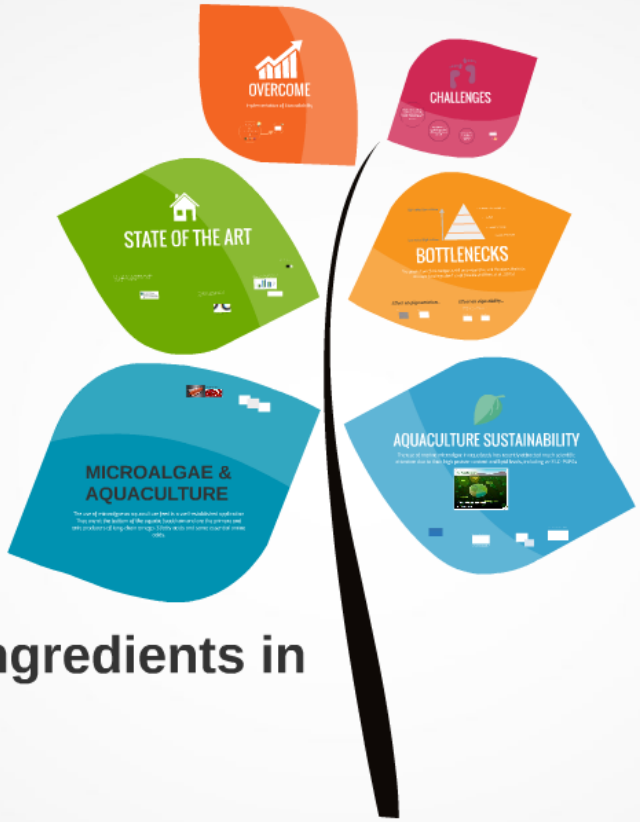
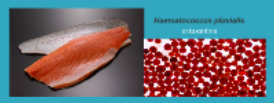
Microalgae biomass as ingredients in aquafeeds

Francesca Tulli
UNIVERSITÀ DEGLI STUDI DI UDINE
Dipartimento di Scienze Agroalimentari, Ambientali e Animali



Microalgae biomass as ingredients in aquafeeds

Francesca Tulli
UNIVERSITÀ DEGLI STUDI DI UDINE
Dipartimento di Scienze Agroalimentari, Ambientali e Animali

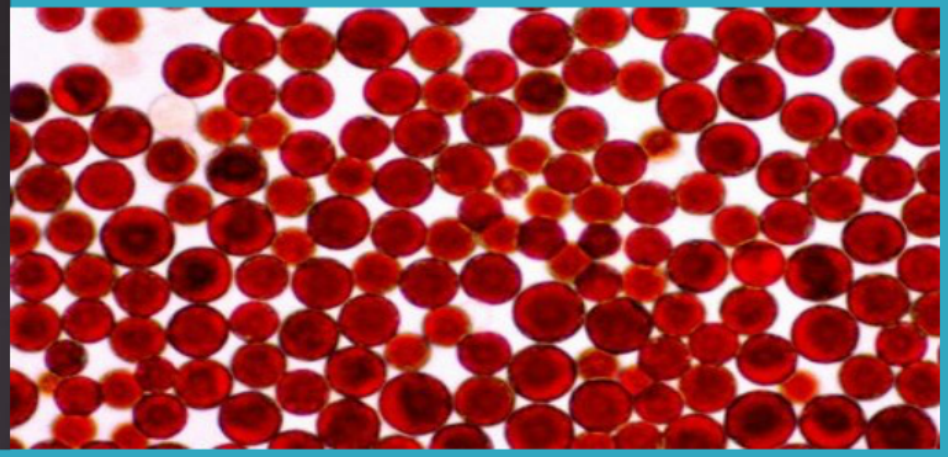


MICROALGAE & AQUACULTURE

The use of microalgae as aquaculture feed is a well-established application They are at the bottom of the aquatic foodchain and are the primary and only producers of long-chain omega-3 fatty acids and some essential amino acids.

