Valorising UK's horticulture waste: bio-based ingredients for the consumer goods sector

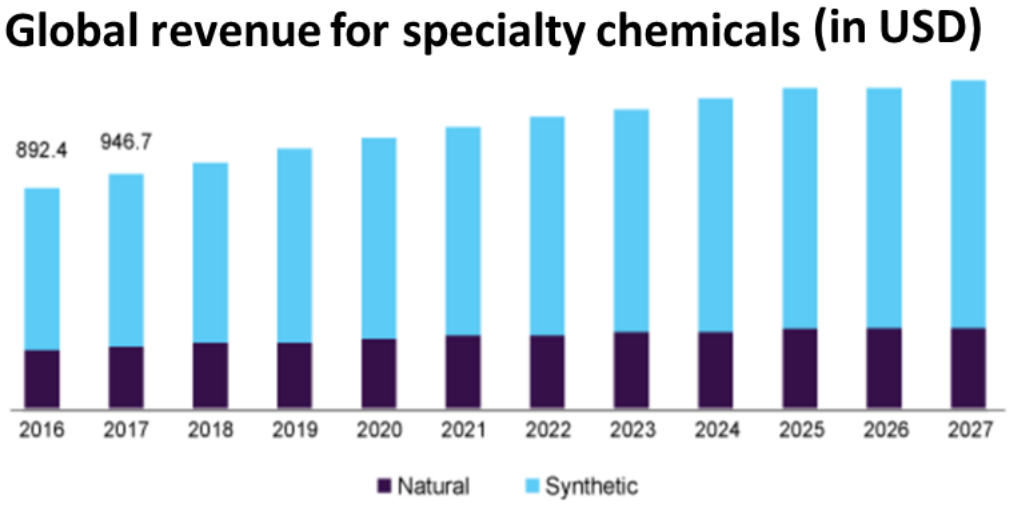
Dr Parimala Shivaprasad, FHEA, AffIChemE
Assistant Professor
Department of Chemical and Environmental Engineering
University of Nottingham

Co-I Supergen Bioenergy Hub

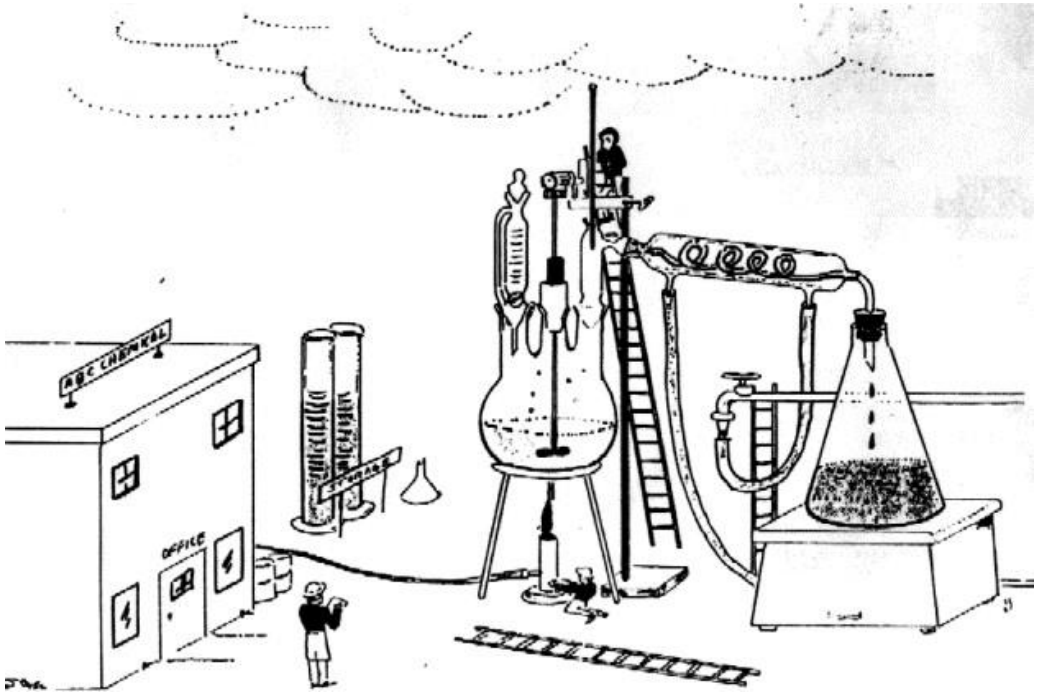
parimala.shivaprasad@nottingham.ac.uk

Current challenge

The chemical industry is the 3rd largest emitter of CO_2 and 87% of the processes are dependent on fossil fuels!



