Efficacious & sustainable production of Dutch ornamentals for cosmetics: a demonstration

Final report

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Report WPR-1174

WAGENINGEN
UNIVERSITY & RESEARCH

Innovatiefonds Hagelunie

Referaat
Doel van dit project is om het potentieel van de Nederlandse sierteelt voor de cosmeticasector aan te tonen door de principes van groene extractie toe te passen op drie Nederlandse voorbeeldgewassen (freesia, tulp en iris). Om hoogwaardige geurmonsters te kunnen genereren werd superkritische vloeistofextractie met CO_2 toegepast om kwetsbare, geurstoffen zorgvuldig te extraheren. Bloemstelen, geoogst bij Nederlandse telers werden vervoerd naar het extractie bedrijf Nateco waar de invloed van verschillende parameters zoals temperatuur, druk en toepassing van een co-solvent, op het verkregen aromaprofiel in een tweetal vooraf geselecteerde freesia-cultivars alsook één tulpencultivar werd geëvalueerd. Hoewel er geen technische beperkingen waren, oordeelde de meesterparfumeur dat de extracten over het algemeen een groene/groenteachtige geur bevatten. In sommige extracten werden weliswaar bloemige en fruitige noten waargenomen echter, deze waren niet intens en werden mogelijk gemaskeerd door zwaardere, wasachtige componenten. De algemene conclusie is dat de geurintensiteit van de geselecteerde variëteiten te laag was om tot hoogwaardige cosmetische toepassingen te komen. Niettemin kan het project worden voortgezet door intenser ruikende freesia en tulp soorten op te nemen of door andere intenser ruikende plantensoorten op te nemen. Tot slot vereist het tijdstip van oogsten extra aandacht zodat men de bloemen in het juiste stadium, met maximale geurafgifte, aflevert bij de extractiefaciliteiten.

Abstract
The aim of this project is to demonstrate the potential of Dutch ornamental cultivation for the cosmetics sector by applying the principles of green extraction to three Dutch example crops (Freesia, Tulip and Iris). To generate high-quality fragrance samples, supercritical fluid extraction with CO_2 is applied to carefully extract fragile, fragrant substances. Flower stems, harvested from Dutch growers were transported to the extraction company Nateco where the influence of different parameters such as temperature, pressure and application of a co-solvent, on the obtained aroma profile in two pre-selected freesia cultivars as well as one tulip cultivar was evaluated. Although there were no technical limitations, the master perfumer judged that the extracts generally encompassed a green, vegetable-like scent. Although floral and fruity notes were observed in some extracts however, these were not intense and possibly masked by more heavier, waxy components. The overall conclusion is that the fragrance intensity of the selected varieties was too low to achieve high-quality cosmetic applications. Nevertheless, the project may continue by including more intense-smelling Freesia and Tulip varieties or by including other more intense-smelling plant species. Moreover, the time of harvesting the peduncles requires some additional attention in order to get the flowers at the right stage of producing fragrances at the extraction facilities.

Reportinfo

Report WPR-1174
Projectnumber: 3742314500
DOI: https://doi.org/10.18174/582192
Theme: Nieuwe verdienmodellen

Dit project is mede tot stand gekomen door bijdragen van de het Innovatiefonds Hagelunie, waarbij EUPLANTCROPP als intermediair het project van aanvraag tot publicatie heeft begeleid.

Disclaimer

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Summary

The aim of the project was to provide a proof-of-concept of an efficacious processing of ornamentals in Dutch horticulture producing pure absolutes for cosmetics, in which pure means:
i. Sustainable growth of plants.
ii. Use of sustainable processing technology.
iii. Pesticide-free absolutes of the highest quality.

Iris, Freesia, and Tulip were the target ornamentals. A three-years project was envisaged. The goal of the first year was piloting of the, growth of Iris and Freesia, logistics, and extraction technology. Iris rhizomes would be collected and stored for 1.5 years at least to enable the conversion of root compounds into fragrances to be extracted. The goal of the second year was to validate and establish the procedures piloted in the first year for Freesia and Tulip and piloting the extraction of Iris. The final year was intended to perform a first upscaling of the fragrance-production by Freesia and Iris and a validation of the extraction of Iris.

