

SUPPLEMENTARY MATERIAL

Techno-Economic Analysis of an Efficient Anthocyanin Extraction Process from Grape Pomace using Eutectic Solvents – A Critical Panorama Regarding Drying Techniques and Reusability of Solvents

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Figures

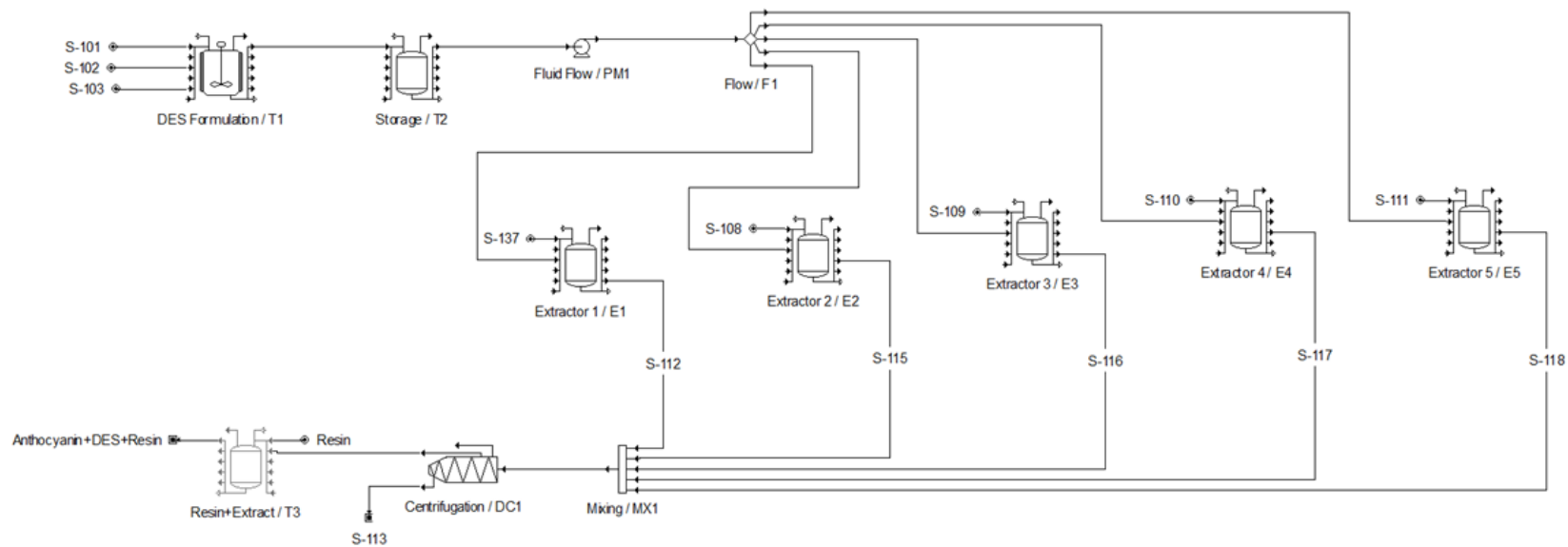


Fig. S1. Original flowsheet provided from SuperPro Software describing the Scenario I