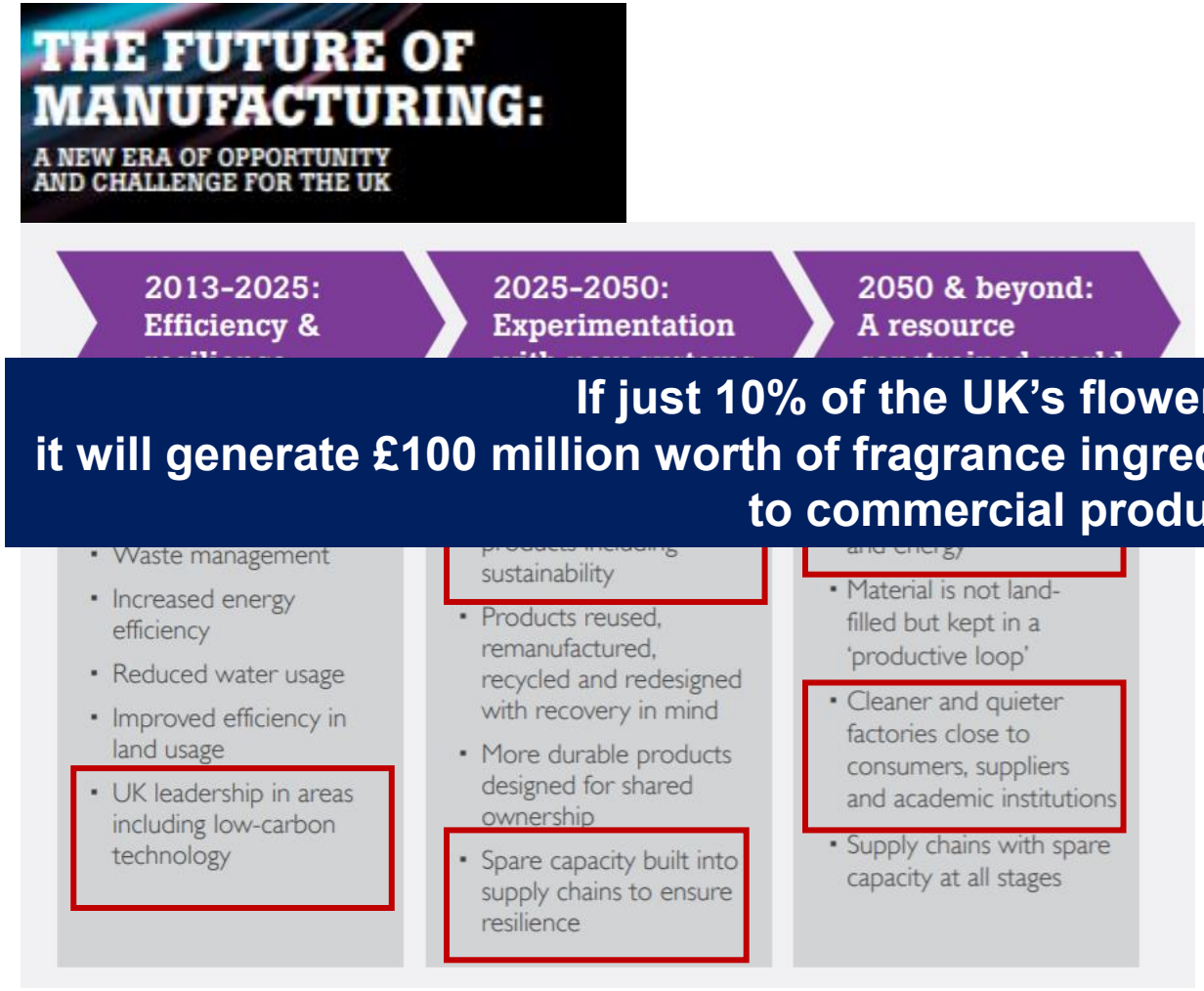
Lack of availability of raw materials and high cost of manufacturing for natural chemicals