The feasibility of capturing the aroma profiles of flowers of two pre-selected Freesia cultivars (Cv. Bordeaux and Soleil) as well as one Tulip cultivar (cv. Strong Gold) was investigated in the first year of the project. Flowering plants were harvested at the growers in The Netherlands and these were transported to the extraction facilities of NATECO in Wolnzach, Bavaria, Germany. The flowers of the fresh plants were subsequently extracted investigating the effects of various extraction parameters such as, temperature, pressure and application of a co-solvent. Evaluation of the extracts by the master-perfumer indicated that these were, in general, not exciting, often encompassing a green, vegetable-like scent. Floral and fruity notes were detected in some of the extracts, but these were not intense and, therefore, masked by more heavy, waxy components in the extracts. The overall conclusion was that the intensity of fragrance of the selected varieties of Freesia and Tulip was too low to arrive at high-quality cosmeceutical applications.

The project may continue by way of including intensely smelling varieties of Freesia and Tulip, if commercially available at all, or replacing these species by ones smelling intensively. In addition, the time of harvesting the peduncles needs some attention to get the flowers at the right stage of producing fragrances at the extraction facilities.

1 Background

Plants have been used in cosmetic products since ancient times. The growing awareness about natural products and their features has resulted in an ascending trend in their demand. As such, sustainability is currently a hot topic in cosmetics (Burger *et al*. 2019). Consumers are seeking for naturality, transparency, traceability, eco-friendly sourcing and fair-trade practices with respect to the daily products they use, like cosmetics (*Amberg and Fogarassy, 2019*). Consequently, the rising awareness of their advantages is expected to have a positive impact on the market over the forecast. Indeed, the demand of natural cosmetics is increasing in Europe (CBI Market Intelligence, 2015). In terms of the global natural cosmetics market, the cosmetic field in particular may benefit from high-added value ingredients. An important factor driving the growth of the regional market is the willingness of consumers to pay a premium price on products they value. At the same time, the stakeholder industry is challenged by hardened regulations (in terms of allergens, for example), restrictions linked to pesticides as well as bans on certain raw materials.

In this context, green extraction of plants is a strategy to meet the demands of the critical cosmetics consumer. The concept and principles of green extraction of natural products have been defined (Chemat *et al*. 2012; Chemat *et al*. 2019). Green extraction starts with the use of renewable plant sources (see Figure 1, below). The use of exotic, endangered, species may result in extinction of these. In contrast, Dutch ornamentals may offer a source of cosmetics avoiding the use of endangered plants. Moreover, greenhouse grown ornamentals provide an adequate and stable supply of materials necessary to reduce and mitigate risks in the supply chain by maintaining a steady target production volume. In addition, the use of cultivated plants enables the selection of specific varieties increasing the efficacy of the green extraction. The demands of cosmetics fit those of Dutch growers of ornamentals. They are, in general, looking for new, added-value, markets of plant compounds.

Supercritical fluid extraction using carbon dioxide (CO_2) fits in the principles two to five of green extraction (Figure 1) as this technology appears as an ideal extraction solution to preserve the original characteristics of plant elements. All five principles together, we should arrive at a natural extract, which means it is a bio-degradable one without contaminants, like pesticides. As mentioned above, the productions of a natural extract should be reproducible to be of value of the cosmetics industry.

The current project focuses on three ornamental crops to demonstrate the value of Dutch horticulture as green source of cosmetics: Iris, Freesia and Tulip. The production of high-quality absolute out of iris is limited in the required long storage of rhizomes after harvest. The time of storage is needed to let rhizomes produce irones, which are the major constituents of the typical iris-fragrance. The optimum seems to be at three years of storage (*cf*. Firmin *et al*. 1998). In addition, the efficacy of the extraction procedure depends on varieties and species. The production of high-ranking freesia-absolute is limited in the extraction procedure. It is currently done by way of a time-consuming and laborious procedure of the so-called cold, or hot, 'enfleurage'. Extraction by way of distillation destroys the Freesia-fragrance.