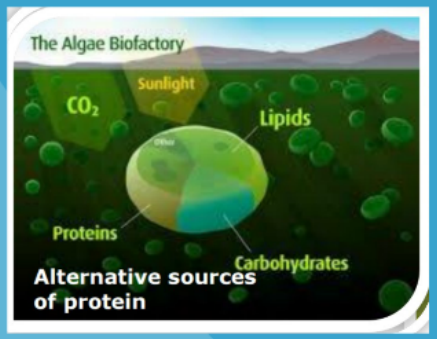
Haematococcus pluvialis

astaxantina



AQUACULTURE SUSTAINABILITY

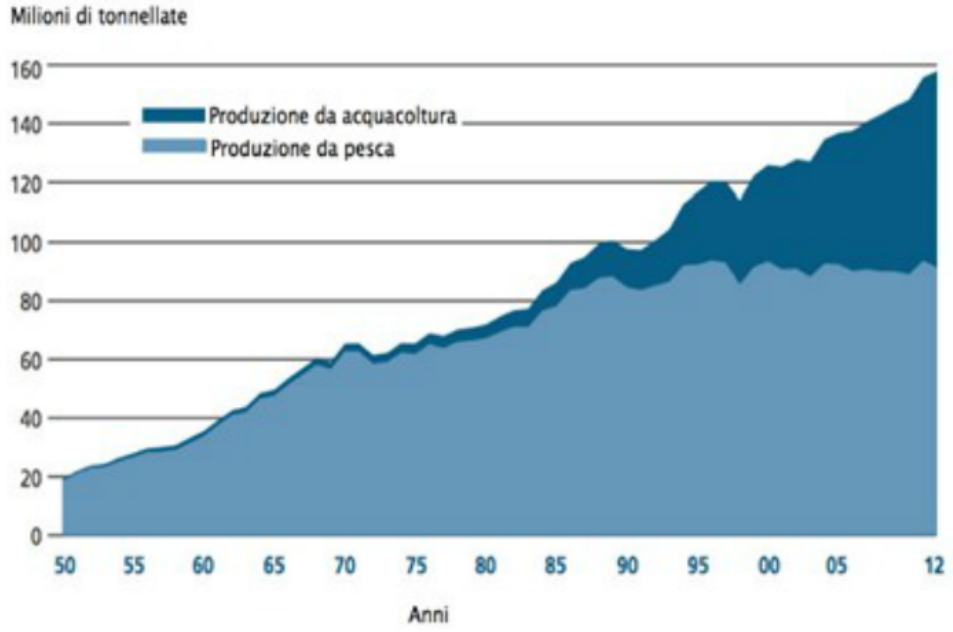
The use of marine microalgae in aquafeeds has recently attracted much scientific attention due to their high protein content and lipid levels, including w-3 LC-PUFAs

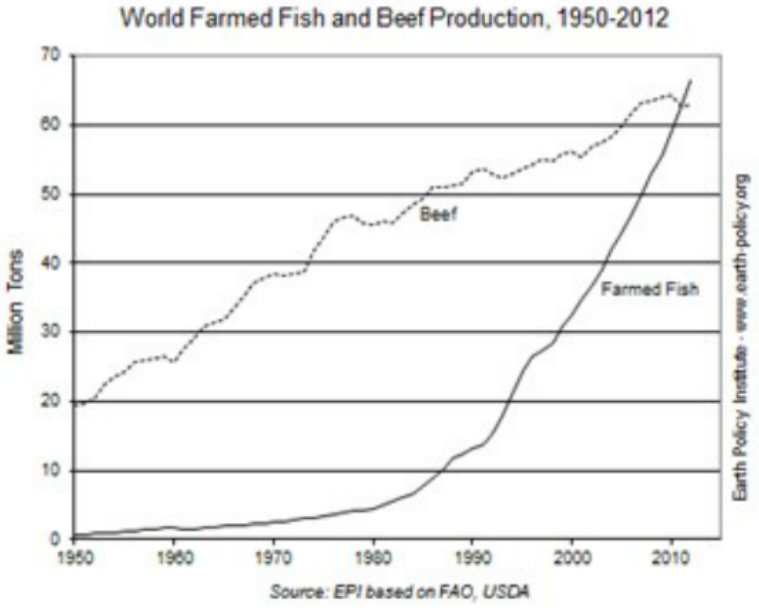


	CP %	EE %	Ash %	GE MJ/kg
Fish meal	63,0	11,0	15,8	20,1
Mais gluten	62,0	5,0	4,8	21,3
Soybean meal	44,0	2,2	6,1	18,2
Wheat meal	12,2	2,9	1,6	16,8
Nostoc sp.	63,4	2,5	4,5	22,6
Artrosphira sp.	61,5	1,0	7,0	20,8
Chlorella sorokiniana	49,2	1,2	7,1	21,5
Nannochloropsis oculata	42,2	3,8	14,6	21,9
Tisochrysis lutea	40,7	16,1	14,7	22,4
Phaeodactylum tricornutum	37,0	2,1	16,3	19,2
Porphiridium cruentum	26,9	0,8	36,0	12,5
Tetraselmis suecica	18,8	2,1	16,4	17,1

The growth rate in farmed food fish production from 1980 to 2010 far outpaced the growth rate for the world population (1.5%), resulting in average annual per capita consumption of farmed fish rising by almost seven times, from 1.1 kg in 1980 to 8.7 kg in 2010 (FAO, 2012).

