# Application of novel feed additives based on botanical extracts to improve productivity and economics in aquaculture

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## Abstract

The strong fluctuations of feed ingredient prices in combination with low market prices for shrimp are challenging the profitability of fish and shrimp farming. This has accelerated a search for alternative formulations and feed additives to improve the cost efficiency of feeding under various scenarios of ingredient cost and availability. Whereas most of the optimizations target resolving nutritional bottlenecks in the formula, maintaining a stable and favorable gut microflora is potentially important to minimize the impact of disease events and to maximize digestive efficiency. The present paper illustrates the potential of phytobiotic feed additives to enhance aquaculture productivity and reduce the impact of diseases and parasites on farm economics. A number of novel feed additives has been derived from specific natural compounds (mostly derived from yeast and herbal extracts, so called "phytobiotics") capable of modulating the microflora towards a favorable composition, favoring the development of beneficial bacteria and inhibiting potentially pathogenic micro-organisms and parasites. The latter strategies have the advantage of being easily applicable at the feedmill on large volumes of feed and avoiding major adaptations of the production protocols at the farm. The efficacy of different botanical products will be illustrated with results from lab and field situations for shrimp (*Litopenaeus vannamei*), Gilthead seabream (*Sparus aurata*), Tra catfish (*Pangasius hypophthalmus*) and Nile tilapia (*Oreochromus niloticus*).

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**Introduction**

The strong fluctuations of feed ingredient prices in combination with low market prices for shrimp are challenging the profitability of fish and shrimp farming. This has accelerated a search for alternative formulations and feed additives to improve the cost efficiency of feeding under various scenarios of ingredient cost and availability. Whereas most of the optimizations target resolving nutritional bottlenecks in the formula, maintaining a stable and favorable gut microflora is potentially important to minimize the impact of disease events and to maximize digestive efficiency. Shrimp are actively "grazing" on the bottom substrate, and therefore highly exposed to exchanges of microflora between the environment and the digestive system. This increases the risk for the proliferation of an unfavorable gut microflora or frequent destabilization of the microflora, which can affect the optimal functioning of the digestive system. Furthermore, the digestive system of shrimp is the main entry port for bacterial and viral infections, which remain a major risk for the profitability of shrimp production.

A number of novel feed additives has been derived from specific natural compounds (mostly derived from yeast and herbal extracts, so called "phytobiotics") capable of modulating the microflora towards a favorable composition, favoring the development of beneficial bacteria and inhibiting potentially pathogenic micro-organisms and parasites. The ban on the use of antibiotic growth promoters in poultry and pigs, and the subsequent search for alternatives, has revealed the potential of phytobiotic products on gut health, feed efficiency, overall performance and productivity (Windisch *et al*., 2008). The evaluation of phytobiotics in aquaculture is a relatively new area of research showing promising results. Seung-Cheol *et al*. (2007) showed that the addition of different single herbal extracts (*Massa medicata*, *Crataegi fructus*, *Artemisia capillaries*, *Cnidium officinale*) or a mixture of all the herbs promoted growth and enhanced some non-specific immunity indicators of red sea bream *Pagrus major*. Among a wide variety of herbs tested against *Aeromonas hydrophila* infection in tilapia (*Oreochromis niloticus*), the ethanol extract of *Psidium guajava* was found to have the highest antimicrobial activity (Pachanawan *et al*., 2008). Citarasu *et al*. (2006) showed effects from including a combination of methanolic plant extracts in the diet of black tiger shrimp (*Penaeus monodon*) on survival and viral load during White Spot Syndrome Virus (WSSV) infection. The dietary administration to *Pangasius* catfish of a synergistic blend of

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botanical extracts with antibacterial and anti-parasitic activities resulted in improved growth and feed conversion, reduced incidence of monogenean gill parasites and improved disease resistance against two important bacterial pathogens (*Edwardsiella ictaluri* and *Aeromonas hydrophila*) in an experimental infection trial (Coutteau *et al*., 2010). The present paper illustrates the potential of phytobiotic feed additives to enhance productivity and reduce the impact of diseases on economics of shrimp farming.