Figure 1 *The six principles of green extraction. Adapted from Burger et al. (2019).*

Extraction based on organic solvents is rather environmental unfriendly. Similarly, extraction of flowers of tulip based on organic solvents is out of order. In addition, the production of tulip-absolute may be limited in the availability of varieties with smelling flowers. Table 1 indicates that the value of absolutes in cosmetics decreases from Iris to Tulip whereas, the importance in horticulture increases taking into account the size of the production area. The use of specific plant parts in cosmetics conflicts with the current use of Iris and Freesia, whereas that of tulip flowers would be rather complementary. In addition, growth of Freesia can be controlled at maximum as it is grown in greenhouses, whereas Iris and Tulip of interest are grown out of doors. Synthetic pesticides-free growth is mandatory for all three species.

Table 1
Overview of three ornamentals selected.

Ornamental	Value in cosmetics	Plant part of interest	Production area
Iris spec.	Very high	Rhizomes	Very small
Freesia spec.	High	Flowers	Small
Tulipa spec	Moderate	Flowers	Large

1.1 Aim of the project

A proof-of-concept of an efficacious processing of ornamentals in Dutch horticulture to produce pure absolutes for cosmetics, in which pure means:
i. Sustainable growth of plants.
ii. Use of sustainable processing technology.
iii. Pesticide-free absolutes of the highest quality.

This report is directed to the activities of the first year of the project evaluating the technological feasibility of pressurized carbon dioxide (CO_2) extraction with regards to the aroma profiles of Tulip and selected cultivars of Freesia.

2 Materials and methods

2.1 Selection and storage of Iris

Rhizomes of *Iris pallida*, *Iris germanica* and *Iris Florentina* were delivered by grower C&T Nulkes at Noordwijk, The Netherlands, in February 2021. The rhizomes were cleaned, dried and subsequently stored at about 20 °C and low humidity.

Rhizomes of *Iris germanica* were delivered by grower Joosten at Rutten, The Netherlands, in January 2022. The rhizomes were cleaned, dried and subsequently stored at about 20 °C and low humidity.

2.2 Selection Freesia varieties by 'the nose'

Two Freesia growers from the Westland are directly involved in this project project: Hofland Freesia B.V. (Maasdijk, The Netherlands) and Barendse Freesias B.V ('s Gravenzande, The Netherlands). In order to select well-scented freesia varieties, both growers were visited along with the master perfumer or, 'nose', Frank Rittler (MagnifiScent). The index scoring list can be found in Supplement table 1 and 2. Master perfumer favorites are shown in last column of supplements, in which 1 indicates the most favorite variety. The variety Bordeaux was ranked first at grower Hofland, whereas cultivar Soleil was ranked as most favourite at Barendse BV. At both locations the scent of open flowers of different cultivars were evaluated. Open flowers were also sampled by the master perfumer for further assessment of the fragrance.

2.3 Sampling and extraction of Freesia flowers 2021

Flowers of the variety **Bordeaux** were ordered from Hofland BV (Maasdijk, The Netherlands). Figure 2 illustrates the workflow for sampling. An order was placed for a total volume of 25 litres of flowers with approximately 2 to 3 opened flowers per bract. Based on weight estimations (Harada and Mihara, 1984) as well as volume estimations per single opened flower, a total number of 17,000 flowers would be required *i. e.* 570 bouquets. Detailed calculations can be found in the excelsheet named: *Oogstarbeid en kosten en aantal Freesiabloemen 2021.xslx*. This sheet is stored on the personal domain of Arca Kromwijk. The upper row of **Figure 3** shows examples of open flowers of Freesia.

Flower sampling was executed on the 20th of September 2021. Three litres of flowers were used to compare processing methods on metabolomic composition and 12 L was dried in a stove oven for 24 hours at 40°C. The dried flowers were, together with approximately 10 L fresh flowers on stalks, transported by UDEX logistics to $NATECO_2$ at Wolnzach, Germany on the 22nd of September.