Aquaculture annual rate increase : 9,2%





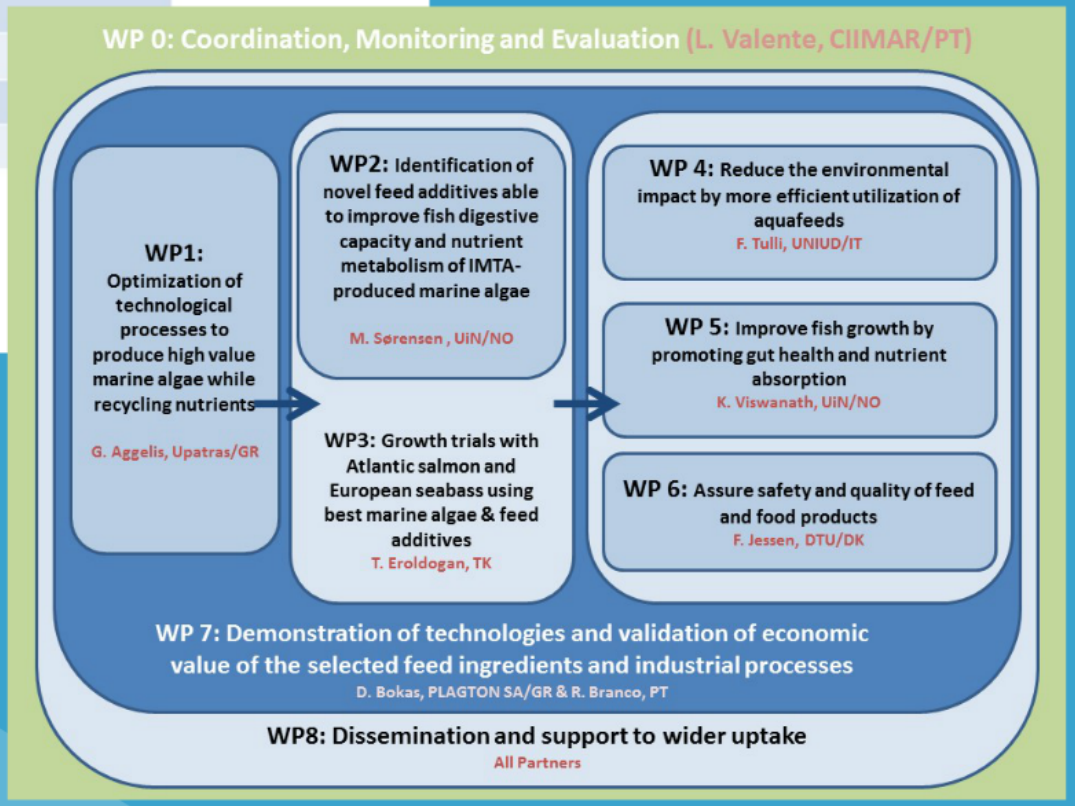
The growth of aquaculture fish production should lead to better market opportunities for algae to replace aquaculture feeds

