KINETICS OF PEPTIDES AND ARGININE PRODUCTION FROM MICROALGAE (SCENEDESMUS SP.) VIA FLASH HYDROLYSIS

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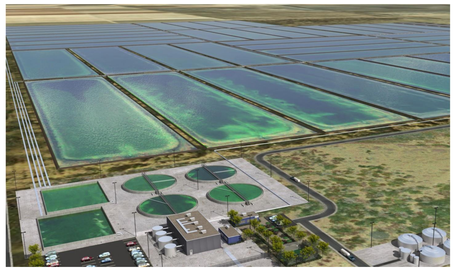
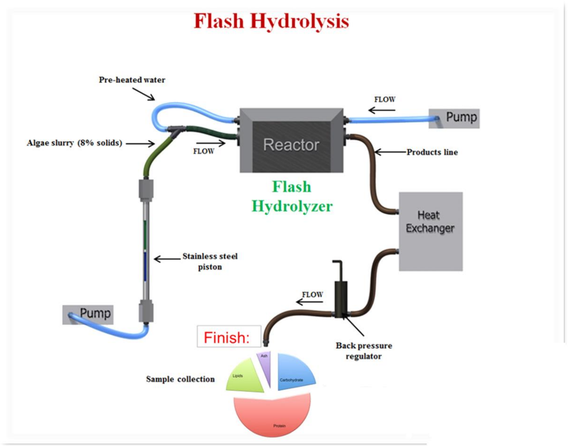
Background and Problem Definition

In order to fill the global need for a renewable transportation fuel, a new generation of high yield biofuels, fuels must come to market. Microalgae have the potential to be a solution to this problem, but they are still not on the market yet due to cost limitations.



In order to make the process cost-efficient we need to seek comprehensive recovery systems for biomass & of its components such as soluble peptides and Arginine in order to exploit the microalgae potential.



Water under subcritical conditions in a continuous flow reactor (Flash Hydrolysis) was proved to be an efficient and environmentally-benign method to hydrolyze proteins from microalgae biomass in a very short residence time (few seconds).

Objectives

The objectives of this study were to:

(i) Optimize the experimental conditions to maximize the yield of arginine and water-soluble peptides production

(ii) Characterize both solids and liquid products obtained after Flash Hydrolysis,

(iii) Estimate the kinetic parameters for protein and arginine solubilization using Flash Hydrolysis process.

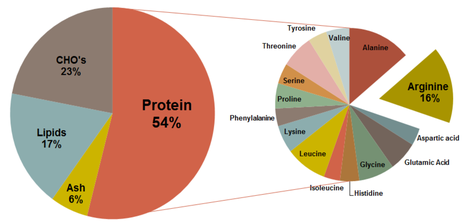
Materials and Methods

Scenedesmus sp. was cultivated in the photobioreactor (PBR) in our lab and used for experiments with the following properties:

Elemental analysis of algae slurry:

C=50.5%, N=9.4%, H=7.9% and Ash=6.1%

Solid content in algae slurry is 7.8% dry basis.



- Experiments conducted in duplicates, reported results are the average values.
- The aqueous phase products were analyzed for TN, TOC, total phenols, soluble peptides (Lowry's method) and arginine content.

	Temperature (°C)	Residence time (s)	Pressure (psi)
Run 1	240	6	3000
Run 2	240	9	3000
Run 3	240	12	3000
Run 4	280	6	3000
Run 5	280	9	3000
Run 6	280	12	3000
Run 7	320	6	3000
Run 8	320	9	3000
Run 9	320	12	3000

Materials and Methods(cont.)

