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LECITHIN EXTRACTION VIA DEGUMMING OF TARWI (LUPINUS MUTABILIS) OIL EXTRACTED BY THE SOXHLET METHOD

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ABSTRACT

The objective of this research work is to obtain lecithin through the degumming of tarwi oil extracted by the Soxhlet method, the motivation for its realization was to provide an industrialization alternative for the use of the grain and the large cultivation area in our country. The work deals with general aspects of tarwi, methods of: debittering and identification of alkaloids, Soxhlet extraction, definition of: degumming, lecithin, optimization of parameters and analysis techniques to be applied to the lecithin obtained. It begins with the degumming of tarwi by the traditional method, followed by drying at 60 °C in a tray dryer, milling, sieving, oil extraction with the Soxhlet method and ethanol as solvent, obtaining lecithin, optimization of influential parameters with experimental design and lecithin characterization. As results, the best parameters for obtaining lecithin are: temperature= 50°C, percentage in weight of water= 20%, agitation speed= 200 rpm and mixing time= 20 min. Finally, the design of a mixing tank at Bench Scale level was carried out. It is concluded that obtaining lecithin from tarwi is viable, becoming an important alternative for the industrialization of this grain.

Keywords: oil, alkaloids, unmoisturized, degumming, lecithin, tarwi.

1. INTRODUCTION

Tarwi (Lupinus mutabilis) is a plant belonging to the legume family that is primarily cultivated in Bolivia, Ecuador, and Peru. In Bolivia, tarwi is known as “chuchus muti”. It is an annual legume species with epigeal germination; it is erect and self-pollinating, with a low rate of cross-pollination (5 to 10%) and a growth period ranging from 6 to 10 months, depending on the planting season and environmental conditions (Meneses, Waarjenberg & Piérola, 1996). It is well known for its high protein and oil content (Jacobsen & Mujica, 2006), from which lecithin can be obtained through the degumming of crude oil. Currently, in Bolivia, there are no projects dedicated to tarwi industrialization projects, despite the fact that a large area es produced in different regions. Thereby yielding a wide variety of derivative products, such as lecithin, which, as a complex of phospholipids, possesses emulsifying properties (Bueschelberger, Ilona & Schoeppe, 2015) could serve as an alternative for industry (Pino, 2021), thereby promoting the economic growth of the communities engaged in its production (Suca & Suca, 2015).

2. MATERIALS AND METHODS

The first step was the debittering of tarwi using the traditional method, being the most suitable and easy to perform (Aguilar, 2021): hydration (12 hrs) water/tarwi= 4:1; cooking (45 min) water/tarwi= 4:1; washing (5 days)

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water/tarwi= 3:1. Subsequently, drying was carried out at a temperature of 60°C (Mamani, 2009) in a tray dryer, followed by grinding and sieving (Leon & Rosell, 2007). For oil extraction, the Soxhlet extractor and 96° ethanol were used as the solvent (Villa & Benalcazar, 2015) with a solvent/solute ratio = 6/1, for 7 hours.

Once the crude oil was extracted, degumming was carried out in the following order: heating the oil to a range of 40 to 70 °C (Blanco, 2007), adding water at ratios of 5 to 30 % w/w, stirring speed of 100 to 400 rpm, and centrifugation (Stroppiano & Comba, n.d.). The influencing parameters were identified and optimized using experimental design, and verified in the laboratory. The lecithin obtained was characterized by the determination of acidity indices, saponification, HLB (Medina, 2013), toluene insoluble matter, acetone insoluble matter, proteins and alkaloids present in the lecithin.

3. RESULTS

3.1. Tarwi debittering

The following results were obtained for the verification of the absence of alkaloids in the debittered tarwi (Table 1).

Table 1. Percentage of alkaloids in debittered samples

Sample (mg)	Dilution	Absorbance	mg (alkaloids)	Alkaloids %
101.1	1:100	0.01017	0.42108	0.41650
107.2	1:100	0.01121	0.43169	0.40270
104	1:100	0.01234	0.44322	0.42617
		Average	**0.43200**	**0.41512**

The value obtained shows the low quantity of alkaloids present in the debittered tarwi.

3.2. Soxhlet extraction of crude oil

To verify the performance of the Soxhlet method in oil extraction, a mass balance was performed, where a yield of 97.07% was obtained (Table 2).