MARINALGAE4aqua

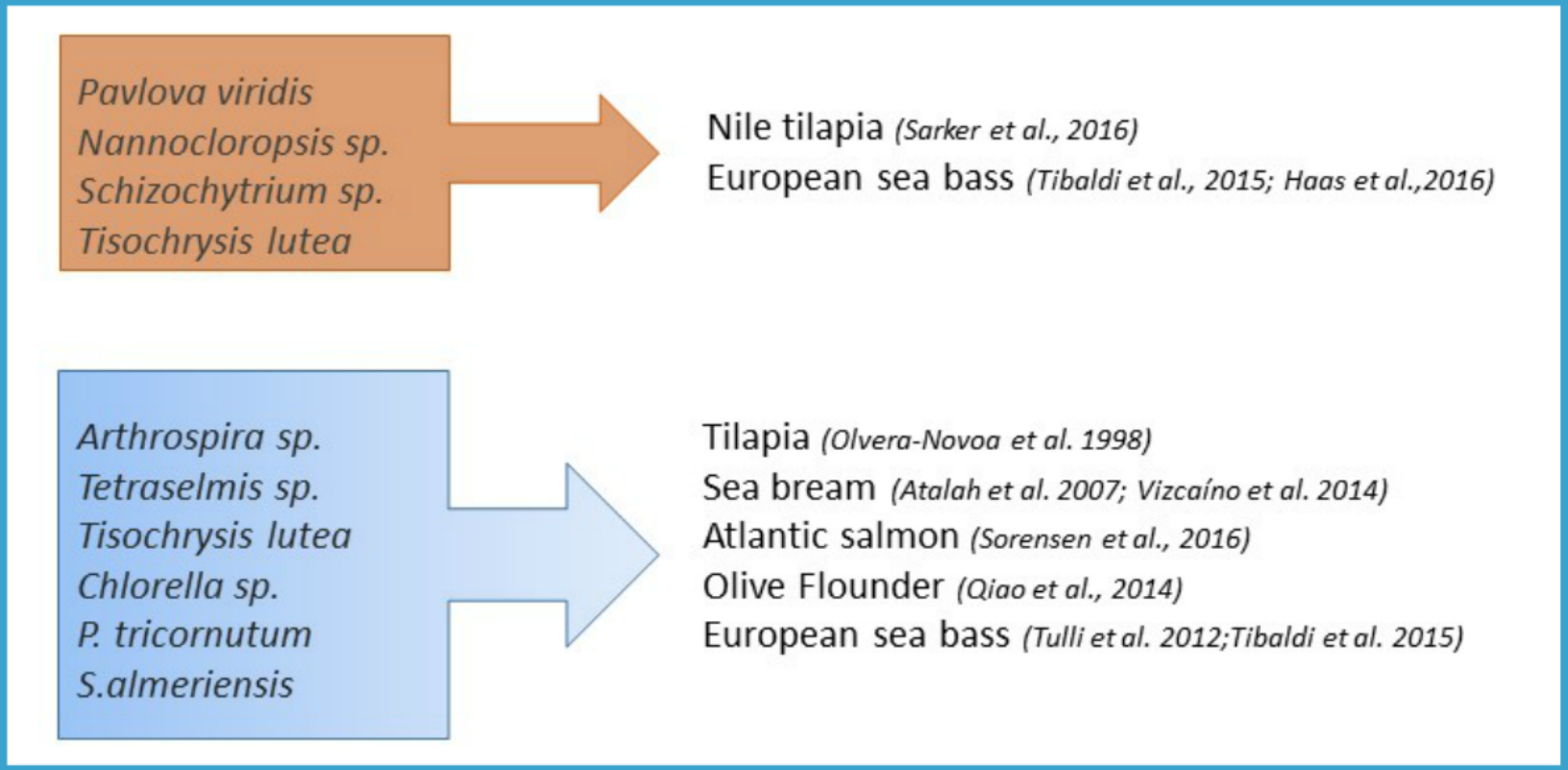
launched July 29, 2016

Improving Bioutilisation of Marine algae as sustainable feed ingredients to increase efficiency and quality of aquaculture production

Partner Country	Institution	Responsible	Contact	Budget (k€)
Portugal	CIIMAR	Luísa M.P. Valente	lvalente@icbas.up.pt	250
Norway	UiN	Kiron Viswanath	Kiron.Viswanath@uin.no	
Denmark	DTU	Flemming Jessen	fjes@food.dtu.d	
Greece	PLAGTON SA	Dimitris Bokas	dimitris_bokas@yahoo.com	
France	FEAP	Cortney Hough	courtney@feap.info	
Italy	UNIUD	Francesca Tulli	francesca.tulli@uniud.it	



Recently several studies have already investigated the use of dried microalgal products in formulated fish feed in order to substitute fish oil and/or fish meal.



STATE OF THE ART

Sea bass growth, feed utilization and quality traits of edible portion resulted not affected by the dietary inclusion of *T. suecica* to replace 20 % fish protein

Effect of the Inclusion of Dried Tetraselmis suecica on Growth, Feed Utilization, and Fillet Composition of European Sea Bass Juveniles Fed Organic Diets

A dietary inclusion of dried T- iso gallbana to replace up to 20% protein and 36 % lipid from marine resources, did not adversely affect sea bass growth performance and feed utilization over 12 weeks not sensory evaluation using triangle test on cooked fillets

Aquaculture

Growth performance and quality traits of European sea bass (D. sarrasa) fed diets including increasing levels of Nannochloropsis sp. (T-ISO) biomass as a source of protein and n-3 long chain PUFA in partial substitution of fish derivatives

A blend of dried T-iso and T. suecica to replace up to 45% protein from marine resources and pro-diag up to 20% total dietary lipid, did not adversely affect sea bass growth performance and feed utilization

Sea bass growth, feed utilization and quality traits of edible portion resulted not affected by the dietary inclusion of *T. suecica* to replace 20 % fish protein

