LIPID EXTRACTION FROM *Chlorella vulgaris* USING ELECTROMAGNETIC FIELD

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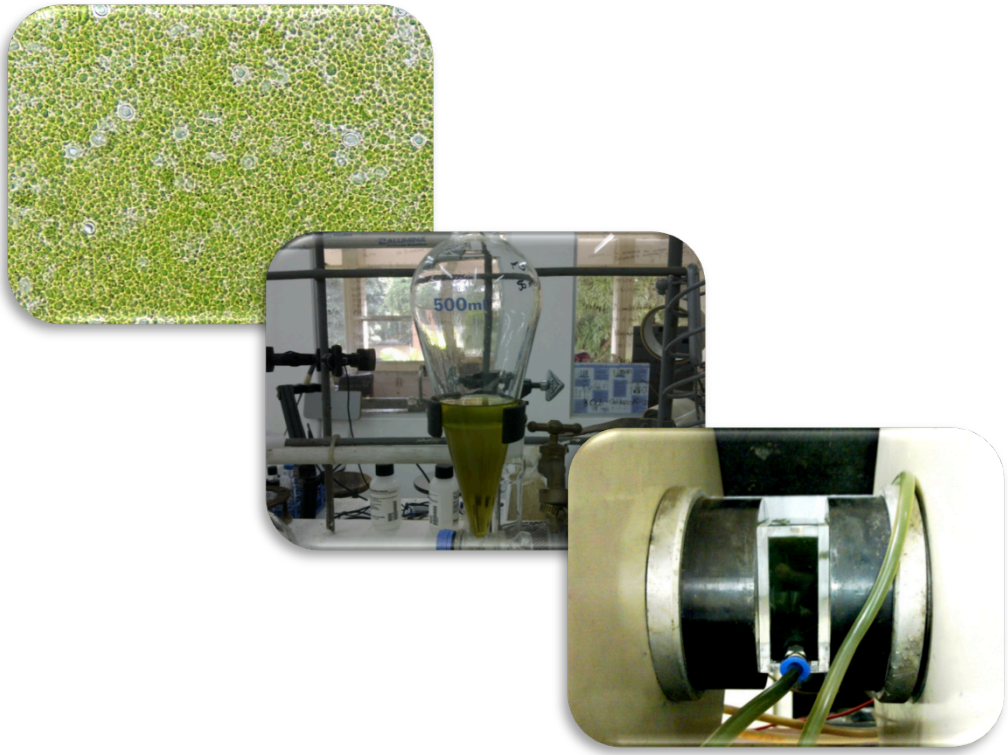
INTRODUCTION

- Aqueous surfactant-assisted extraction or "ASE" and the use of magnetic field or ultrasound.



