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Research Article

Effect of varying dietary protein levels on growth, feeding efficiency, and proximate composition of yellow snapper *Lutjanus argentiventris* (Peters, 1869)

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ABSTRACT. The effect of dietary protein (31, 41, 45, and 55%) was evaluated in quadruplicate in the yellow snapper (*Lutjanus argentiventris*). Specimens were kept in sixteen 200 L plastic tanks for 95 days and the values of growth rate, feeding efficiency and proximate composition of yellow snapper (18 g) were examined. Every 15 days were carried out individual weight measurements and standard length of the total population. At the beginning and end of the experiment, liver and muscle samples were taken for proximate analysis of crude protein and ether extract. In general, the highest gain was obtained with fish fed with 55% crude protein in the diet. The best feed conversion ratio (FCR), specific growth rate (SGR), percent weight gain (WG%), average daily gain (ADG), and feed efficiency rate (FER) were obtained with the fish fed 55% of protein (CP). The protein content in liver decreased in fish fed with protein levels and higher energy compared with the initial fish. Finally, the use of practical diets containing 55% CP is appropriate for optimal growth and efficiency of feed utilization of yellow snapper. The results obtained in this study may be due to the early stage of development of yellow snapper where protein and energy requirements are higher.

Keywords: *Lutjanus argentiventris*, yellow snapper, dietary protein, growth, feed, efficiency, California Gulf.

Efecto de diferentes niveles de proteína en la dieta, sobre el crecimiento, eficiencia alimenticia y composición proximal del pargo amarillo *Lutjanus argentiventris*

RESUMEN. El efecto de diferentes niveles de proteína en la dieta (31, 41, 45 y 55%) fue evaluado por cuadruplicado en el pargo amarillo *Lutjanus argentiventris*. Los organismos fueron mantenidos en 16 tanques de plástico de 200 L por 95 días y los valores de crecimiento, eficiencia alimenticia y composición proximal del pargo amarillo (18 g) fueron examinados. Cada 15 días se llevaron a cabo mediciones de peso individual y longitud estándar del total de la población. Al inicio y al final del experimento, muestras de hígado y músculo fueron tomadas para análisis proximal de proteína cruda y extracto etéreo. En general, la ganancia de peso más alta fue obtenida con los peces alimentados con 55% de proteína. La mejor tasa de conversión alimenticia (FCR), tasa de crecimiento específico (SGR), porcentaje de ganancia de peso (WG%), ganancia diaria promedio (ADG) y tasa de eficiencia alimenticia (FER) se obtuvo con los niveles más altos de proteína cruda. El contenido de proteína en hígado disminuyó en los peces alimentados con los niveles de proteína y energía más altos comparados con el pez inicial. Finalmente, el uso de dietas prácticas conteniendo 55% de proteína cruda es apropiado para un óptimo crecimiento y eficiencia en la utilización del alimento del pargo amarillo. El resultado obtenido en este estudio puede ser debido a la fase temprana de desarrollo del pargo amarillo, donde los requerimientos de proteína y energía son más elevados.

Palabras clave: *Lutjanus argentiventris*, pargo amarillo, proteína dietética, crecimiento, eficiencia alimenticia, golfo de California.

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INTRODUCTION

Fishes of family Lutjanidae (snappers) are an important fishing resource in the gulf of California, mainly along the southeastern cost of Baja California Sur, Mexico (Rodriguez *et al*., 1994). In this region, the yellow-snapper (*Lutjanus argentiventris*) has high potentials for aquaculture given its high quality meat and market value (Fischer *et al*., 1995). However, only a few studies have been devoted to this species. Vazquez *et al*. (2008) studied its feeding habits in La Paz Bay, México, and they observed that in the natural environment *Lutjanus argentiventris* fed on sardine *Harengula thrissina*, toad fish *Porichthys margaritatus*, decapods, penaeid shrimps, stomatopods and cephalopods. For this reason *L. argentiventris* has been categorized as a carnivorous fish, indicating that they are specialist predators with preference for fish eggs and *Harengula thrissina* (Díaz-Uribe, 1994).