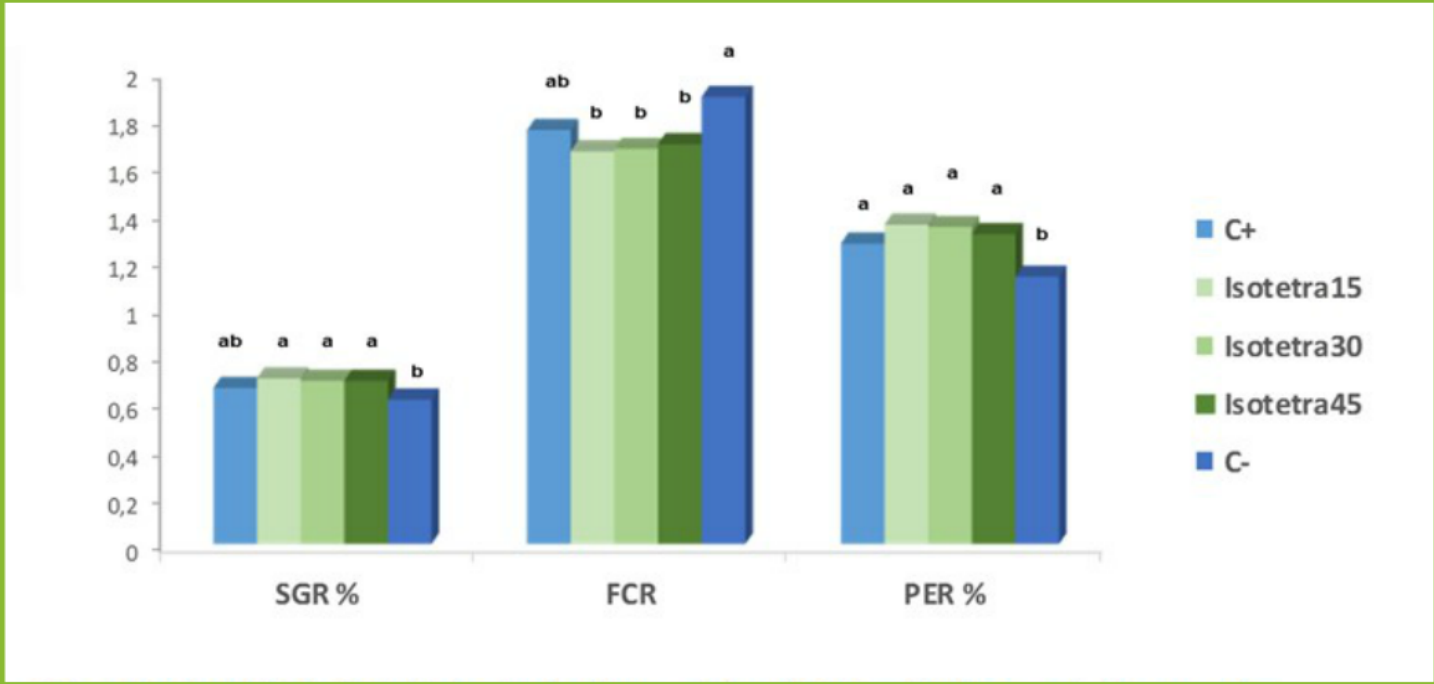
A dietary inclusion of dried T- *Iso galbana* to replace up to 20% protein and 36 % lipid from marine resources, did not adversely affect sea bass growth performance and feed utilization over 12 weeks nor sensory evaluation using triangle test on cooked fillets

Aquaculture
Volume 440, 1 April 2015, Pages 60–68

Growth performance and quality traits of European sea bass (*D. labrax*) fed diets including increasing levels of freeze-dried *Isochrysis* sp. (T-ISO) biomass as a source of protein and n-3 long chain PUFA in partial substitution of fish derivatives

Tibaldi E., Chini Zittelli G., Parisi G., Bruno M., Giorgi G.,Tulli F., Venturini C., Tredici M.R., Poli B.M.

A blend of dried T-*Iso* and *T. suecica* to replace up to 45% protein from marine resources and providing up to 20% total dietary lipid, did not adversely affect sea bass growth performance and feed utilization



Biol. Mar. Mediterr. (2016), 23 (1): 146-149

F. Tulli, M. Bruno, M. Messina, G. Cardinaletti, G. Giorgi[1], I. Galgani[1], M.R. Tredici[1], G. Chini Zittelli[2], B.M. Poli[1], E. Tibaldi

*RESPONSE OF EUROPEAN SEA BASS (*DICENTRARCHUS LABRAX*) TO DIETS INCLUDING MARINE MICROALGAE BIOMASS AS SUSTAINABLE INGREDIENTS*

The flesh of fish fed diets including a blend 2:1 of T-Iso and T. suecica meets the consumers' need for PUFA w3 if 200g are consumed twice a week, as for fish fed a FM based diet diet (EFSA, 2010)