Stitt, E. H. (2002) Chemical Engineering Journal

Opportunity

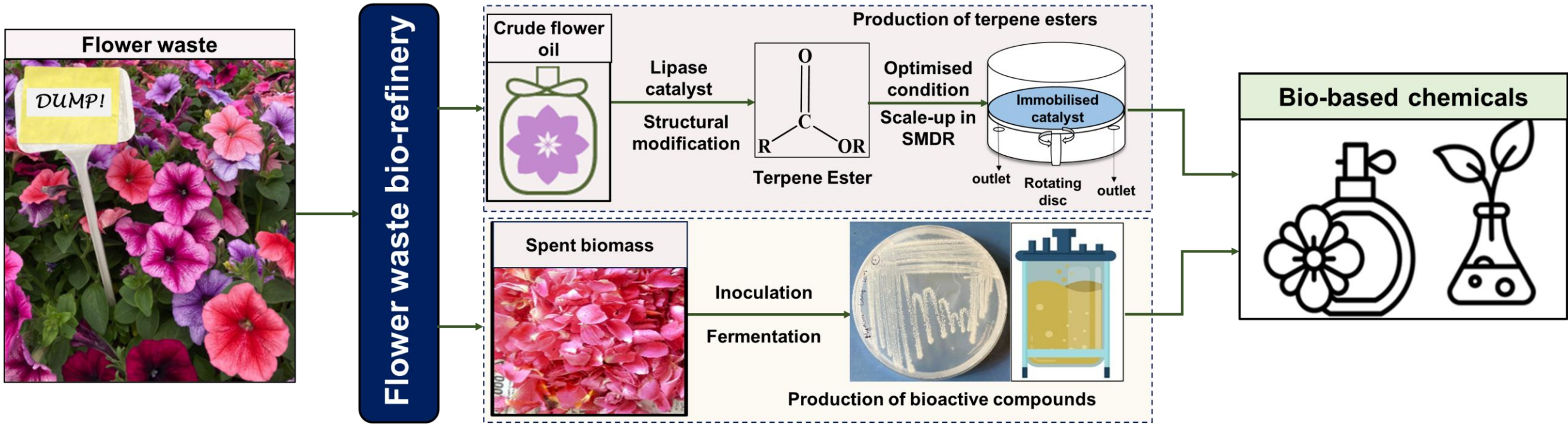
The UK imported £1.23bn of fragrance ingredients in 2020 from EU and non-EU countries (Statista)



Bridge Farm (UK) produce 5m waste flowering plants and cut flowers annually

If just 10% of the UK's flower waste were processed, it will generate £100 million worth of fragrance ingredients and reduce 30% CO_2 emissions compared to commercial production processes

A circular approach to valorising flower waste



University of Nottingham
UK | CHINA | MALAYSIA

Royal Academy of Engineering

High Value Biorenewables

bridge farm

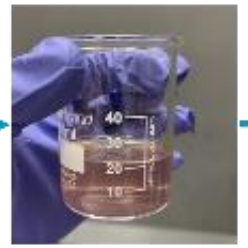
BB Net Biomass Biorefinery Network

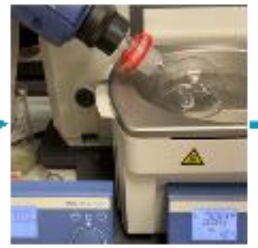
Unilever

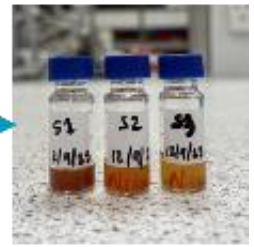
Ultrasound assisted extraction of flowers


Ultrasonication


Filtration

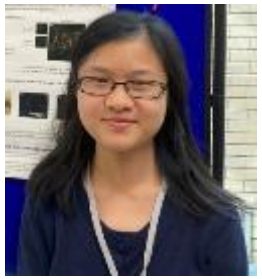

Solvent + extract mixture


Evaporation (using rotary evaporator)


Crude flower oil

Flower	Odour profile
Rose	Floral rose, sweet honey, woody pine, earthy
Marigold	Citrus lemon, lavender, peppermint, woody
Dianthus	Floral rose, peppery, honey, vanilla, citrus
Petunia	Floral rose, butterscotch
Geranium	Citrus orange, floral rose, woody clove

