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Influence of dietary β-glucan on length-weight relationship, condition factor and relative weight of pompano fish (*Trachinotus ovatus*, family carangidae)

Do-Huu Hoang

Abstract
The present research examined the effects of dietary β-glucan concentrations (Diet1: 0%, Diet 2: 0.1%, Diet 3: 0.2% and Diet 4: 0.4%) on length-weight relationship, condition factor and relative weight of pompano fish (*Trachinotus ovatus*). Fourteen fish (mean initial weight, 6.46 g; mean initial length, 62.59 mm) were randomly stocked in each tank with six replicates for each diet. After 56 days, the growth rate was significantly higher in fish fed Diet 2. Folk lengths and weights were measured and data were analyzed using logarithm transform linear equation of Log W = Log a + b Log L. Growth parameters were isometrically in fish fed Diets 2, 3 and 4 with b values were 3.107, 3.078 and 2.969, respectively, however, fish fed Diet 1 had a negative allometric growth (b = 2.672). The correlation coefficient (r) was high in all treated groups (r ≥ 0.898, $P \leq 0.001$). Condition factors (K) ranges from 3.13 to 3.18 with the highest K value was in fish fed Diet 2, significantly higher than fish fed Diet 1 (P = 0.001). It is recommended to include 0.1% β-glucan in the diet to boost growth and condition factor of pompano fish, *T. ovatus.*

Keywords: Pompano fish, *Trachinotus ovatus*, growth, length-weight relationship, condition factor, relative weight

1. Introduction
Aquaculture is one of the fastest developing sectors in the global food industry with an increase from 38.2% to 44.1%, between in 2009 and 2014. Aquaculture production and wild catch fish provided highly valuable nutrition source for humans [1]. However, it was reported that fish catch production is reducing, so aquaculture plays an increasingly important role for seafood supply [2]. On the other hand, the aquaculture development is challenge against many issues including diseases and the use of antibiotics as growth promoters. The use of antibiotics was banned as they harm the aquatic species, the environment and human health [3, 4]. Pompano fish, *Trachinotus ovatus* belonging to the family Carangidae, is distributed throughout Indo-Pacific region. This is a high value aquaculture species which is popularly cultured in Asia [5], with high market value as the special flavor and is cultured and provided to the market over the year. However, pompano aquaculture production is occasionally impacted by diseases. In order to find antibiotic replacement for sustainable aquaculture development many probiotics and prebiotics including β-glucan were proved as safety and efficient products for growth and survival boosting [6-10].

Glucan-specific receptors exist on the membranes of the phagocytic cell [11]. Also, the β-glucan administration was reported to improve immunological responses of the host, intestinal microbiota and disease resistance [12, 13] and improve growth performance of many cultured species [14]. Although some studies did not show positive effects of β-glucan on growth performance, e.g. European sea bass (*Dicentrarchus labrax*) [15], many research proved that β-glucan administration could enhance growth performance of many species including rohu (*Labeo rohita*) [16], koi carp (*Cyprinus carpio koi*) [17], large yellow croaker (*Pseudosciaena crocea*) [18], and snapper (*Pagrus auratus*) [19].

Length-weight relationship (LWR) is a powerful tool which is widely used in fish biology. As length is easier to measure, LWR can be used to calculate fish weight, based on the known length [20, 21]. LWR is impacted by different factors such as the food availability, feeding ratio [22, 23]. Furthermore, the parameters from LWR equation can also provide important information about the structure and function of a population [24]. LWR is also a valuable indicator to estimate the life history of fish in regarding to their habitats or regions [25].

Beside the LWR, condition factor (*K*) is a main parameter used in fishery study [26]. The LWR and condition factor can reflect the well-being status, feeding and physiological condition of a species. Length-weight relationship and condition factor are also important parameters to evaluate health condition [27, 28]. In addition, condition factor (*K*) can be used to estimate changes in nutritional condition, mature size, spawning size and food condition of fish [29, 30]. The *K* value is also considered as an indicator for health and general well-being of fish in relation to the environment [31], season and locations [26, 32].