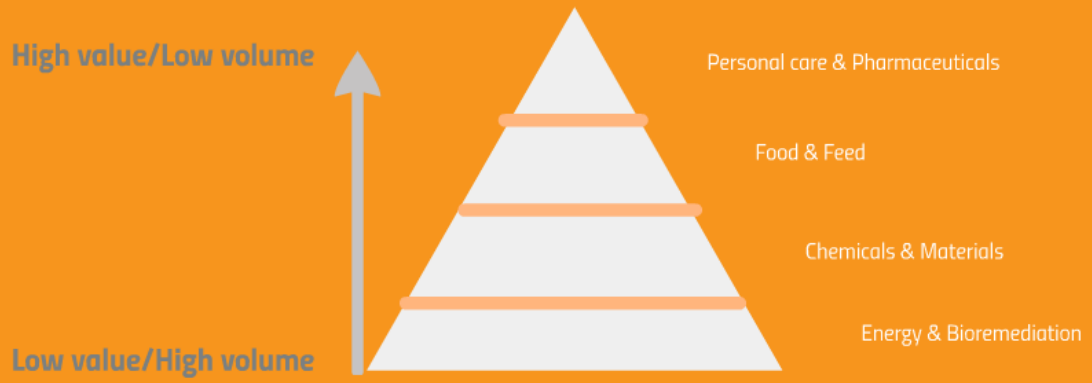
Poli B.M., Bruno M. Chini Zittelli G., Giorgi G., Galigani I., Tredici M.R., Tibaldi E.

Growth and Body Composition of Sea Bass Fed Diets Including Graded Levels of a Blend of Two Marine Microalgae in Low Fish Meal/Oil Diets

WEFTA 2013

43rd WEFTA Meeting, 9-11 October 2013, Tromsø, Norway

WEFTA



BOTTLENECKS

The production of microalgae is still very expensive, and therefore, their use as major feed ingredient is not feasible yet (Haas et al., 2015)

Effect on pigmentation...

Effect on digestibility...

Effect on pigmentation...

Skin

Tulli et al., 2012

Flesh

	Diets		
	Iso0	Iso7	Iso14
Dorsal fillet			
L*	27,57	28,25	29,29
a*	-5,57*	-3,87	-3,56
b*	3,64*	6,43	5,76
Chroma	6,73	7,84	7,2
Hue	147,1*	123,6	127,1

Tibaldi et al., 2015

Skin

Tulli et al., 2012

Flesh

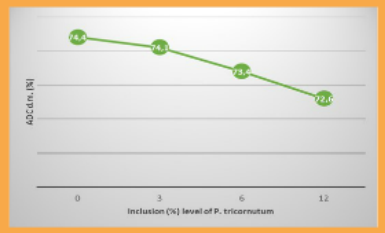
	Diets		
	Iso0	Iso7	Iso14
Dorsal fillet			
L*	27,57	28,25	29,29
a*	-5,57*	-3,87	-3,56
b*	3,64*	6,43	5,76
Chroma	6,73	7,84	7,2
Hue	147,1*	123,6	127,1

Tibaldi et al., 2015

Effect on digestibility...

A reduction in nutrient and energy digestibility with inclusion level of algae in the feed has been observed (Sorensen et al., 2016; Tibaldi et al., 2015; Tulli et al., 2012)

