TECHNION
Israel Institute of Technology

Biotechnology & Food Engineering

Macroalgae - a potential new and renewable source for nutrients

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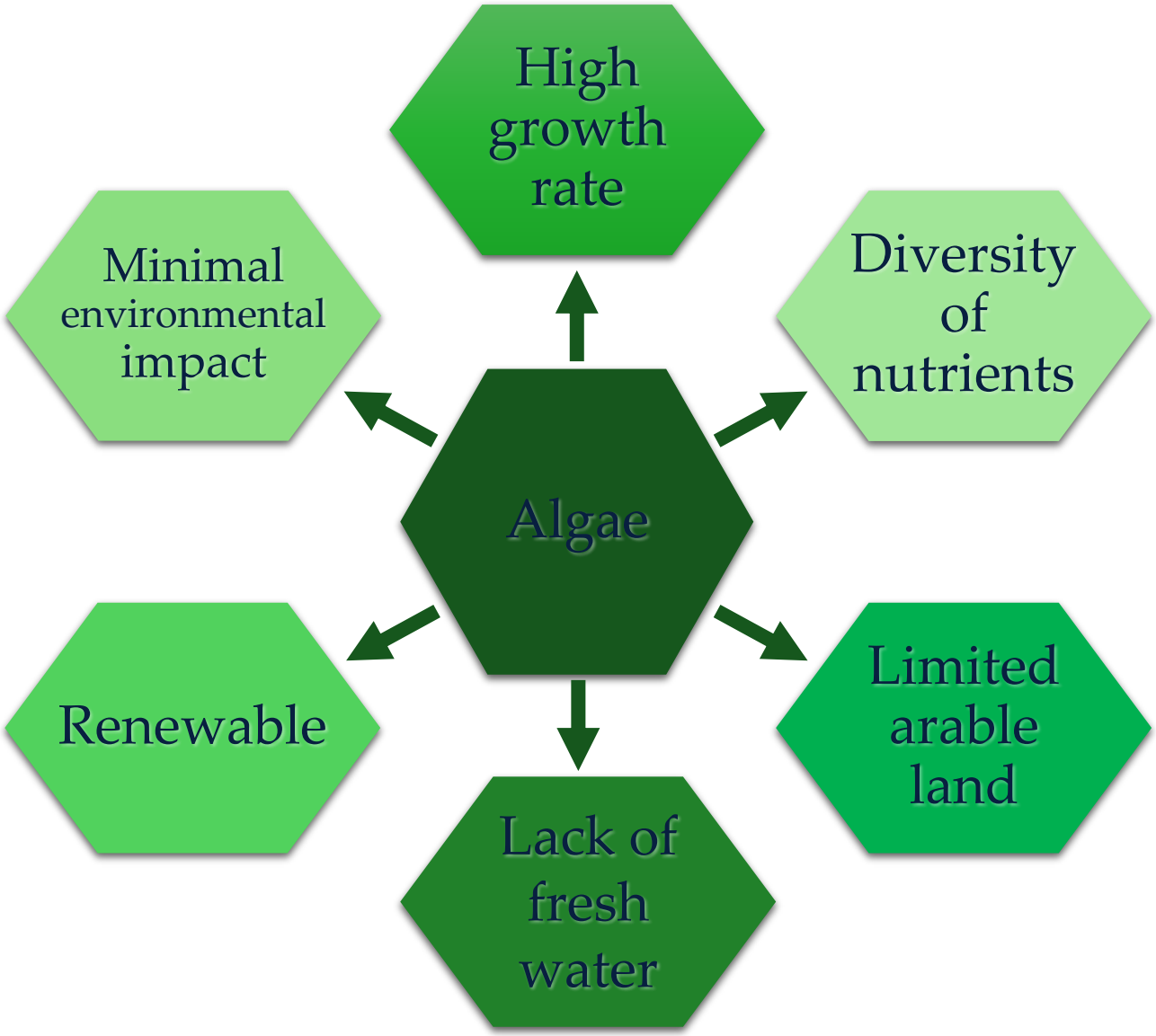
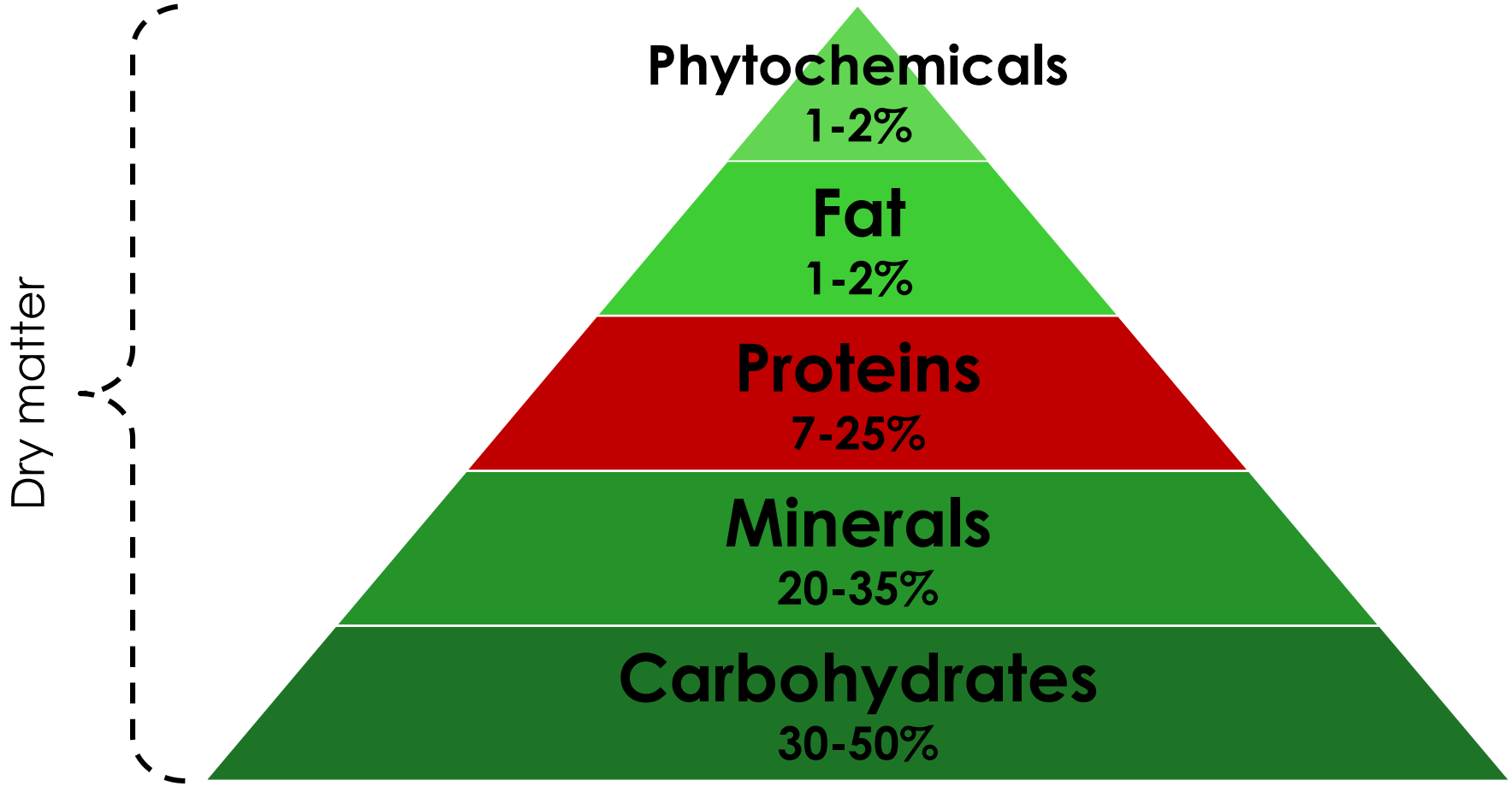
Motivation