Recently, many studies have proposed relative weight (*Wr*) in fisheries to evaluate the nutrition status and environmental preference for aquatic living species [33, 34]. Studies proved that *Wr* value does not depend on measurement units and *Wr* values can be compared fish at different size. Values of *Wr* falling below 100 indicating of low food availability, while *Wr* value is over 100 showing a food surplus [35].

There have been many studies on LWR and condition factor of many aquatic species and many studies on the effects of β-glucan on aquaculture species, however to the best of our knowledge, effects on length-weight relationship and condition factor of pompano have not been studied previously in Vietnam and elsewhere. Therefore, the aim of this study was to examine the effects of β-glucan diet on LWRs and condition factors of the pompano fish (*Trachinotus ovatus*) in laboratory conditions.

2. Materials and methods

2.1. Experimental design

The experiment was conducted at Institute of Oceanography, Nha Trang, Vietnam. The pompano fish, *Trachinotus ovatus* (initial length 62.59 mm ± 0.34 and initial weight 6.46 g ± 0.07) were obtained from a local hatchery and acclimated for 3 weeks and fed commercial diet 2% of their body weight. Each culture tank (350 L) were stocked with 14 fish in six replicate tanks and fed different diet for 8 weeks. At the end of the feeding trial, all fish were measured the length and weighed.

2.2. Formulated diets and feeding the fish

The basal diet formulation was used in the previous study [36-38]. The basal diet composition is in Table 1. The basal diet (Diet 1) was then supplemented with β-glucan (Marcrogard®, Biorigin) to give 0.1% (Diet 2), 0.2% (Diet 3), and 0.4% (Diet 4) of β-glucan in the diets. Ingredients were mixed and extruded into 2 mm pellets, air-dried and then stored at 4 °C until use. During the experimental, fish were hand-fed to apparent satiation twice daily (8:30 and 17:00 h).

Table 1: Composition of diets used in the experiment (crude protein: 48.6%; crude lipid: 7%)

Ingredients (%)	Diet 1	Diet 2	Diet 3	Diet 4
Fish meal	44.60	44.60	44.60	44.60
Wheat gluten	21.10	21.10	21.10	21.10
Soybean	10.40	10.40	10.40	10.40
Fish oil	3.60	3.60	3.60	3.60
Binder	1.10	1.10	1.10	1.10
Mineral premix	1.50	1.50	1.50	1.50
Vitamin premix	1.50	1.50	1.50	1.50
Corn starch	16.20	16.15	16.10	16.00
Macrogard® (β-glucans)	0	0.05	0.10	0.20
Total	100	100	100	100

2.3. Data collection

During the feeding trial, all fish were weighed and total length was measured at the beginning (day 0) and at the end (day 56). Fish were starved for 24 h prior to weighing. Number of dead fish was recorded daily.

Specific Growth rate (SGR, % d^{-1}), SGR (% d^{-1}) = 100 × (Ln Wt - Ln Wo)/t, where Wo and Wt are initial and final days of the experiment, t: cultured days. survival rate = 100 × (Nt) / No. No is the initial number of fish and Nt was number of fish at time t.

2.4. Length-weight relationship, condition factor and relative weight

The length-weight relationship (LWR) was determined by the equation: $W = a L^b$ [26, 39], where W: whole body weight (g), L: fork length (cm), *a:* constant (intercept), *b*: exponent of a length-weight relationship. The LWR equation was then transformed into a linear form: *Log* W = Log (*a*) + *b* Log (L) (*b*: slope of regression line, Log *a*: constant). The statistical significance value of regression and coefficient of determination (R^2) were also presented. The fork length was used as some experimental fish tore the tip of the tail, so fork length is more accuracy measurement than the total length. Also, pompano fish has a deeply forked caudal fin, therefore fork length is more useful [40].

The correlation coefficient (r) was obtained from the coefficient of determination (R^2) and was checked for significance using the critical value of 'R'. The degree of well-being of the cultured fish was expressed by condition factor (*K*) and relative weight (*Wr*) were calculated by the following formulas: $K = 100 \times W/L^3$ [26, 41]; $Wr = 100 \times W/Ws$ where L: body length (cm); W: body weight (g), $Ws = a L^b$, where *a* and *b* are parameters of LWR equation.

