Impact of extraction and pre-treatment methods over physicochemical properties of cashew nut-shell liquid.

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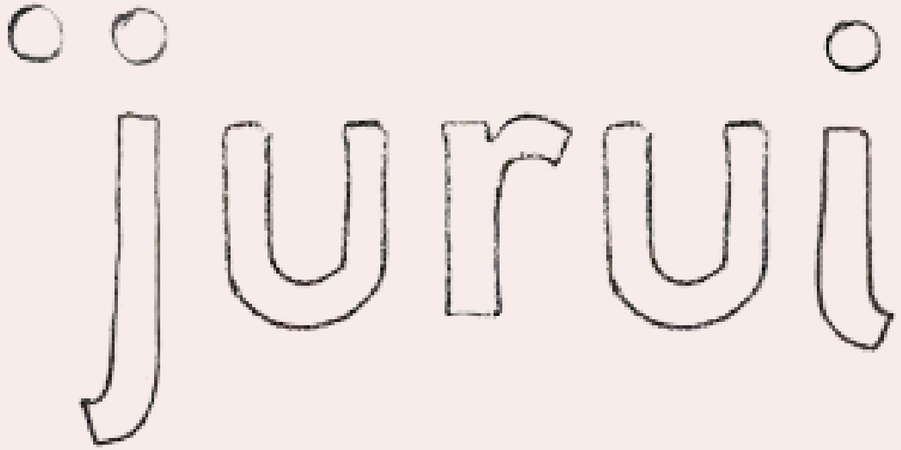
Let me introduce:



Let me introduce:

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Sustainable Cashew

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Strengthen cashew productive chain in Vichada Department

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Integration of knowledge

Chemical Engineering

Design

Mechanical Engineering

Field Work

Trabajo para todo VICHADA GOBIERNO DEPARTAMENTAL

SENA

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Multidisciplinary team

Mechanical Engineering

Escuela Colombiana de Ingeniería Julio Garavito

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Hernán Camilo Pacheco
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C. Hernandez
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Tatiana C Cruz
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Field work

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Amalia Aguilera
Agricultural Engineer
Muriel Murillo
Ecological agricultural production technologist

A. Porras
Project Director

Design

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Santiago de Francisco Vela
Professor
Leonardo Parra Agudelo
Professor
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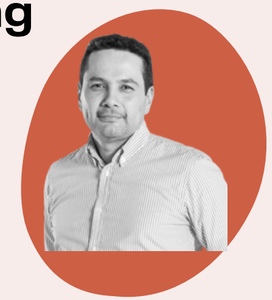
Researcher
Carolina Pérez R
Researcher
Clara Forero L
Researcher
Leyla MarulandaA
Master in technological nnovation management

C. Ayala
Project Leader

Chemical Engineering

Universidad de los Andes

Johan León
Researcher
Gabriela Ortiz
Researcher



O. Álvarez
Project Leader

A. Gonzalez
Professor

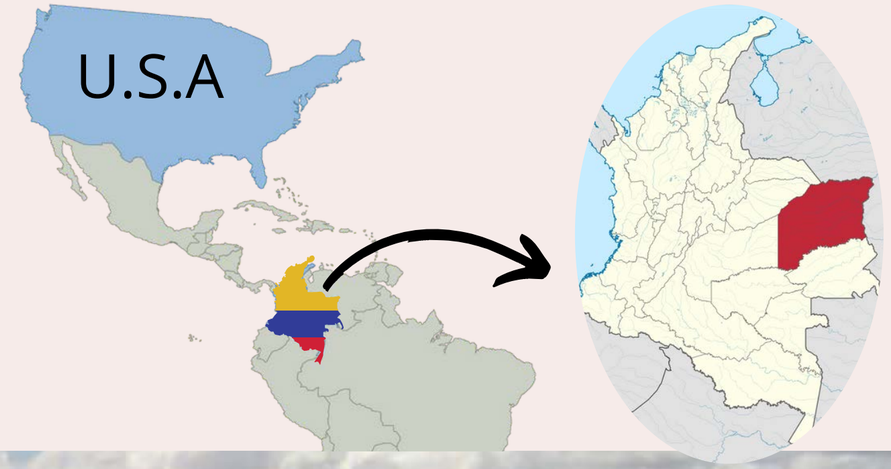
Cashew nut: Global production

Global cashew production is forecasted in 4.46 MT in 2023[a]

[a] Daniel Mervar, (2022), Tridge Agricultural and food database .

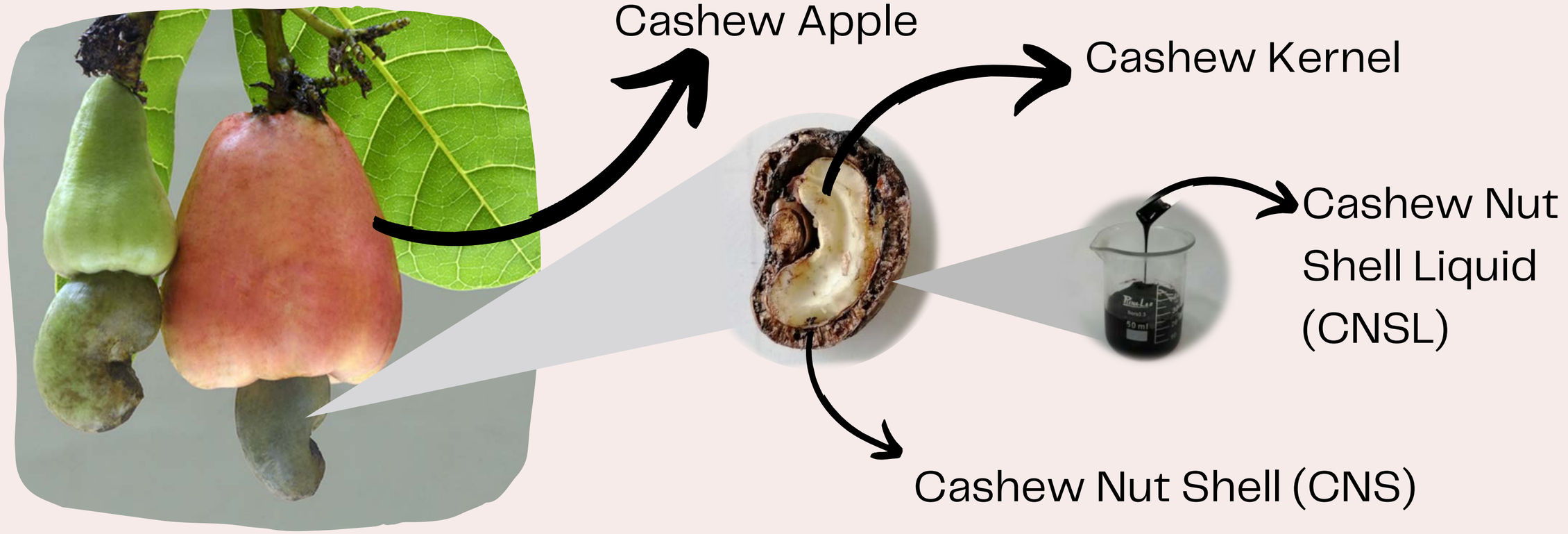
Cashew nut: Perspective in Colombia

- There are 8200 acres ofcashew tree cultivated in Vichada department.[a]
- Each acre produces almost 200kg ofcashew nut each year[a]



[a]Mateus, D et al (2022). Marañón: Un acercamiento al contexto productivo, social, ambiental y agroindustrial en la altillanura de Vichada

Products and by-products of cashew processing



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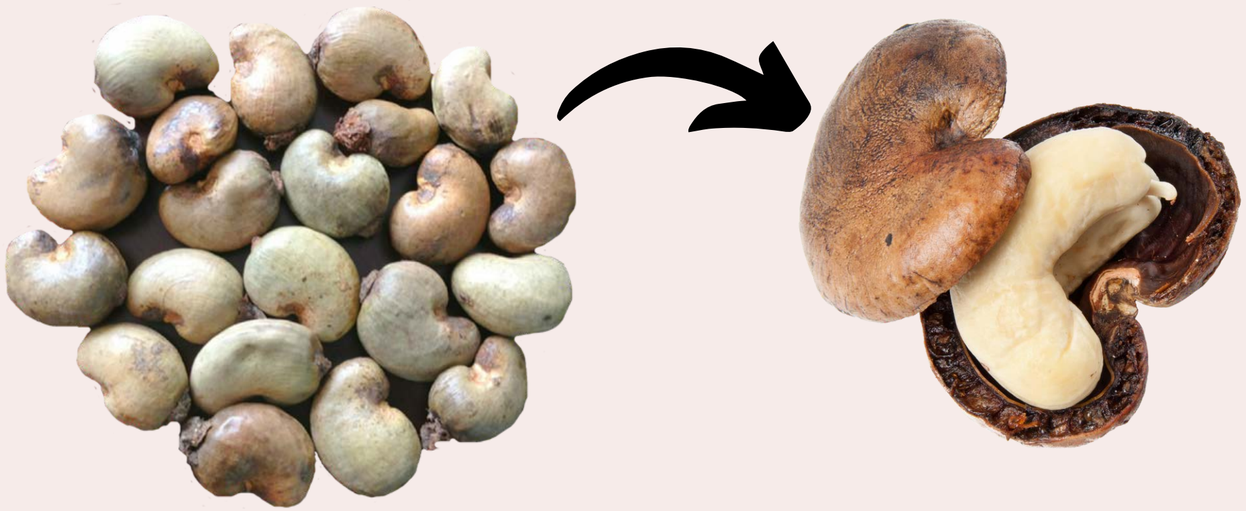
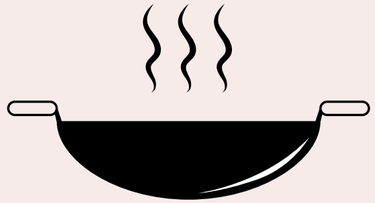
From cashew nut to cashew kernel



Raw cashew Nut

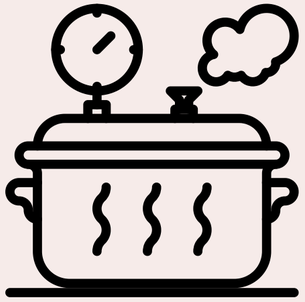
Shelled cashew nut

Roasting



Cashew nuts are roasted in a hot CNSL bath so the shell becomes brittle

Steaming



Cashew nuts are heated with high pressure steam to soften the shell

Current Management of CNS in Vichada

Estimated production of 410 Ton/year[a]

Estimated generation of 1230 Ton/year[a]

[a]Mateus, D et al (2022). Marañón: Un acercamiento al contexto productivo, social, ambiental y agroindustrial en la altillanura de Vichada

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Current Management of CNS in Vichada

- Cashew nut shells are either burned as fuel or treated as solid waste

- Cashew value chain can be enhanced by properly using by-products

From CNS to CNSL

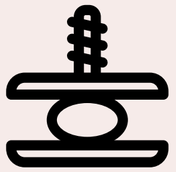
Residual CNS

Valuable CNSL

Solvent extraction

Alternatives such a soxhlet apparatus or supercritical fluid extraction

Mechanical extraction



Alternatives such as screw press or hydraulic press

Thermal extraction

Alternatives such as open pan roasting, hot oil roasting or drum roasting

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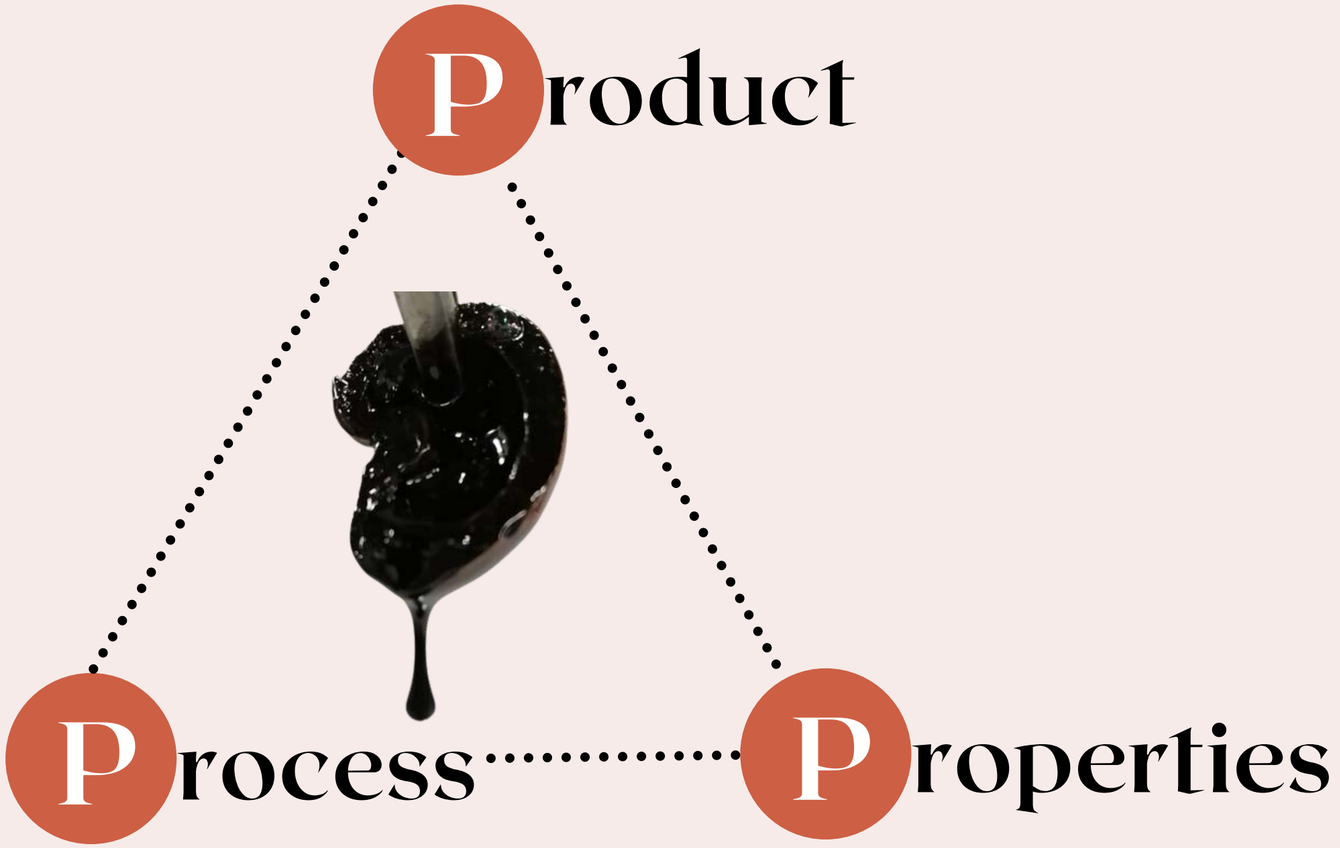
Our approach to product and process design:



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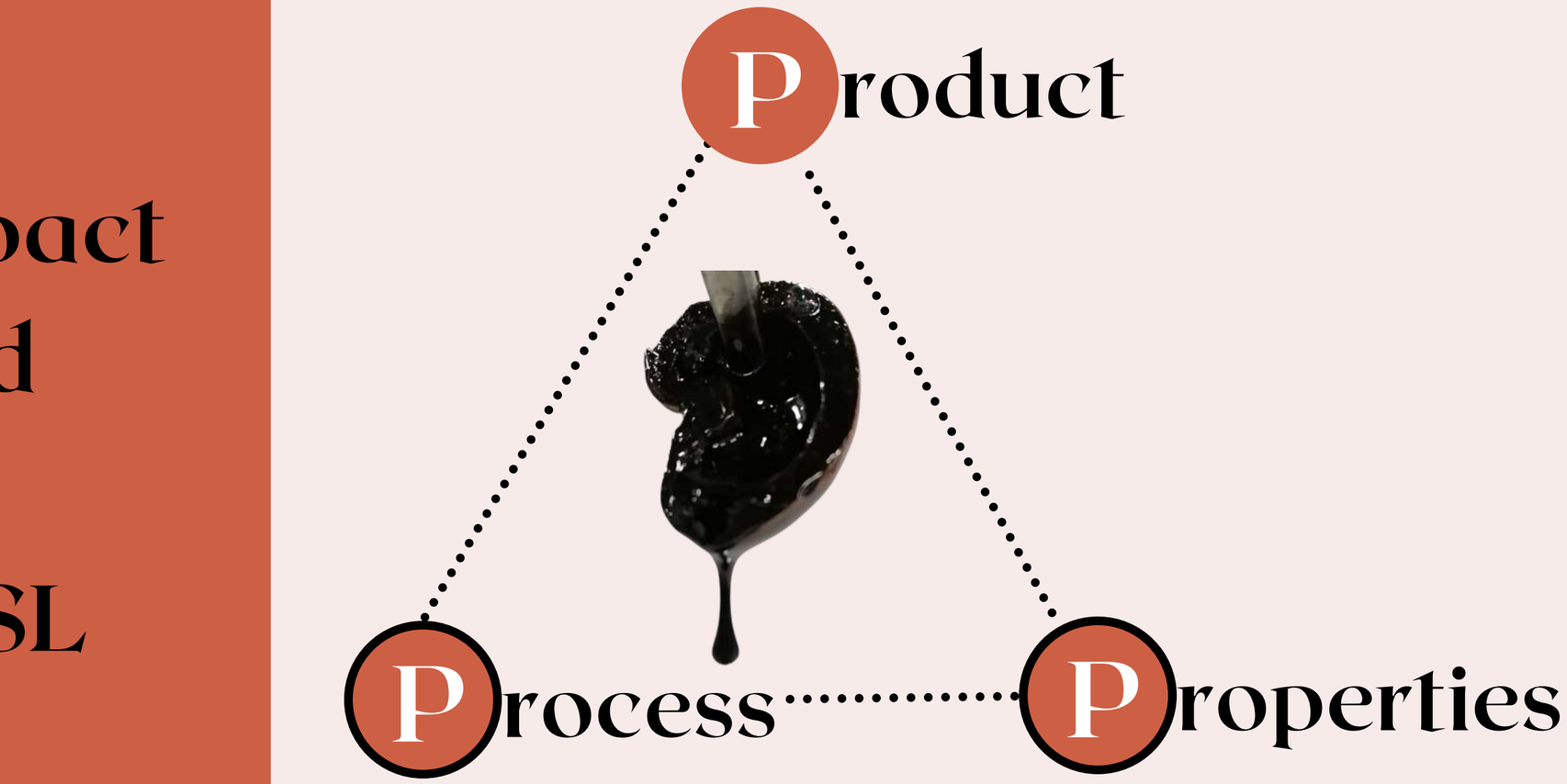
AIM OF STUDY:

Evaluate the impact of extraction and pre-treatment methods on CNSL properties



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Physicochemical characterization

A Viscosity
Flow sweep 1–100 1/s

B Saponification Value
AOAC 940.28

C Acid Value
AOAC 940.28

D Antioxidant Capacity
DPPH Assay, Brand-Williams et al, LWT –Food Sci. Technol. 28 (1995) 25–30

E FTIR Spectroscopy
Sánchez, L et al (2015)

F HPLC
F. Oiram Filho et al. (2018)

Viscosity

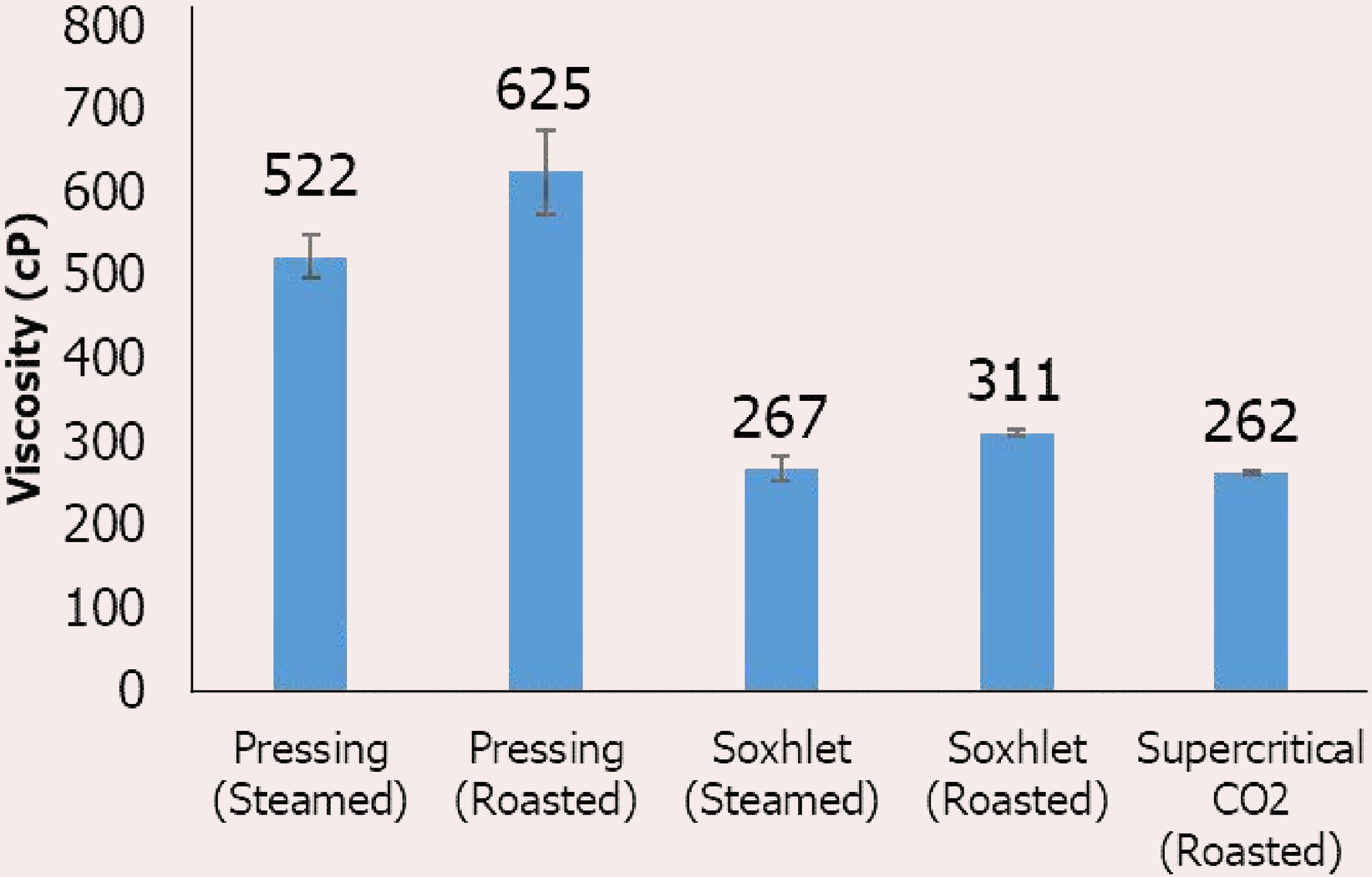
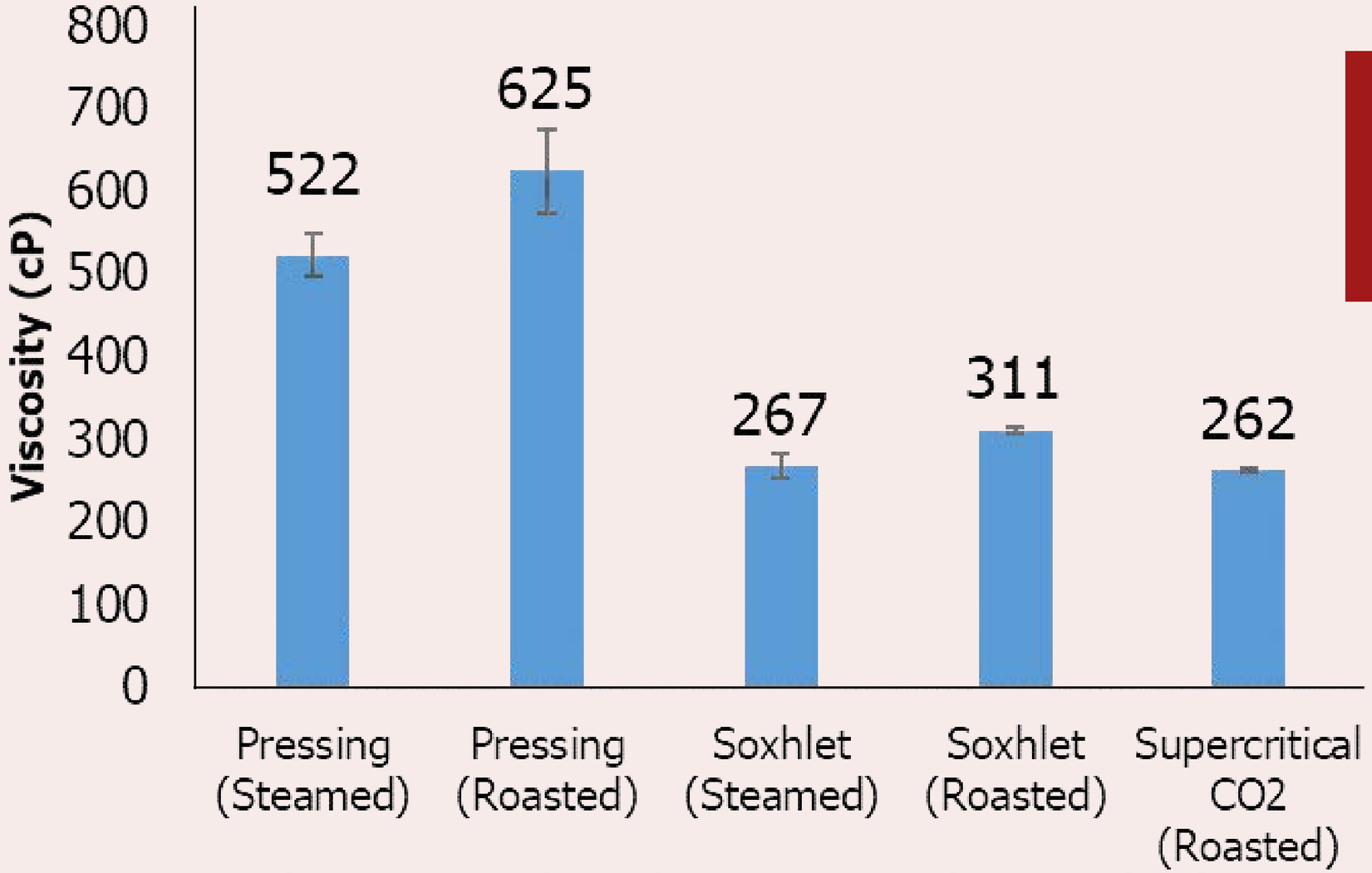


Fig 1. CNSL viscosity vs Extraction methods.

Viscosity



CNSL from steamed CNS recovered by solvent extraction shows lower viscosity

Fig 1. CNSL viscosity vs Extraction methods.

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Viscosity

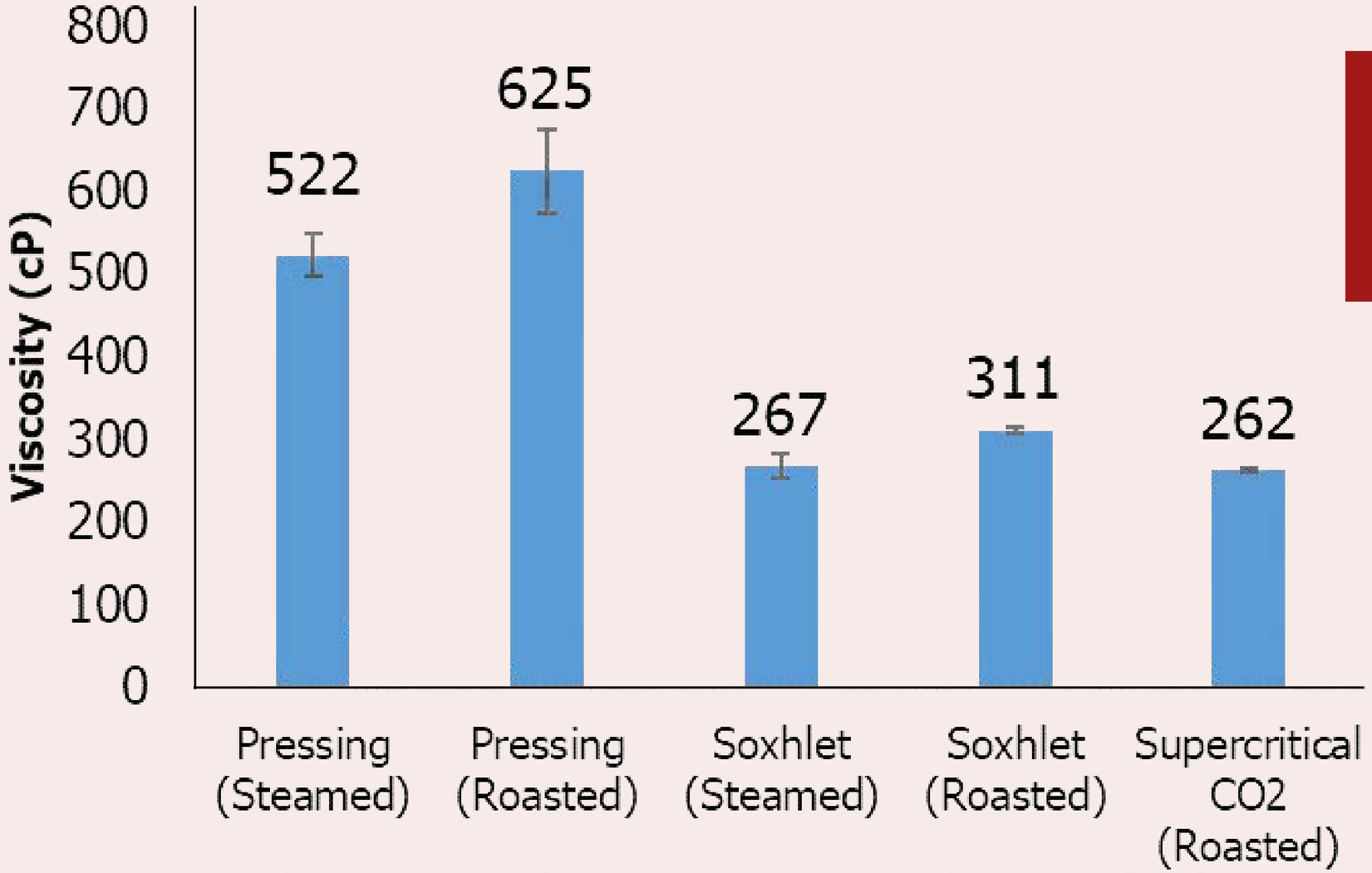

Fig 1. CNSL viscosity vs Extraction methods.

CNSL from steamed CNS recovered by solvent extraction shows lower viscosity

Solvent selectivity doesn't favor the extraction of gums and waxes

Yuliana M, (2012)

Saponification value

Fig 2. CNSL Saponification value vs Extraction methods

Saponification value

CNSL from steamed CNS recovered by solvent extraction shows lower saponification value

Fig 2. CNSL Saponification value vs Extraction methods

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Saponification value

CNSL from steamed CNS recovered by solvent extraction shows lower saponification value

Solvent polarity allow to extract longer fatty acid chains

High temperatures may cause fatty acid chain degradation

Fig 2. CNSL Saponification value vs Extraction methods

Dordević, D.(2020) .

Acid Value

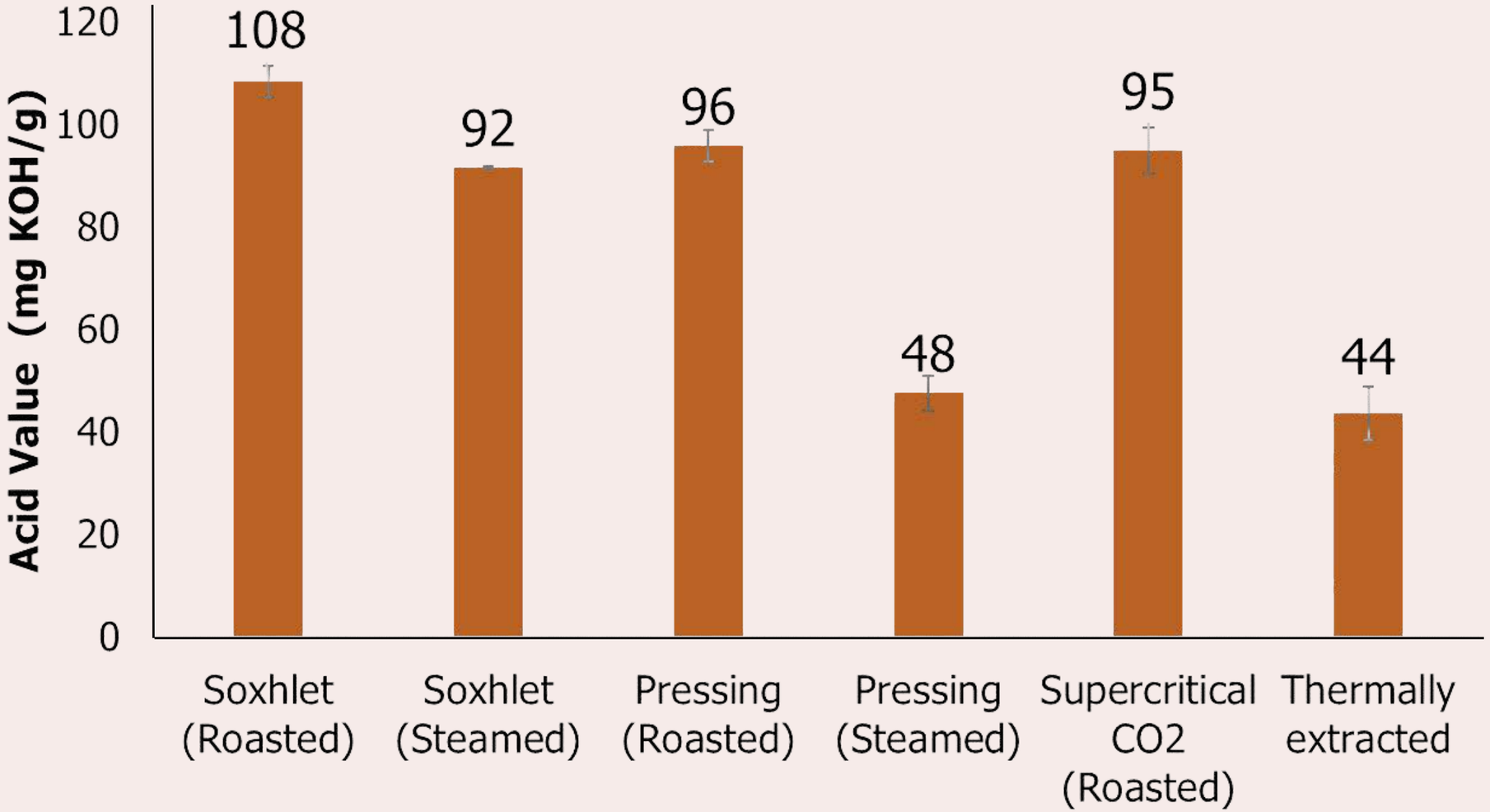
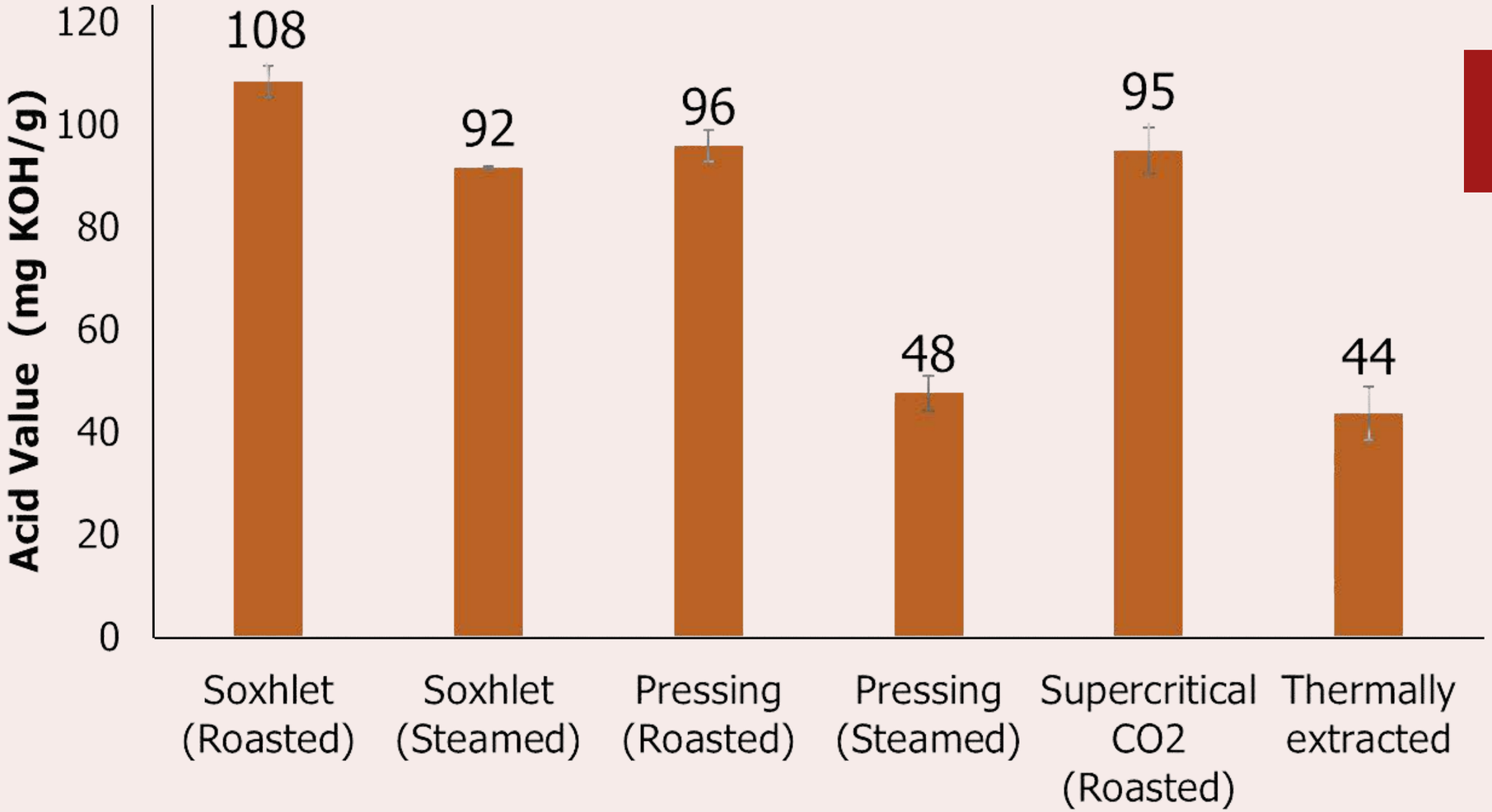