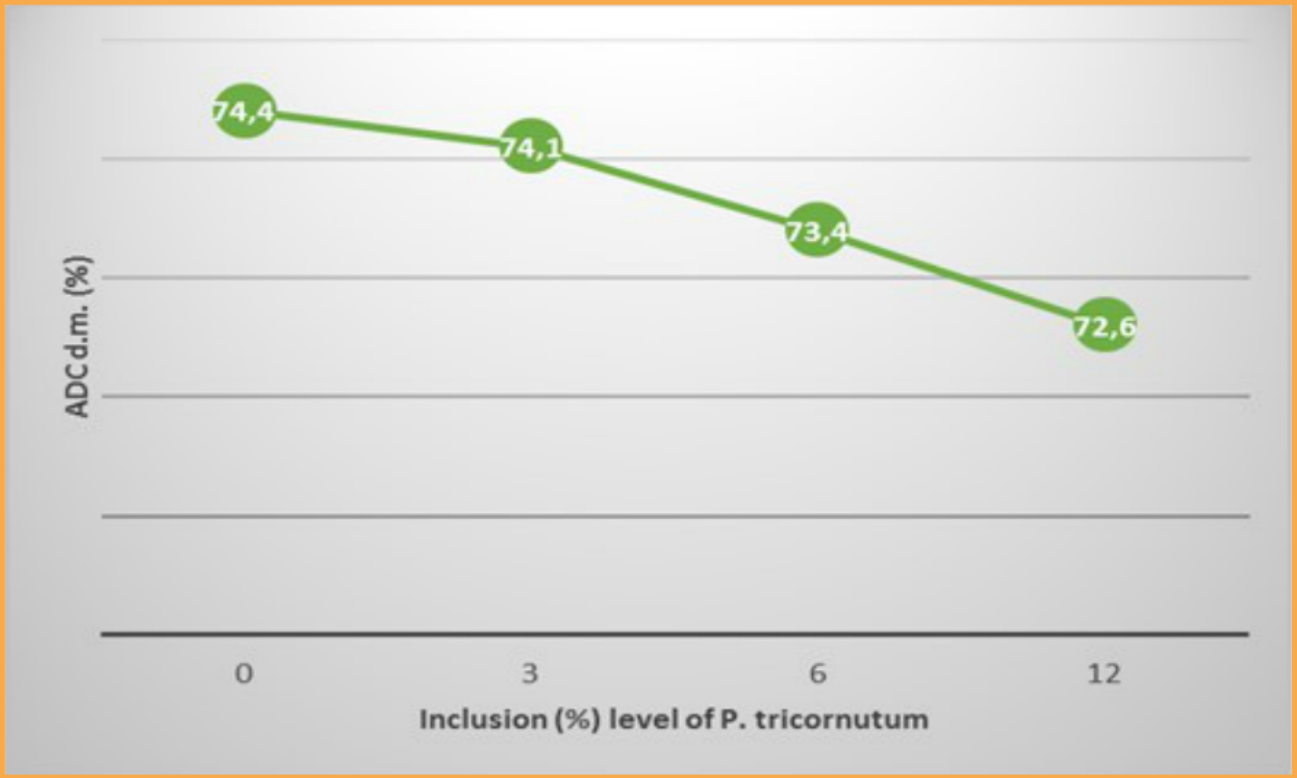
Effects of different level of whole cell of *P. tricornutum* on apparent digestibility in salmon *(da Sorensen et al., 2016)*



Ingredient Apparent Digestibility (ADC) of *Arthrospira*, *Chlorella* and *Schizochytrium* for tilapia *(Sarker et al., 2016)*

	ART	CHL	SCI
ADC %			
Dry matter	79,7	73,4	81,8
Protein	86,1a	80,0b	81,7b
Lipid	94,5b	94,4b	97,9a
Ash	68,5	56,6	65,9
Fiber	83,3a	57,5c	70,6b
Energy	86,3a	83,9b	86,5a

Effects of different level of whole cell of *P. tricornutum* on apparent digestibility in salmon *(da Sorensen et al., 2016)*



Ingredient Apparent Digestibility (ADC) of *Arthrospira, Chlorella* and *Schizochytrium* for tilapia *(Sarker et al., 2016)*

	ART	CHL	SCI
ADC %			
Dry matter	79,7	73,4	81,8
Protein	86,1a	80,0b	81,7b
Lipid	94,5b	94,4b	97,9a
Ash	68,5	56,6	65,9
Fiber	83,3a	57,5c	70,6b
Energy	86,3a	83,9b	86,5a

OVERCOME

Implementation of bioavailability

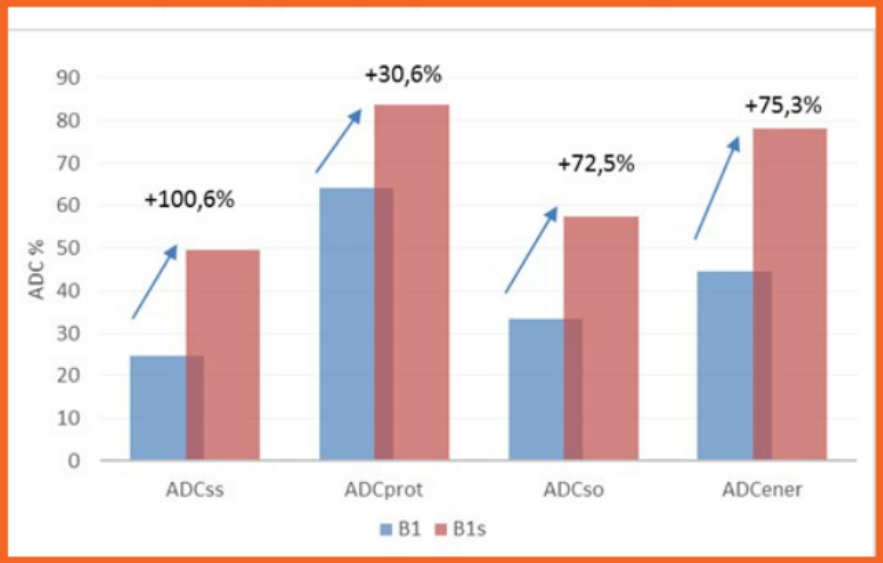
Chlorella sorokiniana, also at limited dietary inclusion level (12%), results in a reduction of nutrient digestibility in sea bass

Does the nutrient bioavailability is limited by cell wall ?