**Phytobiotic growth promoter selected on its capacity to modulate the gut microflora**

Sustainable approaches to modulate the gut microflora in farmed animals include the use of selected bacteria to inoculate the gut (probiotics), specific nutrients promoting the development of selected bacterial strains (prebiotics), and specific natural compounds (mostly derived from yeast and herbal extracts, so called “phytobiotics”) capable of modulating the microflora towards a favorable composition, favoring the development of beneficial bacteria and inhibiting potentially pathogenic micro-organisms. The latter strategies have the advantage of being easily applicable at the feedmill on large volumes of feed and avoiding major adaptations of the production protocols at the farm. A synergistic blend of phytobiotics was selected for their bacteriostatic and bactericidal properties against pathogenic and potentially pathogenic bacteria *in vitro* using the disk diffusion method. This blend was capable of promoting growth significantly in healthy shrimp growing under controlled lab conditions; showing a remarkable 20% increase of weekly weight gain and 4% improvement on food conversion (Table 1).

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*Disk diffusion method to select phytobiotics with bacteriostatic and bactericidal properties against pathogenic and potentially pathogenic bacteria*

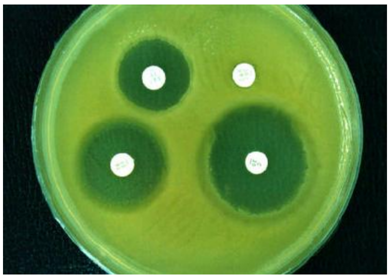

Table 1: Growth and feed utilization of *Litopenaeus vannamei* fed 56 days a control diet or the same control diet supplemented with a synergistic blend of phytobiotics (SANACORE® GM) (clear water tanks of 1 m3, 20 shrimp per tank, average from triplicate tanks ± stdev; Ceulemans & Coutteau, unpublished data).

| | **CONTROL** | **SANACORE® GM** | **% difference** | **p value** |
|---|---|---|---|---|
| Survival (%) | 87 ± 3 | 88 ± 6 | +2% | 0.678 |
| Initial weight (g) | 0.99 ± 0.01 | 0.98 ± 0.01 | -1% | 0.591 |
| Final weight (g) | 8.73 ± 0.34 | 10.29 ± 0.38 | +18% | 0.006 |
| Growth (g/week) | 0.77 ± 0.04 | 0.93 ± 0.04 | +20% | 0.006 |
| Feed Intake (%/Average Body Weight/day)* | 5.0 ± 0.2 | 5.0 ± 0.1 | - | 0.846 |
| FCR | 2.21 ± 0.05 | 2.12 ± 0.04 | -4% | 0.074 |

* feed intake/((initial weight+final weight)/200)/trial days

**Conditions and protocol of the farm evaluation**

The efficacy of phytobiotics was tested under the field conditions for shrimp production in Panama during the dry season (September 2009- February 2010; Ali *et al.*, 2010). The dry season in Panama is characterized by unstable climatological conditions, resulting in strong temperatures fluctuations which in turn affect shrimp growth and the incidence of white spot virus. During the trial, two treatments (referred to as “CONTROL” and “SANACORE GM”) were compared which only differed with regard to the

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supplementation or not of a phytobiotic growth promoter (Sanacore® GM, Nutriad, Belgium) to the standard feed used at the farm. The growth promoter was added during feed processing at the feedmill in the mixer at a dosage of 3 kg/MT of feed during the first month after stocking and at 2.5 kg/MT during the rest of the culture period till harvest.

The trial was carried out in 8 replicate ponds (3 ha each) per treatment, involving 48 ha of pond surface in area "700-B" of the CAMACO Farm (Panama). Experimental design was based on totally random blocks. Average duration of the culture period was 141 days for both treatments (trial ponds were stocked during September 16-18, and harvested during February 3-9). Shrimp used in the trial were obtained from the Larval Production Centre of CAMACO at San Carlos (Panama). They arrived to the farm in PL-10 stage and were acclimated for 10 days in a 100 Ton raceway, being stocked in PL-25 stage at $8/m^2$. Pond management followed routine production protocols of the farm, drying 1 month after last harvest and filling with filtered water using 285 μm nets. Shrimp were fed twice a day from a boat and using 4 adjusting feeding trays/Ha. Base diet formulation was "Campent 25%" from INASA Feed Plant (LARRO Feeds, Panama). Feeding included 2 mm pellets during the first 3 weeks, followed by 2.2 mm pellets till harvest. Water exchange was zero during the first month and 5-7% daily based on water quality requirements. Incoming water was filtered with 1/16" nets until day 60, followed by 1/4" nets until harvest.