Fig 3. CNSL Acid value vs Extraction methods

Acid Value



CNSL from roasted CNS shows higher acid value

Fig 3. CNSL Acid value vs Extraction methods

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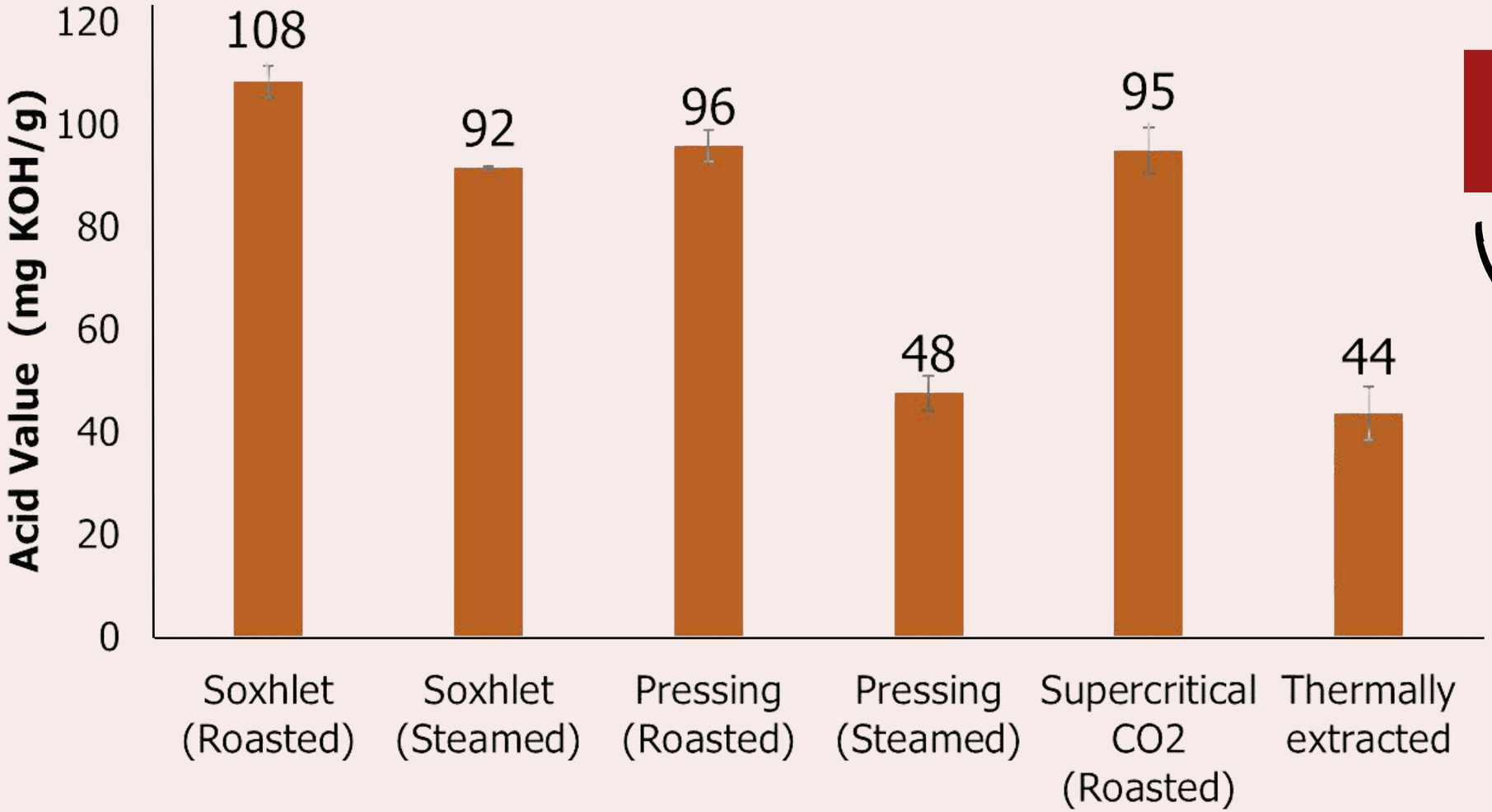


CNSL from roasted CNS shows higher acid value

Roasting damages cellular structure of the shell, thus increasing acidity as a result of enzymatic activity.

Hosseini Bai S (2017)

Fig 3. CNSL Acid value vs Extraction methods

Antioxidant capacity

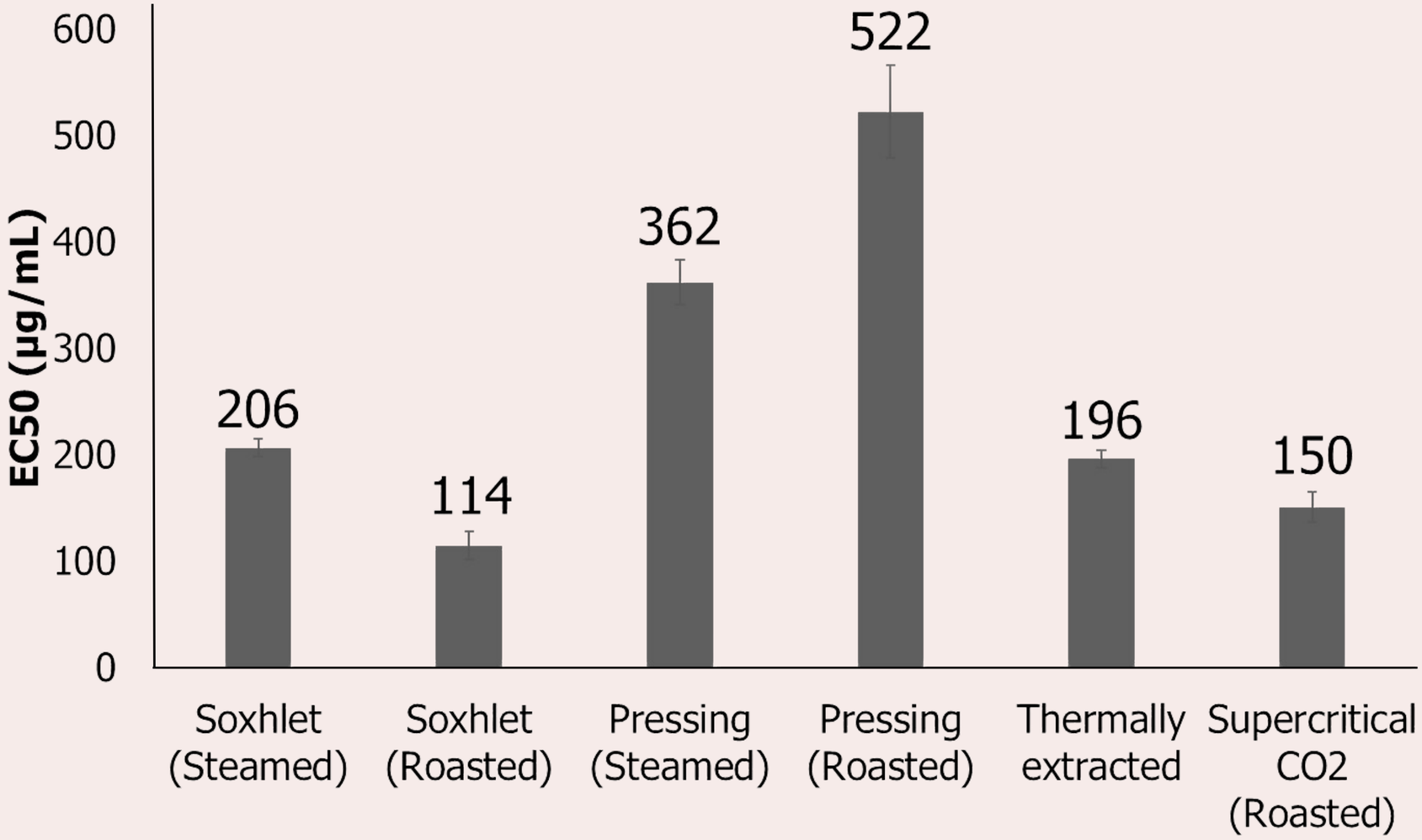
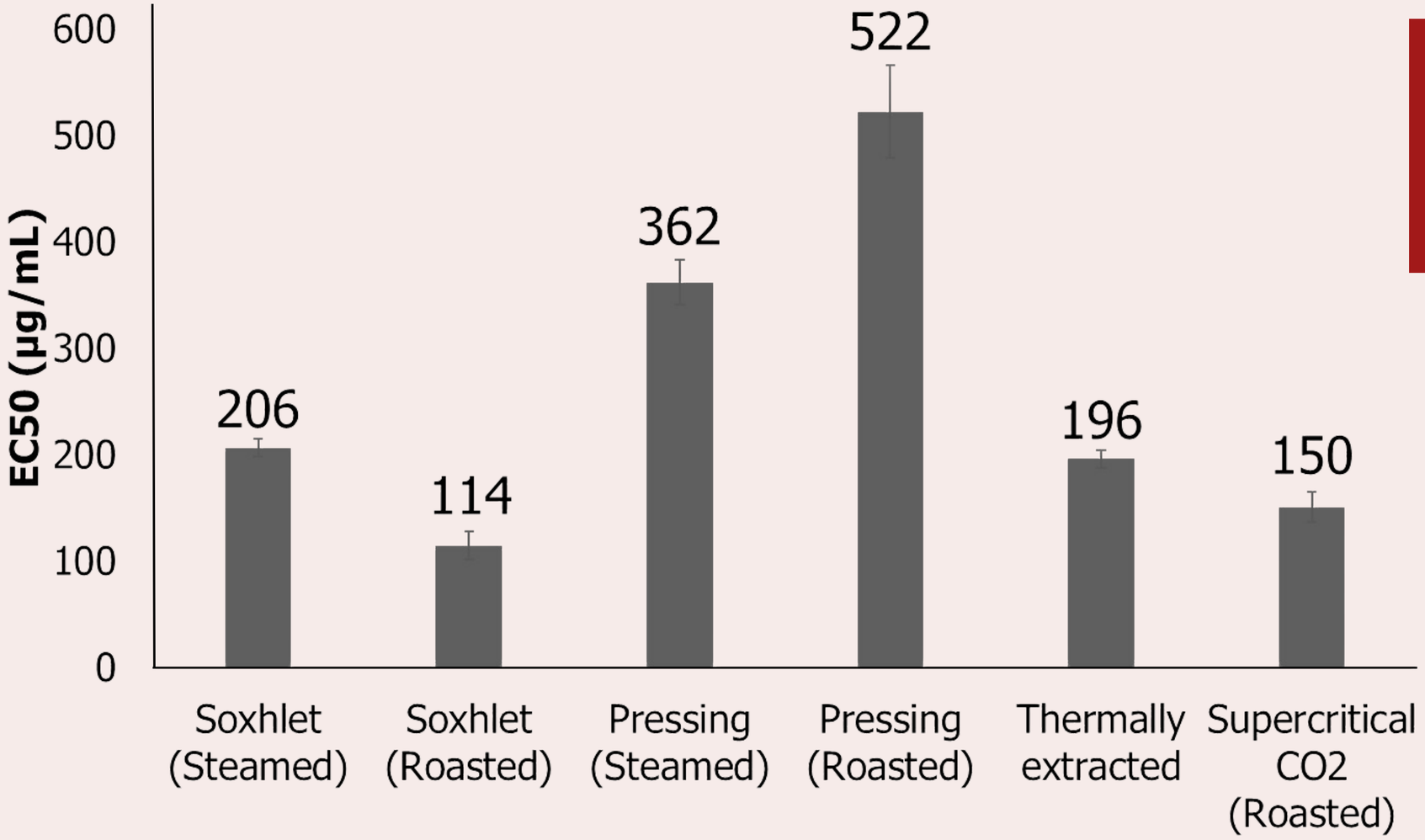


Fig 4. DPPH EC50 vs Extraction methods

Antioxidant capacity



Pressed CNSL shows lower antioxidant capacity than solvent and thermally extracted CNSL

Fig 4. DPPH EC50 vs Extraction methods

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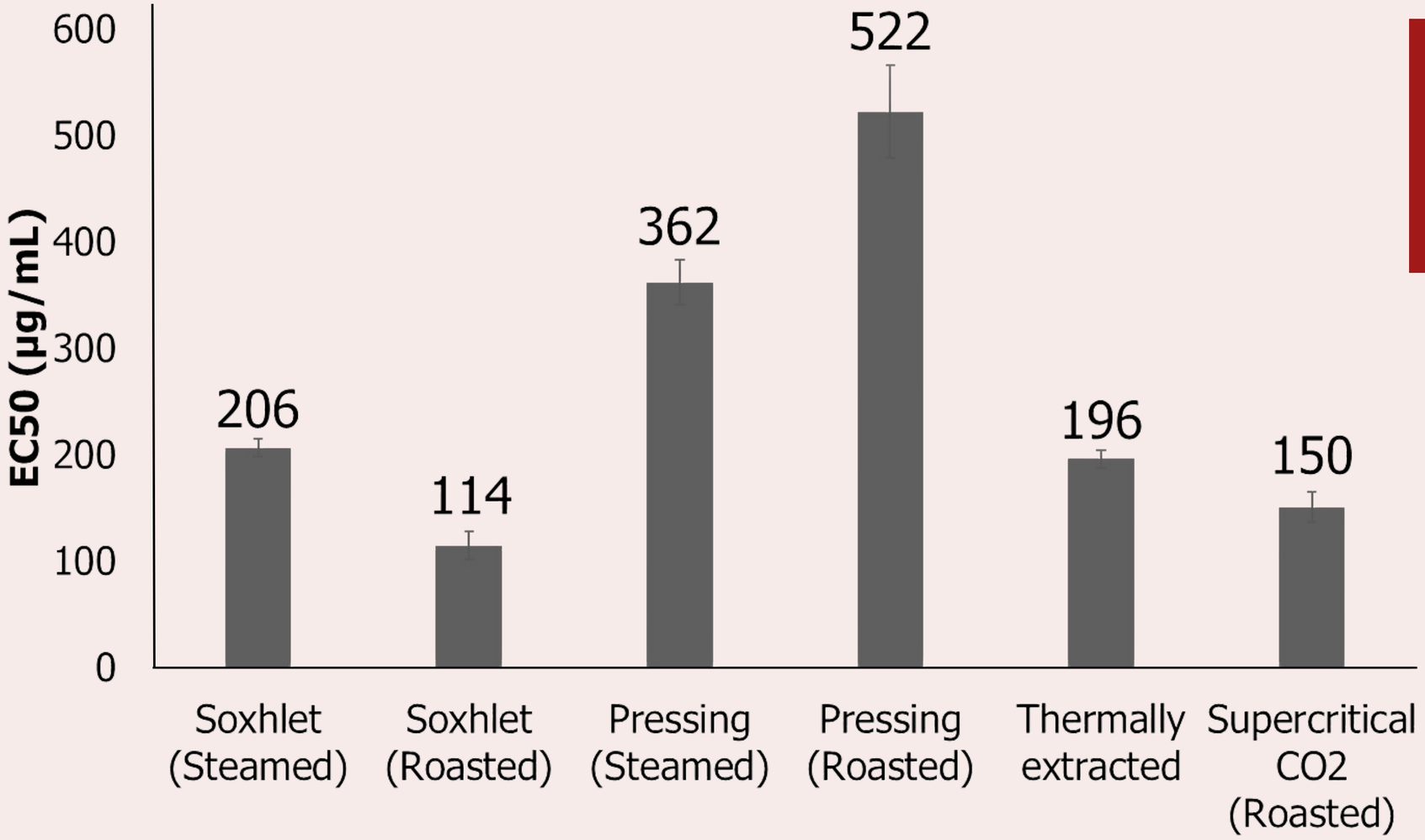
Antioxidant capacity



Pressed CNSL shows lower antioxidant capacity than solvent and thermally extracted CNSL

Solvent can extract other components from the shell with high antioxidant capacity

Damaging of cellular structure by roasting releases antioxidant extractives from the shell

Hosseini Bai S (2017)

Cruz. L (2023)

Fig 4. DPPH EC50 vs Extraction methods

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Preliminary result:

Extraction and pre-treatment methods have an effect over some physicochemical properties of CNSL as an oil.

