Dietary Essential Oils Supplementation: A Powerful Tool to Minimize Nitrogen Losses

Rui Gonçalves, Vera Rodrigues, Rita Colen,
Laura Ribeiro, Gonçalo Santos and Jorge Dias

Several trends put contradictory pressures on the aquaculture industry. Reliance on scarce and costly raw materials such as fishmeal and the optimal use of alternative ingredients constitute a main challenge in aquaculture. Consumer awareness about environmental sustainability encourages producers to improve production performance through sustainable aquaculture practices. However, the use of less costly protein sources and low-nutrient dense diets most likely leads to lower protein digestibility, higher amino acid imbalance, higher carbohydrate and fiber content in feeds. Consequently, this can lead to inefficient nutrient use, resulting in increased feed usage, greater susceptibility to disease and higher ammonia emissions — raising production costs and increasing the ecological footprint.

Improving Gut Performance Is Key

It is no secret that optimum animal performance encompasses a number of factors, including genetic characteristics of the species, diet quality, environmental conditions and absence of disease outbreaks. Add to this competitive industry pressure and the need for efficient use and/or replacement of increasingly expensive raw materials, and the picture becomes even more complex. A focus on good gut performance and gut health can help to successfully navigate this large set of considerations and set the foundation for better growth.

Phytogenic feed additives, consisting of herbs, spices, essential oils and extracts have gained considerable attention as an answer to these challenges. The active ingredients, such as phenols and flavonoids, can exert multiple effects in animals, including improvement of feed conversion ratio (FCR), digestibility, growth rate, reduction of nitrogen excretion and improvement of the gut microbiota and health status. Examples of these ingredients with major active compounds are provided in Table 1.

How Phytogenics Work

Phytogenics can stimulate digestive secretions, increase villi length and density and increase mucous production through an increase in the number of globlet cells. Through different strategies such as matrix-encapsulation, volatile essential oils can be stabilized and may remain active throughout a greater section of the gastrointestinal tract (GIT), thus ensuring that positive effects are not only restricted to a smaller GIT section.

Do Phytogenics Work on Marine Species?

Phytogenics have been successfully used in pigs, cows and broiler chickens, among others, and have great potential for fish aquaculture due to various beneficial biological effects, such as growth promotion, gut function improvement, appetite stimulation, antioxidant effects, and antibacterial, antiparasitic, antistress, and anesthetic activities (Franz *et al*. 2010, Reverter *et al*. 2014). Although the positive effects of phytogenics are broadly accepted for freshwater fish performance such as tilapia *Oreochromis mossambicus* and trout *Oncorhynchus mykiss* (Karásková *et al*. 2015), the beneficial properties and efficacy of phytogenic essential oils for marine fish species is still scarce. Recently we assessed the effect of a commercial blend (Digestarom®) of anise (*Pimpinella anisum*), citrus (*Citrus sinensis*), and oregano (*Origanum vulgare*) essential oils and its encapsulation in a plant protein-rich diet on the growth performance, nutrient utilization and protein digestibility of juvenile seabream (Rodrigues *et al*. 2018).

Reduced Fishmeal Content vs. Feed Efficiency

Three isonitrogenous (crude protein, 45.4 percent DM), isolipidic (18.5 percent DM), and isoenergetic (gross energy, 21.4 kJ/g DM) diets were formulated. The control diet (CTRL diet) included

(continued on page 64)

TABLE 1. Important constituents of selected essential oils (adapted from Tisserand and Young 2014).

Name (Botanical name)	*Source*	*Important constituents*
Anise *(Pimpinella anisum)*	Seeds	trans-anethole, methylchavicol, anise aldehyde
Caraway *(Carum carvi)*	Seeds	carvone, limonene
Oregano *(Origanum vulgare)*	Leaves	carvacrol, thymol, p-cymene
Peppermint *(Mentha arvensis)*	Leaves	menthol, isomenthone, limonene
Rosemary *(Rosmarinum officinalis)*	Leaves	1-8-cineol, α- and β-pinene, borneon
Thyme *(Thymus vulgaris)*	Leaves	thymol, p-cymene, carvacrol

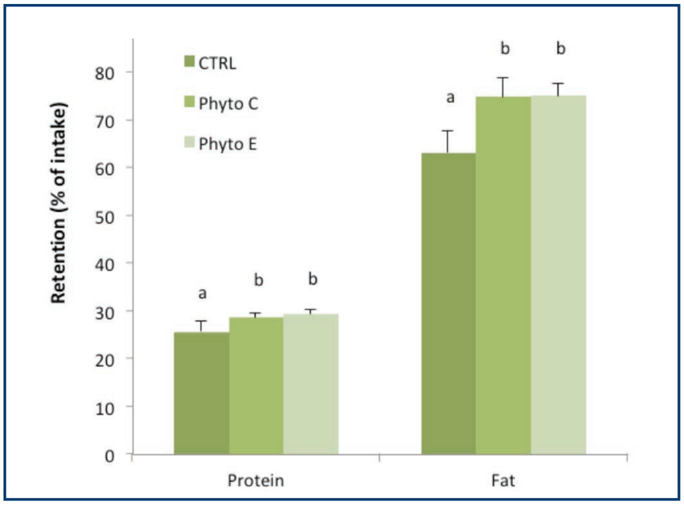

FIGURE 1. *Protein and fat retention in gilthead seabream fed the three experimental diets for 63 days. Bars are means ± s. d. (n = 3). Different letters above bars denote significant differences (Tukey's HSD, P <0.05). CTRL – control diet (Rodrigues* et al. *2018).*