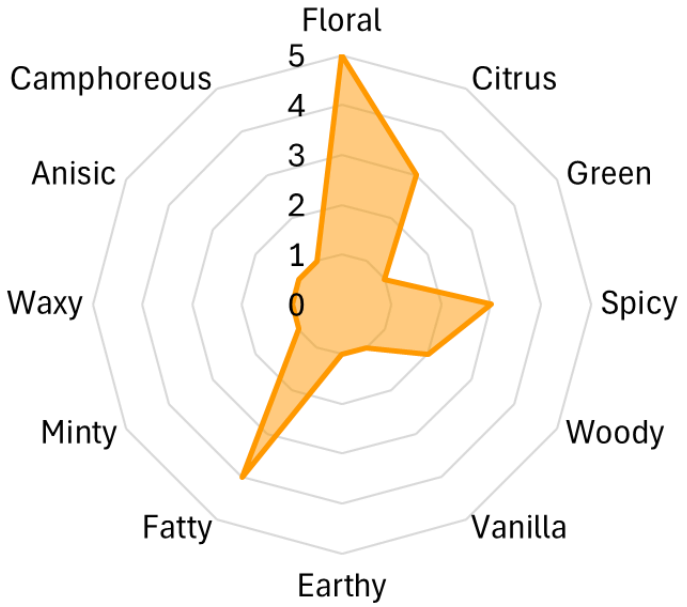
Alisa Wikaputri
PhD student



Xiao Wang
PDRA

Odour profile for Marigold

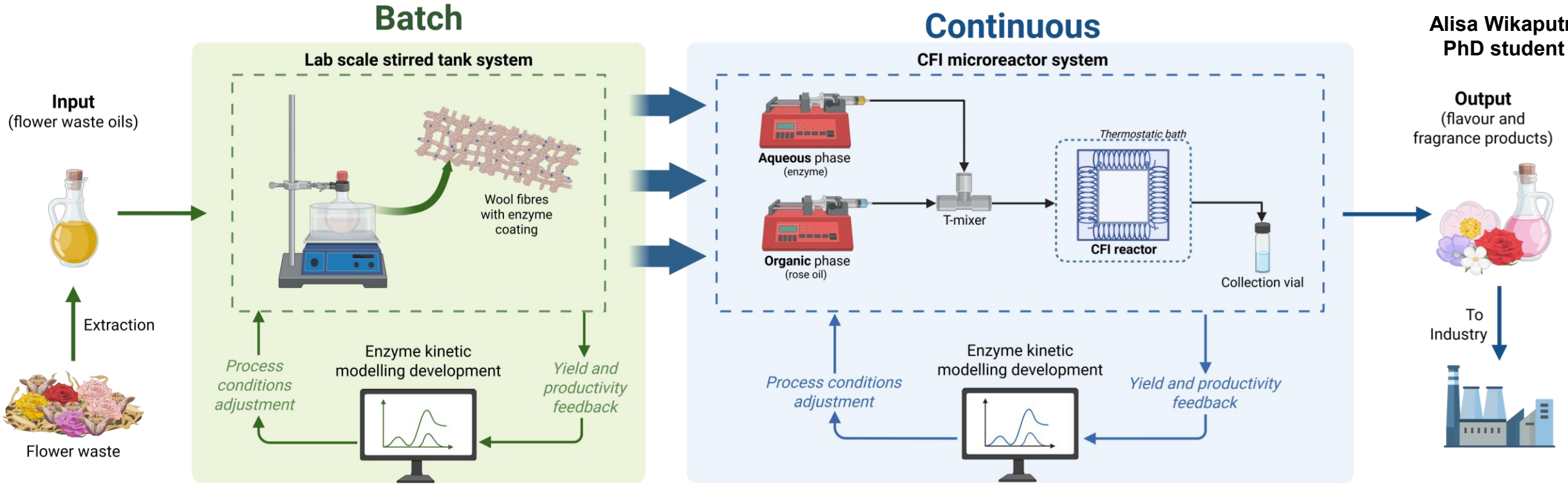
Name	Odour type
caryophyllene	spicy
citral	floral
β-cubebene	citrus
pulegone	minty
methyl vanillate	vanilla