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Preliminary result:

Extraction and pre-treatment methods have an effect over some physicochemical properties of CNSL as an oil.

Is CNSL similar to vegetable oils?

CNSL vs vegetable oils

	 CNSL	 Sunflower Oil[a]	 Soybean Oil[b]	 Clove essential Oil[c]
Viscosity (cP)	260-625	48	48	8
Saponification Value (mgKOH/g)	105-203	188-194	180-200	42
Acid Value (mgKOH/g)	44-108	0.9	0.5	3.84
EC50 (µg/mL)	114-522	14000	10000	13

[a] Aboki,M et al. (2012).

[b] Arawande, J & Amoo, I.A.. (2009). .

[c] Abdel Moneim E(2007)

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CNSL is considerably different than other vegetable oils

FTIR spectroscopy

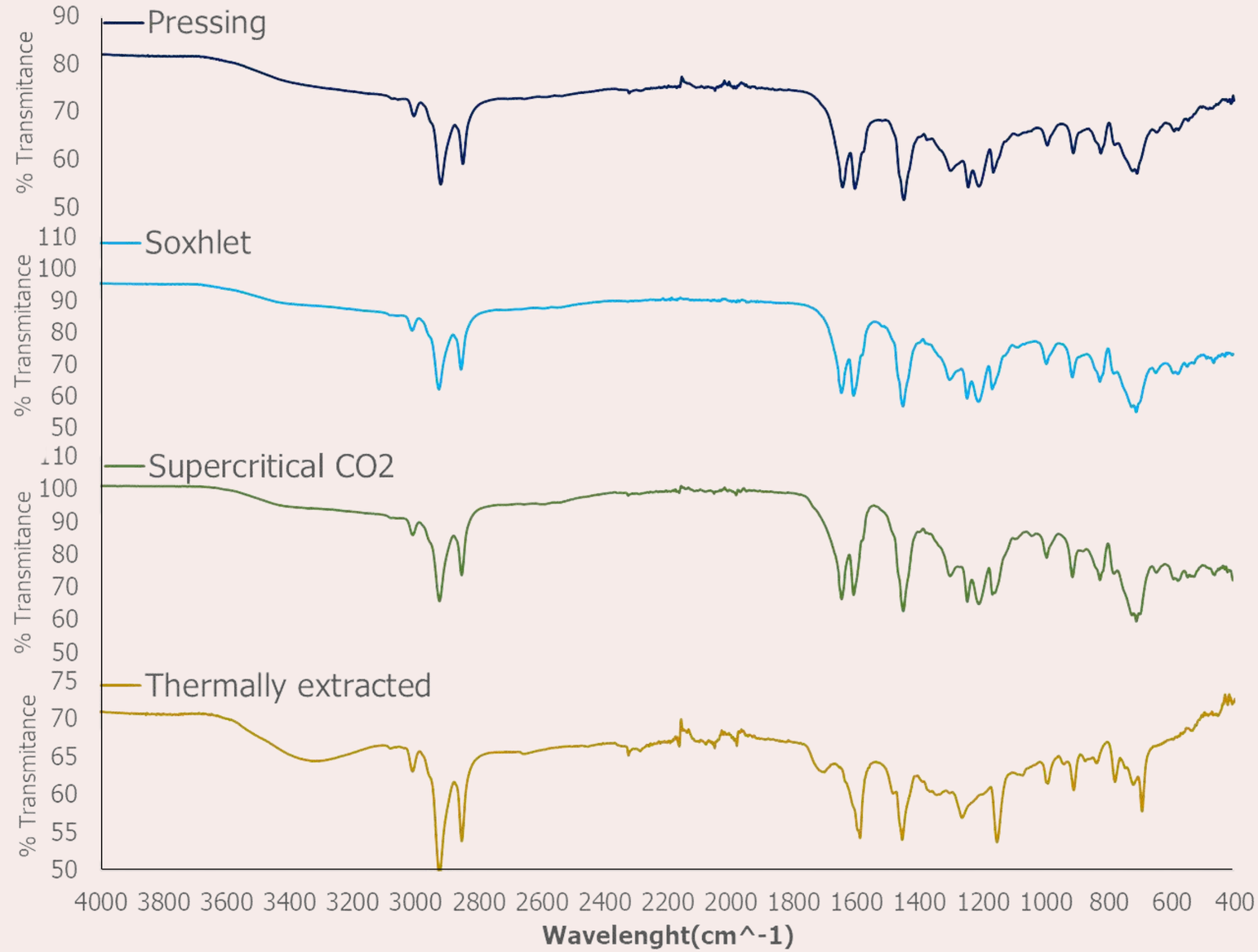


Fig 5. FTIR spectrums of CNSL samples

FTIR spectroscopy

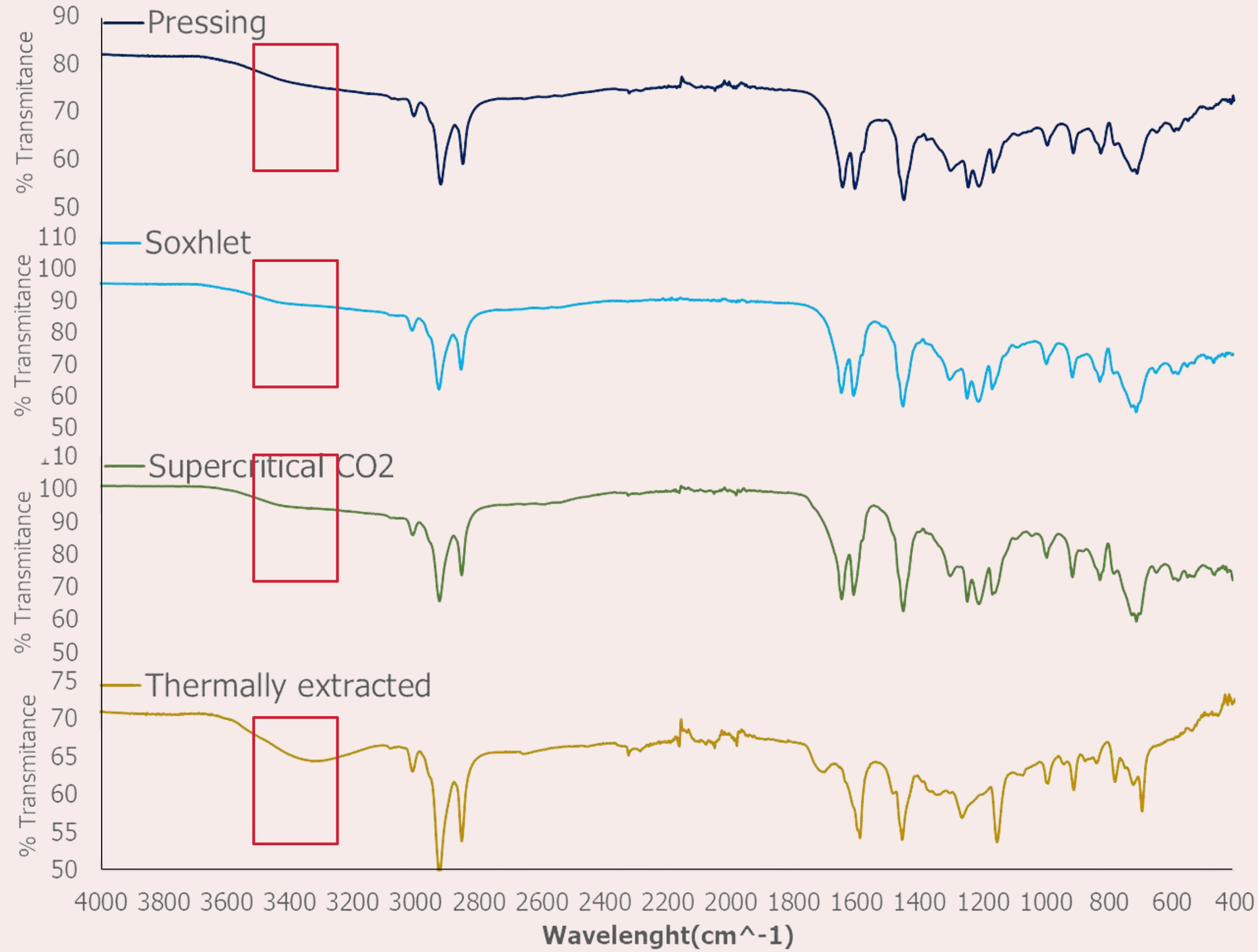
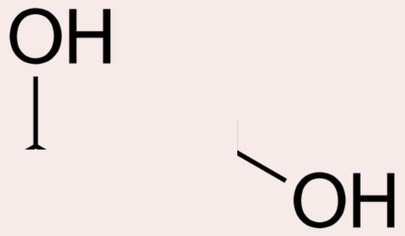


Fig 5. FTIR spectrums of CNSL samples

Vibration of OH groups



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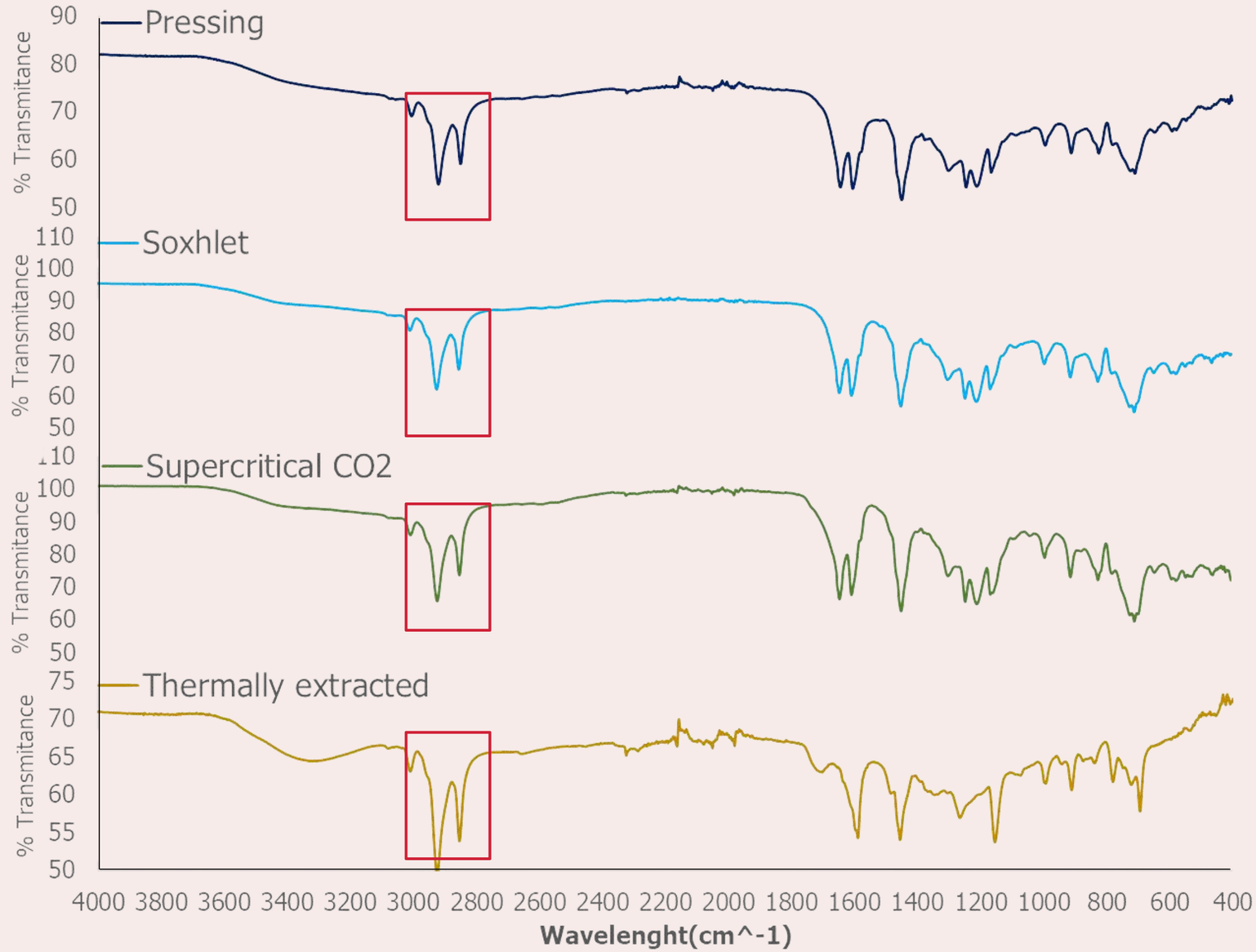
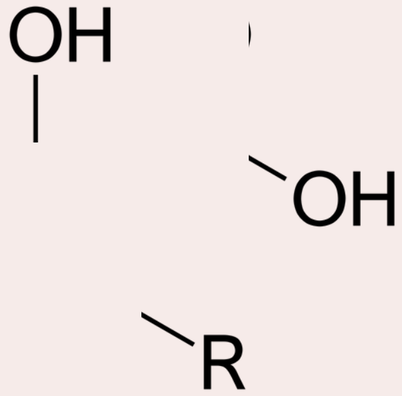


Fig 5. FTIR spectrums of CNSL samples

Vibration of C–C bonding, typical of alyphatic chains



FTIR spectroscopy

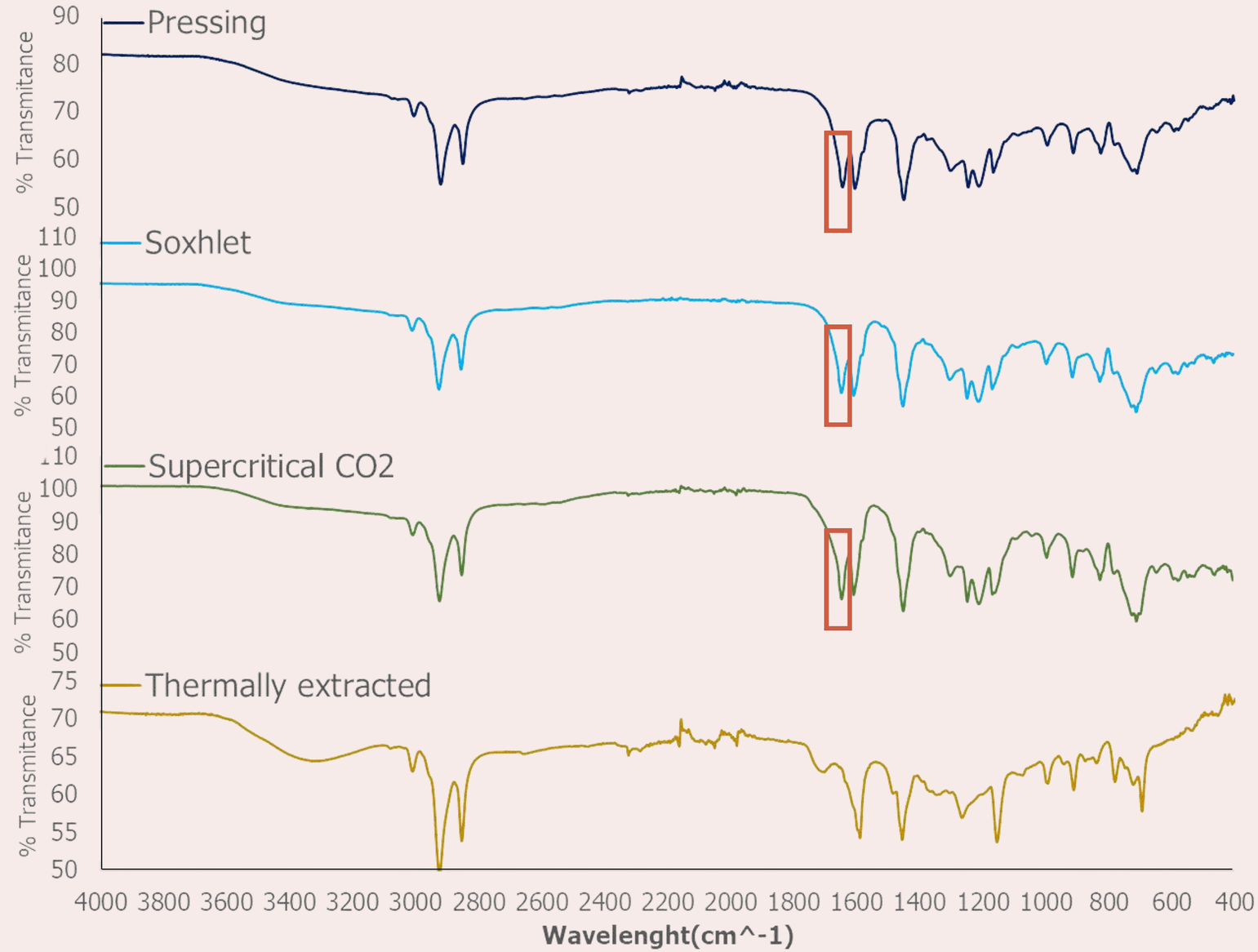
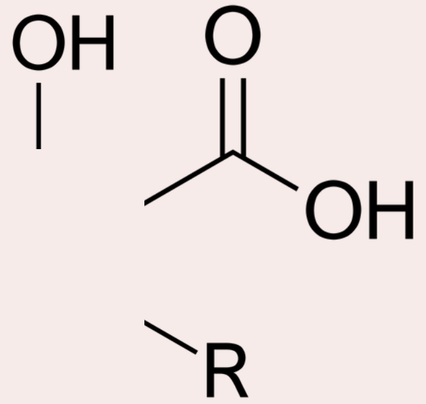


