Determining optimal cashew nut shell liquid extraction method

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1 Objective

Determining the optimal extraction conditions of cashew nut shell liquid (CNSL) out of cashew nut shells (CNS), while maintaining an economically attractive and technically feasible process. The desired yield for the extraction was ≥90 m%.

2 Cashew nuts and shell liquid (CNSL)

Around 67 m% of the shell is CNSL [1].

Global production of $3E^9$ kg shell/$2E^9$ kg nut annually (2017).

Around 80 m% phenolic acids, mainly anacardic acids. Composition dependent on extraction technique.

Liquid finds applications as a fuel (additive), paints, enamels, microbial control and more [2].

Anacardic acid (AA) (triene) finds usage in medical field, as anti-inflammatory and –oxidant [4].

Predominant cultivation in in South-East Asia and West Africa.

India and Vietnam
also import the highest amount
of cashew nuts, topping 47 and
22%, respectively.

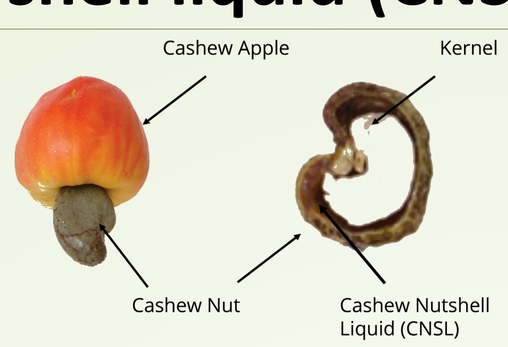

Figure 1: Cashew fruit with its contents

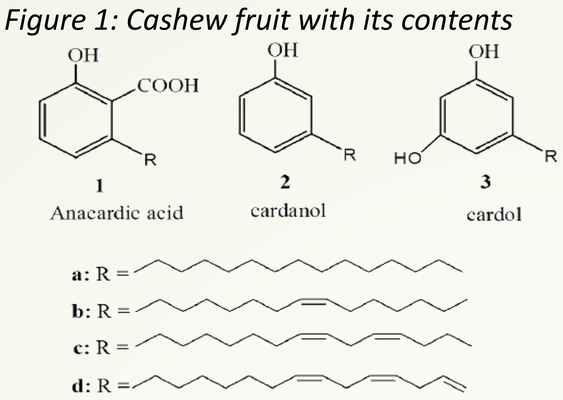

Figure 2: Phenolic acids with carboxylic tails [3]

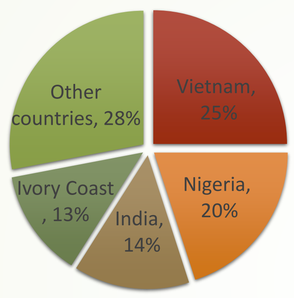

Figure 3: Allocation of global nut production [2]

3 Methodology and parameters

All extractions were performed in a reactor, either with a rotating bed or with a propeller reactor for agitation (*figure 4&5*).
The 'basecase' extraction performance was determined at 50 °C, using 7.5g for 1h at 300rpm, with a rotating bed considering an PSD of 2-4mm, using ethanol in a 1:20 ratio.

Figure 4: Rotating bed Reactor

Figure 5:Propeller stirrer

The table shows the examined parameters and the difference in yield (g CNSL/g CNS), when compared to the basecase result (0.39 g CNSL/g CNS).

Table 1: Extraction parameters and its influence on the yield.

Parameter	Values	Influence Δ (%)
Extraction temperature	20 ° C 70 ° C	-15.4 +2.6
Extraction time	10/20/30/120 min	-28.2/-18.2/-12.8/+3.8
Particle size distribution	6-10 mm	+2.5
Stirring speed	No stirring 1050	-10.3 -7.7
Agitation	Propeller stirrer	-2.6
Solvent use	Ethanol/Heptane	-7.7
Solid/solvent-ratio	1 : 6.7 1 : 13.3	-28.2 -15.4

4 Compound determination

Due to CNSL's analogue composition and focus towards anacardic acid triene, diverse effort was set towards compound analysis. With analytical standards of AA triene and cardonol, and cross-referencing with literature, compounds were qualified and in case of the AA triene and cardonol, quantified. Figure 6 displays an HPLC chromatogram and its corresponding retention times.

