# The Emulsifying Performance of Mildly Derived Extracts from Argan By-products: Towards a Sustainable Production of Natural Emulsifiers

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| 著者（英） | Noamane Taarji |
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# 論文概要
(Summary of the Thesis/Dissertation)

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Student ID: 201636058

Student Name: Taarji Noamane

**1. Title of the Thesis/Dissertation**: The Emulsifying Performance of Mildly Derived Extracts from Argan By-products: Towards a Sustainable Production of Natural Emulsifiers

## 2. Summary (800 – 1,000 words in English)

Argan oil extraction industry generates every year around 170 000 tons of by-products, in the form of press-cake, nutshell and pulp. On average, 1 ha of argan trees can produce 300 Kg of dried fruits, in the form of 20 Kg of kernels and only 8 Kg of oil. This does not only result in the loss of potentially high value-added compounds from these materials but also impacts the local environment, through overexploitation of argan trees for fruit harvesting and oil extraction. Regarding this, a systematic study of the secondary metabolites of argan tree was initiated since the early ’90s. The objective is to identify new bioactive compounds that can increase the tree’s economic and industrial values. The results of this survey allowed to characterize, within the different parts of the argan tree, a wide variety of functional compounds, with some of them already evaluated for different biological activities.

In the introductory section, we presented an overview of the different valorization opportunities of argan by-products in cosmetic and pharmaceutical applications. We also pointed out the great potential of obtaining natural emulsifiers from agro-industrial by-products. Our aim was to suggest the use of argan by-products as a source of natural emulsifiers. In our view, the rich surface-active composition of these materials (e.g. proteins,

saponins), as well as their significant generation quantities, can create potential applications as natural emulsifiers.

In chapter 1, we evaluated the surface-active and emulsifying properties of saponin-rich extracts from argan oil press-cake. Our aim was to produce model oil-in-water (O/W) nanoemulsions using these extracts as sole emulsifiers. Various extracts were initially prepared in order to select the most surface-active one(s) foreseeing emulsions preparation. Fifty percent (v/v) ethanolic extract reduced the interfacial tension to a minimum value at both MCT oil and soybean oil interfaces. This extract was also effective at producing stable nanoemulsions using different oils such as soybean oil, MCT oil and fish oil, and with similar properties to those obtained by conventional emulsifiers such as tween 20.

In chapter 2, we evaluated the physical stability and biological fate of emulsions prepared using argan extract. The emulsions were very sensitive to salt addition (≥25 mM) and to extreme acidic pH (<3) indicating that the main stabilization mechanism is electrostatic, likely due to the presence of surface-active compounds with ionizable groups such as saponins. The emulsions were also very sensitive to gastric conditions, particularly when pepsin was added to the digestion system, which highlights the contribution of proteins to the surface-active and emulsifying properties of this extract.

In chapter 3, we evaluated the emulsifying performance of argan extract in microchannel emulsification (MCE). Our aim was to produce stable monodisperse O/W emulsions using this extract a sole emulsifier. The complex composition of this extract imparted its emulsifying efficiency, by creating a hydrophobic, or slightly hydrophilic, layer on the MC array plate surface. This resulted in unsuccessful emulsification using short MCs but did not affect the emulsification efficiency in longer ones. Using these longer channels, we could produce stable monodisperse O/W emulsions, with similar droplet size and droplet size distribution to those obtained by Tween 80, and for up to 10 h of continuous emulsification.

In chapter 4, we compared the surface-active and emulsifying properties of a crude extract from licorice root and purified saponins from the same origin. Our aim was to examine the contribution of specific compounds to the emulsifying performance of multicomponent plant extracts. As expected, the non-purified extract was more surface-active and effective at producing small droplet size emulsions, in comparison to purified saponins. The emulsions were superiorly stable at low pH and high salt concentrations but less stable at elevated temperatures, suggesting again the contribution of proteins to the observed results. Evidences presented in this chapter indicated that non-purified surface-active extracts, such as argan and licorice root extracts, can provide superior emulsifying ability in comparison to purified emulsifiers. This is due to the contribution of multiple compounds to the overall surface-active and emulsifying properties, and most likely the formation of biogenic complexes between these compounds at the oil/water interface, thus leading to improved droplet coverage and stability.

In the conclusion section, we suggested innovative scenarios for the valorization of argan by-products. We believe that sequential extraction methods should be adopted in the future to simultaneously obtain various bioactive and dietary compounds from these materials. Suitable storage conditions, innovative harvesting methods and adjusted oil production chains should be also considered in order to preserve specific natural compounds in the different parts of argan fruit, without affecting the productivity of the tree. Finally, for successful application in the food and beverages industry, other parameters such as bitterness, the potential toxicity, the cost and the reliability of supply are important.