2.5. Statistical analysis

Descriptive statistics were derived using Excel (Microsoft Excel 2007) statistical functions. The analysis of covariance (ANCOVA) was performed to test the difference in length-weight relationship (LWR) of pompano fish between the diet treatments [42]. The significance of the isometric exponent (*b*) was analyzed by a function: $t_s = (b - 3) / S_b$, where t_s is the 't' student statistics test value, '*b*' is the slope, and S_b is the standard error of '*b*'. If *b* value does not significantly differ from 3, it indicates *isometric* growth; is *b* value is significantly different from 3, larger or smaller indicates *positive* and *negative allometric* growth, respectively [43]. Analysis of variance (ANOVA) was used to test the difference between growth performance, condition factor, relative weight and mean weight and mean length of pompano fish between diet treatments. One sample T-test was performed to compare relative weight (*Wr*) to hypothesized value (100). All statistic tests were executed by SPSS 19 software. When $P < 0.05$, statistical analysis was considered significant difference.

3. Results

3.1. Water quality parameters

There were no significant differences in water parameters in term of temperature, pH, NH_3/NH_4, NO_3-N and NO_2-N observed between different treatments during the feeding trial ($P \geq 0.621$).

3.2. Growth performance and mortality rate of pompano fish fed different concentrations of β-glucan after 56-day feeding trial

At day 56, β-glucan inclusion in the diets significantly influenced on the growth rate of pompano fish. The highest final weight was observed in fish fed Diet 2, with significantly higher than the weight of fish fed Diets 1 (basal) Diets 3 and 4 ($P \leq 0.002$). The final weight of fish fed Diets 1, 3 and 4 did not significantly differ ($P \geq 0.725$). The final mean length among the treatments had same trend with the final mean weight, in which length of fish fed Diet 2 was the highest, and was significantly higher than length of fish fed basal diet ($P \leq 0.022$). However, length of fish fed Diets 1, 3 and 4 did not significantly differ from each other ($P \geq 0.315$). The highest specific growth rate was in the group of fish fed Diet 2, which was significantly higher than the growth of fish fed un-supplemented diet (Diet 1) ($P = 0.020$). The growth rate of pompano fish fed Diets 4, Diet 3 and Diet 1 were not significantly different ($P \geq 0.538$). (Table 2).

Table 2: Growth performance of pompano fish fed different levels of β-glucan. SGR: specific growth rate. Data are presented as mean and SE.

	Diet 1	Diet 2	Diet 3	Diet 4
Initial Weight (g)	6.49 ± 0.10	6.60 ± 0.16	6.48 ± 0.17	6.37 ± 0.13
Initial length (mm)	63.06 ± 0.50	62.88 ± 0.60	62.42 ± 0.56	62.88 ± 0.45
Final weight (g)	39.58 ± 1.45[a]	47.91 ± 1.80[b]	40.43 ± 1.96[a]	39.90 ± 1.61[a]
Final length (mm)	107.11 ± 1.44[a]	113.46 ± 1.51[b]	107.72 ± 1.79[a]	106.89 ± 1.36[a]
SGR (% d^{-1})	2.82 ± 0.16[a]	3.18 ± 0.10[b]	2.86 ± 0.24[a]	2.78 ± 0.11[a]
Mortality rate (%)	15.58 ± 1.34	12.50 ± 1.31	12.50 ± 0.98	13.40 ± 1.51

At the end of the experiment (day 56), mortality of pompano fish ranged from 13.40% to 15.58% (Table 2). The lowest mortalities were in groups of fish fed Diets 2 and 3, which were both 12.50%, followed by the mortality of fish fed Diet 4 (13.40%). The highest mortality was observed in fish fed Diet1 (15.58%). There was no significant difference between them ($P = 0.442$).

3.3. Logarithm transform of length-weight relationship of pompano fish fed different diets

The linear model of length-weight relationship for pompano fish with logarithm transform (Log W = Log *a* + *b* Log L) resulted in high R^2 over 0.807 at the four diet treatments (Table 3). ANCOVA analysis of length-weight relationship at logarithm transformation showed that the slopes (*b* values) significantly differ between the fish fed Diet 1 compared to fish fed Diet 2, 3 and 4 ($P \leq 0.021$). However, there were not significantly different between slopes of fish fed Diets 2, 3 and 4 ($P \geq 0.214$). Student's *t*-test analysis showed that *b* value of pompano fish fed Diet 1 was significantly lower than critical value (*b = 3*), showing a negative allometric growth ($P = 0.031$). However, *b* values of the three groups of pompano fish fed Diets 2, 3 and 4 were not significantly different from critical value (b = 3), indicating isometric growth ($P \geq 0.173$). (Table 3, Figure 1).