THE ROYAL SOCIETY

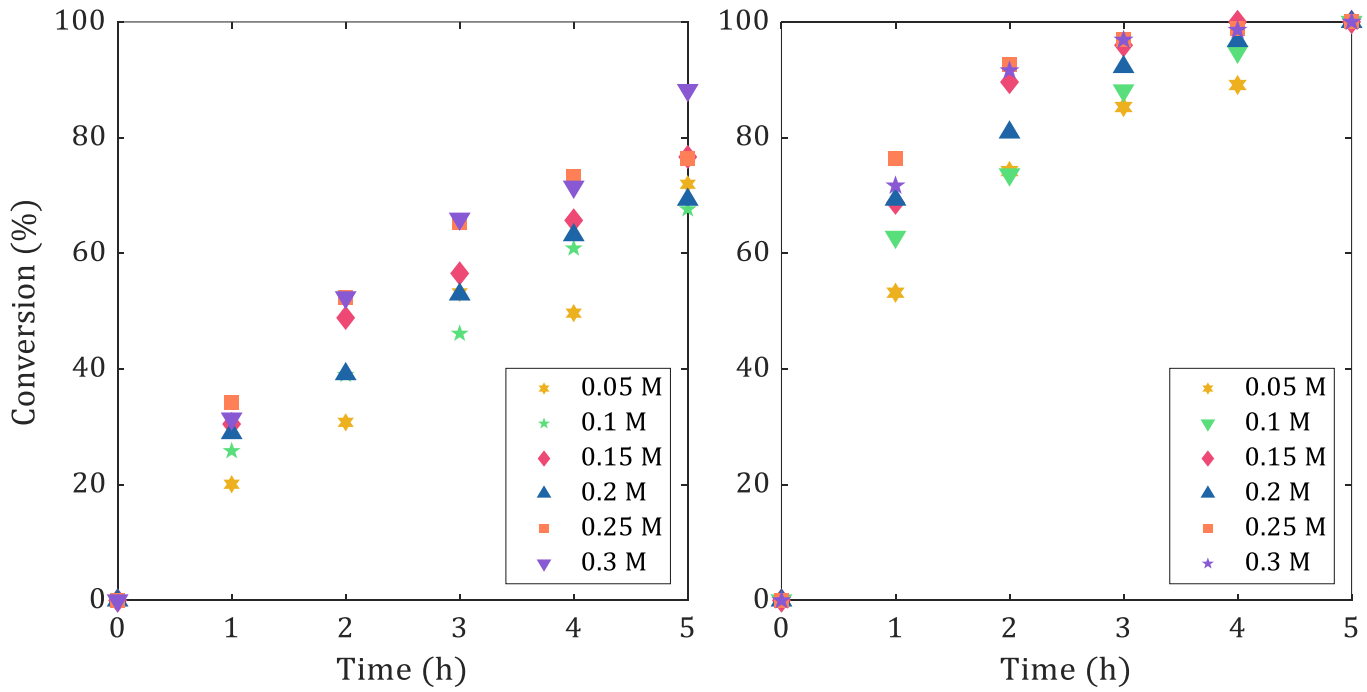
Terpene esters from Rose Geranium oil

Alisa Wikaputri
PhD student



Production of terpene esters from rose geranium oil

1



Progression curves for **a)** citronellol and **b)** geraniol at varying rose geranium oil concentrations (0.05 – 0.30 M)

Achieved **100 % conversion** for geraniol and **88 %** for citronellol

2

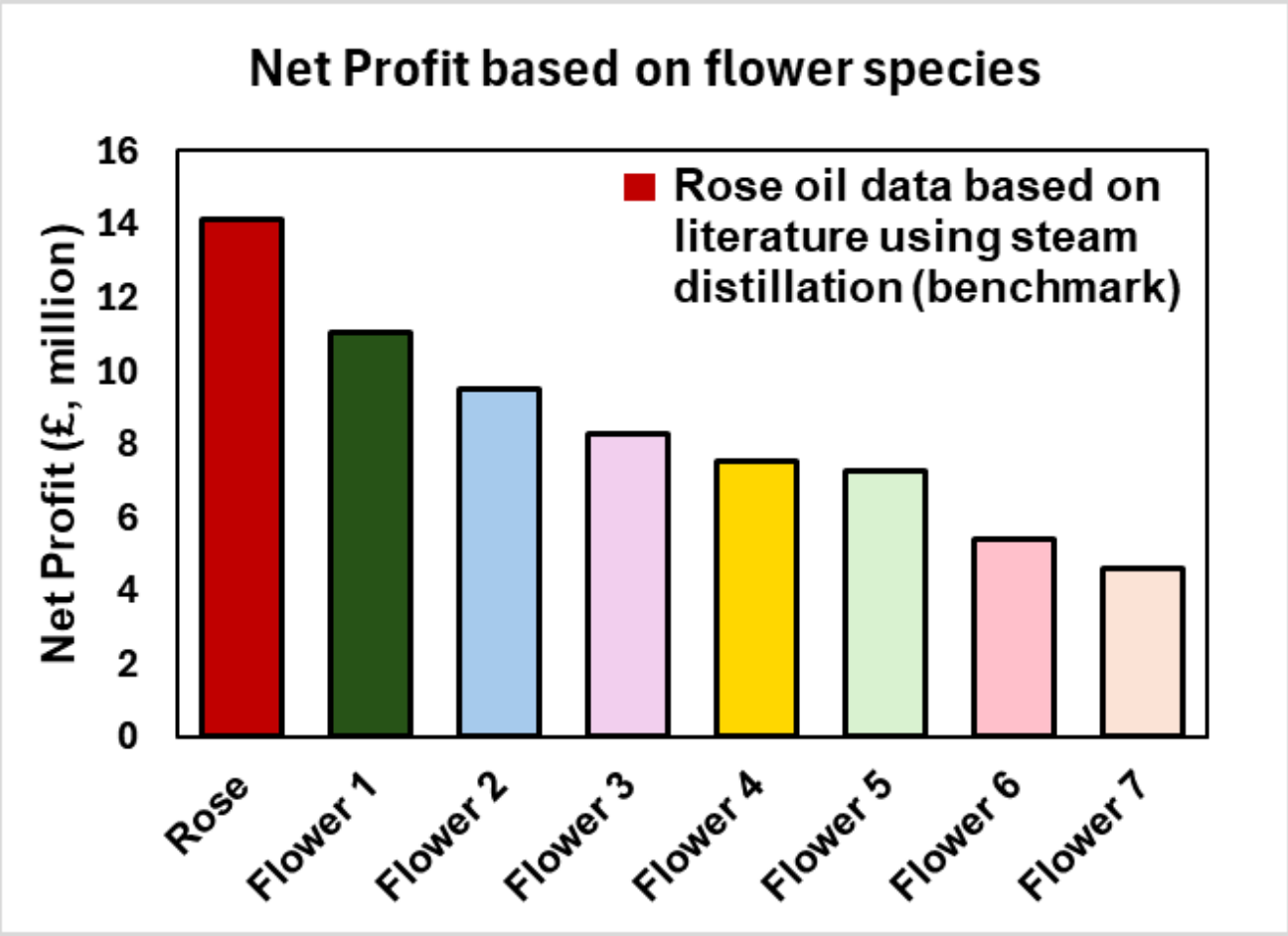
Productivity of solvent-based vs. solvent-free system