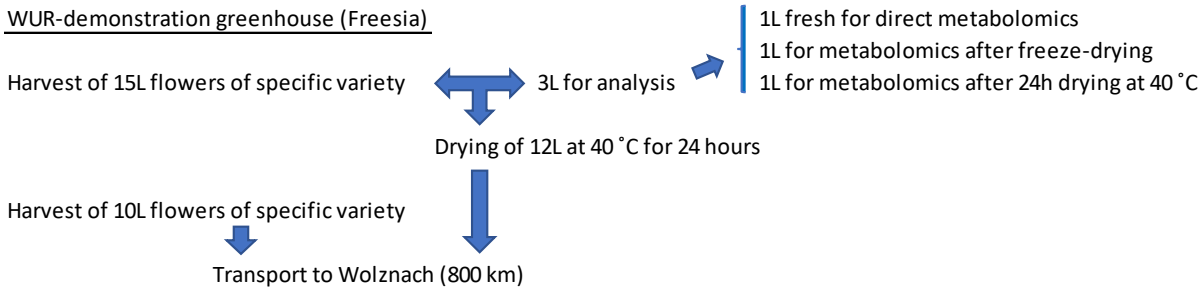


Figure 2 *Sampling scheme freesia flowers cv. Bordeaux, September 2021.*

Figure 3 *On top row, freesia flower sampling in cv. ordeaux. Variance in opening of flower stages (left) and way of harvesting (right). On bottom row, tulip flower sampling in cv. Strong Gold. Tulips were kept on water for 4 days at (30 °C) and, subsequently, at room temperature for 2 days prior to flower picking and extraction (left). Flowers encircled were defined as open (right).*

2.3.1 Extraction of freesia flowers by NATECO$_2$

Extraction pressure, temperature and separation conditions were varied to extract the two types of Freesia material, *i. e.* fresh and dried (Table 2). Isopropyl myristate (IPM) was used as a carrier and it was added into the main flow (CO_2 and extract) prior to the separator in order to trap volatiles. All extracts were stored in a closed cooled vial and evaluated for their scents (see Results). A detailed technical report, *saved as 2021_09 freesia Report 1L4 FrPC.pdf*, can be found in a PDF format. It has been shared and discussed online with the project team on the 5th of November 2021. In addition, an expert, Ecomaat in Sofia, Bulgaria, was consulted to prepare a second series of extractions in 2022. Ecomaat is a producer of flower extracts applying the CO_2-extraction technique for more than 15 years already.

Table 2

Summary of extraction conditions Freesia cv. Bordeaux, September 2021. Blue colour indicates cold conditions of extraction, green intermediate, and yellow the warm ones.

		extraction		pre-fraction Sep1		raw material	CO2	conditions
		pressure	*CO_2*	*pressure*	*CO_2*	*(g)*	*(kg)*	
fresh	1L4 FrPC-1	medium	supercr.	low medium	gas	1910	50	supercrit. extraction, pre fractionation low medium pressure (gas)
	1L4 FrPC-2	medium	liq.	low medium	liq. cold	1000	27	medium cold extraction pre fractionation low medium pressure (liquid)
	1L4 FrPC-3	low	liq. cold	low	liq. cold	1455	15	cold extraction pre fractionation low pressure (liquid)
	1L4 FrPC-4	low	liq. cold	low	liq. cold	1000	15	repeat -3
	1L4 FrPC-5	low	liq. Cold	low	gas	1005	15	cold extraction/ pre fractionation low pressure (gas)
dried	2L4 FrPC-1	low	liq. cold	low	gas	450	15	same as 1L4 FrPC-5