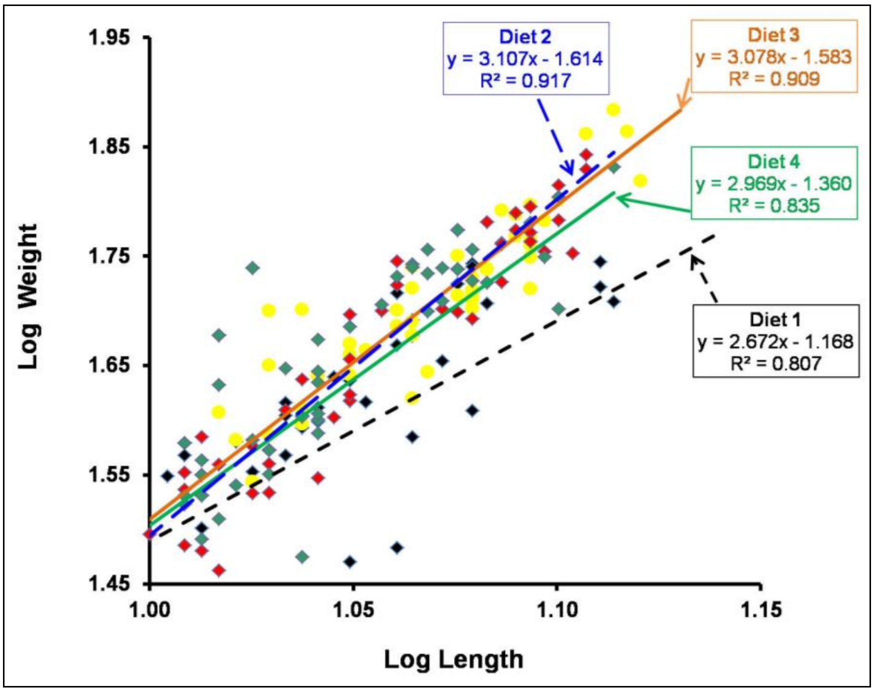

Fig 1: Length-weight relationship (logarithm transform) of pompano fish fed different concentrations of β-glucan.

Table 3: Length–weight relationship (Log W = Log a + b* Log L) of pompano fish fed different levels of β-glucan at day 56.

Treatments	*a*	*b*	SE_a	SE_b	R^2	ANOVA, F test	Sig. of regression
Diet 1	-1.168	2.672	0.171	0.672	0.807	259.549	0.001
Diet 2	-1.614	3.107	0.111	0.108	0.917	822.486	0.001
Diet 3	-1.583	3.078	0.178	0.174	0.909	314.146	0.001
Diet 4	-1.360	2.969	0.118	0.112	0.835	653.991	0.001

3.4. Condition factor (*K*) and relative weight (*Wr*) of pompano fish fed β-glucan diets

Dietary β-glucan levels significantly influenced condition factor (*K*) ($P \leq 0.001$) of pompano fish, with the highest *K* value was in group of fish fed Diet 2 ($K = 3.18$), followed by the three groups of fish fed Diets 1, 3 and 4 with the *K* value were 3.13, 3.14 respectively (Figure 2).

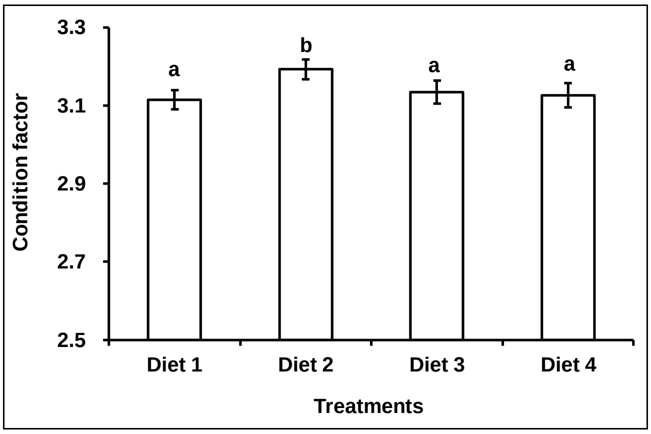

Fig 2: Fulton condition factor (*K*) of pompano fish fed different levels of dietary β-glucan. Data are presented as mean and SE.