More information about the nutritional requirements and utilization of dietary protein in this species is limited. Protein is the most expensive compound in fish feeds, especially in carnivorous species; hence, optimizing protein concentrations is essential to minimize feed cost and to formulate feeds, allowing the best growth with the minimum protein utilization (Alvarez-Gonzalez *et al*., 2001).

Recently, many studies have shown the variability in protein requirements for different species (Gracia-López *et al*., 2003; Sweilum *et al*., 2005; Diyaware *et al*., 2009). These studies showed that protein and energy levels of diets modifies the assimilation efficiency and it is directly dependent of the quality of ingredients, nutritional composition, and formulation process of the diet (Tacon & Forester, 2000). Lack of good quality feed for economic production adversely affects growth rates, disease manifestation, and total harvest of fish (Alatise *et al*., 2006). Avilés-Quevedo *et al.* (1996) indicated the necessity to determine the appropriate quantity of protein for this species to improve growth, body composition, feed conversion, efficiency, and survival of wild yellow snapper juveniles under controlled experimental conditions. The objective of this study was to evaluate the effect of practical diets with different crude protein levels on growth performance, feeding efficiency, and proximate composition of yellow snapper juveniles *Lutjanus argentiventris*.

MATERIALS AND METHODS

Source of fish and husbandry

Four hundred juveniles of yellow snapper (17 ± 5 g) were caught in La Paz Bay, gulf of California (24°00’-25°15’N), Mexico, during summer 2011, using lines and nets. Fish were transported to 200 L plastic tanks in the fisheries laboratory of the Centro de Investigaciones Biológicas del Noroeste (CIBNOR). Fishes were acclimatized in a fiber glass tank (7 m^3) with continuous closed flux for four weeks. Ninety six juveniles (18.00 ± 3.00 g and 10.00 ± 1.00 cm), were randomly distributed into sixteen (16) 200 L tanks, at a density of six fish per tank. The culture tanks were connected to an open system coupled to a mechanical filter, pump and supplementary aeration. Water temperature (26.0 ± 0.1°C), dissolved oxygen (6.5 ± 0.5 mg L^{-1}) and salinity (35.0 ± 0.5 g L^{-1}) were recorded daily.

Experimental diets

Four practical diets were formulated with the aid of Mixit V.5.0 software and fabricated in the CIBNOR Laboratorio de Nutrición Acuicola, according to Civera & Guillaume, (1989). Diets were designed to contain increasing protein level (31, 41, 45 and 55%), using fish meal as the main ingredient. Each diet was prepared by first mixing the macroingredients; fish meal, squid meal, wheat meal, and soybean protein meal, in a Kitchen blender Aid (KS55, Hawaii, USA) for 5 min. The dry ingredients were pulverized, sieved through 0.5 mm. The ingredients were thoroughly mixed in a food mixer prior to the addition of fish oil and soybean lecithin. After dispersion of the oil, water was added to approximately 40% of the total ingredient weight. The final product was extruded at room temperature with a meat grinder and a 2-mm die, and the resulting pellets were dried in a forced-air oven at 37°C for 24 h. To verify the composition of the experimental diets the proximate composition was carried out in the CIBNOR Laboratorio de Bromatología (Table 1). The percentage of dry matter, crude protein (N × 6.25), ether extract, crude fiber, ash, and nitrogen-free extract (NFE) was calculated by standard AOAC (1995) methods, for the experimental diet. Fish were fed to apparent satiation twice a day (09.00 and 17.00 h local time). The amount of feed consumed by the fish was recorded daily in each treatment. Final weight (g), standard length, and survival were recorded. The experiment lasted for 95 days.

Analytical methods

Fish were weighed (W) on day 0 and 15, and thereafter every 20 days until the end, also standard length (SL) and survival were recorded. At the beginning (initial fish) and end of the experiment, proximate analysis of liver and muscle were carried out. Eight fish were randomly taken from each treatment, weighed, and then slaughtered. Protein and

Table 1. Formulation of experimental diets and its chemical composition.
Tabla 1. Formulación de las dietas experimentales y su composición química.