Physical treatment

88% Basal Diet + 12 % Chlorella = Test Diet B1 & B1s

ADC of nutrients and energy of the ingredients



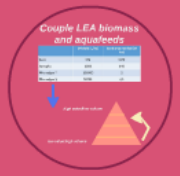
The post production treatment (diet B1s) significantly increased the in vivo digestibility of *Chlorella sorokiniana* (diet B1)

CHALLENGES

Selection of post production treatments economically feasible and suitable with the industrial mass production processes

Development of modified microalgal cell lines with reduced cell wall

Explore the potential of microalgae as functional ingredients in aquafeeds



Selection of post production treatments economically feasible and suitable with the industrial mass production processes

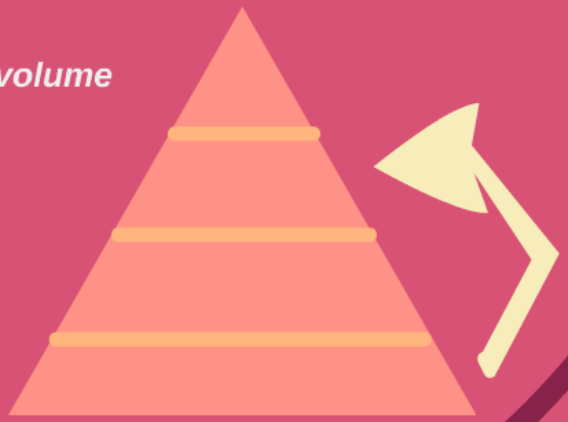
Development of modified microalgal cell lines with reduced cell wall

Explore the potential of microalgae as functional ingredients in aquafeeds

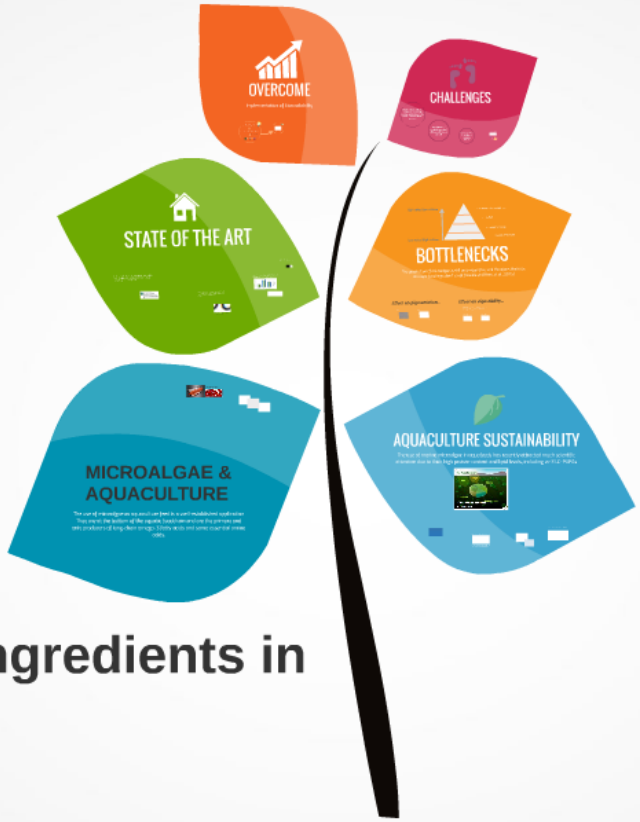
Couple LEA biomass and aquafeeds

	Oil yield (L/ha)	Land area needed (M ha)
Corn	172	1540
Jatropha	1892	140
Microalgae *	136900	2
Microalgae §	58700	4,5

high value/low volume



low value/high volume



Microalgae biomass as ingredients in aquafeeds

Francesca Tulli
UNIVERSITÀ DEGLI STUDI DI UDINE
Dipartimento di Scienze Agroalimentari, Ambientali e Animali

Hanno collaborato alle ricerche:
Tiziana Bongiorno
Massimiliano Bruno
Gloriana Cardinaletti
Graziella Chini Zittelli
Gianluca Giorgi
Maria Messina
Alberto Niccolai
Giuliana Parisi
Bianca Maria Poli
Emilio Tibaldi
Mario Tredici

francesca.tulli@uniud.it