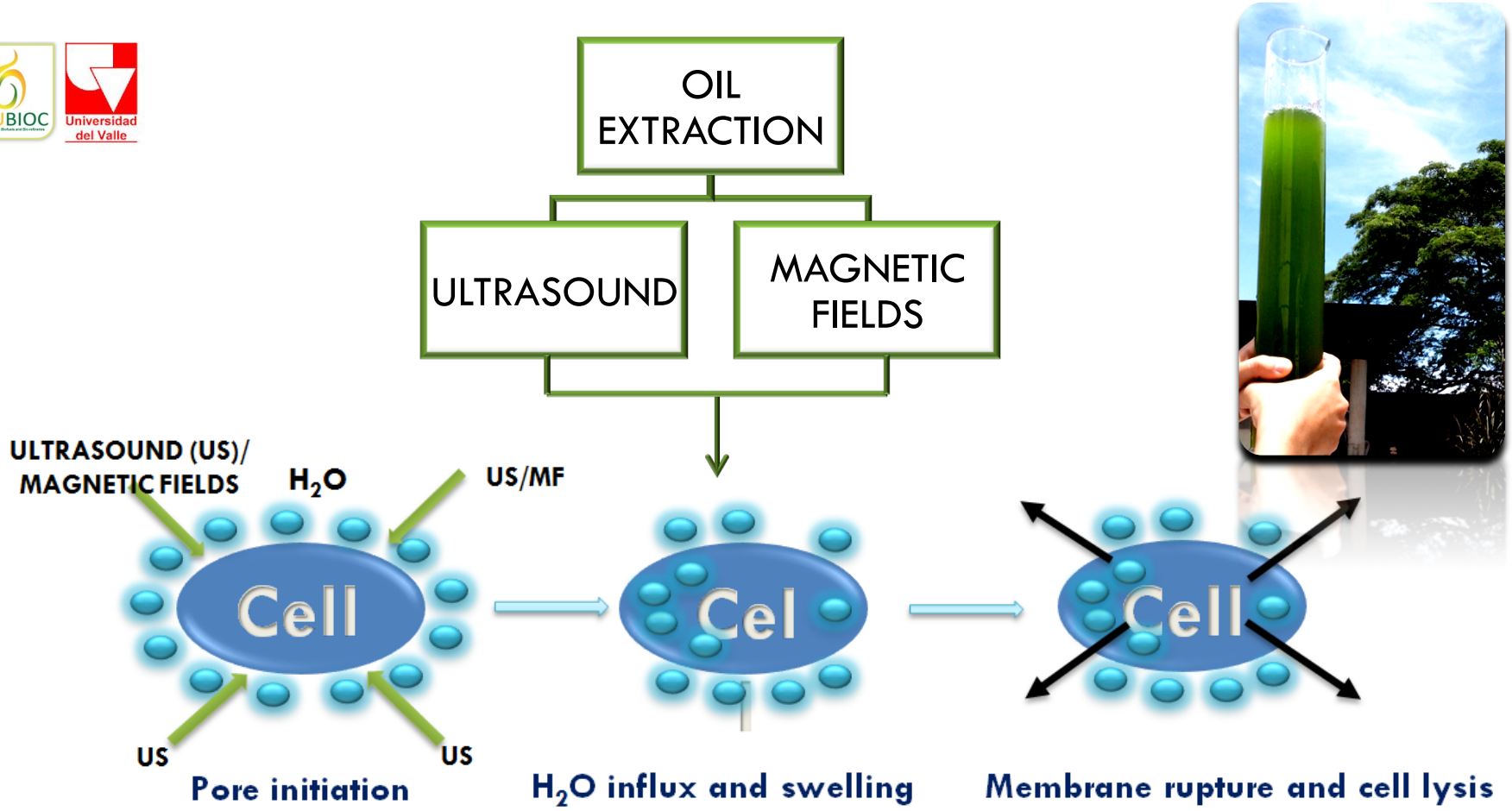
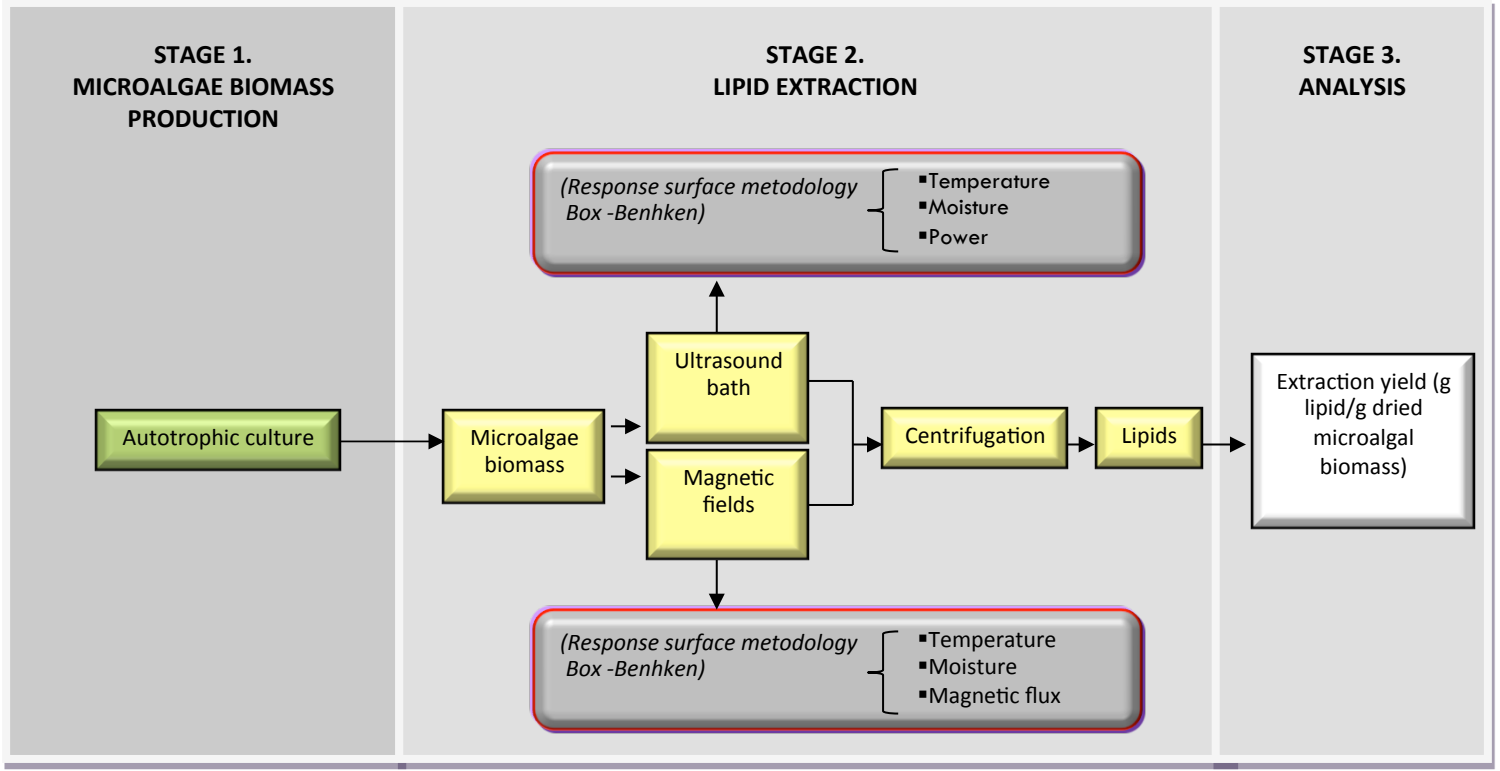


Figure 1. Cellular damage for ultrasound effect (adapted from Chemat *et al*., 2011)

