Ph.D. Thesis proposal[1]

General Information		
Ph.D. Thesis Title	***Valorization of animal fat and snail shell wastes into biodiesel using a circular economy approach***	
USEK Doctoral Program	***Ph.D. in Chemistry***	
Research Center	NA	
Research Group	NA	
Research Axis	***Sustainability***	
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Location (s)	Location 1: USEK	Work shift calendar /per year (%):
	Location 2: (if applicable)	Work shift calendar /per year (%):
Potential funding and scholarship		

Applicant Profile and/or Special Requirements			
Comps Exam Language	☐ Arabic	☐ French	☐ English

Context of the Topic & Scientific Methods ***(Research impact, objectives, design, methods, and outputs)***
Circular economy uses theory and principles from industrial ecology. It aims to close the loop of materials and substances and reduce both resource consumption and discharges into the environment. Circular economy regarding the food system implies reducing the amount of waste generated and revalorization of by-products and food waste. The most of food waste is attributed to meat, poultry, and fish industries. The disposal of animal by-products wastes can cause risks to animal and public health and generates socio-economic and environmental problems. The aim of this thesis is to valorize the animal fat waste into biofuel using the model of circular economy. Transesterification of triglycerides for biodiesel production from waste cooking oil has been extensively studied in the past few years in the faculty of Engineering at USEK. Biodiesel can be synthesized from a variety of feedstocks, including vegetable oils, animal fats, and used cooking oils. Usually, refined vegetable oils are the main feedstock for biodiesel production. However, in the past few years, the prices of these refined vegetable oils (soybean, rapeseed, palm, and others) have been increasing steadily, making biodiesel production from these feedstocks unprofitable in many locations. Waste greases such as used cooking oil and animal fats can also be used as feedstock because of their availability and

[1] Thesis proposal should not exceed two pages

low cost. The use of these waste greases to produce biodiesel opens a route to recycle this waste that otherwise would finish in the drain.
Biodiesel is produced through the transesterification process where triglycerides react with alcohol in the presence of a catalyst making biodiesel as the main product and glycerol as the by-product.
A catalyst is generally used for the transesterification reaction to speed up the process. Various catalysts are used such as acid or basic in homogeneous and heterogeneous mode for biodiesel production. The homogeneous catalysts present some disadvantages such as difficult to separate catalyst from the product and the catalyst can't be reused. Heterogeneous catalysts have many advantages over homogeneous catalysts including easily separation, reusability, non-corrosive, good catalytic activity and selectivity, and no need for purification and neutralization. Many heterogeneous solid acid and base catalysts have been investigated for biodiesel production in transesterification reaction such as zeolite, alkali earth metal oxides and zinc aluminate. Only a few heterogeneous catalysts are being used in industry due to the high costs associated with catalyst synthesis. The best way to reduce the cost of the heterogeneous catalyst for biodiesel production is to use agricultural waste as catalytic materials. Many types of waste have been investigated as catalyst such as egg shell, marble slurry, red mud, shells, fly ash and bones. Among them, CaO-based waste material such as snail shell is one of the most promising heterogeneous base catalysts for biodiesel production.

The objectives of this Thesis are:

1- Optimization of the production of biodiesel on a laboratory scale using waste animal fat as feedstock and snail shell as catalyst for biodiesel production.
2- Based on laboratory experiments, a process design and a computer simulation of the whole process will be carried out.
3- Profit and loss analysis of the biodiesel production process compared to the standard one with vegetable oil.

In this study, we will proceed as follows:
- Extraction and purification of the fat (rendering, degumming)
- Pretreatment of the fat to reduce the acid number before proceeding with the transesterification (study the effect of molar ratio, reaction time, and acid catalyst amount on the acid value of the fat)
- Study the effect of catalyst type (KOH, CH_3OK and CaO), the effect of molar ratio of methanol/oil and catalyst amount on the alkaline–catalyzed transesterification.
- Purification of the biodiesel obtained (vacuum distillation and washing)
- Physicochemical Characterization of the Biodiesel (Mono-, Di-, and Triglycerides, Free and Total Glycerol, Ester Content, Iodine Index, Kinematic Viscosity at 40 °C, density, Cold-Filter Plugging Point, High Heating Value, Elemental Analysis, sulfur content, Oxidative Stability.)
- Design and simulation of the biodiesel production process using Aspen Plus software
- Performing a profit and loss analysis

Surface response methodology will be used to study the effect of catalyst type, the effect of molar ratio of methanol / fat and catalyst amount. This methodology is a commonly employed tool in analyzing experimental data resulting in the optimization of processes or products. The foremost benefit of the RSM is that the amount of data required for assessment, analysis and optimization considerably decreases the total number of tests needed and explores the response surface with equal precision in an efficient way.

Outcomes (OCs) : What do we wish to achieve?	
OC1:	Production biodiesel from animal fat as feedstock, snail shell as catalyst and methanol as reactant
OC2:	Optimized parameters for the conversion of wastes into biodiesel
OC3 :	Design of the whole process of biodiesel production
OC4 :	Simulation of whole process using Aspen Plus
OC5	Analysis the different impact of the processes in different contexts: ethical, global, economic, societal, cultural, and environment.
OC6	Determination of the total capital investment, total production cost and Profitability.

References (R) (5 most recent peer-reviewed publications in the field)	
R1:	Banković-Ilić IB, Stojković IJ, Stamenković OS, et al. Waste animal fats as feedstocks for biodiesel production. *Renew Sustain Energy Rev* 2014; 32: 238–254.
R2:	Adewale P, Dumont M-J, Ngadi M. Recent trends of biodiesel production from animal fat wastes and associated production techniques. *Renew Sustain Energy Rev* 2015; 45: 574–588.
R3 :	Boey P-L, Maniam GP, Hamid SA. Performance of calcium oxide as a heterogeneous catalyst in biodiesel production: A review. *Chem Eng J* 2011; 168: 15–22.
R4 :	Dias JM, Alvim-Ferraz MCM, Almeida MF, et al. Selection of heterogeneous catalysts for biodiesel production from animal fat. *Fuel* 2012; 94: 418–425.
R5 :	Teresa Mata, Adelio Mendes, Nidia Caetano, et al. Properties and sustainability of biodiesel from animal fats and fish oil. *Chem Eng Trans* 2014; 38: 175–180.