Ingredients (g/1000 g diet)	Diet 31%	Diet 41%	Diet 45%	Diet 55%
Fish meal[a]	143	363	474	697
Squid meal[b]	100	100	100	100
Wheat flour[b]	505	314	218	0
Soybean meal[b]	140	140	140	140
Calcium alginate[c]	20	20	20	20
Fish oil[b]	49	19	4	0
Soybean lecithin	5	5	5	5
Vitamin and mineral premix [d]	34	34	34	34
Choline chloride	3.2	3.2	3.2	3.2
Vitamin C[e]	0.6	0.6	0.6	0.6
Proximate composition (% dry matter, except moisture. Mean ± SD)				
Crude protein	32.54 ± 0.29	41.74 ± 0.28	47.12 ± 0.17	56.93 ± 0.17
Ether extract	8.75 ± 0.13	10.70 ± 0.11	14.41 ± 0.15	15.63 ± 0.14
Ash	7.63 ± 0.17	10.20 ± 0.05	11.76 ± 0.05	13.76 ± 0.05
Fiber	0.58 ± 0.09	0.94 ± 0.01	0.12 ± 0.01	nd
NFE	50.5	36.42	26.59	13.69
Gross energy (cal g^{-1})	4843 ± 21	4860 ± 25	4994 ± 18	5032 ± 130
Moisture	12.28 ± 0.02	14.44 ± 0.02	12.24 ± 0.01	12.68 ± 0.13

[a] Nacional product (mainly sardine meal), Solid matter.
[b] Nacional product (*Dosidiscus gigas*), Solid matter.
[c] ALGIMAR, CICIMAR-IPN, La Paz, Baja California Sur, Mexico.
[d] PIASA, La Paz, Baja California Sur, Mexico.
[e] SIGMA.
nd = not detected.
NFE = Nitrogen-free extract, calculated as 100 - (% Protein + % Ether extract + % Ash + % Fiber).

ether extraction were determined (standard Kjeldahl method for protein, ether extraction for lipids) according to AOAC (1995) methods. All samples were stored at -50°C, and then freeze-dried before analytical procedures. The proximate analysis of diets and tissue samples were conducted in triplicate.

The following growth parameters: daily feed intake (DFI), feed conversion ratio (FCR), weight gain (WG%), feed efficiency ratio (FER), protein efficiency ratio (PER), average daily gain (ADG), specific growth rate (SGR), daily energy gain (DEG), and daily protein gain (DPG), were calculated as follows:

Daily feed intake, Average daily gain, Daily energy gain and Daily nitrogen gain was calculated according to (Wang *et al.*, 2005).

Daily feed intake (DFI) = 100 x feed offered (g) / average total weight (g) /days.

The Feed Conversion Ratio (FCR) was calculated per tank from feed intake data and weight gain (Amirkolaie *et al.*, 2005):

FCR = feed intake/wet weight gain.

Weight gain was determined by difference between initial and final body weight.

Weight gain =100 x (final body weight - initial body weight) / initial body weight.

Feed efficiency rate (FER) = weight gain (g) / feed intake (g, dry matter).

Protein Efficiency Ratio (PER) was calculated by dividing the fish weight gain to total protein ingested during the experiment. Total protein ingested was estimated from the daily feed ration multiplied by diet protein content.

PER = wet weight gain/total protein ingested.

Average daily gain (ADG) = (final weight - initial weight) / days.

Specific Growth Rate (SGR) was calculated from the natural logarithm of mean final weight minus the natural logarithm of the mean initial weight and divided by the total number of experimental days expressed as a percentage (Amirkolaie *et al.*, 2005).

Specific growth rate (SGR) = 100 x (Ln W_{final} – Ln $W_{initial}$) / days.

Daily energy gain (DEG) = (final body weight x final body energy - initial body weight x initial body energy) /ABW x days.

Daily nitrogen gain (DPG) = (final body weight x final body nitrogen - initial body weight x initial body nitrogen) /ABW x days.

Where ABW= average body weight.

Survival (%) = (final fish number / initial fish number) x 100.

The Feed Conversion Ratio (FCR) was calculated per tank from feed intake data and weight gain (Amirkolaie *et al.*, 2005):

FCR = feed intake/wet weight gain.