METHODOLOGY

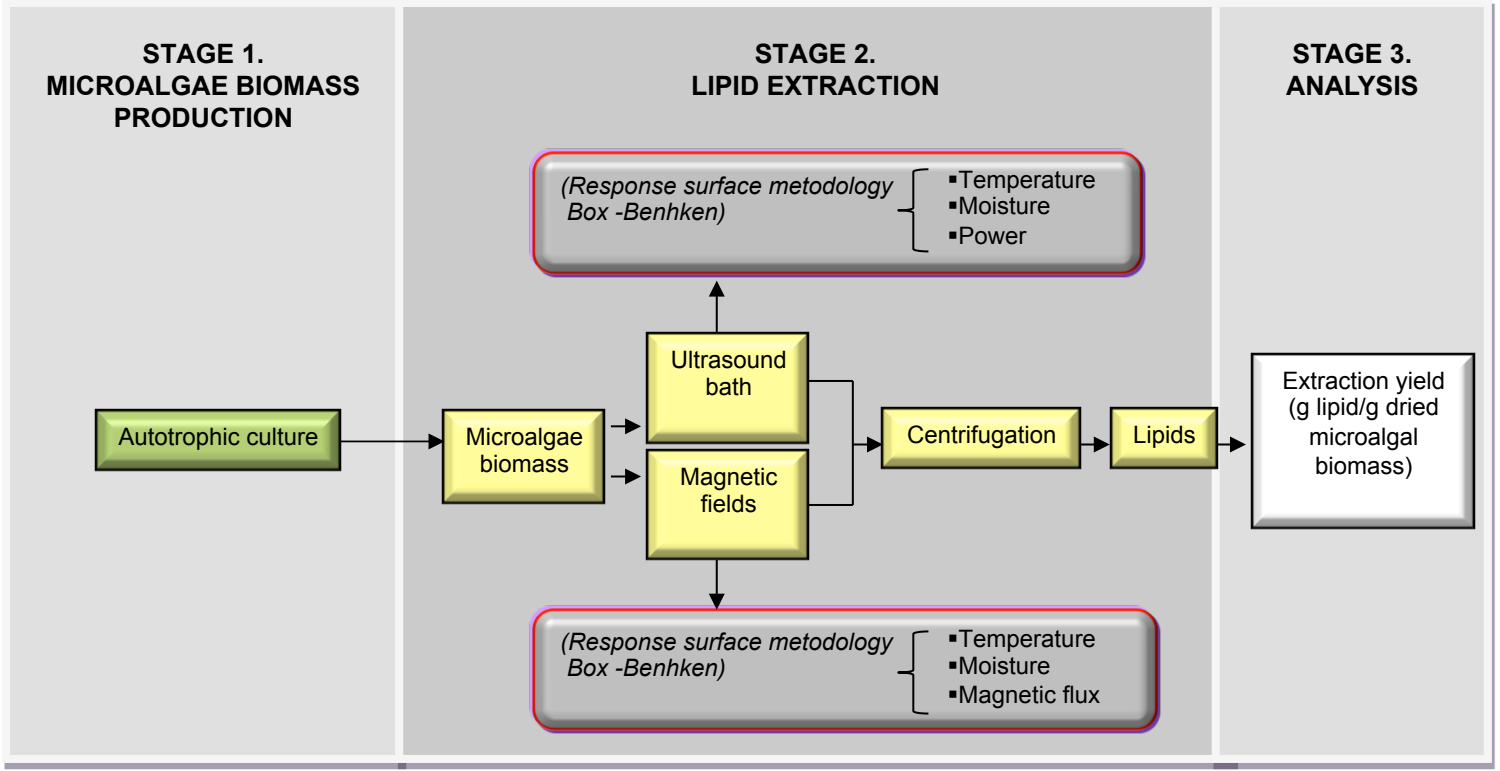


MICROALGAE BIOMASS PRODUCTION

Table 1. Components of the culture medium for microalgae biomass production at pH 6.75 ± 0.5

COMPOUND	TOTAL COMPOSITION (mg/L)
Total nitrogen	60
Ammonia nitrogen	13.7
Nitric nitrogen	22.3
Phosphorus	16
Water-soluble Potassium	5.3
Calcium	13.1
Magnesium	8.2