Proteins + water (excess) → Soluble peptides

Arginine in algae protein + water (excess) → Arginine in aqueous phase

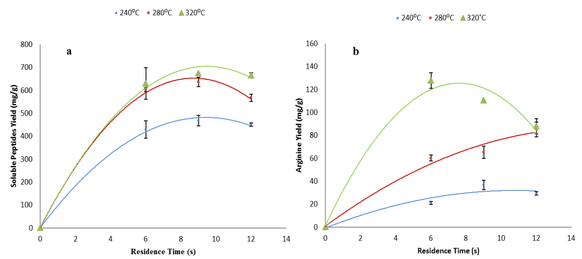
$k = A\, e^{-Ea/RT}$

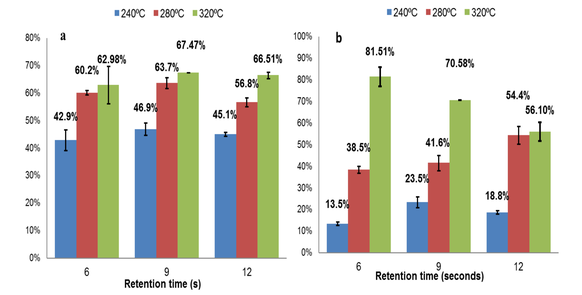
$\ln k = -(Ea/R)\, 1/T + \ln A$

The rate constant k for protein hydrolysis to soluble peptides and arginine was obtained by fitting the experimental values

Results

	TOC		TN		Soluble peptides		Arginine	
	mg/L	Input %	mg/L	Input %	mg/L	Input %	mg/L	Input %
Run 1	1145 ±31	44.1%	218.1 ±9	45.1%	1294 ±93	42.9%	64 ±3	13.5%
Run 2	1264 ±10	48.2%	265.0 ±7	54.3%	1429 ±66	46.9%	112 ±12	23.5%
Run 3	1324 ±20	50.2%	262.9 ±6	53.6%	1382 ±30	45.1%	90 ±5	18.8%
Run 4	1369 ±61	52.5%	313.3 ±1	64.6%	1825 ±34	60.2%	183 ±6	38.5%
Run 5	1483 ±35	56.9%	350.3 ±2	72.2%	1930 ±51	63.7%	198 ±16	41.6%
Run 6	1582 ±35	59.9%	334.5 ±21	68.1%	1743 ±47	56.8%	262 ±19	54.4%
Run 7	1610 ±83	49.6%	480.6 ±32	79.6%	2377 ±216	63.0%	471 ±18	81.5%
Run 8	1713 ±38	54.5%	522.8 ±13	89.3%	2483 ±	67.5%	407 ±	70.6%
Run 9	1737 ±23	55.3%	541.4 ±2	92.6%	2430 ±8	66.5%	306 ±40	56.1%





Control & Repetition Results

Parameter	Protein Solubilization	Arginine Solubilization
k_{240}	0.19 L g^{-1} s^{-1}	0.02 g L^{-1} s^{-1}
k_{280}	0.38 L g^{-1} s^{-1}	0.04 g L^{-1} s^{-1}
k_{320}	0.75 L g^{-1} s^{-1}	0.05 g L^{-1} s^{-1}
Reaction order	2	0
Activation energy (E_a)	43.01 kJ/mol	34.31 kJ/mol

Conclusions

- Peptides and arginine can be separated and purified from the hydrolyzate to develop as high-value co-products from microalgae.
- The experiment at 320 ° C and 9 s residence time was the optimum process condition for soluble-peptides yield whereas the maximum Arginine yield was achieved at 280 ˚C and 6 s of residence time.
- The protein contents in biofuels intermediate (solids) can be significantly reduced (from 54% in the algae biomass to only 10.2% in residue from Run 9 while most of the lipids are still present making it energy-rich macromolecule for biofuels production.

References

1. Garcia-Moscoso, J.L., et al., *Flash hydrolysis of microalgae (Scenedesmus sp.) for protein extraction and production of biofuels intermediates.* The Journal of Supercritical Fluids, 2013. **82**(0): p. 183-190.
2. Garcia-Moscoso, J.L., et al., *Kinetics of Peptides and Arginine Production from Microalgae (Scenedesmus sp.) via Flash Hydrolysis.* Industrial & Engineering Chemistry Research, reviewed.

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