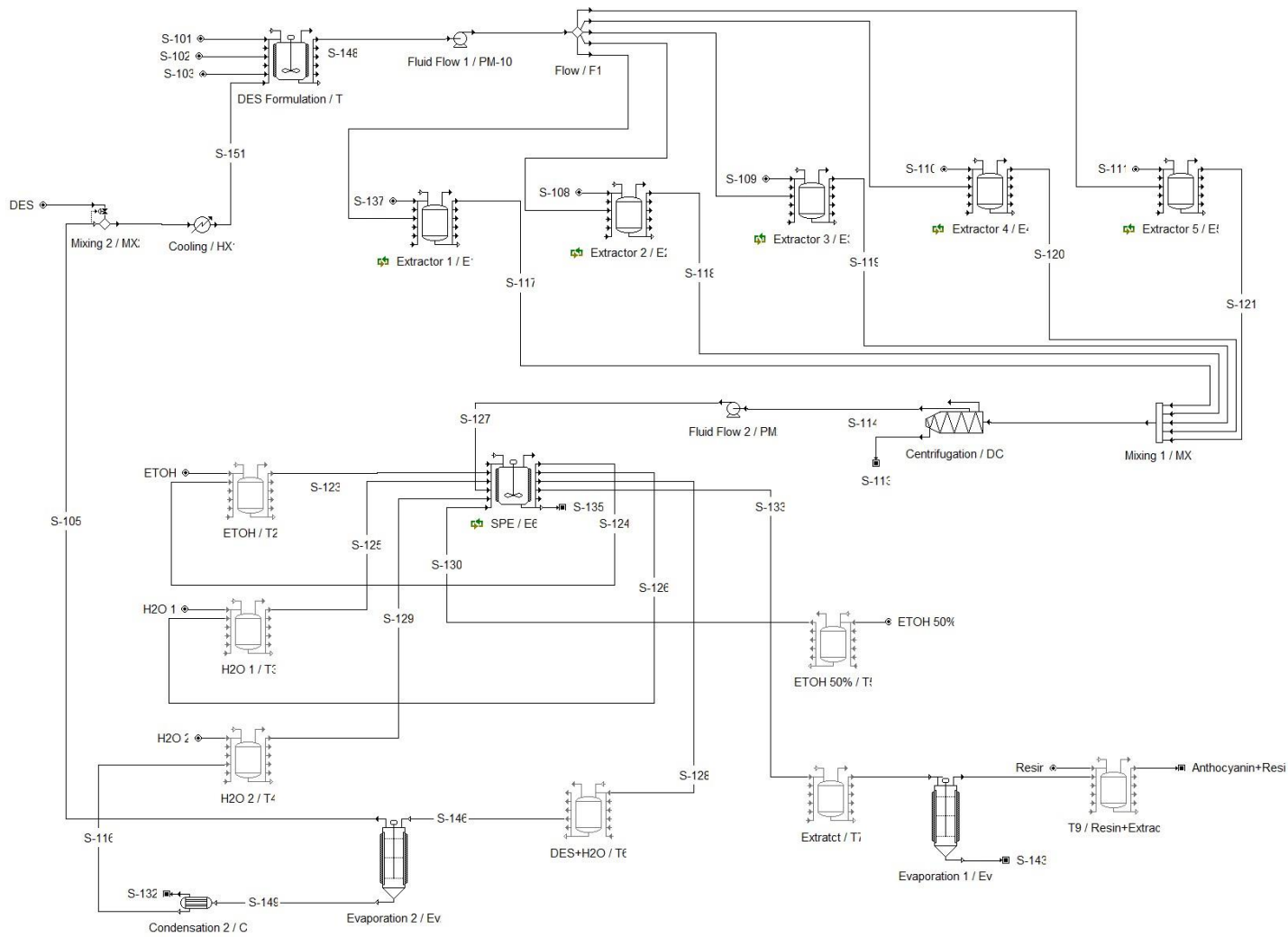


Fig. S2. Original flowsheet provided from SuperPro Software describing the Scenario II