2.3.2 Processing methods flowers and metabolomic analysis

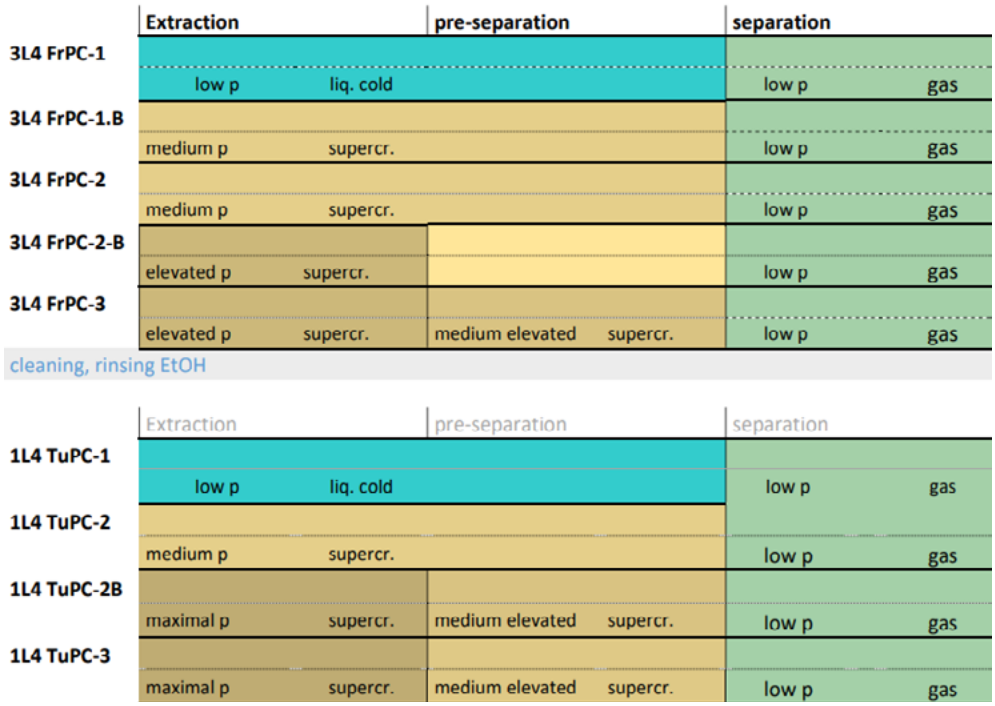
We investigated the effects of three different sampling and processing methods on volatile composition of metabolite profiles (Figure 2). One litre of freshly harvested flowers was oven-dried at 40 °C for 24 hours, or immediately freeze dried in a Sublimator 40 at 0.05 mbar pressure (Zirbus Technology, Bad Grund, Germany) for 72 hours. These volumes correspond with 92.68 grams of fresh weight (FW) and 91.94 g, respectively. Another 1L (90.31 g FW) was sampled for direct extraction in hexane (v/v ratio 1:1). Samples were sent to the Czech University of Life Sciences in Prague for analysis of the chemical composition of volatiles. Oven-dried and freeze-dried samples were homogenised and extracted in hexane. The fresh hexane extract was evaporated *in vacuo* to obtain a similar ratio of DW:hexane as the dried samples. The resulting extracts were qualitatively analysed by gas chromatography-flame ionization detection (GC-FID).

2.4 Sampling and extraction of Tulip and Freesia flowers 2022

The series of extractions at NATECO$_2$ in 2022 included the Tulip cultivar 'Strong Gold'. This cultivar had not been rated by the master perfumer previously. The cultivar was suggested by Martin van Dam, who is researcher 'flower bulbs' at WUR. EKO-Flora at Oostwoud, the Netherlands, delivered 1700 tulip stalks of this variety. Freesia stalks of the cultivar 'Soleil' were harvested in the climate-neutral greenhouse at WUR, Bleiswijk, The Netherlands. This cultivar was previously ranked first by the master-perfumer at the grower Barendse. Tulip and freesia stalks were transported on water under cool conditions (5 to 6°C) by UDEX logistics to NATECO$_2$ on the 5th of April 2022. The various conditions of extraction matrix are presented in Table 3. In contrast to the first series of extractions in 2021, the co-solvent ethanol at a final weight percentage of 5% was used to pre-macerate the flowers. Additional details of extraction and separation are presented in NATECO$_2$'s report '*20220429 3L4 FrPC 1L4TuPC Report'*.

Table 3

Summary of extraction conditions Tulip cv. Strong Gold and Freesia cv. Soleil, April 2022. Colors indicate extraction temperature: cold (blue), intermediate (green) and warm (yellow).



3 Results and discussion

3.1 Selection and storage of Iris

The yield of Iris-rhizomes was in a quantitative sense relatively low at the first time of collection. The amount for each of the species was as follows:

- *Iris pallida*: 99 grammes, less than half a liter.
- *Iris germanica*: 322 grammes, less than half a liter.
- *Iris Florentina*: 769 grammes, over half a liter.

The collection at the second time, concerning *Iris germanica* only, was substantial, *i. e*. more than 3kg, and the material looked fine after cleaning and drying (Figure 3).

The material of the first time of collection is intended for piloting extractions in the second year of the project. The material of the second time is reserved for extractions at optimum in the third year of the project.