METHODOLOGY



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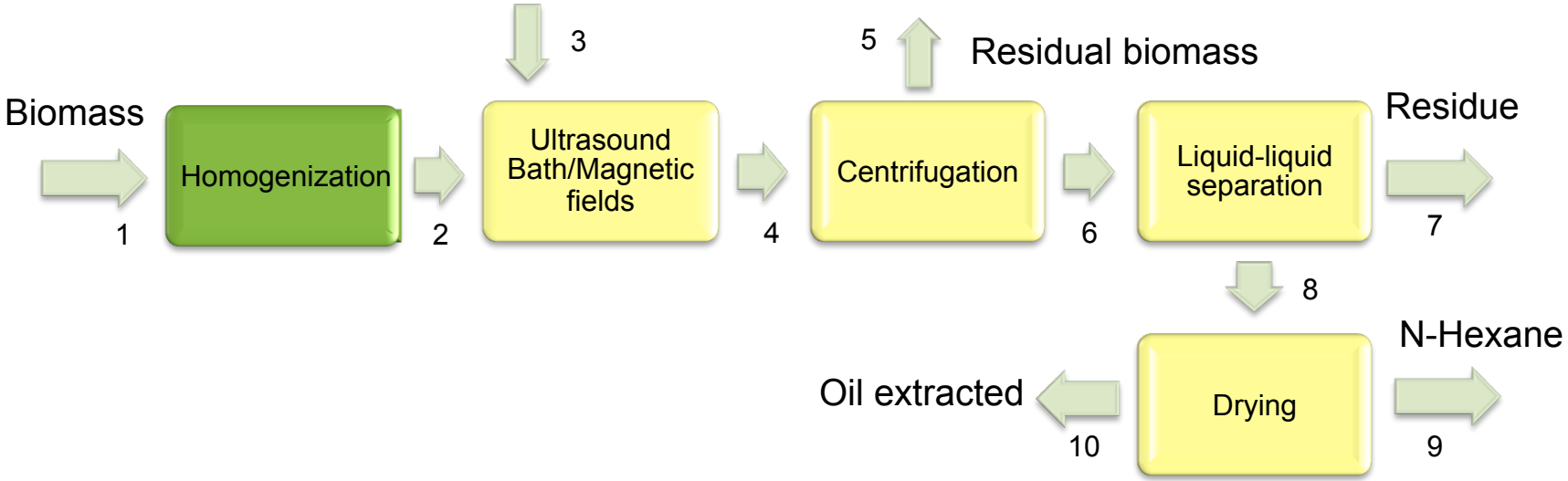

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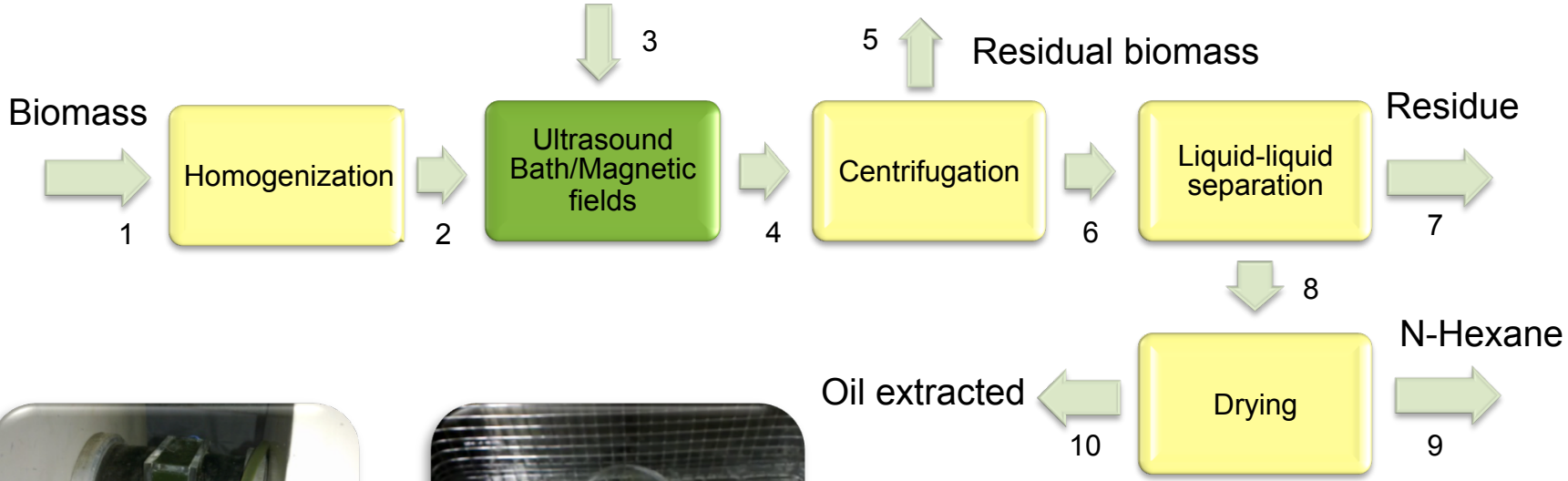


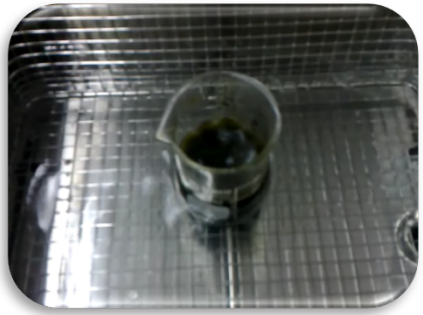
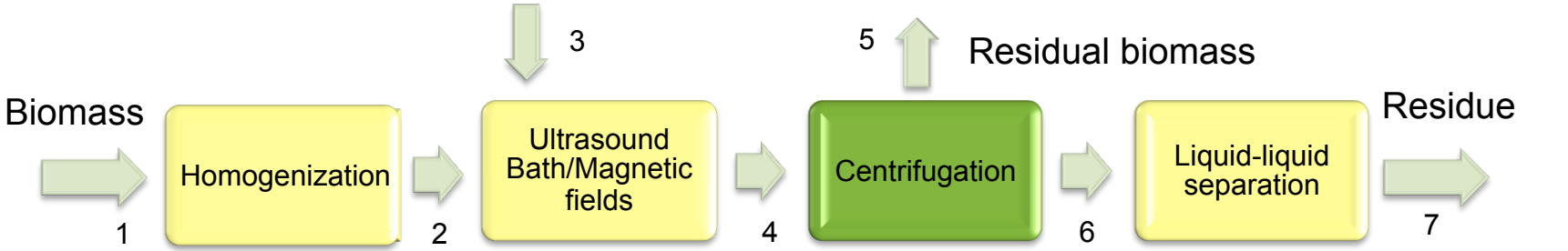