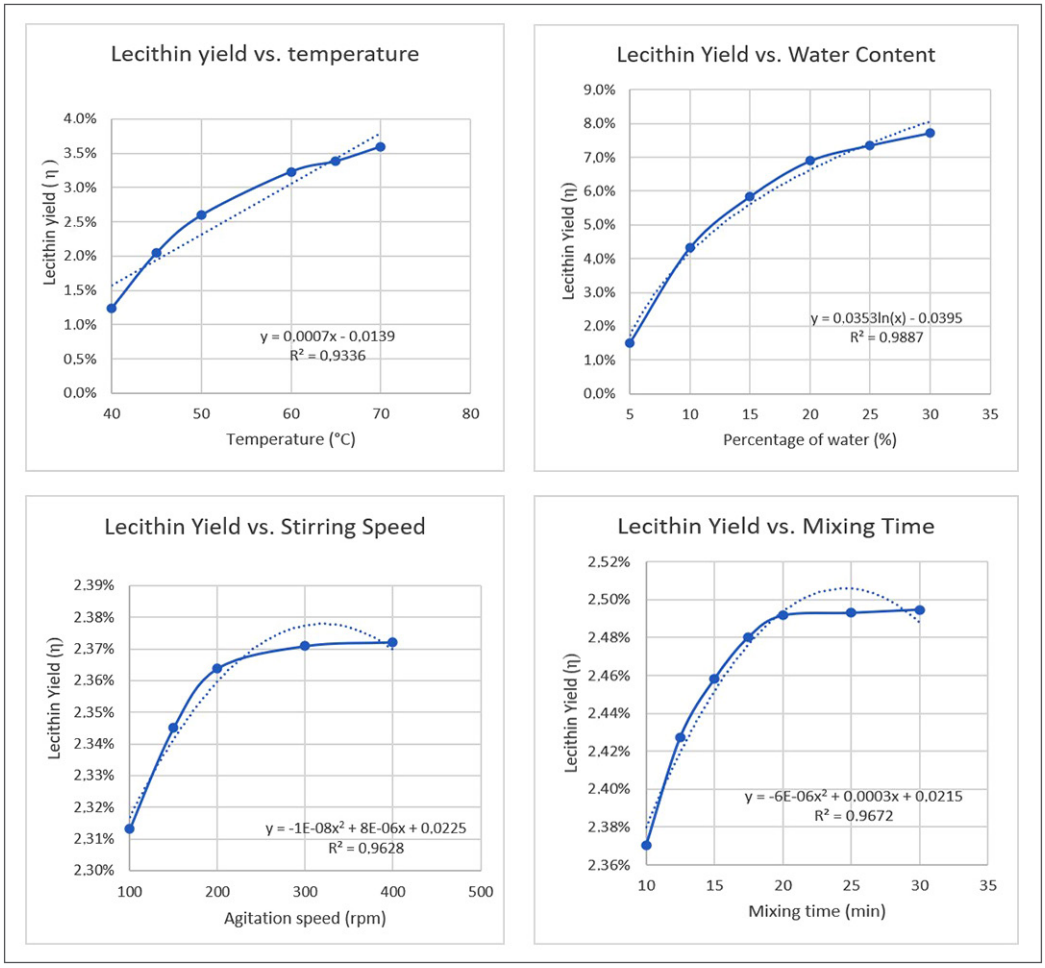
Table 2. Mass balance for oil

Input		Output	
Sample mass	28.029 g	Sample mass	23.2676 g
Oil mass	4.905 g	Oil mass	4.7615 g
Solvent	200 ml	Solvent	200 ml
		Percentage of oil extracted	**97.07 %**

3.3. Study of factors influencing lecithin production

The lecithin was obtained, in a first stage, by studying the behavior of the influencing factors: temperature, percentage of water, agitation speed and mixing time (Figure 1).

Figure 1. Lecithin yield as a function of influencing parameters



The lecithin yield as a function of temperature has a linear behavior, in relation to the percentage of water it presents a logarithmic behavior, while in relation to the speed of agitation and mixing time it shows a polynomial behavior. It is observed that at speeds larger than 300 rpm and times greater than 20 minutes, the obtaining of lecithin is constant.