In addition, relative weight (*Wr*) of fish among the diet treatments ranged from 98.26 to 100.37, with the highest *Wr* was in fish fed Diet 2 (100.37). However, relative weight (*Wr*) of fish in different between the diet treatments were not significantly ($P \geq 0.646$) and *Wr* values of the fish in all the diet treatments did not significantly differ from 100 ($P \geq 0.791$) (Figure 3).

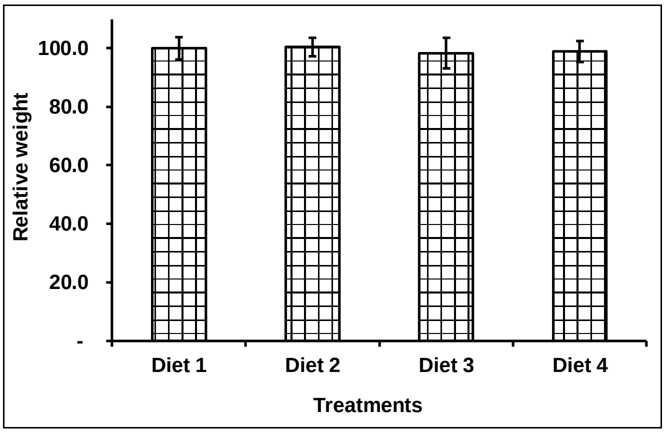

Fig 3: Relative weight (*Wr*) of pompano fish fed different levels of dietary β-glucan. Data are presented as mean and SE.

4. Discussion

This study provides useful information on the effect of dietary β-glucan supplementation on the length-weight relationship (LWR), condition factor (*K*) and relative weight (*Wr*) of pompano fish in the laboratory condition. Length-weight relationship (LWR) is popularly presented by scientists and researchers as useful tools in fishery biology [44, 45]. The parameters of LWR are beneficial to predict weight from the length, computation of condition factor, assessment of stock and estimation of biomass [45]. It was reported that LWR influenced by many factors including the presence of food, feeding ratio, gonad development, spawning period, season, sex and habitat [22, 23]. However, all of these factors were not measured in the current study. In the present study, the LWR of pompano fish were significantly correlated and the length and weight of fish were significantly influenced by the concentration of β-glucan in the diet.

In the LWR, the value of the exponent *b* provides information on the growth of pompano fish. In this study, *b* value of pompano fish fed levels of β-glucan were between 2.67 and 3.12, indicating reliable data [46]. According to Guo [47] the *b* value of pompano fish was 2.64 for male (mean weight 1332 g) and 2.78 for female (1311 g). In our study, mean weight of pompano fish fed Diets 1, 2, 3 and 4 range from 39.58 g to 47.90 g and were significantly different among the treatments, which may indicate *b* value change by nutrition supplement and the possibly the size of fish. Those results are accordance with a study done by Hossain [48], which reported *b* value is influenced by the size of animals. According to Froese [26], there are two possibilities of the *b* value of fish. When the value of *b* less than 3: 1) fish length increase faster than their body mass or 2) small individuals have a better nutrition condition. In the present study, the environmental parameters did not significantly differ between treatments, but the *b* values of pompano fish fed Diet 1 was significantly lower than critical *b* value ($b = 3$). This possibly the cause is the different size fish among the diet treatments at the end which were showed average weight of pompano fish were significantly different at the end of feeding trial. It is in accordance with Hossain [48], who states that the variation in the *b* value for the same species could be attributed to a difference in sampling, sample size or length ranges.