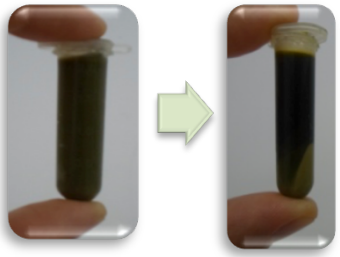
Table 2. Level and Variables involved in both treatments (*Response surface metodology Box -Benhken)*

MAGNETIC FIELD TREATMENT			
LEVEL	**TEMPERATURE (°C)**	**MOISTURE (%)**	**MAGNETIC FLUX DENSITY (mT)**
-1	30	85	55
0	45	91	185
+1	60	97	316
ULTRASOUND TREATMENT			
LEVEL	**TEMPERATURE (°C)**	**MOISTURE (%)**	**POWER (W)**
-1	30	85	20
0	45	91	110
+1	60	97	200

12 Treatments

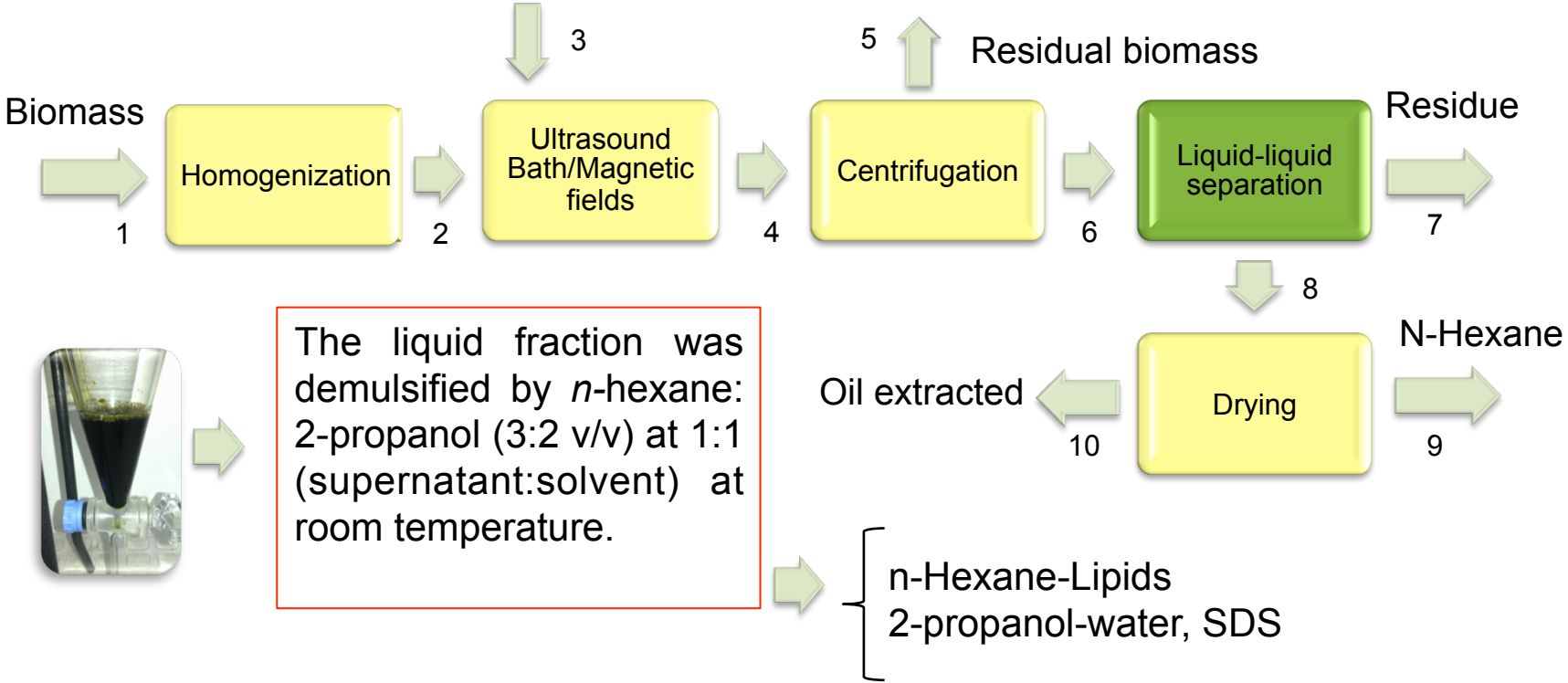
LIPID EXTRACTION



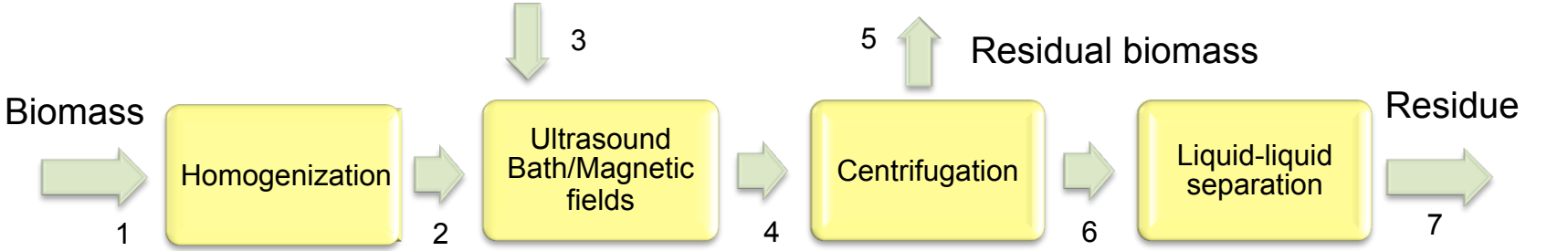


The slurry was centrifuged 10 minutes at 21000*g* (14000 rpm, Hettich EBA 21).

LIPID EXTRACTION

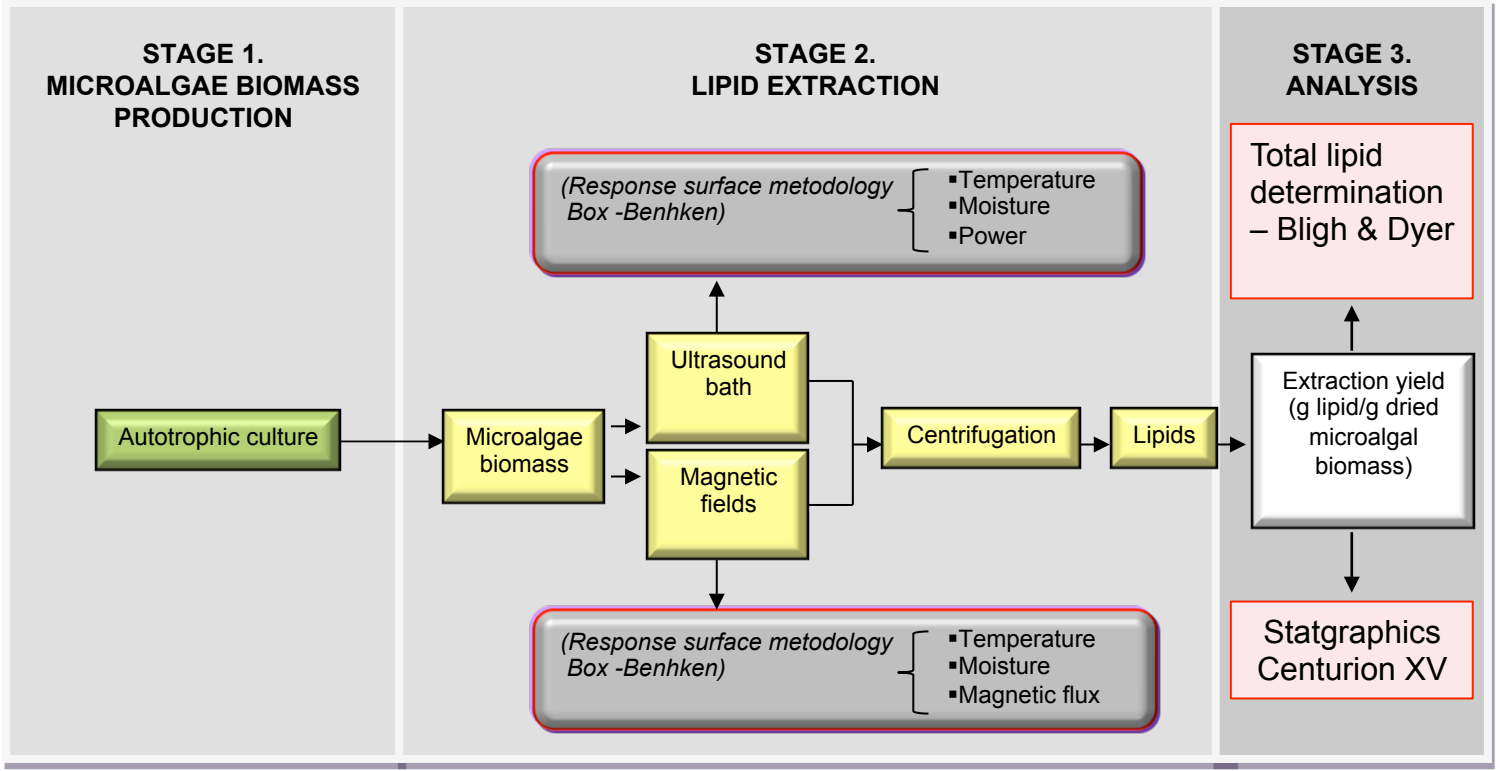


LIPID EXTRACTION



The upper organic phase (oil plus *n*-hexane) was desolventized at 70°C overnight until constant weight