Compound	Productivity (g/L.day) Solvent-based*	Solvent-free using WPFL**
Citronellol	16.5	20.4
Geraniol	27.8	44.4

- 2x productivity over solvent-based systems
- Average ester yield independent of rose oil concentration

*Wikaputri et al. (2024) Journal of Agriculture and Food Research.
**Wikaputri et al. (2025) Biochemical Engineering Journal

Economic assessment based on flower oil quantity and quality



There is potential for horticulture waste originating in the UK, which is non-purpose grown, as an alternative feedstock for high value, fragrance ingredients

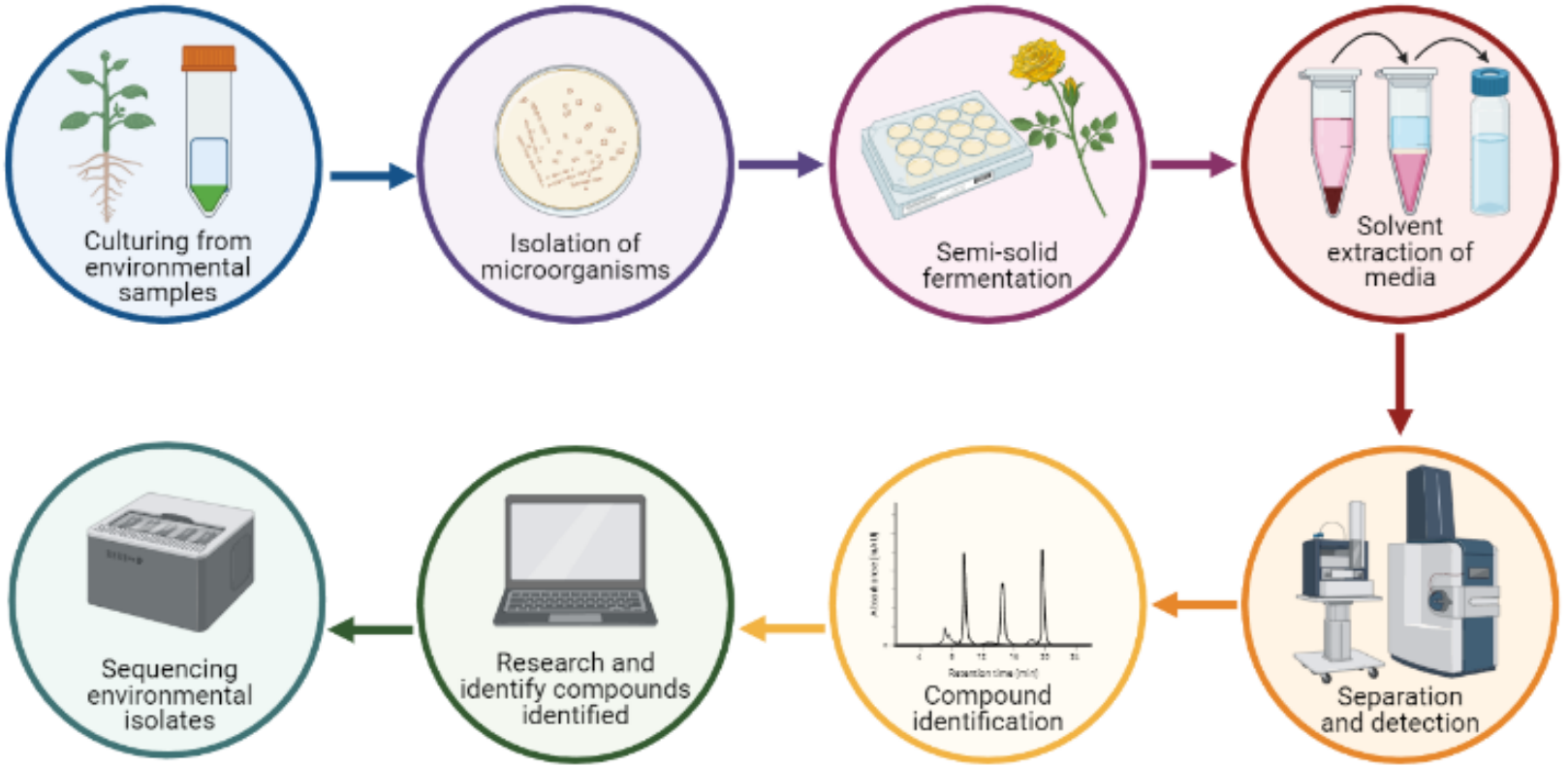
Impact assessment – oil refinery process using purpose grown rose flowers

