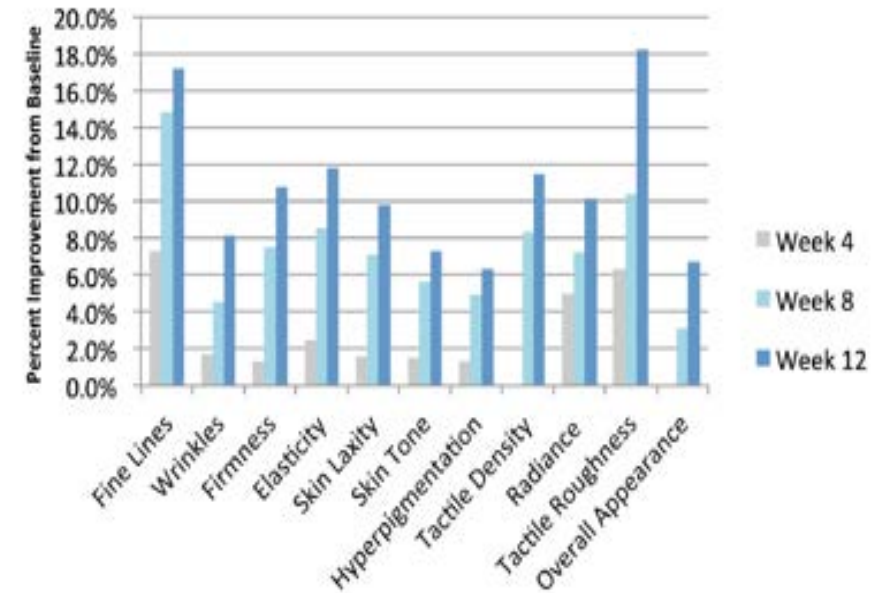
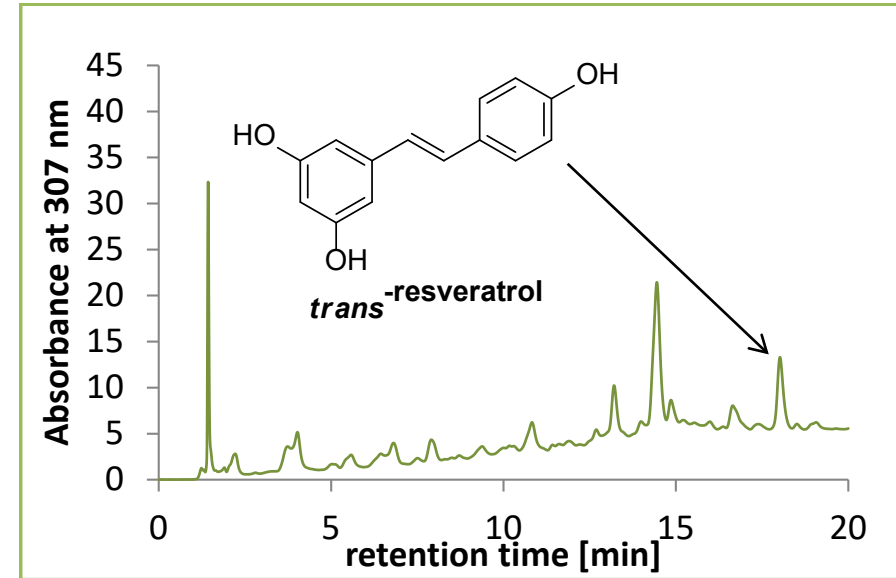


**Pomace material
rich in polyphenols**



Resveratrol

- High concentrations in grape skin (~2x red grapes vs. white grapes)
- **Pinot noir** highest concentration
- **Antioxidant** and **anti-inflammatory** biological properties
- In clinical trials resveratrol shown to **reduce inflammation in skin cells**
- Cosmetic formulations containing resveratrol with other natural antioxidants **improve fine lines, wrinkles and firmness**
- Working with vineyards to secure waste and optimise storage
- Clean extraction procedure developed using green solvent and actives quantified (***trans-resveratrol***)
- Process optimised and **scaled-up** to industrial extraction process



Grape waste skincare

- Uses the **grape skins left after pressing** in English sparkling wine production
- Denbies Wine Estate grape **cultivation methods**: use **less energy** and **less water**
- **Resveratrol, rutin** and other antioxidants extracted
- Formulation also contains organic **grape seed oil** from waste grape seeds
 - Functionally much better for delivery of actives (non-comedogenic)



Thank you!

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