METHODOLOGY

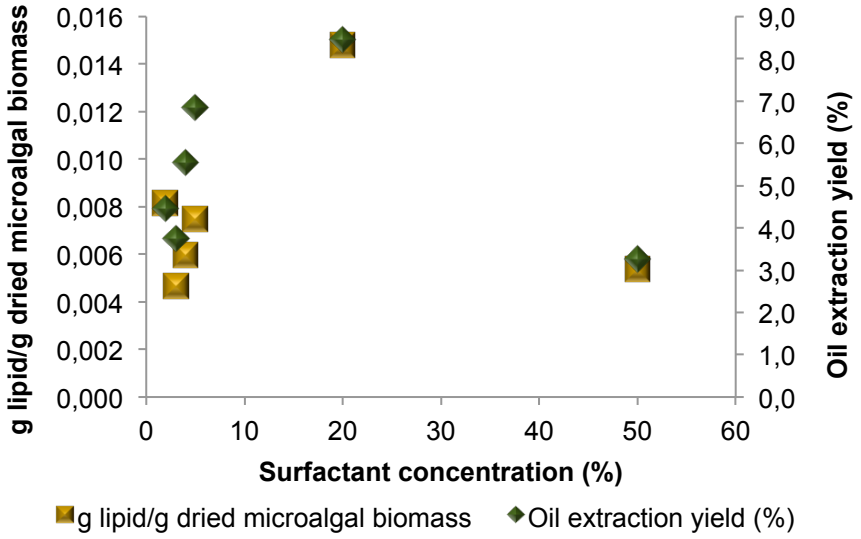


RESULTS AND DISCUSSION

Table 3. Lipid extraction of *Chlorella vulgaris* at different concentrations of SDS without cell disruption.

SDS (%)	SDS (Moles)	Oil extraction yield (%)	g lipid/g dried microalgal biomass
1	0,035	0	0
3	0,104	3,76	4,6E-3
4	0,139	5,56	5,9E-3
5	0,173	6,84	7,5E-3
20	0,693	8,47	1,5E-2
50	1,73	3,25	5,4E-3

Treatment at 20% SDS		g lipid/g dried microalgal biomass
Magnetic fields	Without disruption	2,16E-3
	Disruption	1,13E-2
Ultrasonic bath	Without disruption	1,30E-3
	Disruption	1,64E-3



MAGNETIC FIELD TREATMENT (R^2=89.52%)

Table 4. ANOVA for experimental results.

Source	Sum of squares	Mean Square	*F*-ratio	*p*-Value
A	1,066	1,066	10,74	0,022
B	0,195	0,195	1,97	0,219
C	0,419	0,419	4,22	0,095
AA	0,461	0,461	4,64	0,084
AB	0,006	0,006	0,06	0,821
AC	0,601	0,601	6,05	0,057
BB	0,0007	0,0007	0,01	0,934
BC	0,16	0,16	1,61	0,260
CC	0,223	0,223	2,25	0,194
Error total	0,496	0,099		
Total (corr.)	3,593			

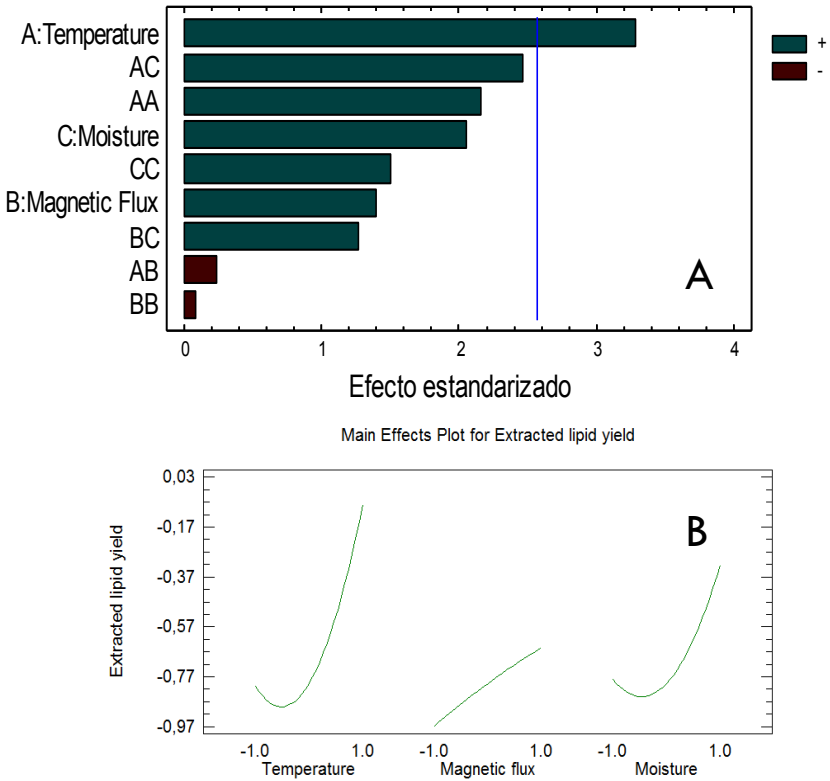


Figure 2. A. Pareto diagram. B. Principal effects. A:Temperature, B:Magnetic Flux (Magnetic field treatment), C:Moisture