3.4. Optimization of influencing parameters

Knowing the factors influencing the production of tarwi lecithin, optimization was carried out with experimental design with the following results (Table 3).

Table 3. Solution predicted by the Design-expert program 12

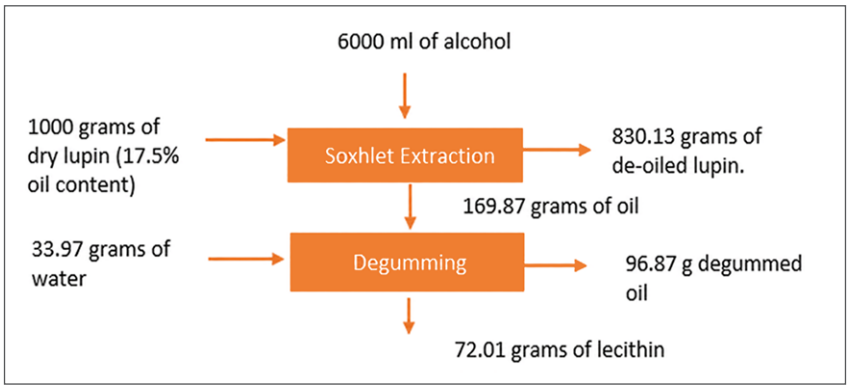
Number	Percentage of wáter	Temp	Stirring speed	Mixing time	Lecithin	Desirability
1	20 %	50 °C	200 rpm	20 min	7.274 %	0.972

Number: Shows the solution number that the experimental design identified as the best solution.
Desirability: A value between 0.8 and 0.9 indicates a quite good solution.

3.5. Verification of the solution predicted by the experimental design

To verify the solution obtained in the experimental design, 1000 grams of tarwi were handled, performing a mass balance as shown below (Figure 2).

Figure 2. Mass balance for the verification of the predicted solution



After performing the necessary calculations, the following yields were obtained

$$Experimental\ yield = \frac{m_{Lecithin}}{m_{Dry\ tarwi}} * 100 \qquad Ec.\ 1$$

$$Experimental\ yield = 7.201\ \%$$

Where: $m_{Lecithin}$= Lecithin mass obtained (g)
$m_{Dry\ tarwi}$ = Dried tarwi mass used (g)

3.6. Characterization of the lecithin obtained

Once the lecithin was obtained, the determination of the indices for its characterization was carried out (Table 4).

Table 4. Characterization indices for Lecithin

Acidity index	10.886 % oleic
Saponification index	130.731 mg KOH/g
HLB index (type of emulsifier)	-220.172 (W/O emulsifying agent)
Amount of phosphorus	0.074 mg P
Matter insoluble in toluene	0.015 %
Matter insoluble in acetone	62.3 %
Proteins	NO
Alkaloids	NO

The values for acetone-insoluble matter and toluene are remarkable, according to the specifications of the NSPA (National Soybean Processors Association, cited by Orthoefer (1995), the minimum percentage of acetone-insoluble matter that lecithin must have is 62%, while the percentage of toluene-insoluble matter must be a maximum of 0.3%, values that are fulfilled by the lecithin produced in this study.

3.7. Design of a mixing tank

Finally, a mixing tank was designed for the degumming process (Villa & Benalcazar, 2015). A calculation basis of 20 liters was used, and the height of the tank was calculated using equation 2 (Corsini, 2020):

$$V = \frac{\pi}{4} * h^3 \qquad Ec.\ 2$$

$$h = 30\ cm$$

Where: V = Oil volume (cm3)
h = Tank Height (cm)

With the geometric relationship: $$\frac{D_t}{h} = 1 \qquad Ec.\ 3$$

Where: D_t = Tank diameter (cm)
h = Tank Height (cm)

Considering a safety margin for the height of 25%, the following dimensions are obtained (Table 5)

Table 5. Mixing tank dimensions

Tank diameter	30 cm
Tank height	38 cm

For shaking, a flat leaf and 6-leaf disc type agitator was chosen; using the geometric relationships (Table 6), the dimensions of the agitator were calculated (Table 7).

