

Green solvents for lupin debittering: a sustainable twist to improve lupin-beer synergy

Mónia A. R. Martins^{1,2}, Nathan Z. Barbosa^{1,2}, Filipe H. B. Sosa³, João A. P. Coutinho³, Olga Ferreira^{1,2}, Simão P. Pinho^{1,2}

¹CIMO, School of Sciences and Technology, Polytechnic Institute of Bragança, Bragança, Portugal; ²SusTEC, Polytechnic Institute of Bragança, Bragança, Portugal; ³CICECO - Aveiro Institute of Materials, University of Aveiro, Aveiro, Portugal

Problem

Lupin beans have been widely cultivated but the presence of **toxic quinolizidine alkaloids (QAs)** limits their industrial applications. The traditional debittering process is commonly accomplished by a soaking process that uses large amounts of fresh water.

Solution

Use of **green solvents** as hydrotropes & scCO₂ co-solvents for improving the **debittering** of Andean lupin beans.

Results

COSMO-RS predictive tool was used to screen the dissolution behavior of QAs in alternative solvents:

Traditional solvents

	Water	1,3-Butanediol	1,1,1,2-tetrafluoroethane	1,2-Propanediol	1-Butanol	2-Butanol	2-Nitropropane	2-Propanol	Acetone	Benzyl Alcohol	Cyclohexane	Dichloromethane	Dihetyl ether	Dimethyl ether	Ethanol	Ethyl Acetate	Glycerol	Glycerol triacetate	Glycerol tributyrate	Hexane	Methanol	Methyl acetate	Triethyl citrate
$\Sigma \ln \gamma_{13}^{\infty}$	13.1	2.4	-1.1	8.2	1.7	-1.8	-2.1	8.1	1.7	0.3	0.4	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2

Ionic Liquids / Molten Salts

	[dMEA]Br	[MGua]Cl	[dEMSu]Cl	[Ch]Br	[N1111][Cl]y	[EMPy]Cl	[MIM]SuCl	[1,2,3-M]Cl	[1,3-M]MCl	[1,1-MPy]Br	[EMMorph]Cl	[MPy]Cl	[N1111][Me]l	[N1112]Br	[N1111]Cl	[N1111][CO3]	[dMEA]Cl	[N1111][For]	[Ch]Cl	[1,1-MPy]Cl	[EB-Py]Cl	[N1111][NO2]	[N1112]Cl	[N1111]Br	[N1111]Cl
$\Sigma \ln \gamma_{13}^{\infty}$	-2.58	-3.03	-3.27	-3.43	-3.50	-3.83	-4.13	-4.05	-4.02	-4.37	-4.13	-4.57	-4.44	-5.08	-4.36	-4.85	-5.34	-5.34	-5.56	-5.59	-5.81	-6.11	-6.81	-8.20	-11.14

Eutectic mixtures

	p-toluenesulfonic acid	Dihydroacetoin	Ferric chloride	Zinc chloride	Galic acid	Vanilic acid	p-hydroxybenzoic acid	5-phenylvaleric acid	Phenylacetic acid	Benzoic acid	Citric acid	Acetic acid	Tartaric acid	Itaconic acid	Fumaric acid	Oxalic acid	Malonic acid	Pyruvic acid	Hexadecanoic acid	Tetradecanoic acid	Dodecanoic acid	Formic acid	Thymol	4-chlorophenol	Hydroquinone	Resorcinol	Catechol	2,4,6-trimethyl phenol	3,4-dimethyl phenol	o-cresol	Phenol
$\Sigma \ln \gamma_{13}^{\infty}$	-1.83	-2.49	-2.81	-2.94	-3.28	-3.43	-3.50	-3.83	-4.13	-4.37	-4.57	-4.85	-5.08	-5.34	-5.56	-5.81	-6.11	-6.81	-8.20	-11.14	-12.47	-11.62	-10.93	-11.14	-12.47	-11.62	-10.93	-11.14	-12.47	-11.62	-10.93

COSMO-RS $\ln \gamma_{13}^{\infty}$ of QAs in different pure solvents at 298.15 K

Lower the $\ln \gamma_{13}^{\infty}$ value \Rightarrow Substances more mutually soluble \Rightarrow Greater the solvent capacity

- **COSMO-RS** is a useful **predictive tool** for the **screening** of ILs and eutectic solvents in lupin bean debittering;
- Preliminary results indicate the potential of **economic molten salts** and/or **terpene-based mixtures**, warranting experimental exploration.

The research aims to sustainably debitter Andean lupin beans using supercritical carbon dioxide and green solvents, enhancing food security, reducing water use and contamination, fostering innovation, and minimizing environmental impact.