Table 5. MAGNETIC FIELD TREATMENT RESULTS

Temperature (°C)	Magnetic flux (mT)	Moisture (%)	Oil extraction yield (%)	g lipid/g dried microalgal biomass
45,0	185,50	0,91	9,11	0,0047
30,0	185,5	0,85	12,05	0,0061
45,0	55,0	0,97	5,63	0,0029
60,0	316,00	0,91	18,12	0,0092
45,0	185,5	0,91	8,04	0,0041
45,0	55,0	0,85	8,57	0,0044
60,0	185,50	0,97	39,64	0,0203
30,0	316,0	0,91	10,45	0,0052
45,0	316,0	0,97	24,29	0,0123
45,0	316,0	0,85	13,66	0,0098
30,0	185,50	0,97	10,62	0,0000
60,0	185,5	0,85	14,73	0,0074
60,0	55,0	0,91	20,63	0,0103
30,0	55,0	0,91	10,36	0,0053
45,0	185,5	0,91	10,18	0,0034

ULTRASOUND TREATMENT (R^2=93.65%)

Table 6. ANOVA for experimental results.

Source	Sum of squares	Mean Square	*F*-ratio	*p*-Value
A	0,5442	0,5443	12,82	0,016
B	0,9832	0,9832	23,16	0,005
C	0,0667	0,0667	1,57	0,265
AA	0,0501	0,0501	1,18	0,327
AB	0,3256	0,3255	7,67	0,039
AC	0,2794	0,2794	6,58	0,050
BB	0,4708	0,4708	11,09	0,021
BC	0,3567	0,3566	8,40	0,034
CC	0,4814	0,4814	11,34	0,019
Error total	0,2123	0,0424		
Total (corr.)	3,348			

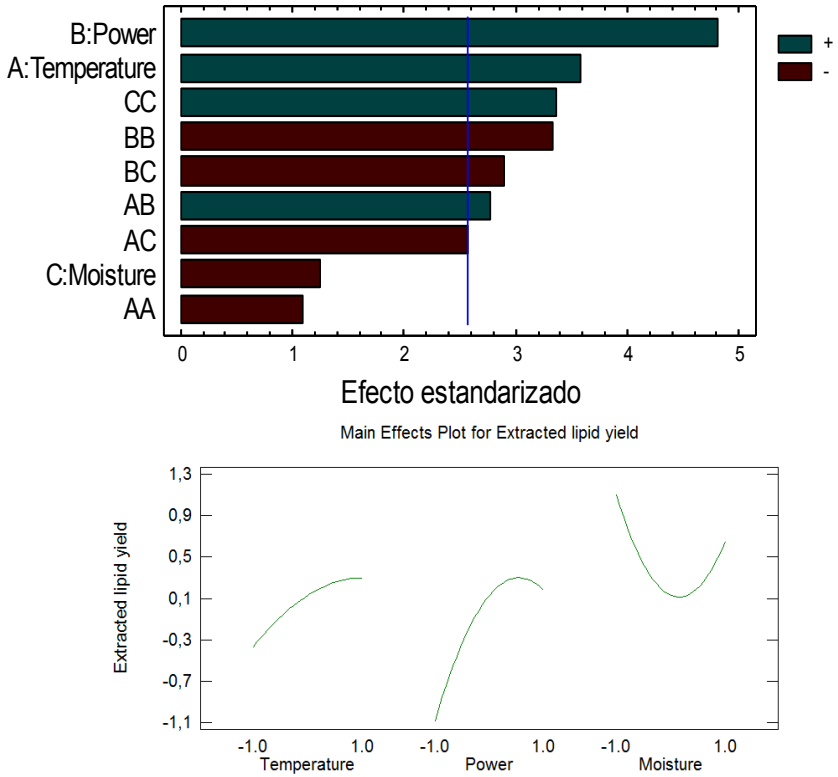


Figure 3. A. Pareto diagram. B. Principal effects. A:Temperature, B:Power (Ultrasound treatment), C:Moisture

Table 7. ULTRASOUND TREATMENT RESULTS

Power (W)	Moisture (%)	Temperature (°C)	Oil extraction yield (%)	g lipid/g dried microalgal biomass
110	0,97	45	22,906	0,01267
110	0,85	30	9,934	0,00549
20	0,97	45	14,122	0,00787
200	0,91	60	26,519	0,01453
110	0,91	45	14,368	0,00791
20	0,85	45	9,031	0,00484
110	0,91	60	17,734	0,00952
200	0,97	30	14,286	0,00796
200	0,97	45	13,629	0,00753
200	0,91	45	16,995	0,00833
110	0,91	60	20,279	0,01118
20	0,85	60	8,498	0,00476
20	0,91	30	1,779	0,00098
110	0,91	45	16,256	0,00864
110	0,91	45	14,450	0,00793

CONCLUSIONS

- Aqueous surfactant-assited extraction (ASE), with the use of magnetic field and ultrasound, it's a clean process easily adapted for microalgae lipid extraction.
- High treatment temperature significantly impacted on lipid extraction for both treatments.
- The only drawback is that the yield is still below of the conventional method. However, the use of magnetic field, ultrasound with SDS, corroborates that the method allows an extraction with good yield, less pollution and significant economic and safety benefits.

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