Fig 5. FTIR spectrums of CNSL samples

Vibration of C=O bonding, typical on carboxylic acids



FTIR spectroscopy

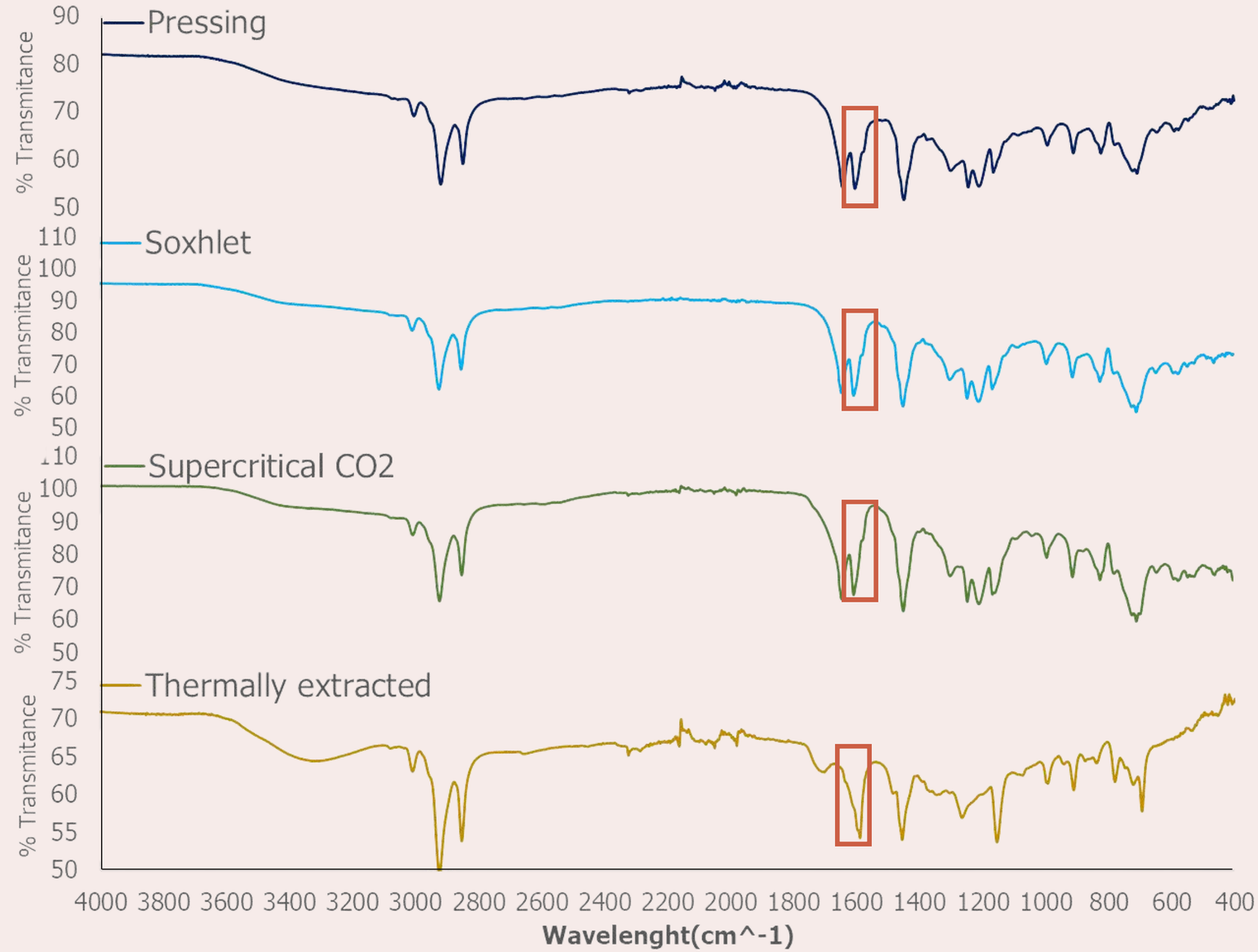
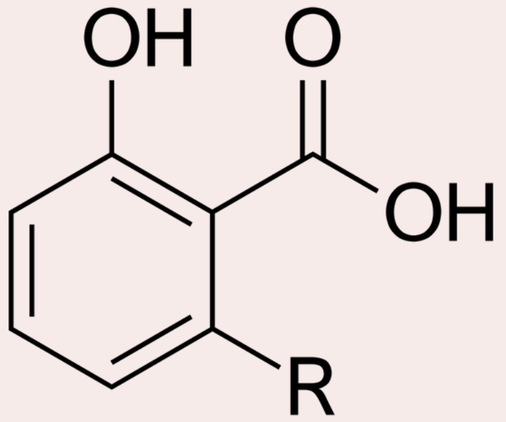


Fig 5. FTIR spectrums of CNSL samples

Vibration of C=C bonding, typical on benzene rings.



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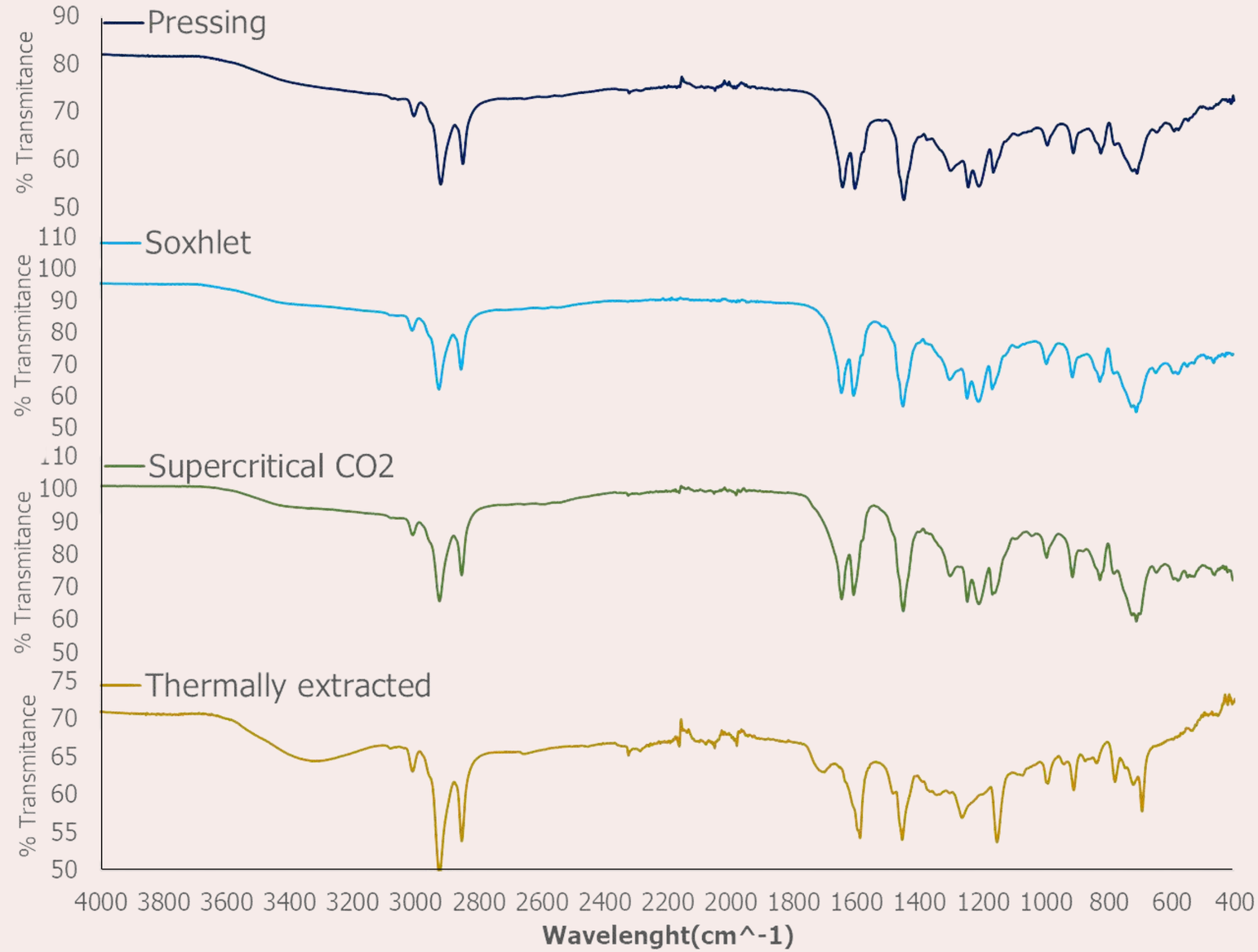
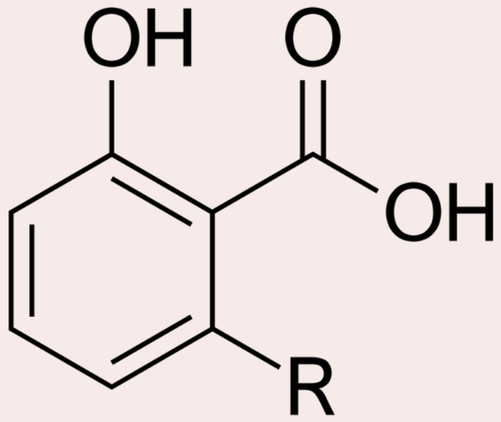


Fig 5. FTIR spectrums of CNSL samples

All samples present the typical functional groups of phenolic lipids



Anacardic Acid

FTIR spectroscopy

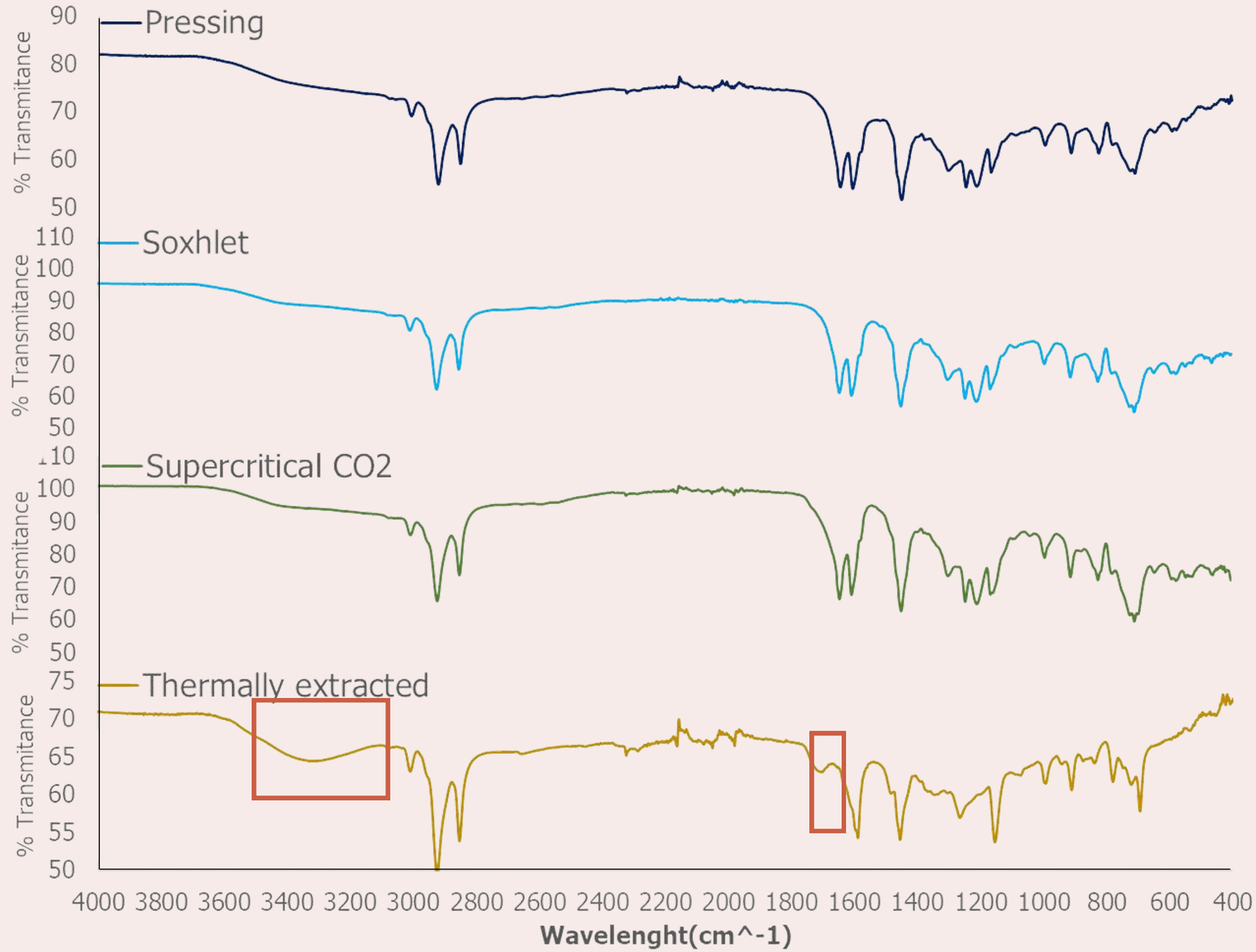
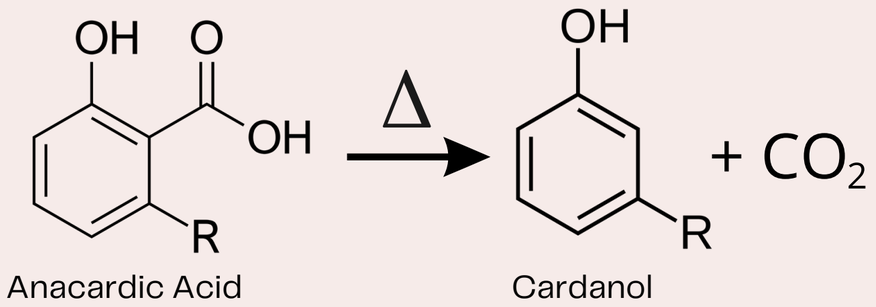