Table 6. Geometric relationships for an inclined blade impeller

H/Dt	W/Da	Da/Dt	E/Dt	j/Dt	f/Dt	g/Da
1	0.2	0.5	0.33	0.1	0.02	0.25

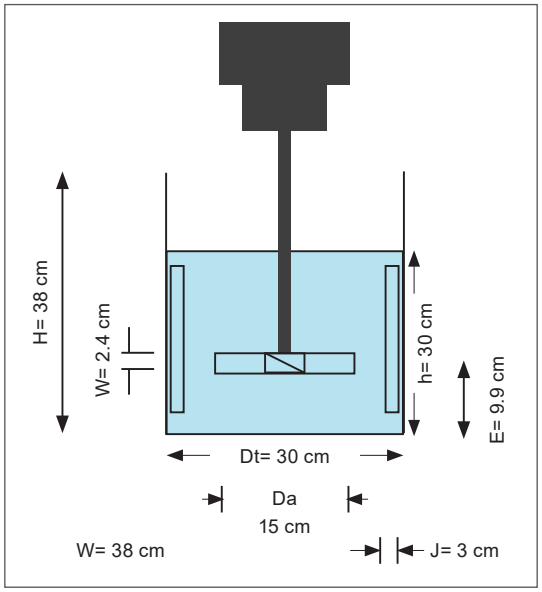
H/Dt = Relation Total height of the tank / Tank diameter
W/Da = Relation Impeller height / Impeller Diameter
Da/Dt = Relation Impeller Diameter / Tank diameter
E/Dt = Relation Height between the bottom of the tank and the impeller / Tank diameter
j/Dt = Relation Width of the deflector plate /Tank diameter
f/Dt = Relation Distance between the tank wall and the deflector/ Tank diameter
g/Da = Relation Impeller Radius /Impeller Diaeter

Table 7. Stirrer dimensions

Da	15 cm
E	9.9 cm
J	3 cm
W	2.4 cm
F	0.6 cm
G	3 cm

The final dimensions of the mixing tank are presented in Figure 3.

Figure 3. Final dimensions of the stirring tank



The degumming process to obtain lecithin requires heating to an optimum temperature of 50°C; with this value, the heat required for the heating system was calculated:

$$Q = m * C_P * \Delta T \qquad Ec.\ 4$$

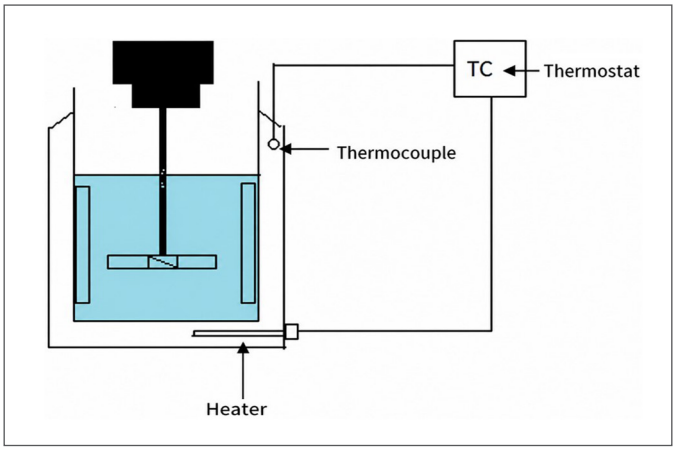
$$V = \frac{(31.41 + 6.28)}{20} \frac{Kg}{min} * 1.8 \frac{KJ}{Kg * °C} * (50 - 25)°C$$

$$Q = 5089.5 \frac{J}{s}$$

Donde: Q = Heat required for heating (J/s)
m = Oil-based heating mass ready in 20 minutes (kg)
C_P = Specific heat of oil (kJ/(kg∗°C))
ΔT = Temperature Change (°C)

Knowing the heat required for degumming, a 6000 W heat sink is selected. To prevent overheating, automatic control with an on/off controller will be used (Figure 4).

Figure 4. Heating system



4. CONCLUSIONS

- Tarwi lecithin was obtained by aqueous degumming of the oil extracted by Soxhlet with a yield of 7.201%.

- The optimized parameters for obtaining lecithin are: Stirring speed = 200 rpm; temperature = 50°C; mixing time = 20 min; water percentage = 20% w/w.

- Oil extraction using the Soxhlet method was successfully carried out, achieving a yield of 97.07%.

- The designed bench-scale tank has as its main characteristic the use of a turbine-type stirrer that will ensure the correct mixing and hydration of the phospholipids.

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