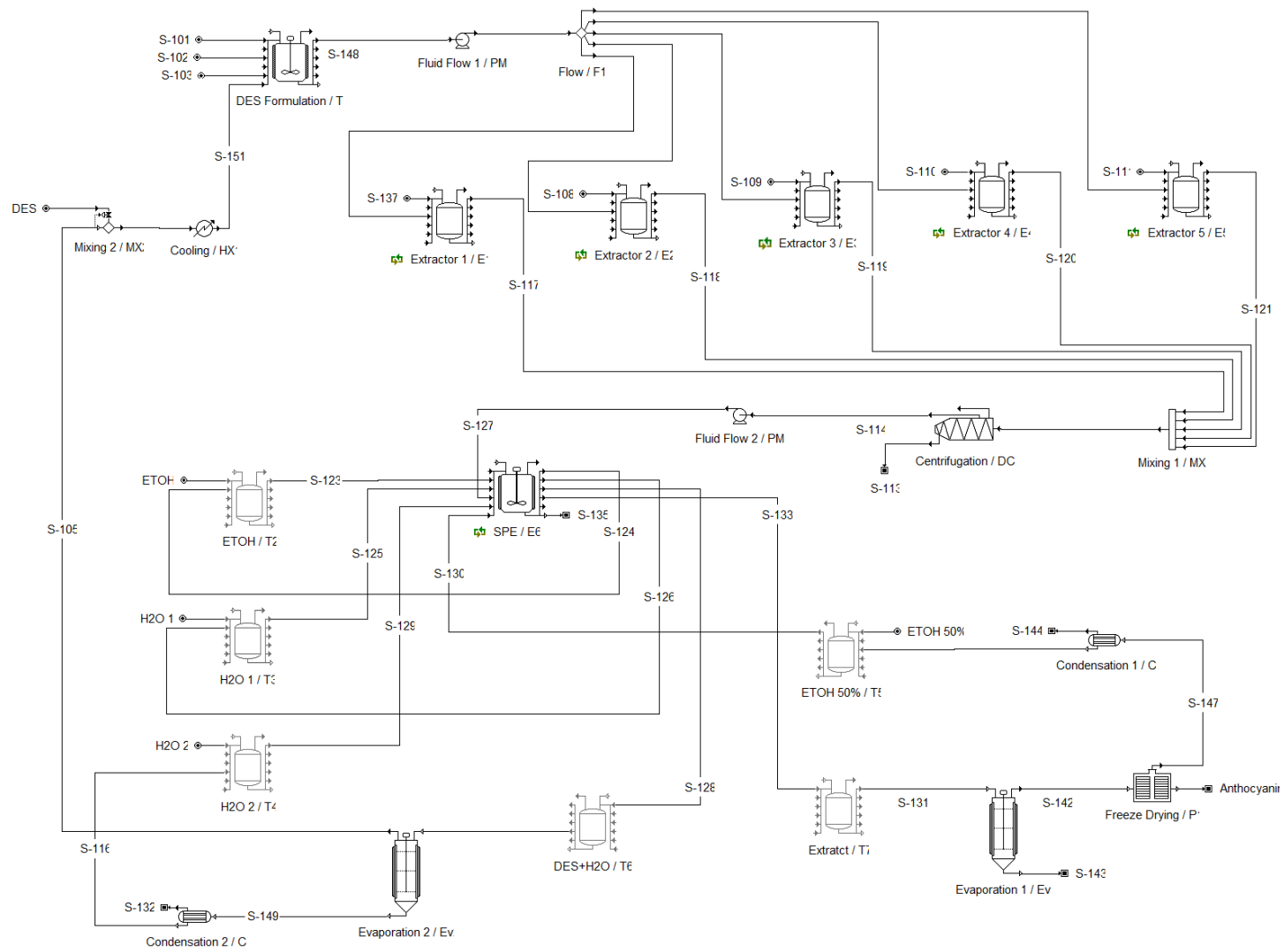


Fig. S3. Original flowsheet provided from SuperPro Software describing the Scenario III

Tables

Table S1. The base cost for each piece of equipment composing the three different scenarios.

| Equipment | n^a | Unit base cost (US\$) | Scenario I | | Scenario II | | Scenario III | |
|---|-------|-----------------------|------------|---------------|-------------|---------------|--------------|---------------|
| | | | N^d | Valor (US\$) | N^d | Valor (US\$) | N^d | Valor (US\$) |
| Stainless steel tanks (50 L) ^b | - | 1000 | 1 | 1000 | 5 | 5000 | 5 | 5000 |
| Stainless steel tanks (200 L) ^b | - | 4000 | 0 | 0 | 2 | 8000 | 2 | 8000 |
| Mechanical stirrer + Stainless steel tank (50L) ^b | - | 3818 | 1 | 3818 | 2 | 7636 | 2 | 7636 |
| Extraction vessel (1.3 L) ^b | - | 300 | 5 | 1500 | 5 | 1500 | 5 | 1500 |
| Ultrasound ^b | - | 28000 | 5 | 140000 | 5 | 140000 | 5 | 140000 |
| Centrifuge ^b | - | 10350 | 1 | 10350 | 1 | 10350 | 1 | 10350 |
| Pump ^c | 0.55 | 3920 | 0 | 0 | 1 | 33707 | 1 | 33707 |
| Evaporator ^c | 0.53 | 2300 | 0 | 0 | 2 | 36577 | 2 | 36577 |
| Condenser ^c | 0.59 | 2000 | 0 | 0 | 2 | 40221 | 2 | 40221 |
| Freeze-dryer ^c | 0.59 | 8000 | 0 | 0 | 0 | 0 | 1 | 80442 |
| Structural material for supporting the equipment ^c | 0.6 | 4060 | 1 | 21226 | 1 | 42453 | 1 | 42453 |
| Piping, connectors, crossheads, mixers and splitters ^c | 0.6 | 3660 | 1 | 19135 | 1 | 38270 | 1 | 38270 |
| TOTAL | - | - | - | 197030 | - | 363715 | - | 444156 |

^a Constant depending on equipment type based on Turton et al. (2008) and Peters et al. (2003); ^b Direct quotation; ^c based on Viganó et al. (2022); ^d N means amount of equipment.