- Growth of global population – 10 billion people by 2050
- Decrease in available land area
- Decrease in fresh water resources

Why algae?


High growth rate
Minimal environmental impact
Diversity of nutrients
Algae
Renewable
Limited arable land
Lack of fresh water

Chemical composition of algae



Algae as a source for variety of nutrients

Carbohydrates

- Digestible
- Indigestible

Proteins

- Essential amino acids
- Functional properties

Phytochemicals

- Phenols
- Carotenoids
- Vitamins

Fat

- PUFAs
- Sterols (phytosterols)

Minerals

- Macro elements: Na, K, Ca, Mg
- Trace elements: I, Fe, Zn, Mn, Cu

Nutritional composition of algae

Chlorophyta Rhodophyta

Nutritional composition of algae

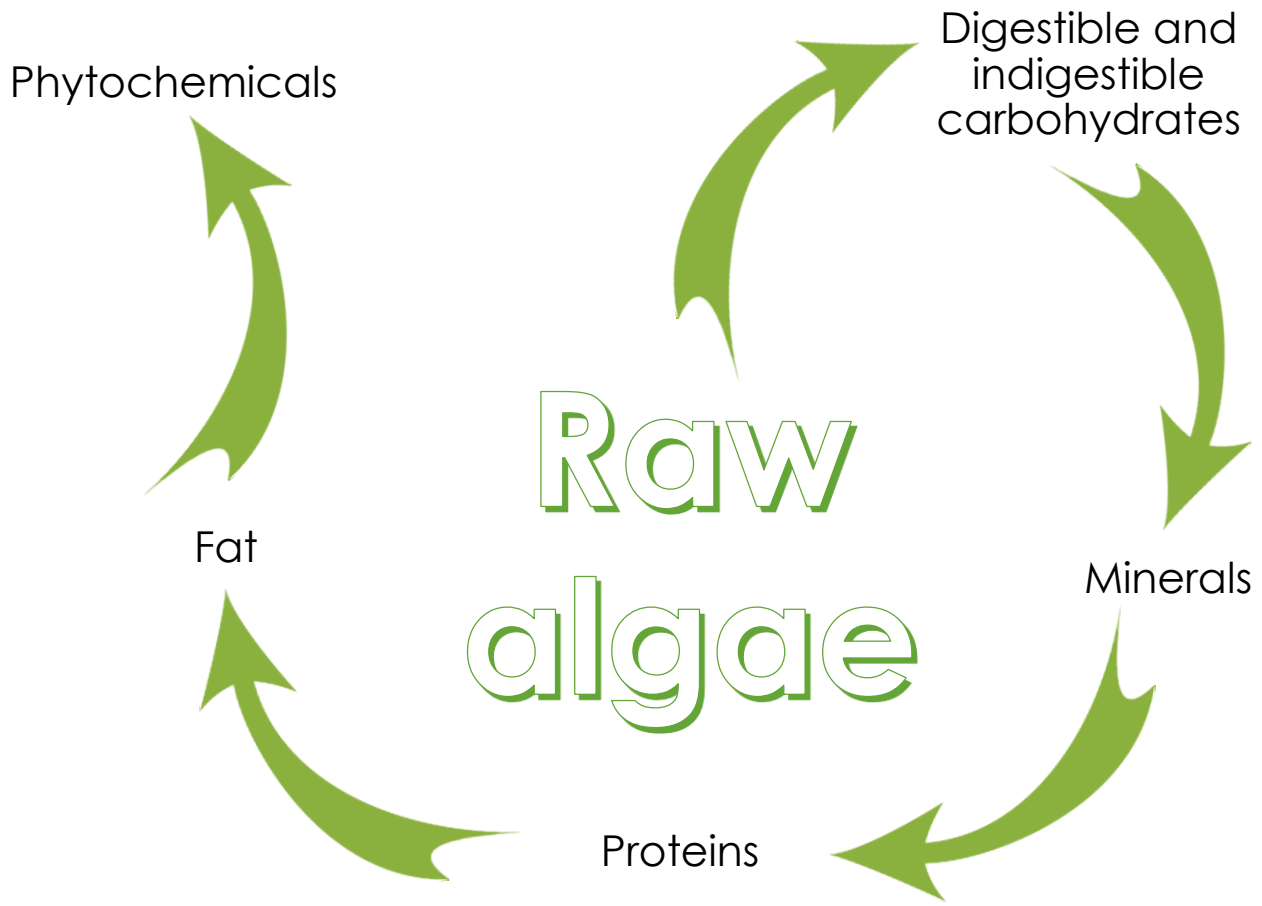
Parameter	*G. gracilis*	*O. pinnatifida*	*G. turuturu*
% moisture ($g/100g_{dry\ seaweed}$)	7.99 ± 0.02 a	11.77 ± 0.01 e	11.68 ± 0.05 e
% total Protein ($g/100g_{dry\ seaweed}$)	20.2 ± 0.6 d	23.8 ± 0.6 f	22.5 ± 0.3 e
% total sugars[1] ($g/100g_{dry\ seaweed}$)	46.6	32.4	43.2
% total fat ($g/100g_{dry\ seaweed}$)	0.60 ± 0.01 a	0.9 ± 0.1 a	2.2 ± 0.1 c
Total phenolic content (μg cathecol equiv/$g_{dry\ seaweed}$)	228 ± 14 a	337 ± 22 b	208 ± 8 a
% organic matter ($g/100g_{dry\ seaweed}$)	67.21 ± 0.01 d	57.6 ± 0.2 a	67.80 ± 0.06 d
% ash ($g/100g_{dry\ seaweed}$)	24.8 ± 0.03 b	30.62 ± 0.25 a	20.52 ± 0.01 c