3.2 Selection of freesia varieties by 'the nose'

The master-perfumer noticed that the scent at Barendse (visited on September 2, 10.00-11.00) was more intense than at Hofland (visited on September 1, 14.00-15.00). The exact cause of this could not be determined. Potential causes include time of the day and the stage of the plants from which flowers were harvested. At Hofland BV, the first flower stalks were harvested and there were many flower stalks per plant (high plant load). At the location of Barendse, the crop was older and peduncles were harvested on that day. At that stage, there are only few flowers on the plant (low plant load) leaving potentially more assimilates for flowers available. Moreover, by then the watering was reduced already to allow the tubers to go into summer dormancy. The overall fragrance profiles of the varieties at both greenhouse locations were alike however, it was slightly more intense at the grower Barendse (Supplement table 1 and 2). The first series of extractions, in 2021, was based on the cultivar Bordeaux (Hofland, Maasdijk) based on logistic arrangements.

Figure 4 *Rhizomes of Iris germanica after cleaning and drying, January 2022.*

Table 4

Summary of the evaluation of Freesia cv. Bordeaux extracts by the master-perfumer. Blue color indicates cold conditions of extraction, green intermediate, and yellow the warm ones.

		Seperator 1 Water	Separator 2 Water	Separator 2 Extract
fresh	1L4 FrPC-1	Cooked, caramel, rubber, aromatic, black	Vegetable, cabbage, cooked, floral	Vegetable, green, slightly fruity, floral
	1L4 FrPC-2	Burned, sweet, caramel, black	Vegetable, cabbage, cooked, floral	Vegetable, green, slightly fruity, floral
	1L4 FrPC-3	Vegetable, cabbage, cooked	Vegetable, cabbage, cooked, floral, strong	Vegetable, green, slightly fruity, floral
	1L4 FrPC-4	----	----	Vegetable, green, not so intensive
	1L4 FrPC-5	----	----	Vegetable, green, slightly fruity, floral, greenhouse
dried	2L4 FrPC-1	Vegetable, cabbage, cooked,	----	Vegetable, green, slightly fruity, floral, greenhouse

3.3 Processing and extraction of Freesia flowers 2021

The results of the evaluation by the master perfumer are listed in Table 4. These indicate that the majority of extracts have an unpleasantly scent classified as cabbage-like for aqueous extracts and green/vegetable-like for oily extracts. Extraction of fresh flowers did not yield better results than dried flowers. It seems that the essential oil was co-extracted with higher molecular weight compounds (*i. e.* heavy waxes) that masked the scent of the high-quality compounds in the extracts.

3.3.1 Processing of flowers and metabolomic analysis

Results of principal component analysis (PCA) demonstrated clearly that extracts of fresh flowers differ significantly in volatile fingerprint from those derived from freeze-dried and oven-dried flowers, respectively (Figure 5). The volatile fingerprints of extracts of oven-dried and freeze-dried samples are quite similar. A subsequent analysis indicated that extracts of fresh flowers encompassed most volatiles.

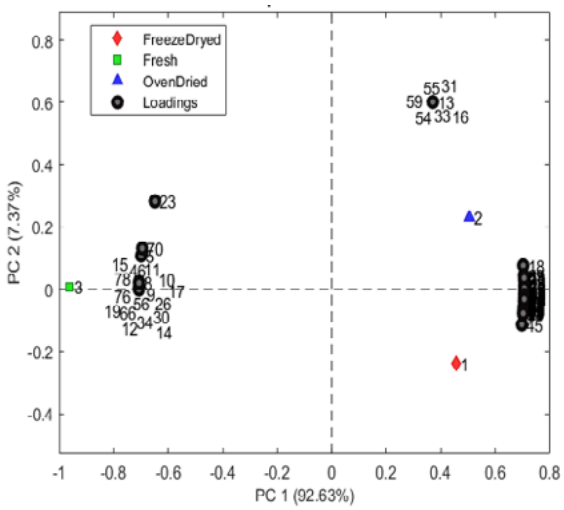


Figure 5 *PCA-scatter plot of processing methods of freesia flowers: fresh extraction in hexane, freeze drying (72hrs), and drying at 40 C (24 hrs). Percentage of variation explained by a principal component in parentheses.*