Statistical analysis

Normality of distribution and homogeneity of variance were tested according to Kolmogorov-Smirnov (Kolmogorov, 1933; Smirnov, 1948) test and Levine test, respectively. Data of weight and standard length were analyzed by one-way ANOVA with level of protein as factor. Means were separated by Duncan's multiple range (Duncan, 1955) or Tukey nonparametric multiple test. When the data were not normally distributed, a Kruskal–Wallis analysis was used (survival, crude protein, ether extract composition in muscle and liver of fish). Statistical analyses were made using Statistica v. 6.0 (StatSoft, Tulsa, OK, USA). Differences were considered significant at $P \leq 0.05$.

RESULTS

Growth determination

At 15 days of the experiment, the fish fed with 55% protein diet showed significant differences ($P < 0.05$) in final weight compared with the rest of the treatments, where the lowest protein level was obtained from fish fed 31% protein diet (CP) diet. For the standard length, there was no significant correlation between mean weight and standard length (Table 2).

Feed efficiency

No significant differences were detected in the daily feed intake (DFI) in all treatments. Feed conversion ratio (FCR) was better when fish were fed with 55% (2.36) and 41% (2.78) protein levels; the worst FCR was obtained with the lowest crude protein level (31%). Fish fed with 55% crude protein diet showed the highest significant differences in WG, FER, ADG, and SGR compared with the fish fed with the rest of the diets. PER and DPG were highest in fish fed with 31% protein. These feed utilization variables decreased with increasing crude protein level. No significant differences ($P > 0.05$) were observed in terms survival among the entire set of treatments (Table 3).

Proximate analysis

There was no significant difference ($P > 0.05$) between crude protein content in muscle in the control fish (initial fish) compared with those fed 45 and 55% for 95 days; however, significant differences were observed between fish fed 31 and 41% crude protein diets. The ether extract content in the fish muscle was inversely proportional to crude protein content. In this case, fish fed with 31% crude protein diet was higher than the rest of the entire diets where the initial fish showed the lowest percent of ether extract.

For the liver, the protein content of initial fish was similar to those obtain in fish fed 31% crude protein diet. However this result was higher compared with the rest of the treatments. For the ether extract content, this factor was found highest for initial fish compared with experimental diets. Ether extract content between experimental diets increased with increase in crude protein level (Table 4).

DISCUSSION

The success of intensive fish culture depends, to a large extent, on adequate information on nutrient requirements, especially dietary protein, which is the most expensive component in artificial fish diets (Siddiqui *et al.*, 1991). Any reduction in dietary protein level without affecting fish growth can substantially reduce the cost of fish feed (Jamabo & Alfred-Ockiya, 2008). Dietary protein is used by fish for growth, energy and body maintenance (Kaushik & Medale, 1994). The present work concluded that yellow snapper fed with 55% protein level showed the best response in all measured parameters. Yellow snapper is a carnivorous marine fish that feeds on large quantities of fish eggs and sardines (*Harengula thrissina*), therefore, high protein requirement would be expected (Vazquez *et al.*, 2008). Another reason could be due to the early stage of the yellow snapper (juvenile 18 g) where the protein requirements are also

Table 2. Growth performance of juvenile yellow snapper fed at different dietary protein levels for 95 days (Mean ± SD).

Tabla 2. Crecimiento de juveniles de pargo amarillo alimentado con diferentes niveles de proteína en la dieta por 95 días (Media ± SD).