Parameter	*S. muticum*	*S. polyschides*	*C. tomentosum*
% moisture ($g/100g_{dry\ seaweed}$)	9.64 ± 0.08 c	10.88 ± 0.04 d	9.0 ± 0.2 b
% total Protein ($g/100g_{dry\ seaweed}$)	16.9 ± 0.2 b	14.44 ± 0.1 a	18.8 ± 0.1 c
% total sugars[1] ($g/100g_{dry\ seaweed}$)	49.3	45.6	32.8
% total fat ($g/100g_{dry\ seaweed}$)	1.45 ± 0.07 b	1.1 ± 0.1 ab	3.6 ± 0.2 d
Total phenolic content (μg cathecol equiv/$g_{dry\ seaweed}$)	499 ± 32 c	224 ± 13 a	920 ± 84 d
% organic matter ($g/100g_{dry\ seaweed}$)	67.41 ± 0.02 d	60.97 ± 0.05 c	55.0 ± 0.7 b
% ash ($g/100g_{dry\ seaweed}$)	22.94 ± 0.06 d	28.15 ± 0.01 e	35.99 ± 0.48 f

Source: D. Rodrigues et al. Food Chemistry, 183:197–207, 2015.

Zero waste agenda

- Nutritional benefits
- Economical benefits
- Environmental benefits



Algae Proteins

- Source for essential amino acids
- Antioxidants
- Surfactants
- Gelling agents

Ulva rigida

- Sea Lettuce
- Edible seaweed, chlorophyte family
- High content of polysaccharides (14-40% DB)
- Good source for proteins (7-24% DB)

Table 1 Total amino acid of wild and farmed *Ulva* species (in g amino acid per 100 g protein)

	Wild *U. capensis*	Wild *U. rigida*	*U. lactuca* (I & J farm)	Leguminous plant[a]	Ovalbumin (eggs)[b]
Isoleucine	3.5±0.0	3.1±0.2	3.7±0.0	3.6	4.8
Leucine	6.8±0.2	5.2±0.2	6.7±0.1	7.3	6.2
Lysine	3.7±0.1	3.7±0.3	4.2±0.1	6.5	7.7
Methionine	1.5±0.1	1.5±0.2	1.6±0.1	1.4	3.1
Cysteine	0.0±0.0	1.1±0.1	0.4±0.4	1.3	0.0
Phenylalanine	4.0±0.2	3.3±0.2	4.0±0.0	2.4	4.1
Tyrosine	2.0±0.1	2.2±0.2	2.1±0.1	2.6	1.8
Threonine	5.0±0.1	5.0±0.3	4.7±0.0	4.0	3.0
Valine	6.3±0.0	5.6±0.4	6.2±0.0	4.5	5.4
Histidine	1.7±0.1	1.4±0.2	1.8±0.1	4.0	4.1
Aspartic acid	17.2±0.6	13.0±1.1	12.3±0.9	5.4	6.2
Glutamic acid	10.9±0.2	9.4±1.0	9.0±0.5	6.7	9.9
Proline	3.6±0.2	4.3±0.4	5.3±0.6	0.0	2.8
Serine	6.4±0.2	6.1±0.8	5.9±0.0	0.0	6.8
Glycine	8.8±0.2	7.8±0.2	10.7±0.6	0.0	3.4
Alanine	11.8±0.2	12.3±0.7	14.2±0.4	1.3	0.0
Arginine	3.3±0.3	4.6±0.5	3.6±0.3	14.0	11.7
Ammonia	1.5±0.0	1.2±0.1	1.3±0.1	–	–