Fig 5. FTIR spectrums of CNSL samples

Thermally extracted CNSL doesn't show vibration of carbonyl group

Decarboxylation of Anacardic acid

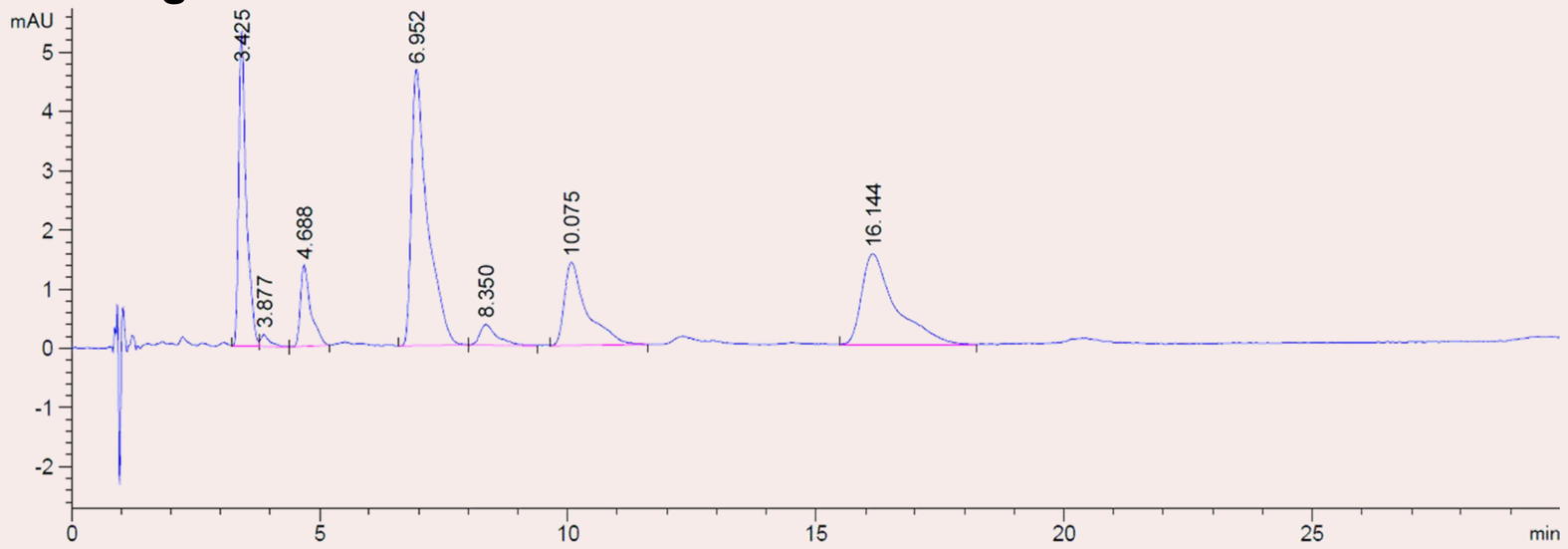


Anacardic Acid

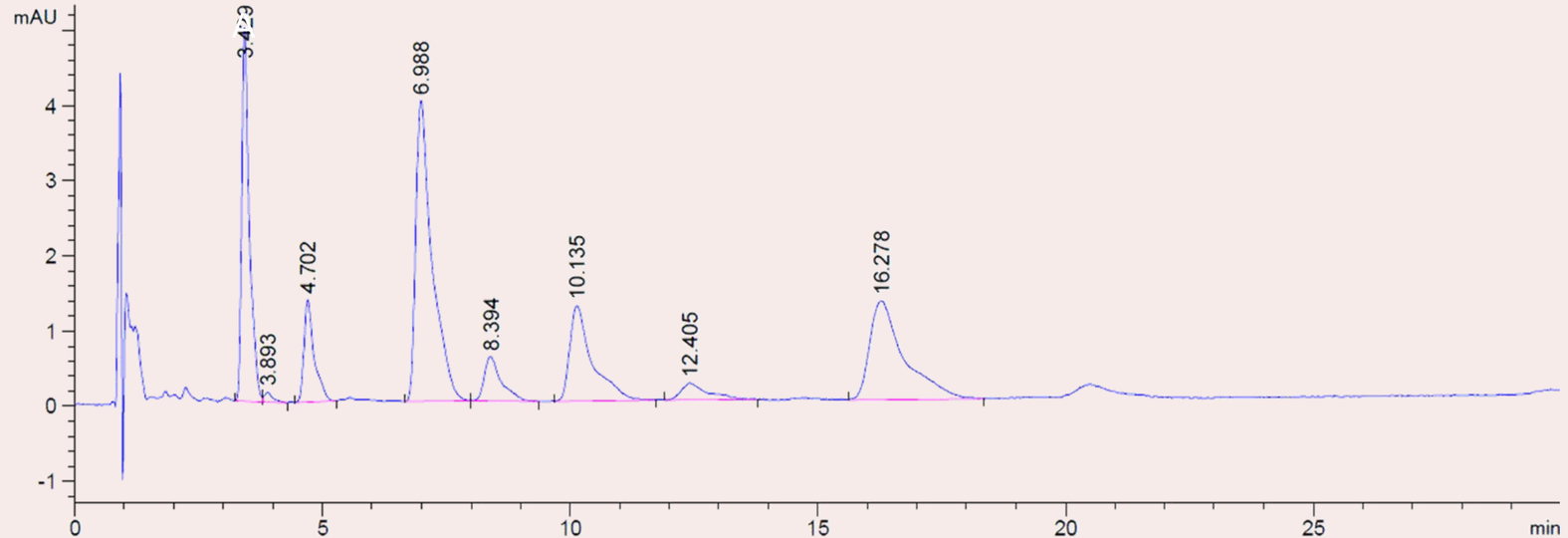
Cardanol

HPLC

Pressing



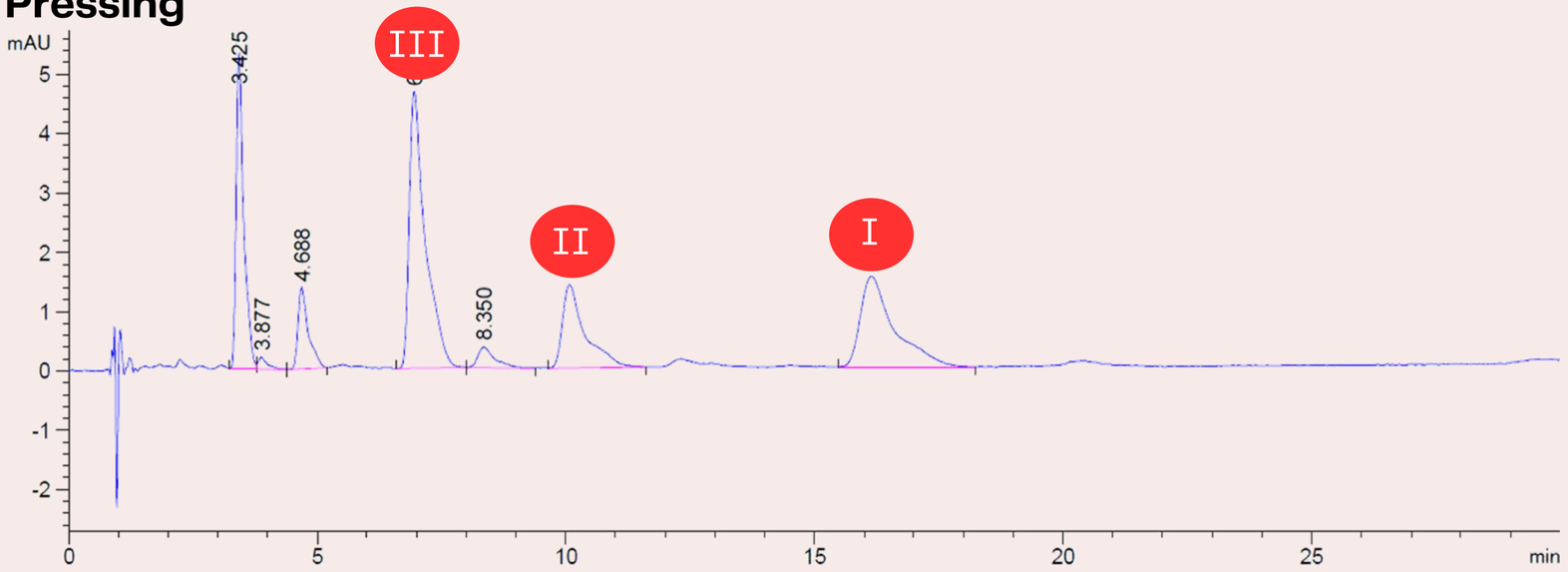
Soxhlet



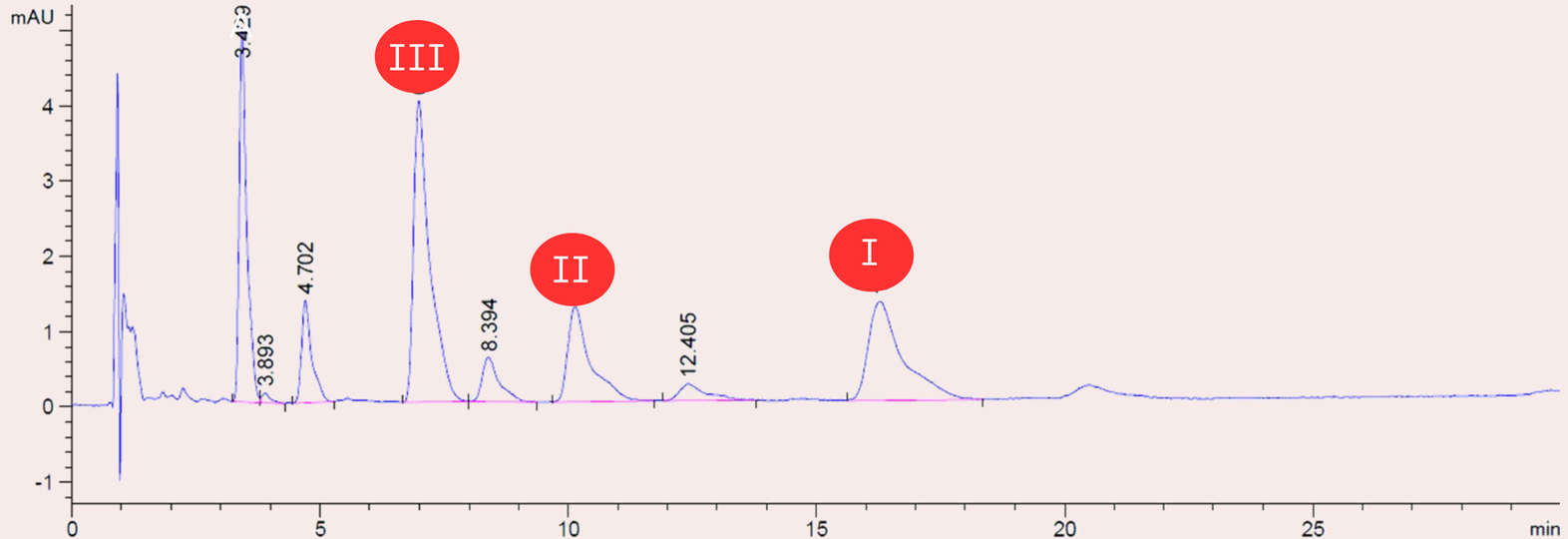
Identification of phenolic lipids

HPLC

Pressing

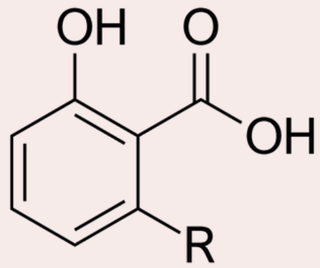


Solvent extraction



Identification of phenolic lipids

Anacardic acid (AA)



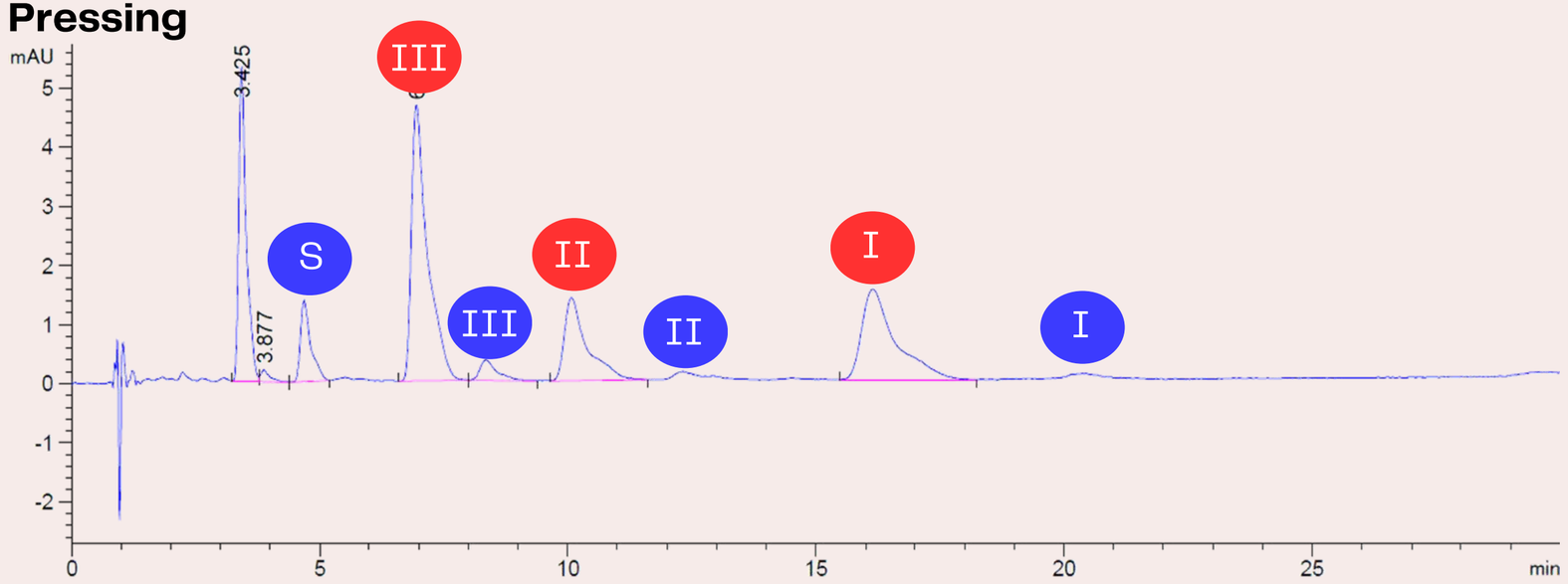
III AA Triene

II AA Diene

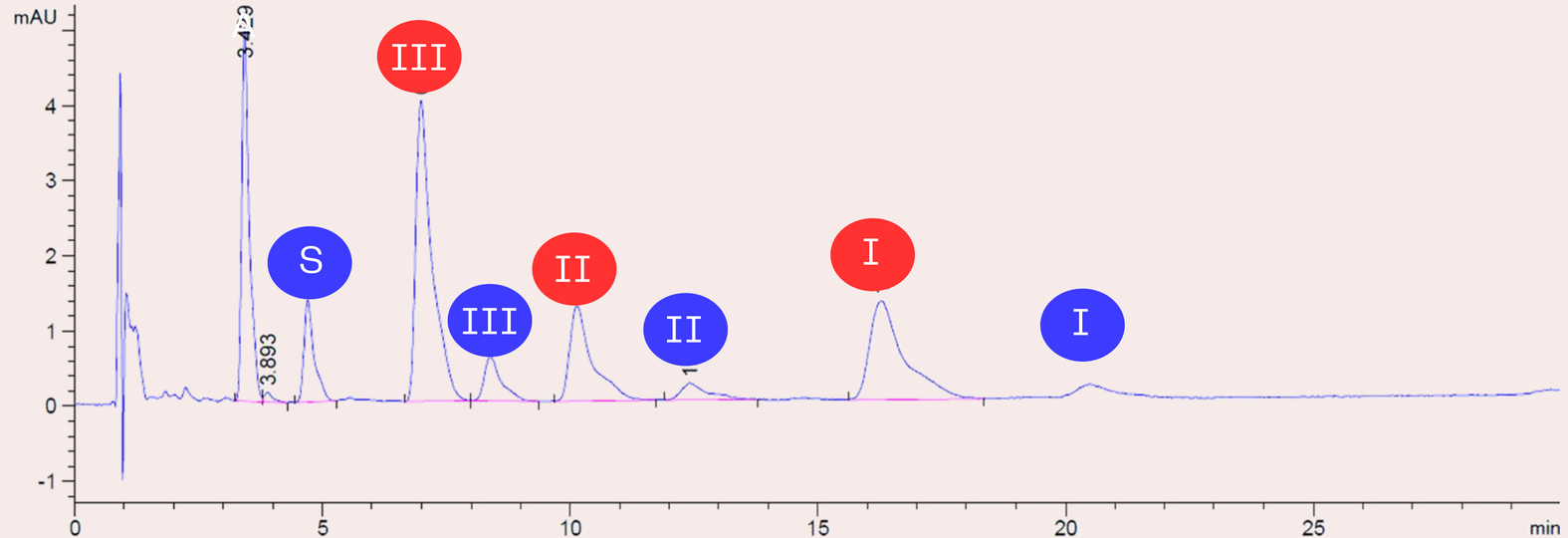
I AA Monoene

HPLC

Pressing

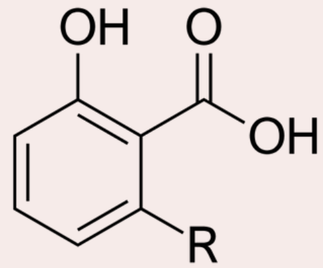


Solvent extraction



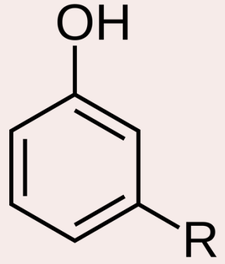
Identification of phenolic lipids

Anacardic acid (AA)



- III AA Triene
- II AA Diene
- I AA Monoene

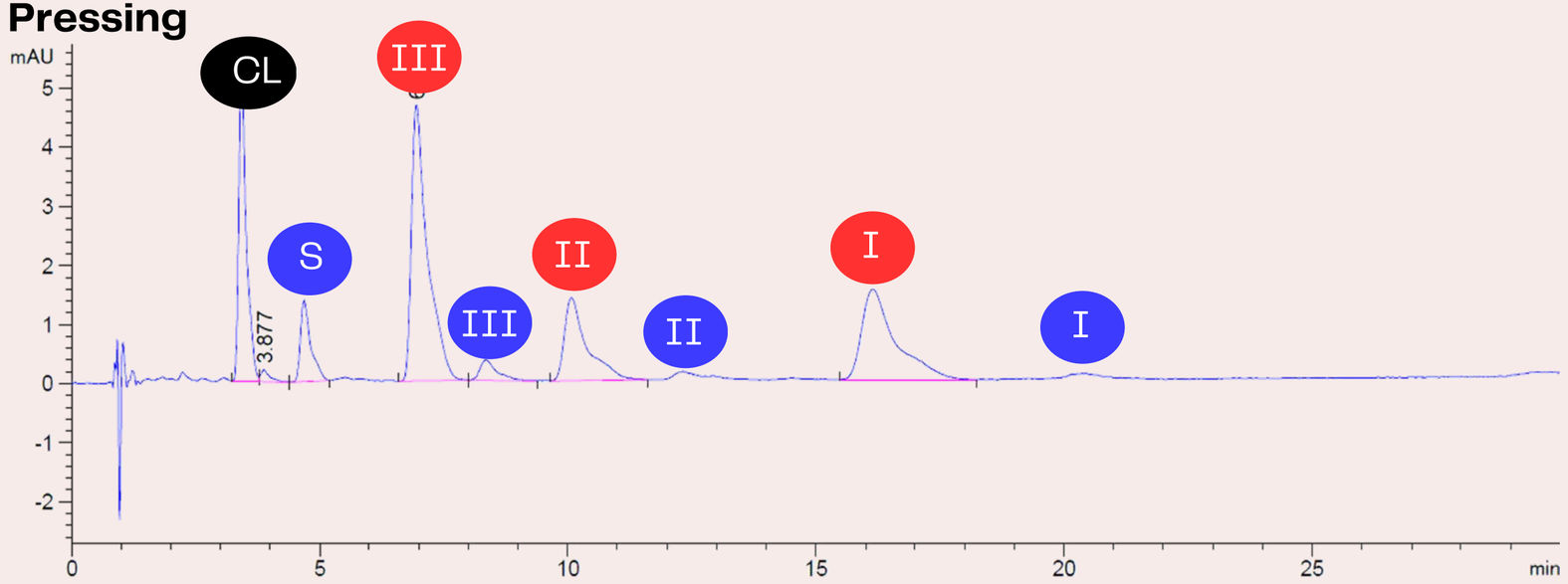
Cardanol (C)