Impact category	Unit	Flower production	Oil production	Oil refinery	Transport	Waste	Net emission
Global warming	kg CO_2 eq	1699.9	404.06	12.461	1.9822	4.1389	2122.6
		80.1%	19.04%	0.59%	0.09%	0.2%	100%

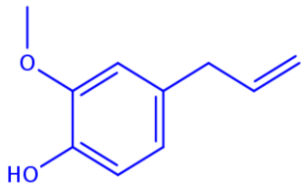
Key observations

- Over 99% of the global warming impact from flower production and subsequent oil production
- The high share of the impact from production is the result of the low yield (0.05%) of the oil distillation process which requires large quantities (1:2000 kg) of rose flowers
- Transesterification process contributes only to 0.59% of the total impact
- Transportation and waste treatment (vinyl acetate as waste solvent) is negligible

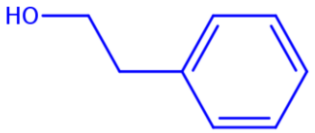
Microbes as whole cell catalysts for flower waste valorisation



Sarah Evans
PhD student



Eugenol

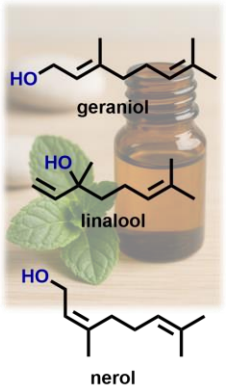


Phenlethyl Alcohol

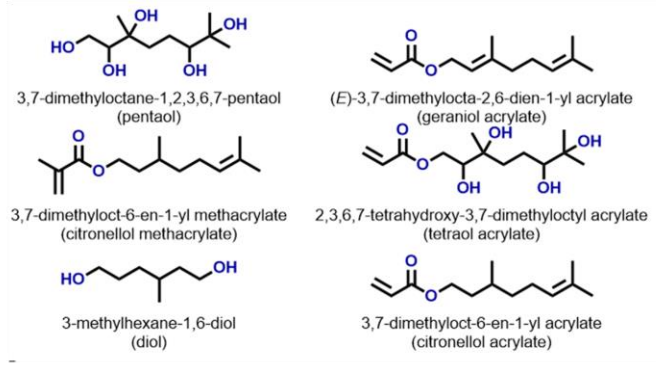
BBSRC Doctoral Training Partnerships

Synthesis of bio-based monomers

extraction

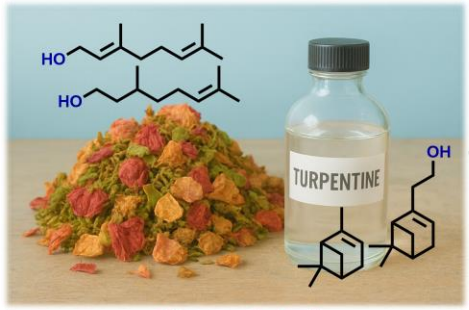


functionalisation



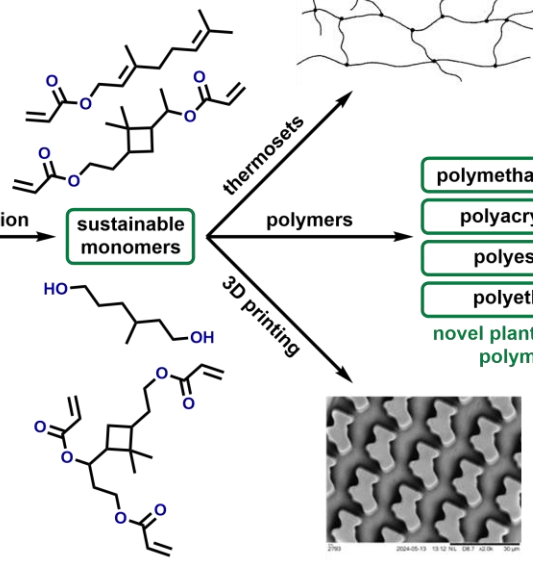
polymerisation/ application