Source: D. Shuuluka et al. Journal of applied phycology, 25.2:677-685, 2013.

U. rigida chemical composition

Proximate composition	Relative % on dry weight basis
Carbohydrate	37 ± 3.9
Cellulose	23.8 ± 1.2
Starch	7.6 ± 1.1
Protein	6.2 ± 0.9
Carbon	28.1 ± 1.2
Nitrogen	4.5 ± 0.7
Hydrogen	5.5 ± 1.3
Sulphur	2.3 ± 0.4

Biochemical composition of *U. rigida*.

Proximate composition	Relative % on dry weight basis
Carbohydrate	15.88 ± 1.82
Protein	13.69 ± 0.68
Lipid	1.55 ± 0.06
Moisture	3.22 ± 0.07
Ash	50.39 ± 0.35
Carbon	19.41 ± 0.21
Hydrogen	2.43 ± 0.01
Nitrogen	2.19 ± 0.11
Sulfur	0.49 ± 0.10
Organic matter	46.85 ± 0.54

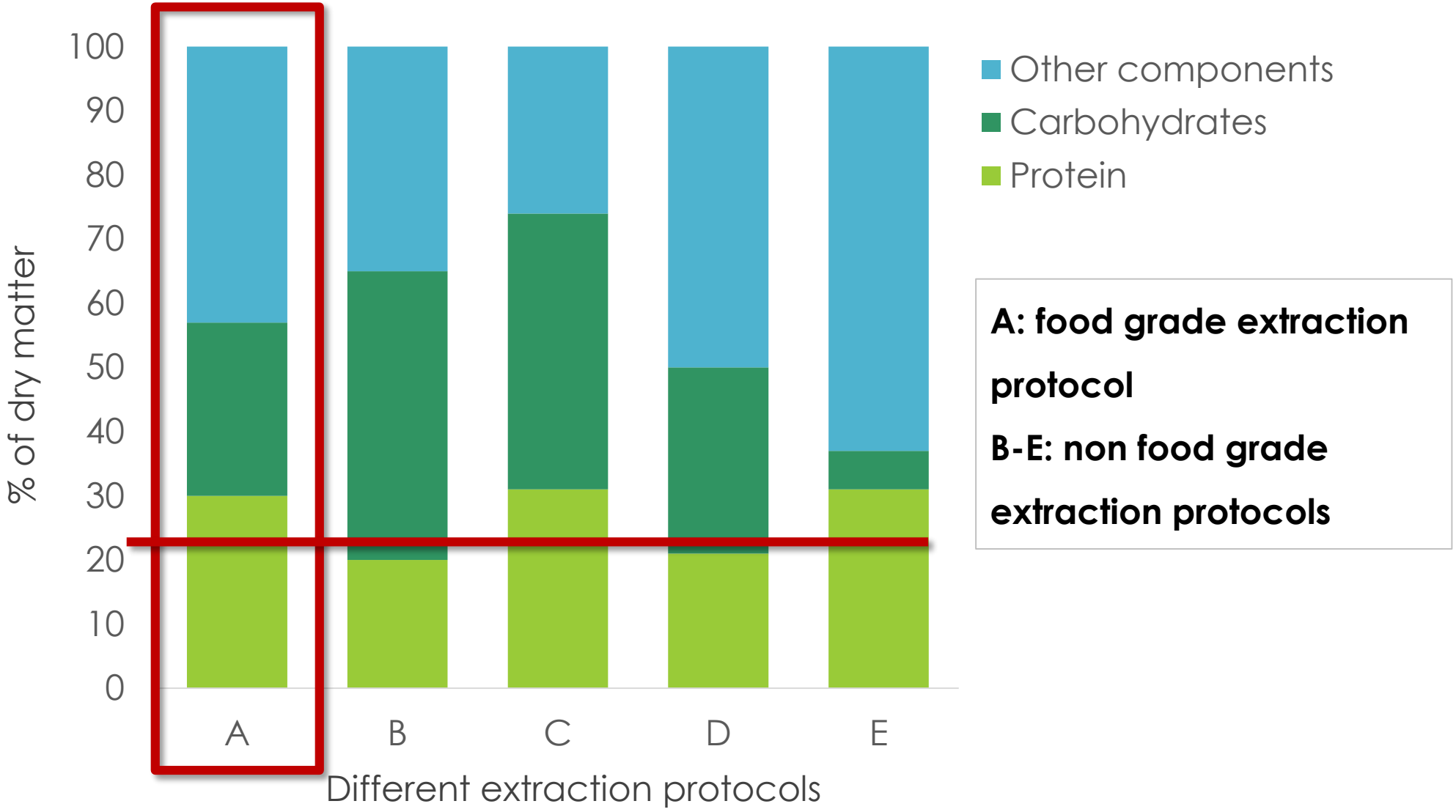
Source: L. Korzen et al. RSC Advances, 5.21:16223-16229, 2015.
R. Karray et al. Waste Management, 61:171-178, 2017.