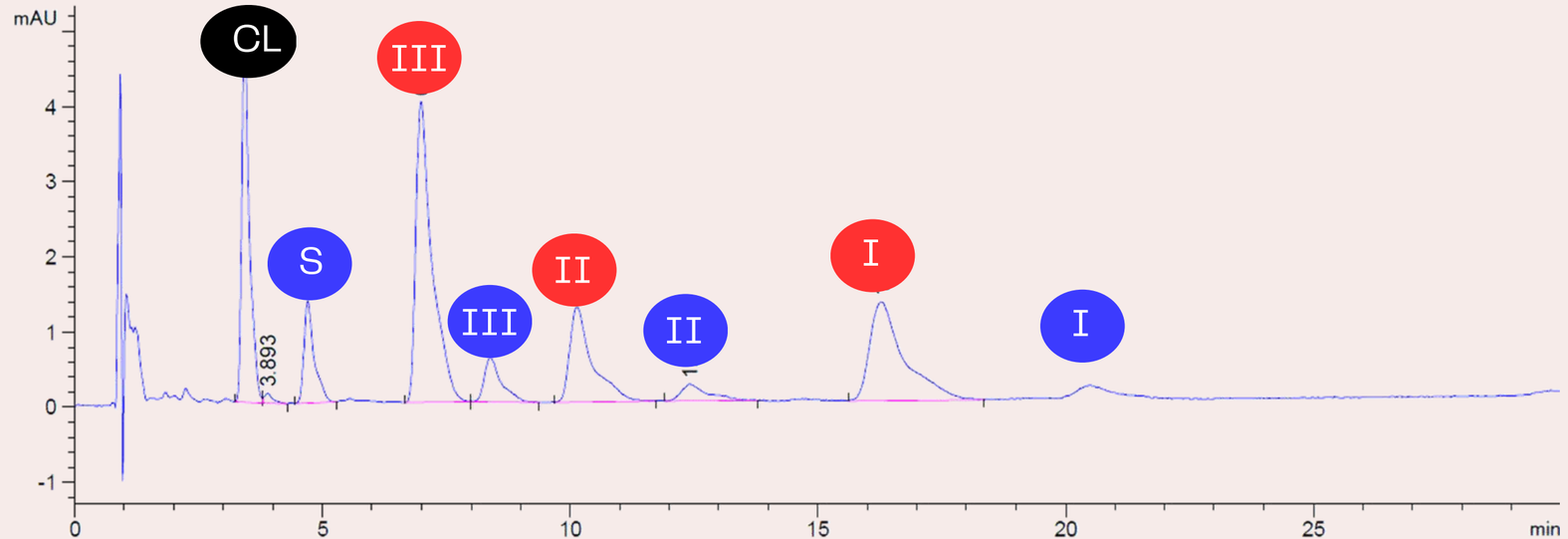
- III C Triene
- II C Diene
- I C Monoene
- S Saturated C

HPLC

Pressing

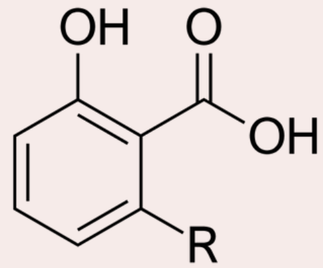


Solvent extraction



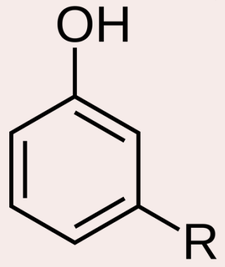
Identification of phenolic lipids

Anacardic acid (AA)



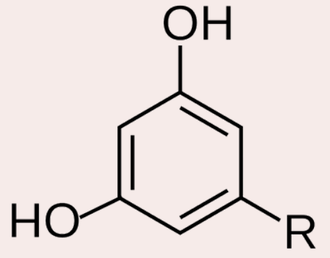
- III AA Triene
- II AA Diene
- I AA Monoene

Cardanol (C)



- III C Triene
- II C Diene
- I C Monoene
- S Saturated C

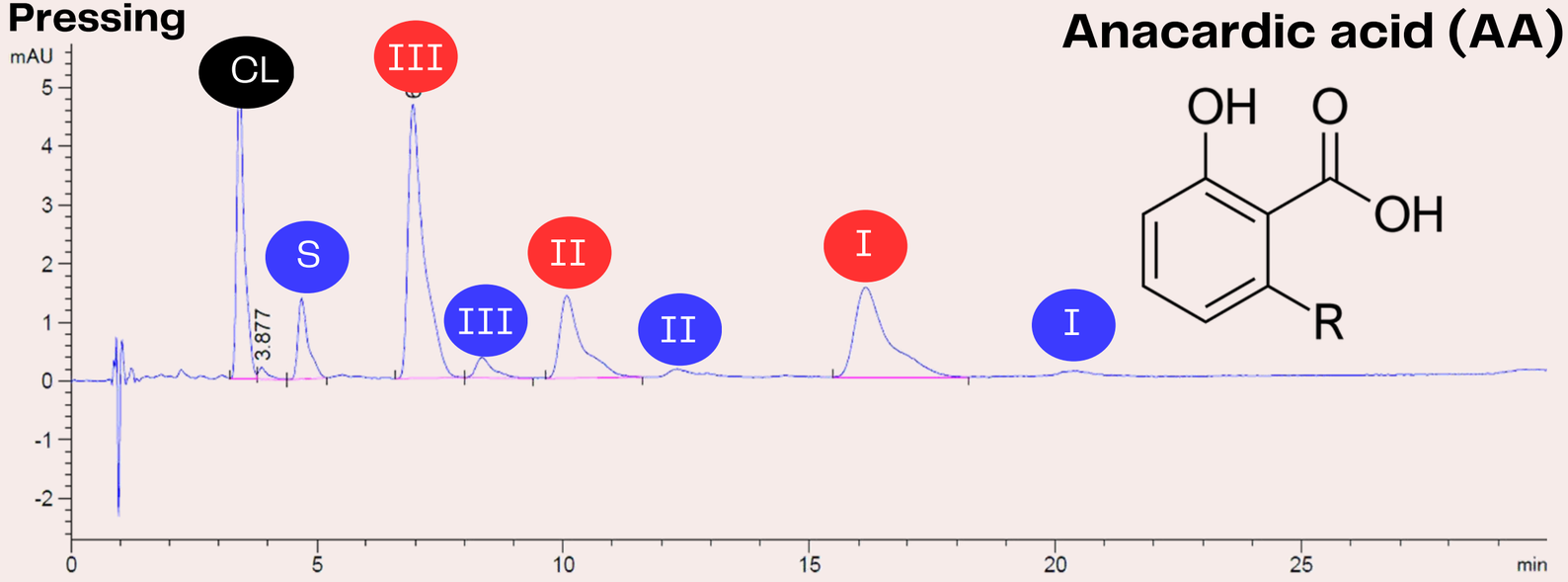
Cardol (CL)



- CL CL Triene

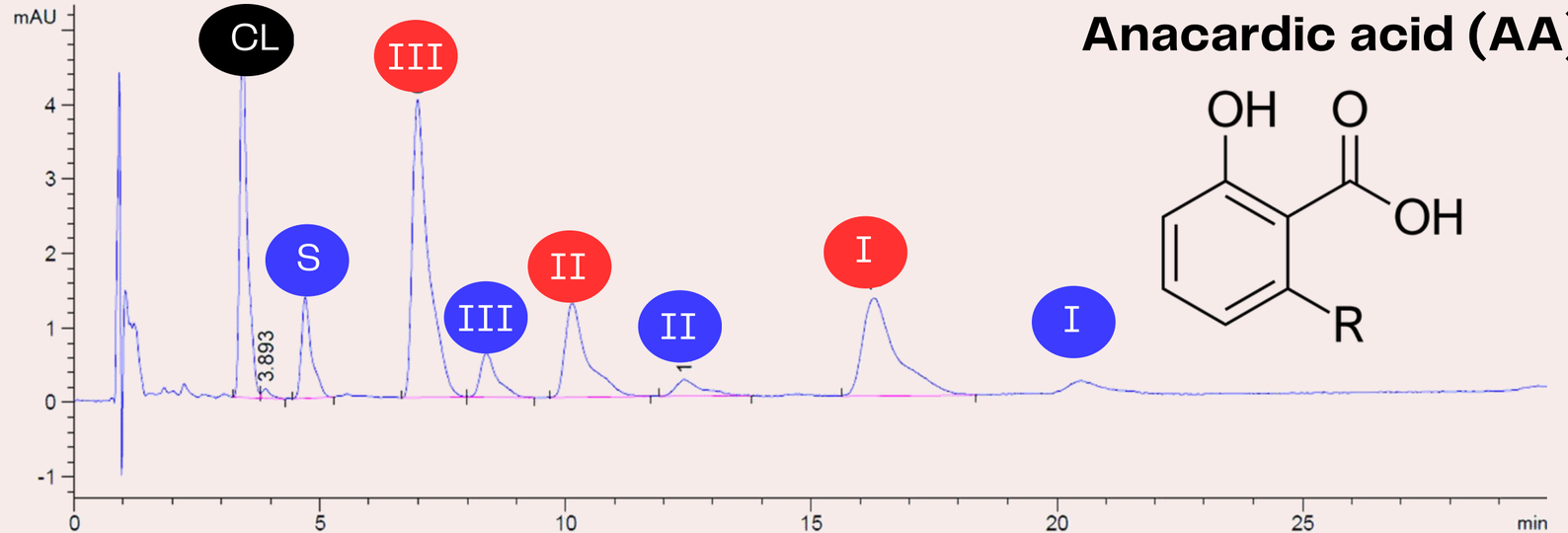
HPLC

Pressing



Anacardic acid (AA)

Solvent extraction



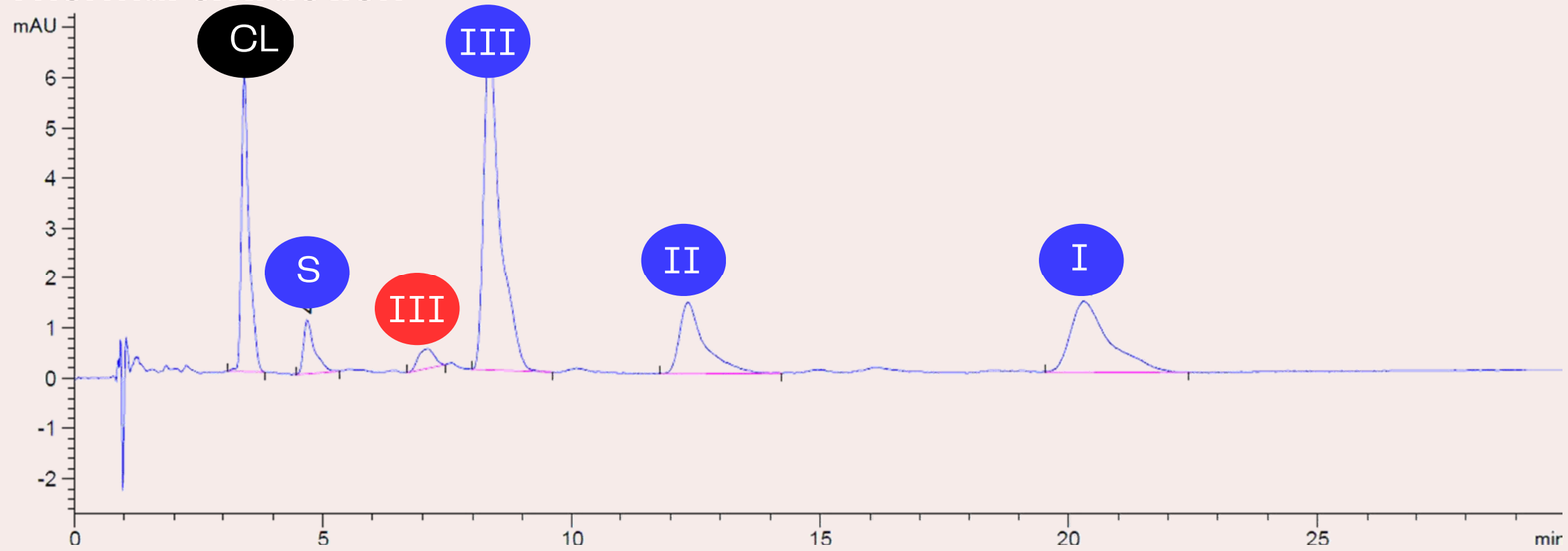
Anacardic acid (AA)

Phenolic lipids are in similar proportions between CNSL extracted by solvent or pressing

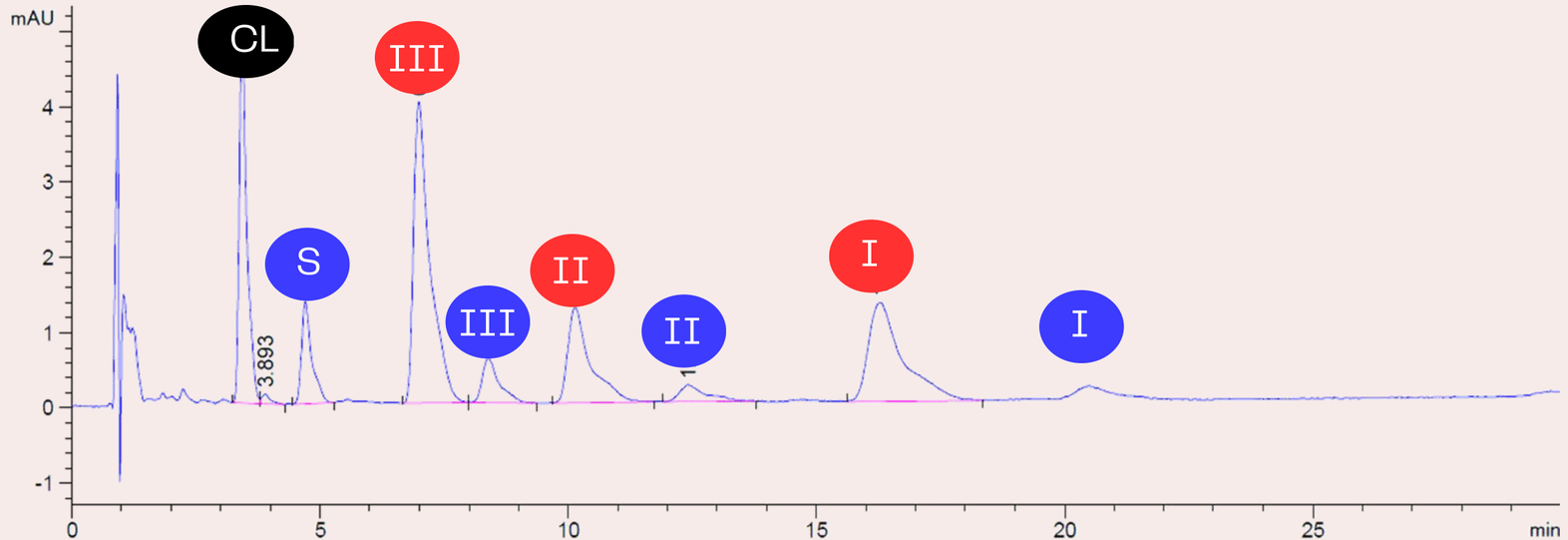
→ High content of A.A in CNSL

HPLC

Thermal extraction

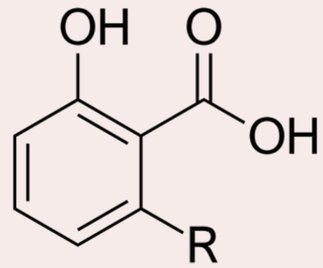


Solvent extraction



Identification of phenolic lipids

Anacardic acid (AA)

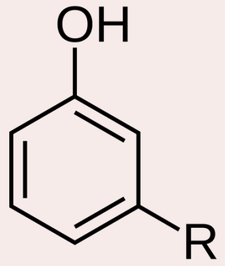


III AA Triene

II AA Diene

I AA Monoene

Cardanol (C)



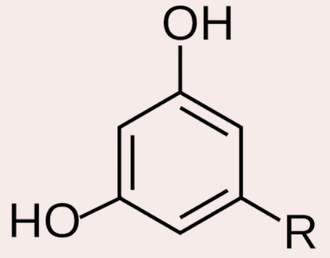
III C Triene

II C Diene

I C Monoene

S Saturated C

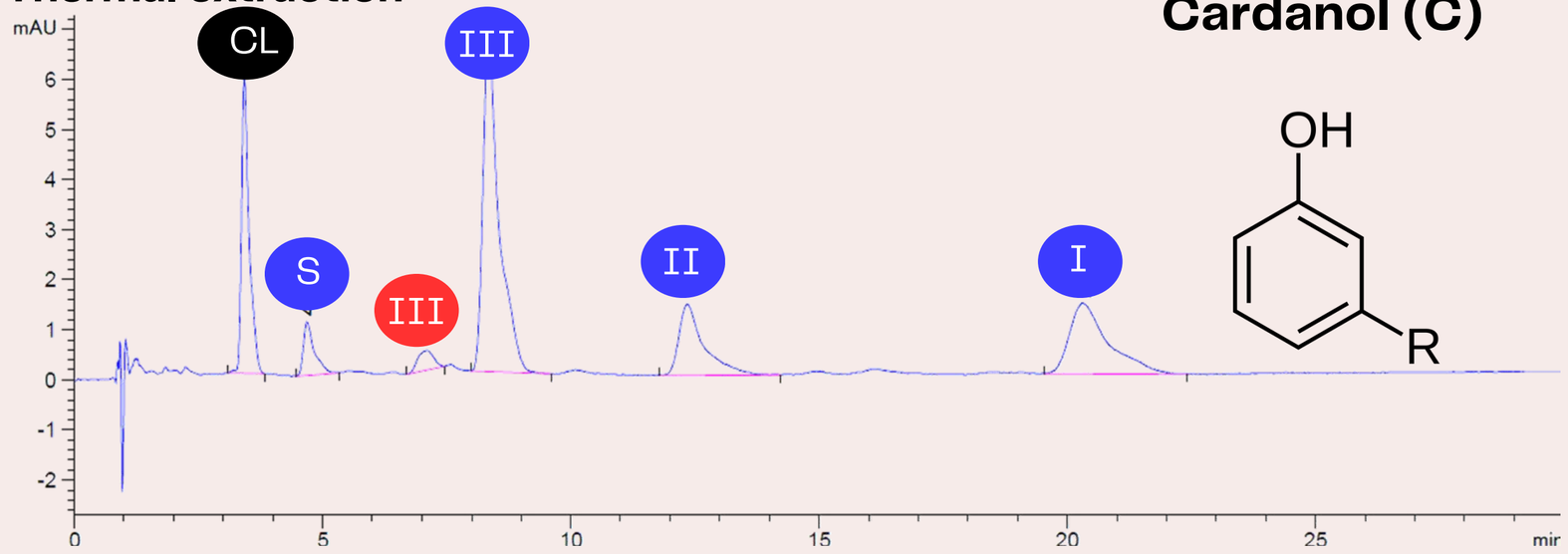
Cardol (CL)