Table S2. Economic parameters input used in the SuperPro Designer 10.0® software.

| Total Costs | Scenario I | Scenario II | Scenario III |
|--|-------------------|--------------------|---------------------|
| <i>Fixed capital investment</i> | | | |
| Pilot plant | \$197030 | \$363715 | \$444156 |
| Depreciation rate ^b | 10%/year | 10%/year | US\$ 10%/year |
| Annual maintenance rate ^b | 6%/year | 6%/year | 6%/year |
| <i>Cost of operational labor</i> | | | |
| Wage ^c | US\$ 11.20/h | US\$ 11.20/h | US\$ 11.20/h |
| Number of workers | 1 | 2 | 2 |
| <i>Cost of raw material</i> | | | |
| Pre-processing grape skin ^d | US\$ 40.00/t | US\$ 40.00/t | US\$ 40.00/t |
| Absolute ethanol ^e | US\$ 3.80/kg | US\$ 3.80/kg | US\$ 3.80/kg |
| Ethanol 50% | US\$ 9.00/kg | US\$ 9.00/kg | US\$ 9.00/kg |
| Nicotinamide ^e | US\$ 105.00/kg | US\$ 105.00/kg | US\$ 105.00/kg |
| Acetic acid ^e | US\$ 24.00/kg | US\$ 24.00/kg | US\$ 24.00/kg |
| Sepra C _{18E} ^e | US\$ 8.000/kg | US\$ 8.000/kg | US\$ 8.000/kg |
| SiO ² | US\$ 3.48/kg | US\$ 3.48/kg | US\$ 3.48/kg |
| <i>Cost of utilities</i> | | | |
| Electricity ^c | US\$ 0.17/kWh | US\$ 0.17/kWh | US\$ 0.17/kWh |
| Water steam (high pressure) ^f | US\$ 20.00/t | US\$ 20.00/t | US\$ 20.00/t |
| Water ^f | US\$ 0.50/t | US\$ 0.50/t | US\$ 0.50/t |

^aEstimated cost using Eq. (1) and direct quotation; ^bfixed value based on Viganó et al. (2022); ^cBased on de Aguiar et al. (2020) and Viganó et al. (2022); ^dBase on Veggi et al. (2014); ^eDirect quotation; ^f SuperPro Designer 10.0® database.

Table S3. Sequence of simulated activities for Scenario I.

| Activity | Start (min) | Duration (min) |
|---------------------------|--------------------|-----------------------|
| Complete recipe | 0 | 130 |
| Solvent preparation (DES) | 0 | 60 |
| Storage DES | 0 | 130 |
| | | |
| Raw material loading | 0 | 5 |
| Swelling of raw material | 5 | 25 |
| UAE in the five reactors | 30 | 40 |
| Centrifugation | 70 | 15 |
| | | |
| SiO ₂ loading | 85 | 15 |
| Absorption | 100 | 15 |
| Powder product unloading | 115 | 15 |

Table S4. Sequence of simulated activities for Scenario II.

| Activity | Start (min) | Duration (min) |
|------------------------------------|--------------------|-----------------------|
| Complete recipe | 0 | 640 |
| Solvent preparation (DES) | 0 | 60 |
| Storage DES | 0 | 640 |
| Sepra C ₁₈ E loading | 0 | 5 |
| Activation with EtOH | 0 | 5 |
| Conditioning with H ₂ O | 0 | 5 |
| | | |
| Raw material loading | 0 | 5 |
| Swelling of raw material | 5 | 25 |
| UAE in the five reactors | 30 | 40 |
| Centrifugation | 70 | 15 |
| Adsorption | 85 | 5 |
| DES removal with H ₂ O | 90 | 5 |
| Elution with EtOH | 95 | 5 |
| | | |
| Raw material loading | 70 | 5 |
| Swelling of raw material | 75 | 25 |
| UAE in the five reactors | 100 | 40 |
| Centrifugation | 140 | 15 |
| Adsorption | 155 | 5 |
| DES removal with H ₂ O | 160 | 5 |
| Elution with EtOH | 165 | 5 |
| | | |
| Raw material loading | 155 | 5 |
| Swelling of raw material | 160 | 25 |
| UAE in the five reactors | 185 | 40 |
| Centrifugation | 225 | 15 |
| Adsorption | 240 | 5 |
| DES removal with H ₂ O | 245 | 5 |
| Elution with EtOH | 250 | 5 |
| | | |
| Raw material loading | 225 | 5 |
| Swelling of raw material | 230 | 25 |
| UAE in the five reactors | 255 | 40 |
| Centrifugation | 295 | 15 |
| Adsorption | 310 | 5 |
| DES removal with H ₂ O | 315 | 5 |
| Elution with EtOH | 320 | 5 |
| | | |
| Raw material loading | 295 | 5 |