3.4 Sampling and extraction of Tulip and Freesia flowers 2022

The charm of Tulip is in its' variety of colours and shapes, but there are only few smelling cultivars. A late blooming cultivar 'Strong gold' was used for the series of extractions of tulip. This cultivar is related to 'Purple Price', 'Salmon Prince' and 'Ruby price', of which the first, together with cv. 'Strong Gold', share the parent variety 'Yokohama' (Leeggangers *et al*. 2017; Oyama-Okubo and Tsuji, 2019). All flowers were closed at arrival at NATECO$_2$. The flowers were harvested at the so-called cutting stage 1, which means 'raw and closed'. As such, stems were put in water at a higher temperature to induce flower opening. Flower extractions were carried out 1 week after transportation Despite the fact that cultivar 'Strong Gold' is known to be a temperature-sensitive cultivar (Leeggangers *et al*. 2017) opening of flowers was very slow. The master-perfumer reported that extracts had a green, vegetable like odour that have very little potential for fragrances or other cosmeceutical applications (Table 5).

Flowers of Freesia grown in the climate-neutral greenhouse at WUR (Bleiswijk) were also subjected to a series of extractions at NATECO$_2$. The variety 'Soleil' was used. It was one of the varieties grown at Barendse and it was ranked highest by the master-perfumer in 2021. The extraction procedure included pre-soaking of the flowers in 5% ethanol, as suggested by the expert of Ecomaat after the first series of extractions (see section 2.3.1). The evaluation of the extracts by the master-perfumer is presented in Table 6. The scents were, in general, classified as green, woody or earthy.

Table 5

Summary of the evaluation of the extracts of tulip cv. Strong Gold by the master-perfumer in 2022. Blue color indicates cold conditions of extraction, green intermediate, and yellow the warm ones.

Seperator 1			Separator 2		
1L4 TuPC # 1	**Sep1**	green, fruity, waxy, alcohol, caramel	1L4 TuPC # 1.1	**Sep2**	fresh, green, grass, alcohol
			1L4 TuPC # 1.2	**Sep2**	green, aromatic, grass, green beans
			1L4 TuPC # 2	**Sep2**	tumeric, vegetable
			1L4 TuPC # 2B	**Sep2**	turpentine,aromatic, grass
			1L4 TuPC #3.1	**Sep2**	vegetable, fruity, green, plastic
			1L4 TuPC #3.2	**Sep2**	Tumeric, green beans, wormwood

Table 6

Summary of the evaluation of the extracts of Freesia cv. Soleil by the master-perfumer in 2022. Colors indicate extraction temperature: cold (blue), intermediate (green) and warm (yellow).

Seperator 1		Separator 2	
3L4 FrPC #1 **Sep1**	alcohol, green, fruity, earthy	3L4 FrPC #1 **Sep2**	green, leafy, valerian, earthy, alcohol,
3L4 FrPC #1B **Sep1**	fruity, bitter almond, marzipan, vegetable	3L4 FrPC #1B **Sep2**	woody, laefy, alcohol, nutty
		3L4 FrPC #2.1 **Sep2**	fruity, leafy, green, alcohol, artichoke
		3L4 FrPC #2.2 **Sep2**	green beans, fruity, woody, soup
		3L4 FrPC #2.3 **Sep2**	marzipan, bitter almond, green, alcohol,
		3L4 FrPC #2B **Sep2**	green, vegetable, green beans, peas,
		3L4 FrPC #3 **Sep2**	alcohol, earthy, rooty, conichon, soup

4 Conclusions and recommendations

The focus of the first year of the project was on piloting and settling procedures to extract fragrances from Freesia and Tulip, respectively. The results indicated that the production of high-quality absolutes is currently limited in the availability of intense-smelling varieties of Freesia and Tulip, respectively, rather than technical constraints. The master perfumer concluded that the generated extracts were not exciting and these contained a green, vegetable-like, scent often. Floral and fruity notes were determined in some of the extracts, but these were too weak. These notes were, therefore, masked by more heavy, waxy components.

We may go for a follow-up of the results presented here by way of improving the delivery of flowers at the extraction facilities. Flowering should be at a stage of volatiles production at maximum, when delivered for extraction. It implies harvesting the peduncles at a proper stage and, subsequently, a swift transport to the extraction facilities. A proper timing of harvesting can be determined at a small-scale by dynamic sampling of volatiles using headspace solid phase microextraction (HS-SPME) and, subsequent, analysis using gas chromatography mass spectrometry (GC-MS). In contrast, we do not see a major improvement of the extraction procedures. These seem to be fine regarding the extraction of Freesia and Tulip, respectively.