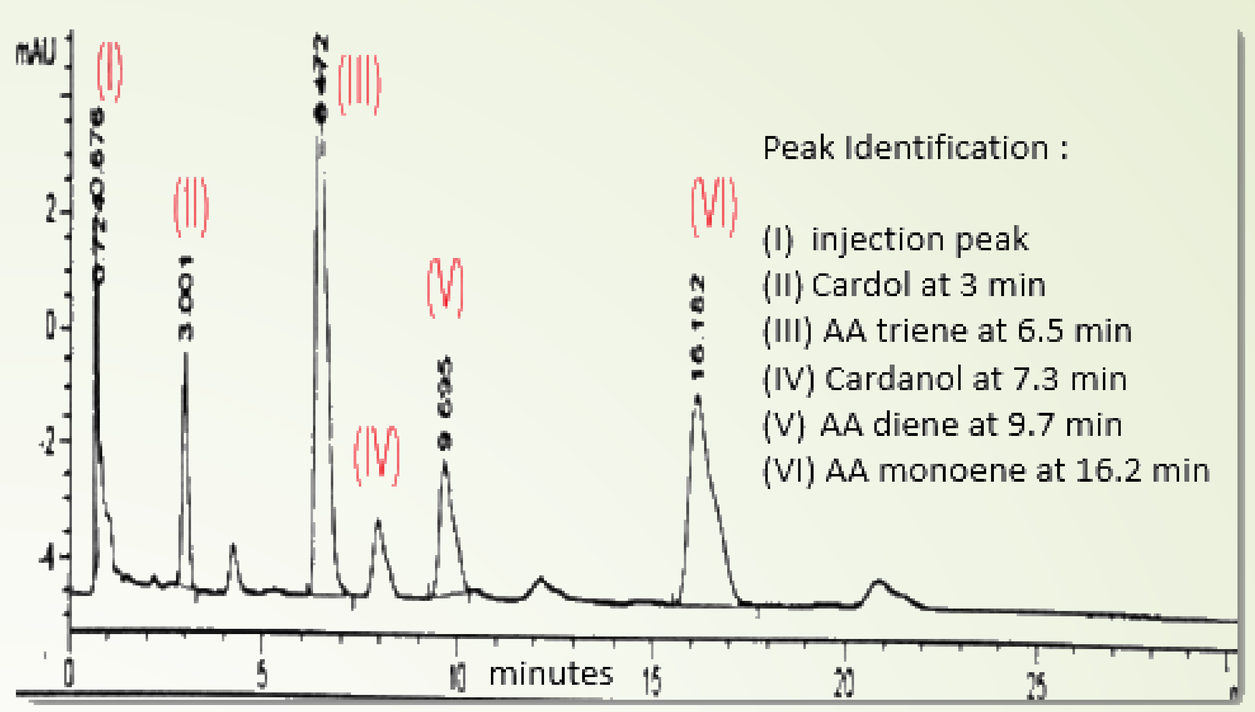

Figure 6: HPLC chromatogram of CNSL-sample extracted under baseline conditions

5 Thermogravimetric analysis (TGA)

In order to get a complete view of the liquids' composition, a TGA analysis was performed on the baseline sample. Data shows 10 m% liquid was still present in the solids, with a total of 29 m% available. The rest composed of lignin (27m%), cellulose (10m%) and hemicellulose (34m%)