Growth was estimated in weekly evaluations and feed adjustments were done based on these growth estimates. Survival and shrimp size was estimated using cast-nets on a weekly basis. Final production data at harvest were obtained from the ALTRIX processing plant, based on head-on and tails packed product. Data were analyzed under descriptive and biometrical statistics, submitting results to ANOVA, Duncan and Squared Chi tests. Production variables that were compared between treatments included survival, harvested crop yield per ha, feed conversion ratio (FCR), total feed distributed per pond, weekly growth and average harvest weight per shrimp.

## Production results

The supplementation of the phytobiotic feed additive resulted in improved values for all production parameters analysed in this study (Table 2; Fig. 1). Survival and processed crop yield (lb/ha) presented highly significant improvements ($P<0.03$), amounting to a relative increase with 24% and 35% compared to the control group, respectively. Although the other parameters did not show significant differences, important improvements were observed for the treatment receiving the phytobiotic, including 5.8% larger average shrimp size at harvest and 12% better feed conversion compared to the control group. The addition of the phytobiotic reduced drastically the variability of production results among ponds fed the same feed (average coefficient of variation between ponds for the 6 production parameters: control 18% versus SANACORE group 10%; Table 2).

Table 2: Production results after processing for control ponds and treatment ponds receiving phytobiotic supplement after 141 days of culture (average and standard deviation of 8 replicate ponds of 3ha per treatment; data from Ali *et al*., 2010).

| **Treatment** | **Survival** | **Shrimp size (g)** | **Crop Yield (kg/ha)** | **Feed (kg/pond 3ha)** | **FCR** | **Weekly Growth (g/wk)** | **Average coefficient of variation for parameters listed (CV%)** |
|---|---|---|---|---|---|---|---|
| Sanacore® GM | 55.5 ± 7.1 [a] | 16.6 ± 1.5 [a] | 735 ± 78 [a] | 4,170 ± 338 [a] | 1.91 ± 0.23 [a] | 0.825 ± 0.075 [a] | 10% |
| Control | 44.6 ± 10.6 [b] | 15.7± 2.9 [a] | 543 ± 90 [b] | 3,464 ± 396 [b] | 2.17 ± 0.39 [a] | 0.776 ± 0.137 [a] | 18% |
| ***% change Sanacore vs Control*** | +24.4% | +5.8% | +35.2% | +20.4% | -12.1% | +6.3% | -41% |
| ***P* Value** | 0.0304 | 0.4395 | 0.0004 | 0.0018 | 0.7130 | 0.3876 | --- |

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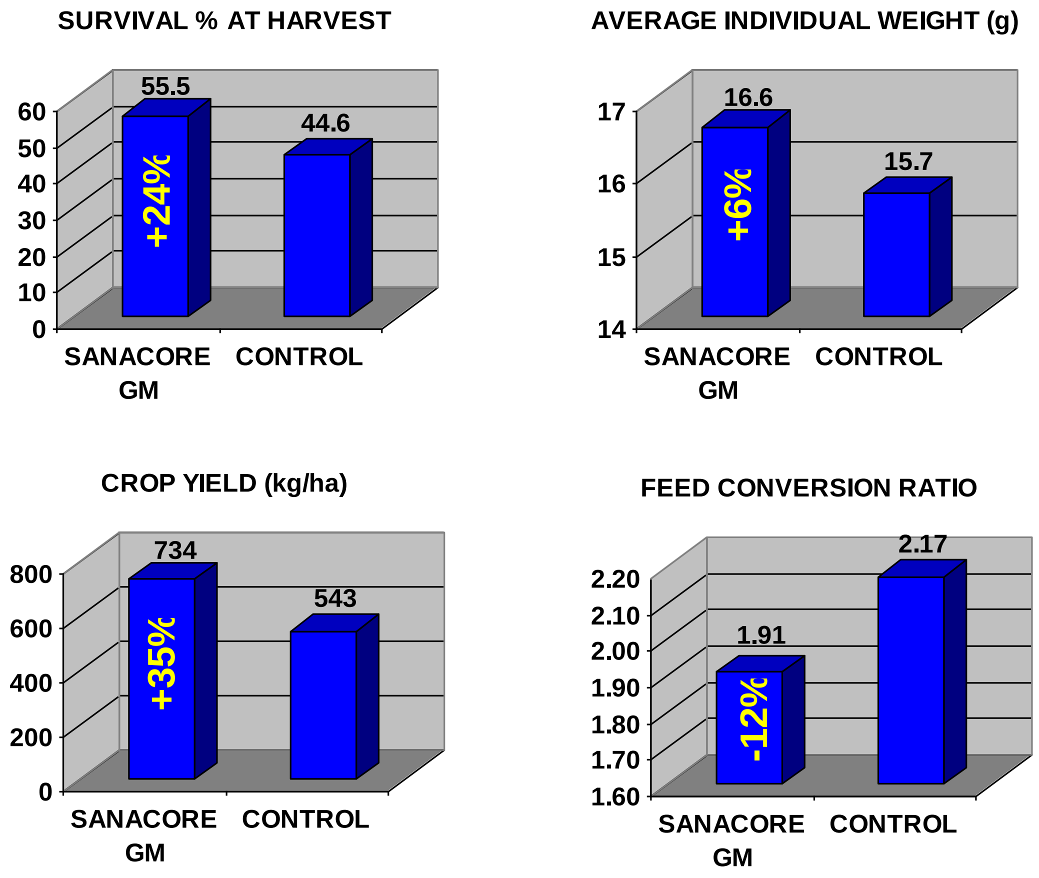
Fig 1: Production results after processing for control ponds and treatment ponds receiving the phytobiotic supplement after 141 days of culture (average and standard deviation of 8 replicate ponds of 3ha per treatment; data from Ali *et al*., 2010).