| | | |
|-----------------------------------|-----|----|
| Swelling of raw material | 300 | 25 |
| UAE in the five reactors | 325 | 40 |
| Centrifugation | 365 | 15 |
| Adsorption | 380 | 5 |
| DES removal with H ₂ O | 385 | 5 |
| Elution with EtOH | 390 | 5 |
| | | |
| Raw material loading | 365 | 5 |
| Swelling of raw material | 370 | 25 |
| UAE in the five reactors | 395 | 40 |
| Centrifugation | 435 | 15 |
| Adsorption | 450 | 5 |
| DES removal with H ₂ O | 455 | 5 |
| Elution with EtOH | 460 | 5 |
| | | |
| Raw material loading | 435 | 5 |
| Swelling of raw material | 440 | 25 |
| UAE in the five reactors | 465 | 40 |
| Centrifugation | 505 | 15 |
| Adsorption | 520 | 5 |
| DES removal with H ₂ O | 525 | 5 |
| Elution with EtOH | 530 | 5 |
| Sepra discharge | 535 | 5 |
| | | |
| Evaporation | 535 | 60 |
| Condensation | 535 | 60 |
| Evaporation | 535 | 60 |
| Condensation | 535 | 60 |
| | | |
| SiO ₂ loading | 595 | 15 |
| Absorption | 610 | 15 |
| Powder product unloading | 625 | 15 |

Table S5. Sequence of simulated activities for Scenario III.

| Activity | Start (min) | Duration (min) |
|------------------------------------|--------------------|-----------------------|
| Complete recipe | 0 | 665 |
| Solvent preparation (DES) | 0 | 60 |
| Storage DES | 0 | 665 |
| Sepra C ₁₈ E loading | 0 | 5 |
| Activation with EtOH | 0 | 5 |
| Conditioning with H ₂ O | 0 | 5 |
| | | |
| Raw material loading | 0 | 5 |
| Swelling of raw material | 5 | 25 |
| UAE in the five reactors | 30 | 40 |
| Centrifugation | 70 | 15 |
| Adsorption | 85 | 5 |
| DES removal with H ₂ O | 90 | 5 |
| Elution with EtOH | 95 | 5 |
| | | |
| Raw material loading | 70 | 5 |
| Swelling of raw material | 75 | 25 |
| UAE in the five reactors | 100 | 40 |
| Centrifugation | 140 | 15 |
| Adsorption | 155 | 5 |
| DES removal with H ₂ O | 160 | 5 |
| Elution with EtOH | 165 | 5 |
| | | |
| Raw material loading | 155 | 5 |
| Swelling of raw material | 160 | 25 |
| UAE in the five reactors | 185 | 40 |
| Centrifugation | 225 | 15 |
| Adsorption | 240 | 5 |
| DES removal with H ₂ O | 245 | 5 |
| Elution with EtOH | 250 | 5 |
| | | |
| Raw material loading | 225 | 5 |
| Swelling of raw material | 230 | 25 |
| UAE in the five reactors | 255 | 40 |
| Centrifugation | 295 | 15 |
| Adsorption | 310 | 5 |
| DES removal with H ₂ O | 315 | 5 |
| Elution with EtOH | 320 | 5 |
| | | |
| Raw material loading | 295 | 5 |

| | | |
|-----------------------------------|-----|-----|
| Swelling of raw material | 300 | 25 |
| UAE in the five reactors | 325 | 40 |
| Centrifugation | 365 | 15 |
| Adsorption | 380 | 5 |
| DES removal with H ₂ O | 385 | 5 |
| Elution with EtOH | 390 | 5 |
| | | |
| Raw material loading | 365 | 5 |
| Swelling of raw material | 370 | 25 |
| UAE in the five reactors | 395 | 40 |
| Centrifugation | 435 | 15 |
| Adsorption | 450 | 5 |
| DES removal with H ₂ O | 455 | 5 |
| Elution with EtOH | 460 | 5 |
| | | |
| Raw material loading | 435 | 5 |
| Swelling of raw material | 440 | 25 |
| UAE in the five reactors | 465 | 40 |
| Centrifugation | 505 | 15 |
| Adsorption | 520 | 5 |
| DES removal with H ₂ O | 525 | 5 |
| Elution with EtOH | 530 | 5 |
| | | |
| Raw material loading | 505 | 5 |
| Swelling of raw material | 510 | 25 |
| UAE in the five reactors | 535 | 40 |
| Centrifugation | 575 | 15 |
| Adsorption | 590 | 5 |
| DES removal with H ₂ O | 595 | 5 |
| Elution with EtOH | 600 | 5 |
| Sepra discharge | 605 | 5 |
| | | |
| Evaporation | 605 | 60 |
| Condensation | 605 | 60 |
| Evaporation | 605 | 60 |
| Condensation | 605 | 60 |
| Freeze-drying | 0 | 665 |