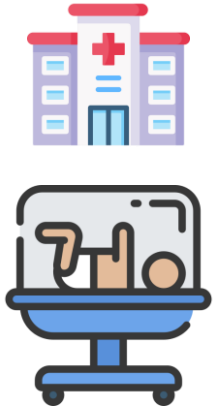
Personal and home care formulations



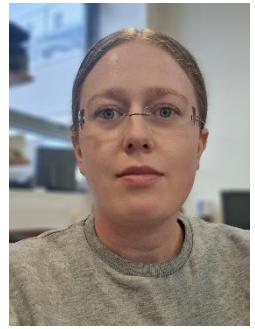
biomass-derived terpenes

functionalisation





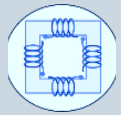
Biofilm resistant materials for neonatal care



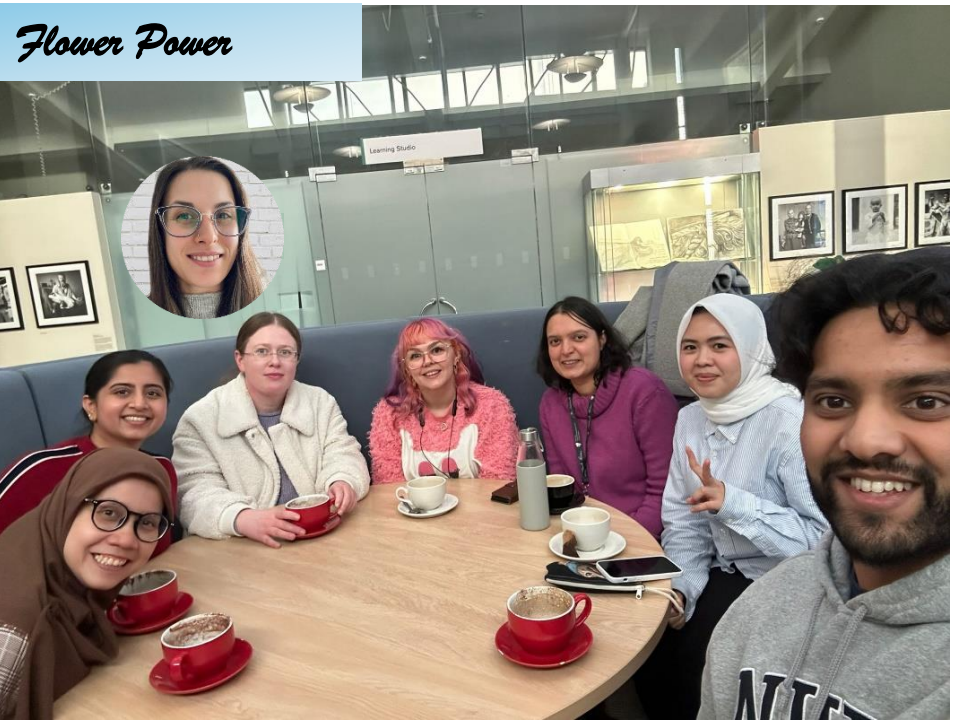
Monika Dabrowska
Research Fellow

Shyam Rana
PhD student

Next steps in the project

- Seasonal variation in composition of flower oils and effect on structural modification
-  Reaction scale-up in flow reactor and the spinning mesh disc reactor
- Estimation of profitability for the biorefinery process
- LCA for the flower waste biorefinery using modular processes

Acknowledgement



Academic collaborators:
Prof Rob Stockman
Prof Derek Irvine
Dr Samantha Bryan
Dr Ioanna Dimitriou
Prof Jonathan Hirst
Prof Suja George

Visiting researchers:
James Richardson
Araminta Praud
Rhea Satpute
Federica Bianciot
Dr Max Winslow

Industry partners:
Unilever: Dr Craig Jones and Dr Neil Parry

Bridge Farm: Dr Ray Marriott and
PhD studentship for Rebecca Still

Croda: Sarah Davidson and Dr Damien Kelly

parimala.shivaprasad@nottingham.ac.uk