Condition factor (*K*) can be very important to fisheries biology. The value of *K* can be calculated from length and weight data, providing the overall condition of the fish. Also, condition factor is proposed as an indicator for health and general well-being of fish in relation to the environment [31]. High condition factor (*K*) may show suitable environmental conditions (such as habitat conditions, much prey availability) and low *K* values indicate of a low optimal environment [49]. In the present research, the *K* values of pompano fish were over one which indicates that they were cultured in good condition. However, condition factor may be influenced by the size of pompano fish. Forsatkar [50] reported that condition factor of pompano fish were 3.04 - 3.4 (fish size 63 - 67 g), while Guo [47] revealed that pompano K value were 11.47 and 14.31 for male (1332 g) and female (1311 g), respectively. In our present study, *K* value range from 3.13 - 3.18 and the mean weight of fish were 106 - 113 g. However, in the current study fork length was used, while other studies used total length of fish. In fact, in our experiment, some fish tore their tail, so using fork length were more accuracy than using total length. The accuracy of using fork length instead of total length is popular in fisheries research [40]. In addition, the *K* value was also impacted by the mature size, spawning size and food condition [29, 30], suggesting more studies or sampling on various conditions of fish.

In this study, pompano fish fed the diet inclusion of 0.1% of β-glucan showed the highest growth response and higher condition factor. In accordance to our result, dietary β-glucan boosted growth and survival in a number of aquaculture species including koi carp *Cyprinus carpio koi* [17], large yellow croaker *Pseudosciaena crocea* [18], rohu *Labeo rohita* fingerlings [16], rainbow trout *Oncorhynchus mykiss* [51] and pompano fish [36]. Also, dietary β-glucan enhanced the immune parameters of the host, gut microbiota and resistance to pathogens [12, 13]; promoted the intestinal microbial species richness and reduced the number of disease bacteria such as

Vibrio sp, in carp [52, 53] and reduced number of *Vibrio* in pompano [36]. The growth enhancement may be due to the energetic benefits obtained through β-glucan administration [18], manipulation of intestinal microbiota [54], and production of digestive enzymes by these beneficial bacteria [55], enhancement immune parameter as well as reduction the pathogen of the host [12, 13]. In the present study, immune response, intestinal enzyme and microbiota were not examined, however, improvement in growth and condition factor representing for general well-being as discuss below may request further studies on the immune response, microbiota, disease and environmental resistance capacity of pompano fed dietary β-glucan supplementation. The higher condition factor of pompano fish fed 0.1% β-glucan in the diet possibly indicate for increase health condition or well-being. Also, this shows the ability of β-glucan administration to replace antibiotic as growth promoter in pompano fish aquaculture. However, further studies should be conducted to test the effect of dietary β-glucan on immune response of pompano fish.

In the present study, the growth and condition factor of fish fed diets supplemented 0.2% and 0.4% β-glucan did not significantly differ from those in fish fed basal diet. This is in accordance with other studies which show nutrition supplementation was higher than requirement may cause adverse effects on aquatic animals [56, 57]. Similar to a previous study Do-Huu [36], the present study shows that supplementation of higher concentrations of β-glucan might diminish the growth of pompano fish.

Recently, many authors recommended relative weight (*Wr*) as it has advantages over condition factor. This is because *Wr* does not depend on measurement units and can be used to compare fish at different size and among populations [41, 49]. If values of *Wr* is below 100 indicating problems such as low food availability; while *Wr* value is over 100 showing a good food surplus [35]. In the present study, *Wr* values of pompano fish all the diet treatments including basal diet did not significantly differ from critical value (*Wr* = 100), indicating a sufficient feed providing [24]. This may also show the basal formulated diet is appropriate to use for the dietary supplementation of pompano fish. The results of *Wr* values also indicate water quality or environmental conditions in the present experiment were still adequate for pompano fish.

5. Conclusion

This study confirmed that growth rate, length-weight relationships and condition factor of pompano fish influenced by levels of dietary β-glucan supplementation. The finding in this study suggests that the diet of pompano fish should add 0.1% β-glucan to gain better growth performance and general well-being of this species. However, this result is limited in captivity and it needs to be done with the larger sample size and in different conditions to have a better understanding of nutrition requirement of this species. Also, further study on seasonal variations of environmental condition, reproduction, sex ratio and interaction of those of biology of pompano fish in Vietnam should be conducted experimentally.

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