Cell lysis

- Mechanical disruption
- Liquid homogenization
- Ultrasonication
- Osmotic shock

Results

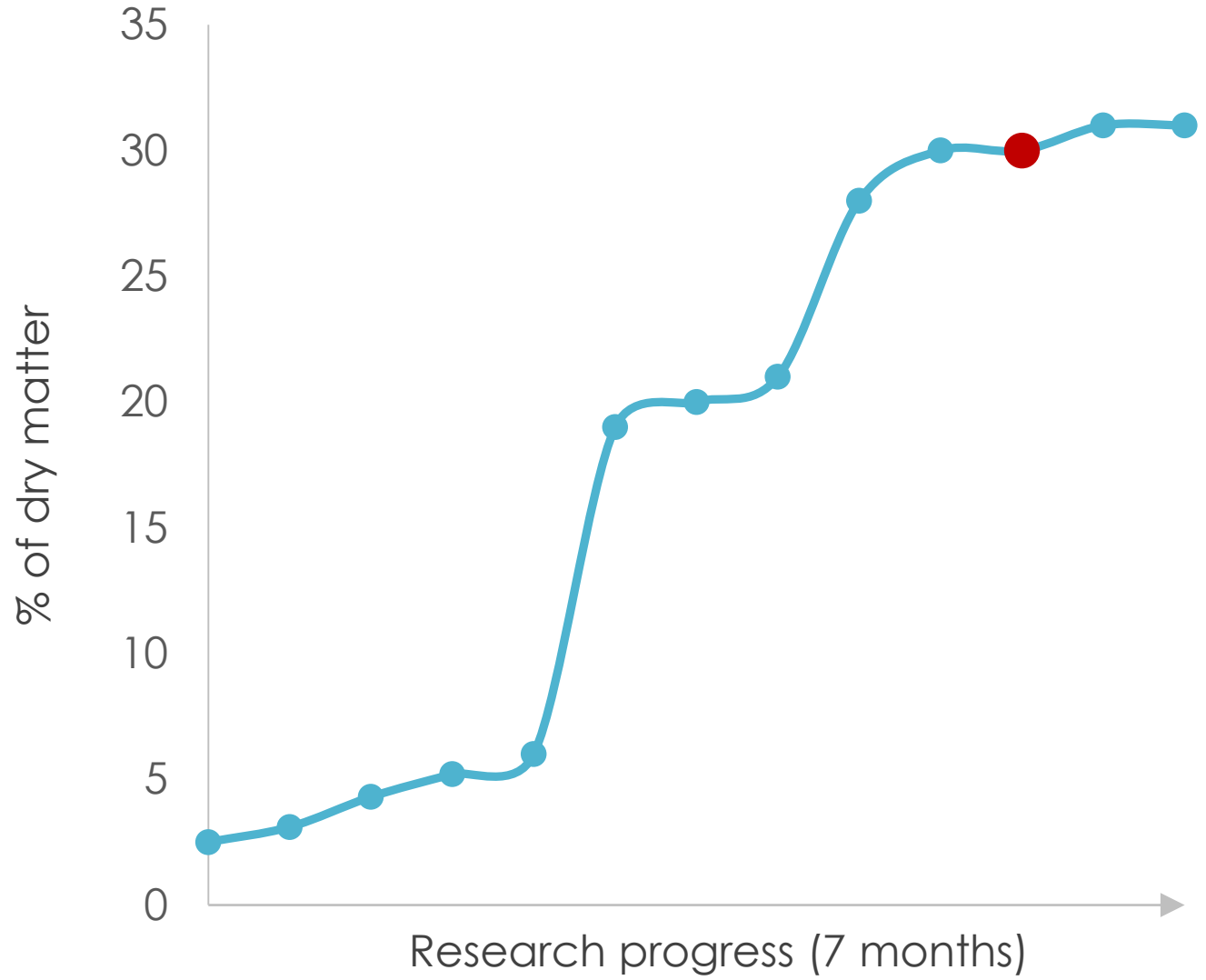
Composition of protein enriched powders



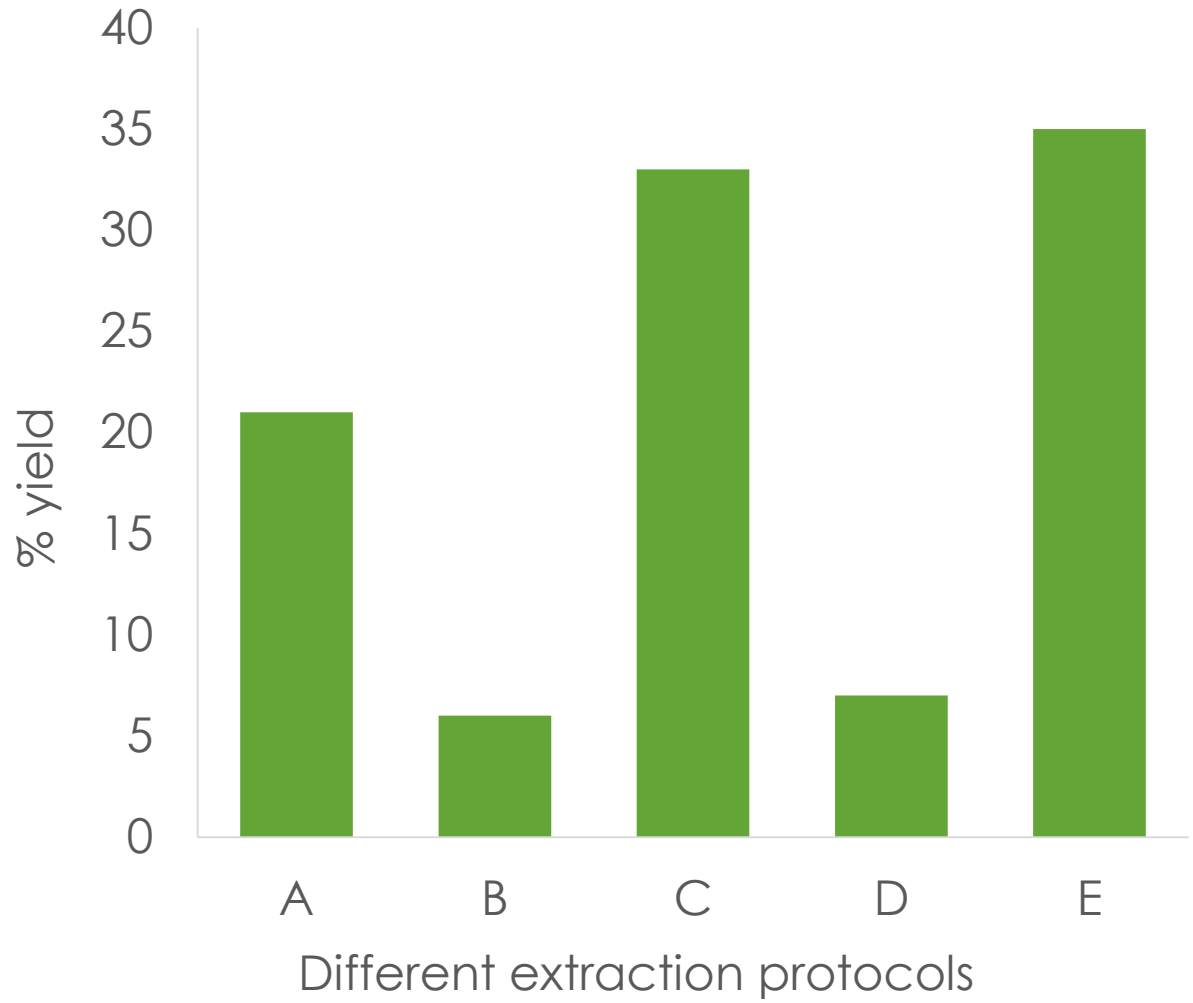
A: food grade extraction protocol

B-E: non food grade extraction protocols