practical ingredients that fulfilled the nutritional requirements of seabream juveniles, low levels of marine-derived protein (19 percent), and high levels of plant-derived protein (pea protein concentrate, soybean meal, wheat gluten and corn gluten) (Table 2). The diet was supplemented with selected essential amino acids and inorganic phosphorus to avoid nutritional deficiencies. Two additional experimental diets were formulated based on the CTRL diet: a commercial blend of anise, citrus, and oregano essential oils[1] at 1.2 g/kg (diet Phyto C), and a similar blend in encapsulated form[2] at 0.2 g/kg (diet Phyto E). Triplicate groups of 20 seabream juveniles, with a mean initial body weight of 28 ± 2 g were fed one of the three experimental diets for 63 days. Fish were grown in 100-L circular plastic tanks supplied with flow-through seawater at 24 ± 2 C and dissolved oxygen levels above 7 mg/L, in a 12 h light - 12 h dark cycle.

Maximization of Protein and Fat Retention and Reduction of Nitrogenous Losses

Voluntary feed intake was not affected by the different dietary supplementations, suggesting that were no differences in feed palatability among diets due to the presence of the essential oils. The different dietary supplementations had similar effects on FBW, daily weight gain, SGR, VFI, FCR, and PER of seabream juveniles (Table 3). Moreover, the ADC of dry matter and protein was not affected by the different dietary supplementations.

Protein and fat retention (Fig. 1) and N budget (Fig. 2) were calculated based on weight gain, feed intake, ADC, and whole-body composition. Both Phyto C and Phyto E diets significantly enhanced fat retention, whereas only Phyto E significantly enhanced protein retention. Daily nitrogen gain was similar among dietary treatments (0.37 to 0.38 g N/kg/day; P = 0.90), but metabolic and fecal nitrogenous losses were somewhat lower in fish fed Phyto E (metabolic loss: 0.81±0.01 g N/kg/day; fecal loss 0.09±0.01 g N/kg/day) than CTRL (metabolic loss: 1.00±0.09 g N/kg/day; fecal loss 0.11±0.01 g N/kg/day) diet.

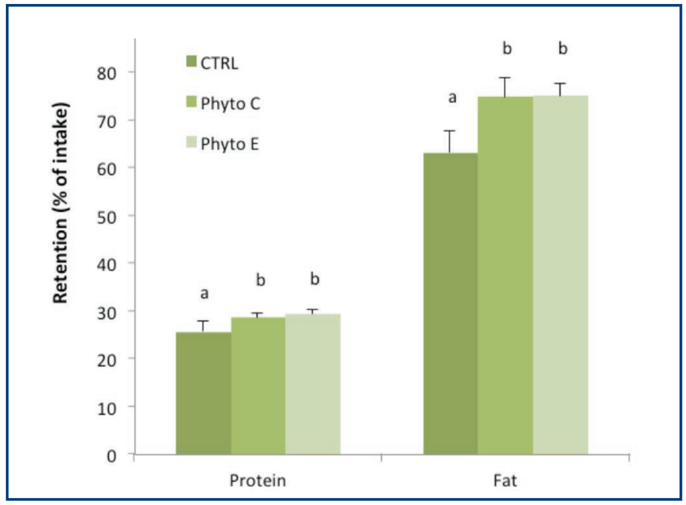

FIGURE 2. *Daily nitrogen (N) budget in gilthead seabream fed the three experimental diets for 63 days. Bars are means ± s. d. (n = 3). N gain = final carcass N content – initial carcass N content. Fecal N loss = crude N intake x (100 – ADC Nitrogen). Metabolic N losses = digestible N intake – N gain. Different letters within bars denote significant differences (Tukey's HSD, P <0.05) among treatments for fecal N losses and metabolic losses. n.s. – non-significant (P >0.05) (Rodrigues* et al. *2018).*

Conclusion

This research indicated that adding a commercially available blend of anise, citrus, and oregano essential oils to a low FM diet positively affected protein and fat retention, and reduced nitrogenous losses. No significant differences were observed on performance and digestive processes of juvenile seabream, regardless of whether the encapsulated formula was used or not, although the short experimental period may contribute to the lack of statistical differences.