Time (days)	Protein level (%)			
	31	41	45	55
Weight (g)				
0	17.17 ± 2.51	18.12 ± 2.43	18.67 ± 2.53	17.81 ± 2.16
15	18.21 ± 2.77[b]	18.65 ± 2.65[b]	18.86 ± 2.24[b]	20.48 ± 2.53[a]
35	20.37 ± 3.45[c]	21.50 ± 2.51[b]	21.11 ± 2.41[b]	23.95 ± 3.56[a]
55	21.89 ± 4.38[b]	22.79 ± 3.01[b]	22.58 ± 2.95[b]	26.70 ± 5.08[a]
75	24.27 ± 6.58[b]	29.73 ± 12.35[a]	26.67 ± 4.63[b]	32.31 ± 8.00[a]
95	29.62 ± 10.47[b]	36.94 ± 7.65[a]	34.12 ± 7.47[ab]	40.20 ± 11.16[a]
Standard length (cm)				
0	87.2 ± 4.9	88.0 ± 5.4	89.4 ± 4.3	88.4 ± 4.3
15	86.4 ± 4.0	87.6 ± 4.3	87.6 ± 3.3	88.6 ± 4.2
35	89.5 ± 5.9b	90.6 ± 5.1[b]	91.0 ± 3.9[b]	93.8 ± 4.3[a]
55	91.5 ± 6.1b	93.6 ± 4.8[b]	92.3 ± 5.0[b]	97.8 ± 7.2[a]
75	95.8 ± 10.9b	100.8 ± 11.1[ab]	97.6 ± 8.4[ab]	105.0 ± 10.1[a]
95	99.7 ± 12.0b	108.1 ± 7.7[ab]	104.8 ± 8.1[ab]	111.0 ± 10.8[a]

Means with different superscript letters within a row are significantly different (P < 0.05).

Table 3. Growth, percent survival, and fed efficiency of yellow snapper juveniles fed at different dietary protein levels (Mean ± SD).

Tabla 3. Crecimiento, porcentaje de supervivencia y eficiencia alimenticia de juveniles de pargo amarillo alimentado con diferentes niveles de proteína en la dieta (Media ± SD).

	Protein level (%)			
	31	41	45	55
DFI[1]	0.12 ± 0.02	0.12 ± 0.03	0.12 ± 0.01	0.13 ± 0.02
FCR[2]	4.00 ± 0.60[a]	2.78 ± 0.32[bc]	3.19 ± 0.12[b]	2.36 ± 0.11[c]
WG%[3]	84.60 ± 11.10[c]	103.14 ± 10.50[b]	82.61 ± 23.20[c]	125.92 ± 32.40[a]
FER[4]	25.96 ± 0.41[c]	36.16 ± 0.30[b]	31.46 ± 0.51[b]	42.56 ± 0.32[a]
PER[5]	0.96 ± 0.10[a]	0.86 ± 0.04[b]	0.69 ± 0.16[c]	0.75 ± 0.12[c]
ADG[6]	3.27 ± 0.32[b]	3.78 ± 0.31[b]	4.06 ± 0.23[b]	5.97 ± 0.12[a]
SGR[7]	0.57 ± 0.10[c]	0.75 ± 0.05[b]	0.63 ± 0.13[cb]	0.85 ± 0.15[a]
DEG[8]	2.33 ± 0.19	2.01 ± 0.64	2.36 ± 0.14	2.58 ± 0.31
DPG[9]	77.19 ± 6.33[a]	57.66 ± 18.44[b]	59.81 ± 3.57[b]	52.82 ± 6.28[b]
Survival (%)[8]	100	100	100	100

Means with different superscript letters within a row are significantly different (P < 0.05).
[1]Daily feed intake (DFI); [2]Feed conversion ratio (FCR); [3]Weight gain (WG%); [4]Feed efficiency rate (FER); [5]Protein efficiency rate (PER); [6]Average daily gain (ADG); [7]Specific growth rate (SGR); [8]Daily energy gain (DEG); [9]Daily protein gain (DPG); [10]Survival.

high. This protein level is similar to those reported by other authors for strictly carnivorous species such as Mediterranean yellowtail (*Seriola dumerilii*), Murray cod (*Maccullochella peelii peelii*), dentex (*Dentex dentex*) and Senegalese sole (*Solea senegalensis*) where 50% protein content was the optimum level

Table 4. Muscle and liver biochemical composition (% dry matter) of yellow snapper juveniles fed at different dietary protein levels (Mean ± SD).

Tabla 4. Composición bioquímica de musculo e hígado (% material seca) de juveniles de pargo amarillo alimentado con diferentes niveles de proteína en la dieta (Media ± SD).