Improvement of %protein in extract



Protein extraction yield



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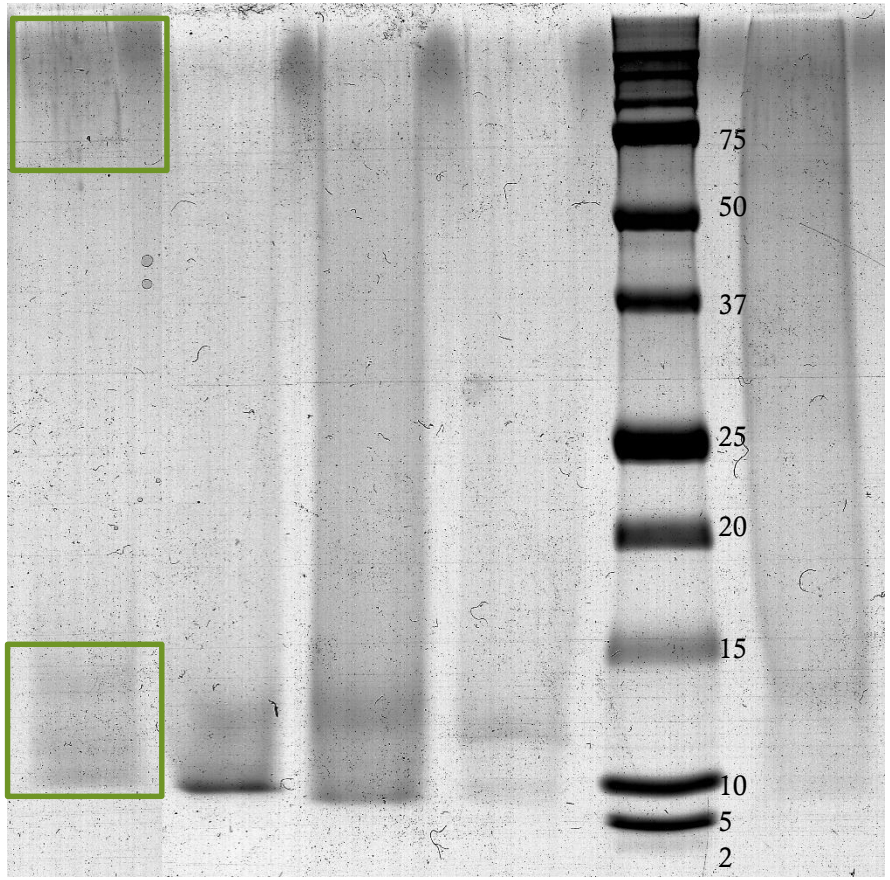

Conclusions

- Algae consist of a wide range of nutrients.
- Many of these nutrients have significant importance in human nutrition and great economic potential for the food industry.
- **Establishing an offshore facility for algae cultivation will boost the development and utilization of this renewable and sustainable source for nutrients.**

Acknowledgements

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Thank You

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