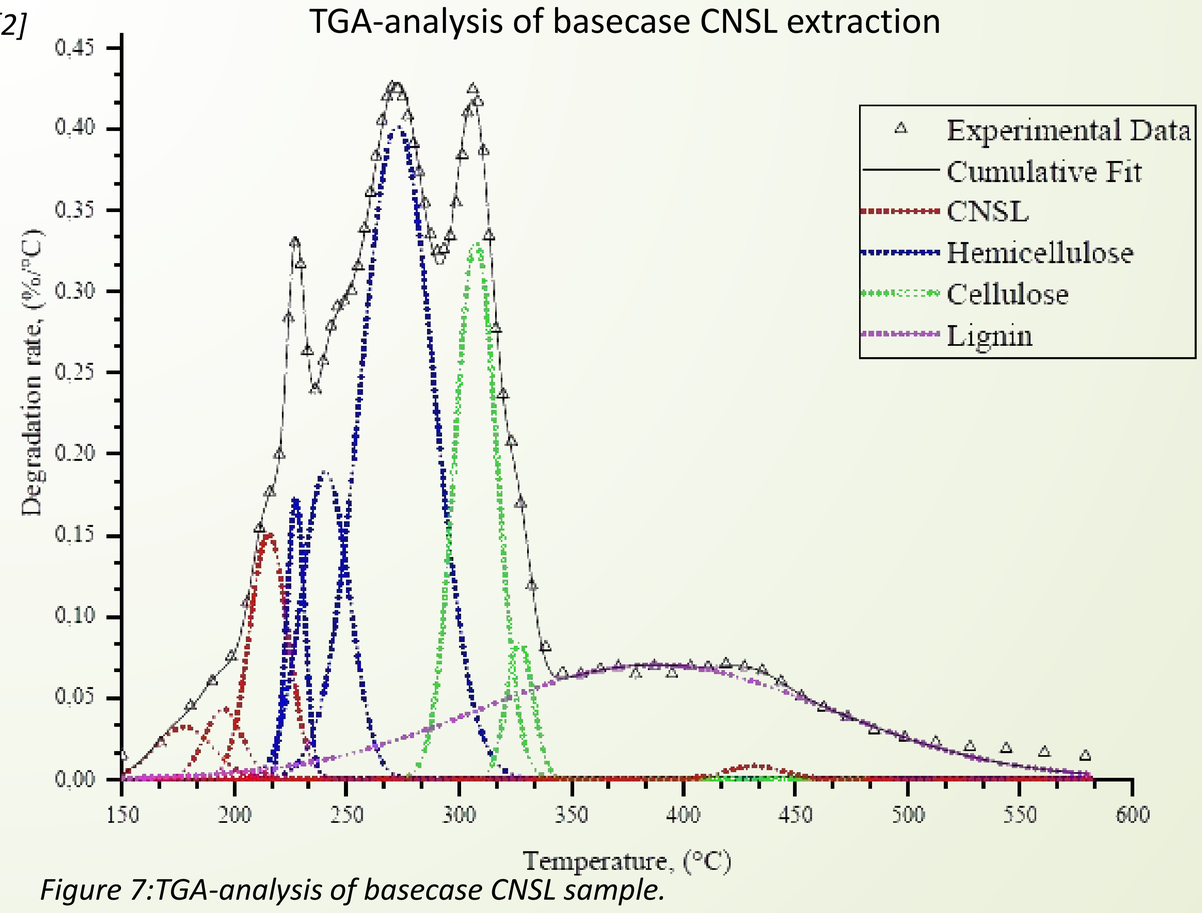

Figure 7:TGA-analysis of basecase CNSL sample.

6 Conclusions and future work

The maximum yield was around 78 m%, therefore the goal of an ≥90 m% extraction yield, was not achieved. This yield was produced using 70 °C, for 1h at 300rpm, with a rotating bed considering an PSD of 2-4mm, using ethanol in a 1:20 ratio. Furthermore, solid/solvent-ratio and temperature were found to be most influential, regarding both positive and negative influence on the yield.

Literature shows [5] different extraction techniques such as supercritical fluid extraction as suitable alternative to regular solvent extraction. Therefore it is recommended to investigate this approach.

Optimizing extraction and separation of anacardic acids brings lucrative opportunities in the form of bio-based anti-inflammatories and –oxidants

References: [1] *"Cashew Nut Exports Expected to Exceed 3 Billion USD." Vietnamplus.vn, VietnamPlus, 2 Nov. 2017*
[2] *S. Y. L. et al, "A comprehensive metabolic map for production of bio-based chemicals" Elsevier, 2019*
[3] *S. M. Morais, "Anacardic acid constituents from CNSL: NMR characterization and the effect of unsaturation on its biological activities", Pubmed, 2017*
[4] *M. Q. de Souza et al, "Molecular evaluation of anti-inflammatory activity of phenolic lipid extracted from cashew nut shell liquid (CNSL)", Springer, 2018*
[5] *M. Tejas Gandhi, „Studies on effect of various solvents on extraction of cashew nut shell liquid," 2012.*