CL CL Triene

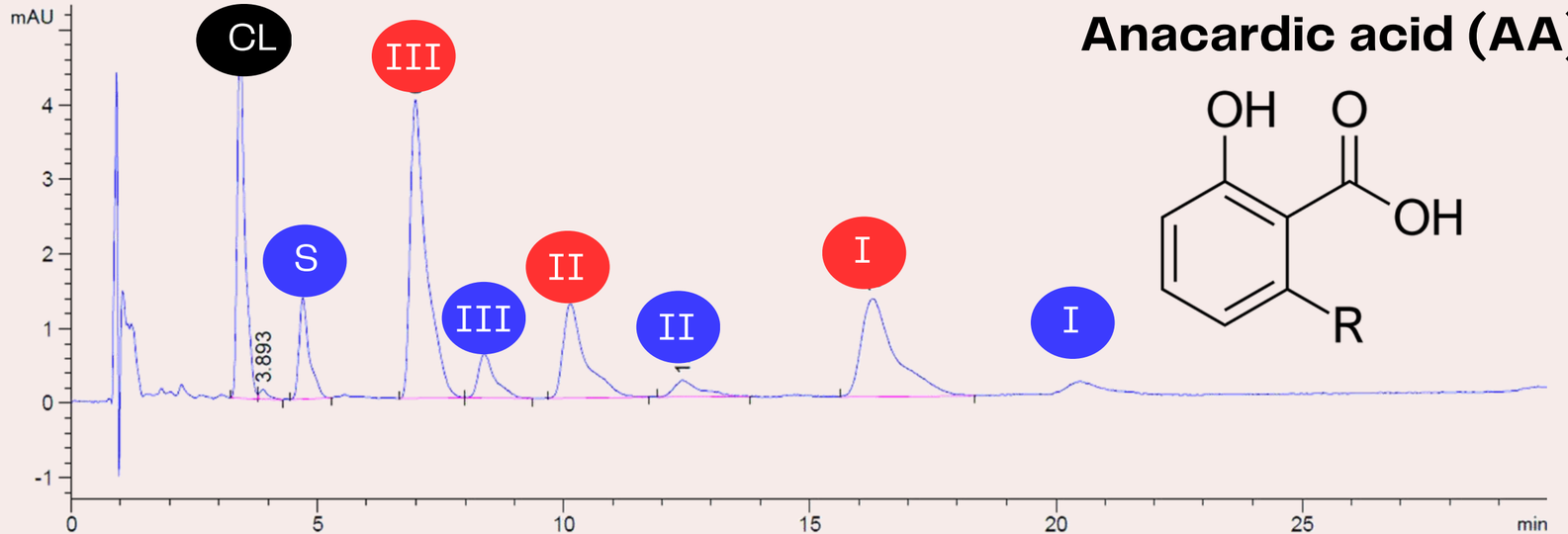
HPLC

Thermal extraction



Cardanol (C)

Solvent extraction



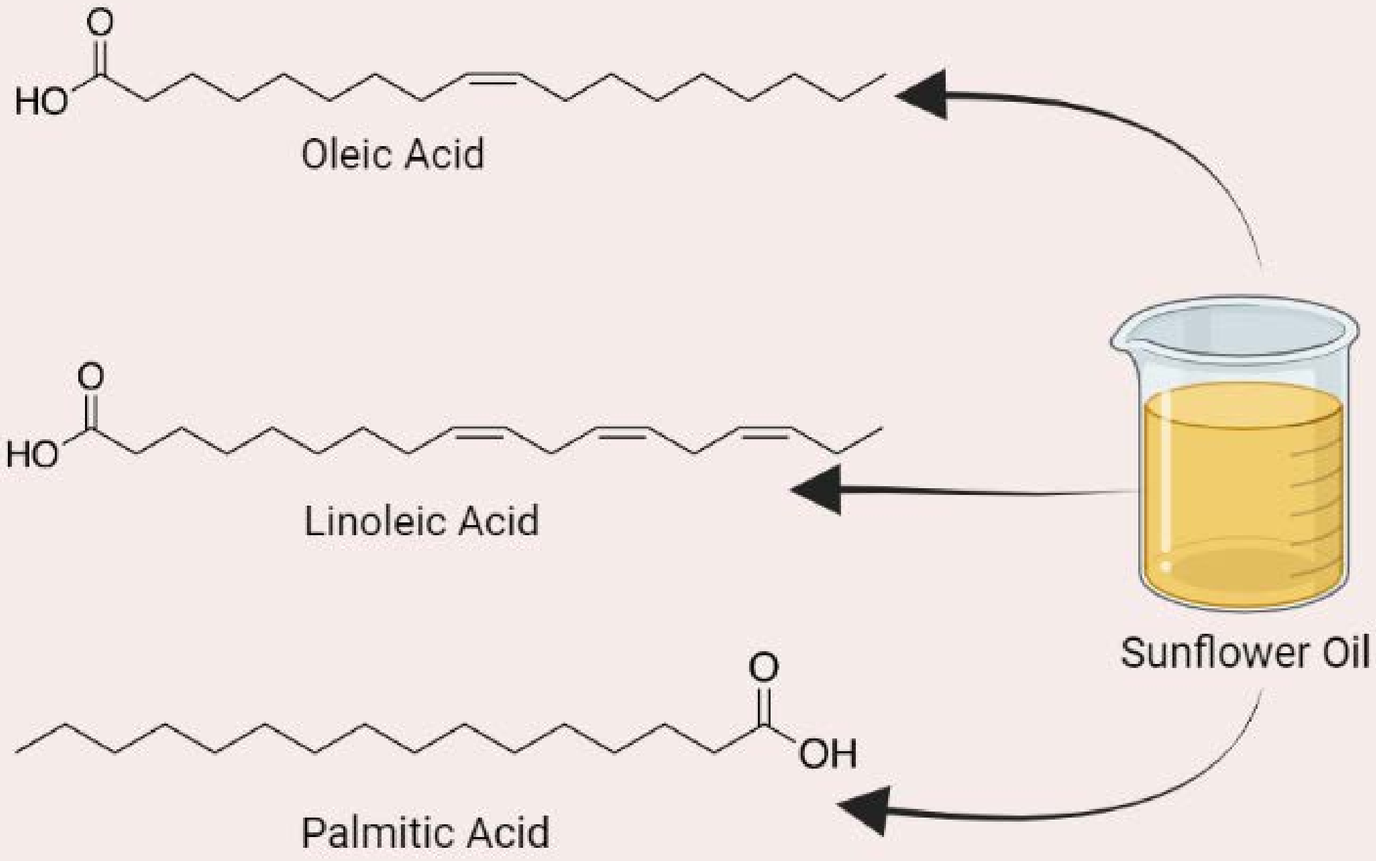
Anacardic acid (AA)

Thermal extraction promotes descarboxylation of CNSL

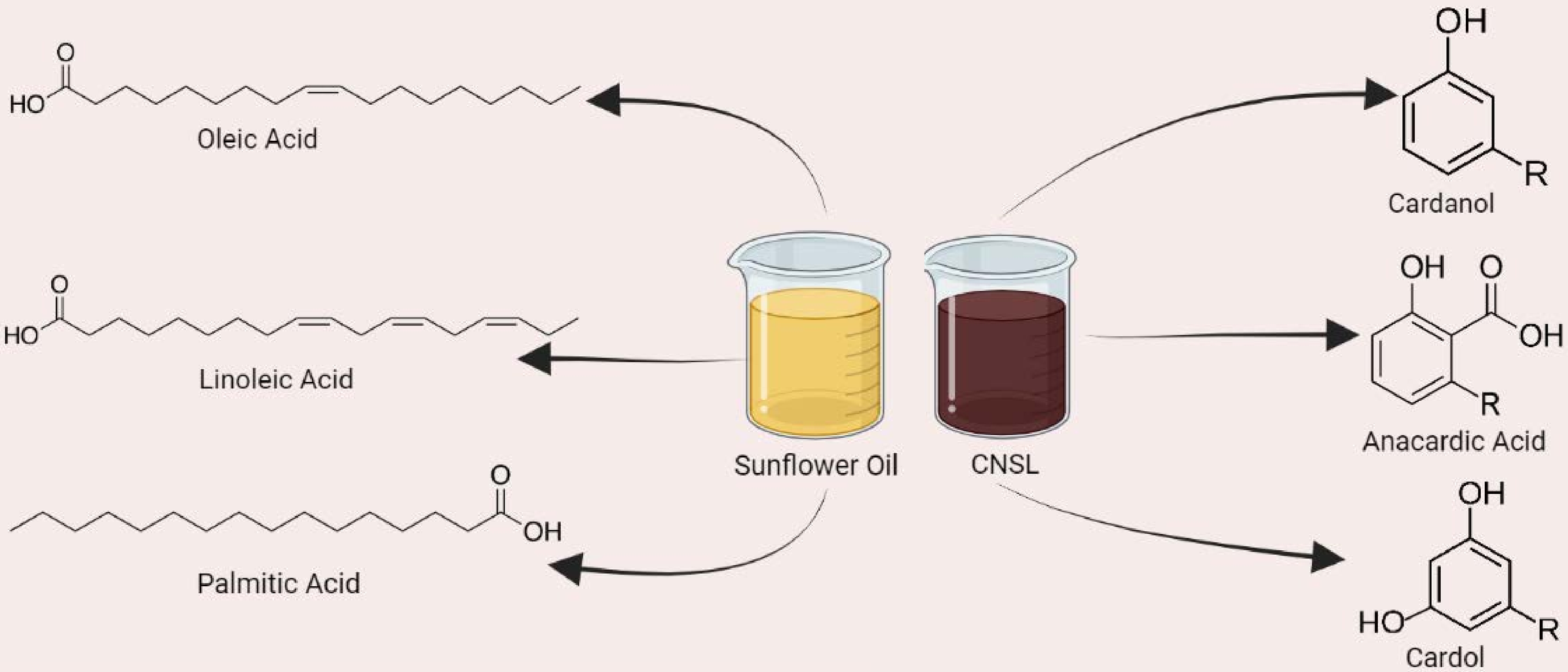
Thermally extracted CNSL has high content of cardanol

CNSL: Valuable by-product

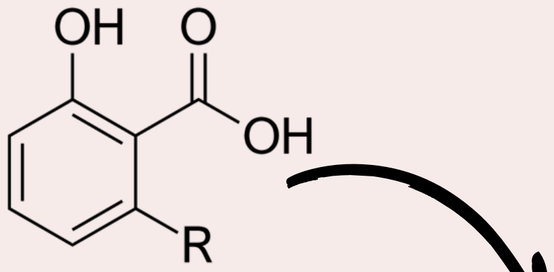
CNSL: Source of phenolic lipids



CNSL: Source of phenolic lipids



CNSL vs vegetable oils



CNSL

Sunflower Oil[a]

Soybean Oil[b]

Clove essential Oil[c]

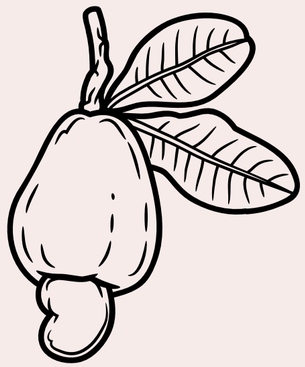
	CNSL	Sunflower Oil[a]	Soybean Oil[b]	Clove essential Oil[c]
Viscosity (cP)	260-625	48	48	8
Saponification Value (mgKOH/g)	105-203	188-194	180-200	42
Acid Value (mgKOH/g)	44-108	0.9	0.5	3.84
EC50 (µg/mL)	114-522	14000	10000	13

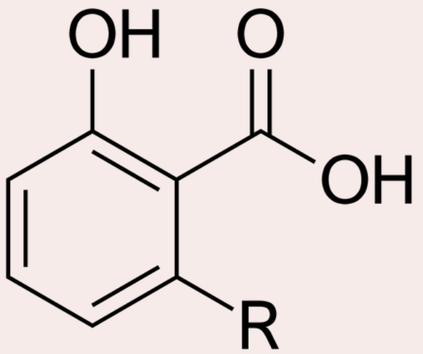
[a] Aboki,M et al. (2012).

[b] Arawande, J & Amoo, I.A.. (2009). .

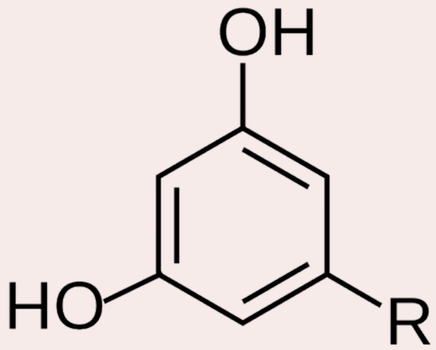
[c] Abdel Moneim E(2007)

CNSL: Sustainable raw material

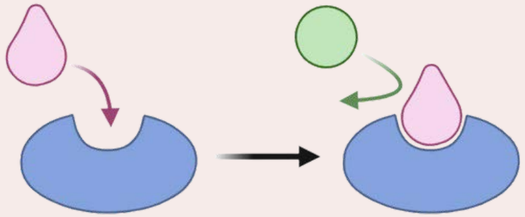




Anacardic Acid



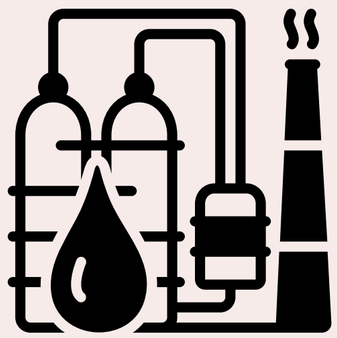
Cardol

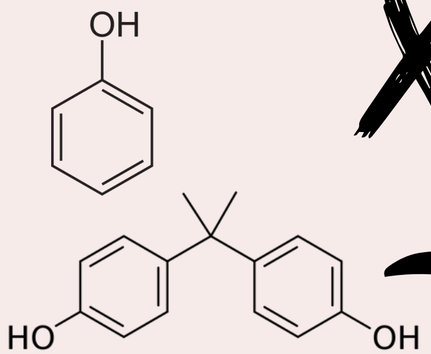


Enzymatic Inhibitors

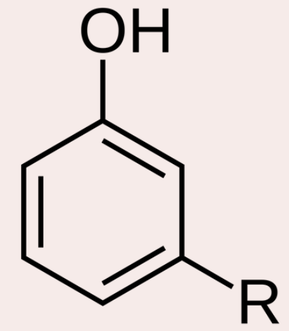
Green Insecticides

CNSL: Sustainable raw material





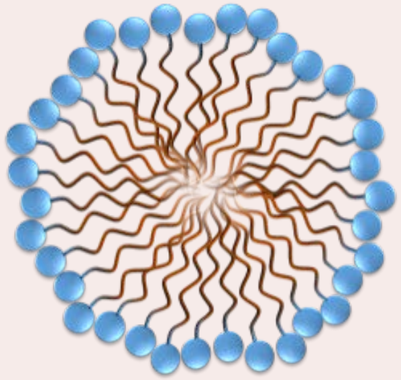
Petrochemical derivatives



Cardanol

Polymeric Resins

Additives

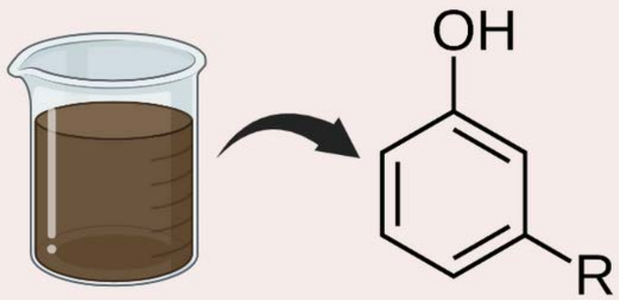


Surfactants

Conclusion:

Effects of extraction and pre-treatment methods on CNSL

Both pre-treatment and extraction methods show an effect over physicochemical properties of CNSL as an oil.



CNSL: source of phenolic lipids

Physicochemical properties of CNSL differ from those of conventional vegetable oils due to the presence of phenolic lipids. However, only thermal extraction seems to affect phenolic lipid profile due to descarboxylation reaction.

CNSL: Potentially sustainable raw material

CNSL chemical composition makes it a suitable raw material for sustainable product design.

Acknoledgments

The authors would like to thank the Ministry of Science, Technology and Innovation and the OCAD of ACTeI, who carried out the feasibility, prioritization, and approval of this research with resources from the General Royalties System – SGR in the Call No. 6 of the Project "USE OF AGROINDUSTRIAL BY-PRODUCTS OF CASHEW PROCESSING IN VICHADA DEPARTMENT- BPIN 2020000100571". Likewise, we thank the government and the community of the department in general for their interest and participation in the activities carried out to date

The authors

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