We may also opt for a follow-up using other, more intense, smelling varieties of Freesia and Tulip, respectively, if commercially available. It requires a profound search with the aid of the master-perfumer. Alternatively, we may opt for other species, of which the fragrance is sufficient according to the master-perfumer. If so, we need to repeat the first year settling the procedures for the new species.

We recommend that a follow-up first of all includes intense-smelling varieties and species. It is the best guarantee to achieve absolutes of high quality. Absolutes that have a substantial added value for the growers. Optimisation of the harvesting procedure is a second point of concern in a follow-up. The results presented here provide a guidance of optimisation regarding Freesia and Tulip. Extraction of the rhizomes of Iris, which have been collected in the first year of the project, is recommended to be part of a follow-up, as we expect absolutes of high quality from these.

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Annex 1 Supplement tables

Table 1

Marinus Hofland on 1-9-2021, 14.00-15.00h, in sequence of scenting these. Scent and rank according to master-perfumerer.

Variety	Photo*	Breeder Flower colour Single or doubleflower**	Scent	Rank
Belleville		Van den Bos White Doubleflower	Floral, fresh, green, linalool, rose, Ionone, citrus, more muguet	5
Marseille		Van den Bos Yellow Doubleflower	Floral, fresh, green, linalool, rose, Ionone, citrus, orange	6
Ambassador		Hofland White Singleflower	Floral, fresh, green, linalool, rose, Ionone, citrus, more muguet	5
Inzell		White Singleflower	Floral, fresh, green, linalool, rose, Ionone, citrus, more muguet	5
Pitsy Queen	No picture	Pink/Red	Floral, fresh, green, linalool, rose, Ionone, citrus	-
Delta River		Van den Bos Blue Singleflower	Floral, fresh, green, linalool, rose, citrus, more Ionone, stronger fruity	3

Variety	Photo*	Breeder Flower colour Single or doubleflower**	Scent	Rank
Bordeaux		Penning Red Singleflower	Floral, fresh, green, linalool, rose, citrus, more Ionone, stronger fruity	1
Orion		Hofland Light pink Singleflower	Floral, fresh, green, linalool, rose, citrus, more Ionone, stronger fruity, apricot	4
Cassis		Van den Bos Dark Pink Doubleflower	Floral, fresh, green, linalool, rose, Ionone, citrus, jasmine	2

* Photos from website of the Breeders. Photo Inzell from website unicumfreesia.nl. No photo of Pitsy Queen available.

** In the single flowering varieties there are only six flowersepals, in the doubleflowering varieties there are extra sepals in the centre of the flowers.

Table 2

Freesia varieties evaluated in greenhouse of Barendse on 2-9-2021, 10.00-11.00h. Scent and rank according to master-perfumerer.

Variety	Photo*	Breeder Flowercolour Single or doubleflower**	Scent	Rank
Belleville		Van den Bos White Doubleflower	Floral, fresh, green, linalool, rose, Ionone, citrus, more muguet	2
Soleil		Van den Bos Yellow Doubleflower	Floral, fresh, green, linalool, rose, Ionone, citrus, orange,	1
Costa		Van den Bos (Dark) Pink Singleflower	Floral, fresh, green, linalool, rose, Ionone, citrus, jasmine	-
Honeymoon		Penning Light Pink Doubleflower	Floral, fresh, green, linalool, rose, Ionone,rosy	-
Blue Moon		Van den Bos Blue Singleflower	Floral, fresh, green, linalool, rose, citrus, more Ionone, stronger fruity	3
Diamond River		Van den Bos White Singleflower	Floral, fresh, green, linalool, rose, Ionone, citrus, more muguet	-

Variety	Photo*	Breeder Flowercolour Single or doubleflower**	Scent	Rank
Mandarine		Van den Bos Red (yellow heart when flower is open) Doubleflower		4

* Photos from website of the Breeders. Photo Inzell from website unicumfreesia.nl. No photo of Pitsy Queen available.

** In the single flowering varieties there are only six flowersepals, in the doubleflowering varieties there are extra sepals in the centre of the flowers.

To explore the potential of nature to improve the quality of life

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Report WPR-1174

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