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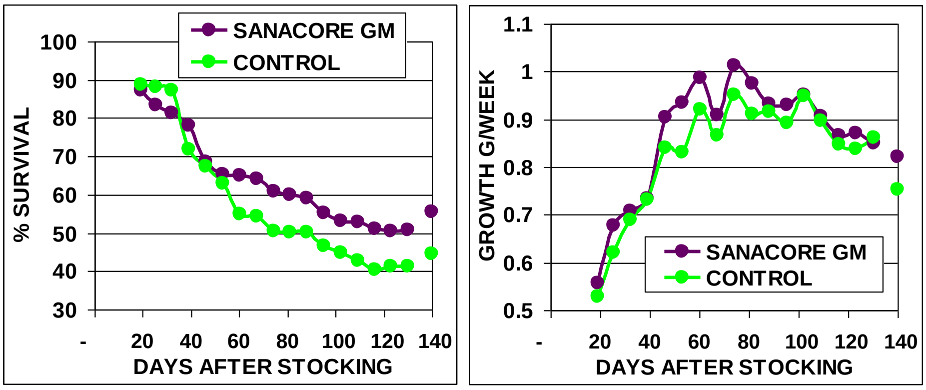
Sampling using cast nets indicated the incidence of major mortalities during the first 2 months after stocking. The phytobiotic treatment maintained an advantage on survival rate compared to the control group of approximately 10% from 2 months after stocking till final harvest (Fig. 2). Weekly estimates of average shrimp size showed periods of superior weekly weight gain throughout the production cycle for shrimp fed the phytobiotic product, with major differences observed between 50 and 100 days after stocking.

Fig. 2: Estimated survival and weekly weight gain from sampling following the standard production protocol. Data represent average from 8 replicate ponds of 3 ha each; data for 141 days of culture represent actual harvest data (; data from Ali *et al*., 2010).




The drastic effects of the phytobiotic product on survival may be related to the fact that this study was performed during the worst farming cycle of the year in Panama, when shrimp ponds are exposed to severe transitional changes in weather at the end of the wet season and the beginning of the dry season. Natural White Spot Disease outbreaks were observed during shrimp farming in both treatments under similar frequency and severity; WSSV virus was confirmed by immuno-chromatography and nested-PCR tests. The presence of a synergistic blend of phytobiotics with antimicrobial activity, possibly protected the shrimp from co-infections with opportunistic bacteria, often the major cause of mortality in WSSV-infected shrimp.

Higher crop yield per hectare due to better survival often results in slower growth due to reduced availability of natural food. Despite significantly higher survival and crop yield, a positive effect was observed of phytobiotics on growth rate and food conversion. This confirmed that the continuous dosing of natural anti-microbial activity in the feed results

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in beneficial physiological effects from stabilizing the microflora present in the digestive system.

**Conclusion**

The economic analysis showed that under the local conditions of production parameters and feed ingredient cost, the feed cost per lb of shrimp produced was reduced with 10.9% due to the application of the phytobiotic additive. The current trial showed promising results for using phytobiotics to improve productivity and reduce the impact of disease incidences on economic performance of shrimp farming. Further work is underway to validate the results of the present study, involving a higher production area and covering both dry and wet seasons.

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