Dietary supplementation of a low FM diet with the phytogenic essential oils tested resulted in a non-significant but notable reduction of FCR values (Table 3). In absolute terms, the reduction ranged from 9 percent in the Phyto C diet to 12 percent in the Phyto E diet, bringing some economic advantages for farmers. The FCR observed in the present study, together with the similar feed intake among experimental treatments, significantly enhanced protein and fat retention in seabream fed the two supplemented diets (Fig. 1). Protein retention can be associated with increased growth and/or low FM diet, and fat retention can be associated with increased energy. The estimated parameters associated with dietary protein utilization suggest that protein retention in seabream fed Phyto C and Phyto E was driven by decreased nitrogenous metabolic and fecal losses (Fig. 2) rather than by improved protein deposition.

Notes

Rui Gonçalves, Scientist – Aquaculture at BIOMIN
Rui.goncalves@biomin.net
Vera Rodrigues, Rita Colen, Laura Ribeiro, Gonçalo Santos, Jorge Dias

1 Digestarom® P.E.P. 1000

2 Digestarom® P.E.P. MGE 150

References

Franz, C., K. Baser and W. Windisch. 2010. Essential oils and aromatic plants in animal feeding–a European perspective. A review. Flavour and Fragrance Journal 25:327-340.

Karásková, K., P.Suchý and E. Straková. 2015. Current use of phytogenic feed additives in animal nutrition: a review. Czech Journal of Animal Science 60:521-530.

Reverter, M., N. Bontemps, D. Lecchini, B. Banaigs and P. Sasal. 2014. Use of plant extracts in fish aquaculture as an alternative to chemotherapy: current status and future perspectives. Aquaculture 433:50-61.

Rodrigues, V., R. Colen, L. Ribeiro, G. Santos, R. A. Gonçalves and J. Dias. 2018. Effect of dietary essential oils supplementation on growth performance, nutrient utilization, and protein digestibility of juvenile gilthead seabream fed a low-fishmeal diet. Journal of the World Aquaculture Society 49:676-685.

Tisserand, R. and R. Young. 2014. 2 - Essential oil composition. Pages 5-22 *In:* R. Tisserand and R. Young, editors. Essential Oil Safety (Second Edition). Churchill Livingstone, St. Louis, MO, USA.

TABLE 2. Formulation and proximate composition of the experimental diets tested in the present study.

Ingredients, %	*CTRL*	*Phyto C*	*Phyto E*
Fishmeal 70 LT	7.0	7.0	7.0
Fishmeal FAQ	7.0	7.0	7.0
CPSP 90	5.0	5.0	5.0
Pea protein concentrate	14.0	14.0	14.0
Wheat gluten	8.0	8.0	8.0
Corn gluten	5.0	5.0	5.0
Soybean meal 48	9.0	9.0	9.0
Wheat DDGS	5.3	5.3	5.3
Wheat meal	21.5	21.5	21.5
Fish oil	10.0	10.0	10.0
Rapeseed oil	3.2	3.2	3.2
Vitamin & Mineral Premix	1.0	1.0	1.0
Di-calcium phosphate	2.0	2.0	2.0
L-Lysine	1.5	1.5	1.5
DL-Methionine	0.5	0.5	0.5
Supplemental products (g/kg)			
PEP 1000[1]		1.2	
PEP MGE 150[2]			0.2

(Rodrigues et al. *2018).*

TABLE 3. Growth performance of gilthead seabream fed the three experimental diets for 63 days.

Growth performance	*CTRL*	*Phyto C*	*Phyto E*	*P-value*
IBW (g)		27.9 ± 2.1		-
FBW (g)	84.3 ± 2.2	86.8 ± 1.2	87.7 ± 2.2	0.166
Weight gain (%IBW/day)	3.15 ± 0.19	3.19 ± 0.15	3.26 ± 0.20	0.773
SGR (%/day)	1.76 ± 0.04	1.80 ± 0.02	1.82 ± 0.04	0.121
VFI (%IBW/day)	4.04 ± 0.07	3.73 ± 0.40	3.66 ± 0.31	0.317
FCR	1.28 ± 0.07	1.16 ± 0.07	1.12 ± 0.05	0.056
PER	1.83 ± 0.10	1.99 ± 0.13	2.11 ± 0.09	0.051
ADC Dry matter (%)	83.6 ± 0.4	83.6 ± 0.2	83.9 ± 0.2	0.495
ADC Protein (%)	92.3 ± 0.2	92.4 ± 0.1	92.5 ± 0.0	0.531

Values are means ± s. d. (n = 3, except ADC where n = 2). IBW – Initial body weight; FBW – Final body weight; SGR – Specific growth rate; VFI – Voluntary feed intake; FCR – Feed conversion ratio; PER – Protein efficiency ratio; ADC – Apparent digestibility coefficient. (Rodrigues et al. *2018).*