	Protein level at 95 days				
	Initial fish	31	41	45	55
Muscle					
Protein	86.68 ± 0.88	79.33 ± 0.33[c]	81.12 ± 0.22[b]	84.08 ± 0.09[a]	85.08 ± 0.11[a]
Ether extract	5.78 ± 0.04	10.56 ± 0.32[a]	9.36 ± 0.40[b]	10.03 ± 0.23[ab]	7.35 ± 0.40[c]
Liver					
Protein	24.55 ± 0.50	25.83 ± 0.19[a]	20.81 ± 0.17[b]	21.33 ± 0.43[b]	20.33 ± 0.59[b]
Ether extract	62.67 ± 0.49	41.20 ± 0.31[c]	49.70 ± 0.32[b]	51.33 ± 0.10[b]	58.05 ± 0.80[a]

Means with different superscript letters within a row are significantly different ($P < 0.05$).

(Jover *et al*., 1999; De Silva *et al*., 2002; Espinos *et al*., 2003; Rodiles *et al*., 2012). According to the data in Table 2, all fish had low growth from day 35-55, but highest in the 55%-group. The 41% group had particularly high growth in day 55-75. When calculating SGR for each period, the highest SGR-value is in the 45% group in the last 20 days. Low protein levels have been determined for species with different feeding habits such as Asian sea bass (*Lates calcarifer*), gilthead sea bream (*Sparus aurata*), European sea bass (*Dicentrarchus labrax*), spotted sand bass (*Paralabrax maculatofasciatus*), rockfish (*Sebastes schlegeli*), rohu (*Labeo rohita*), and red drum (*Scienops ocellatus*) where a range from 35 to 45% optimum protein content were determined for the best growth of those species (Catacutan & Coloso, 1995; Santinha *et al*., 1996; Pérez *et al*., 1997; Thoman *et al*., 1999; Alvarez-González *et al*., 2001; Lee *et al*., 2002a; Satpathy *et al*., 2003; Webb & Gatlin III, 2003). About feed utilization parameters, we can observe a best FCR in fish fed with 55% protein level. The feed conversion ratio (FCR) was similar to those obtained by Jover *et al*. (1999) for Mediterranean yellowtail juveniles (2.44) with an optimum protein level of 50%. However, this value (FCR) is better than those reported for other commercially cultivated marine fishes such as Atlantic cod (1.27), Asian sea bass (1.09), European sea bass (1.34), and red drum (1.6). These lower values were obtained after many years of research in those species, which allow implementing more profitable diets (Houlihan *et al*., 1988; Catacutan & Coloso 1995; Pérez *et al*., 1997; Webb & Gatlin III, 2003). For FER, our best value (42.56) was obtained for fish fed with 55% protein diet; this is lower than those reported for red drum (98.7), rockfish (82.0), and ayu (*Plecogglossus altivelis*) (63.8) (Thoman *et al*., 1999; Lee *et al*., 2002a, 2002b). PER decreased with increase in crude protein from 31% (0.96) to 55% (0.75). De la Higuera *et al*. (1989) found a decrease in PER for European eel *Anguilla anguilla* as the dietary protein increased; Martínez-Palacios *et al*. (1996) found the same pattern for Mexican cichlid *Cichlasoma urophthalmus*, and Ellis *et al.* (1996) reported similar results for Nassau grouper. On the other hand, values for PER were low for all diets in this study (0.69-0.96) compared with Atlantic cod (1.69), gilthead seabream (1.67), European sea bass (1.26), spotted sand bass (1.42), rockfish (1.8), dentex (1.30), and red drum (1.9) (Houlihan *et al*., 1988; Santhina *et al*., 1996; Gouveia & Davies 2000; Alvarez-González *et al*., 2001; Lee *et al*., 2002a; Espinos *et al*., 2003; Webb & Gatlin III *et al*., 2003). This agrees with the poor WG% obtained for our fish (82.6-125.92) for a trial period of 95 days. Normally, a high quality of diet is required during the 4-6 weeks period for growing juvenile fish (35-40 to 100 g) (Vechklang *et al*., 2011). From this perspective, it is necessary to implement better formulations with high digestive ingredients as terrestrial animal protein and even to include some quantity of predigested ingredients (fish hydrolyze), that allows to increase the attraction towards the food (Kristinsson & Rasco, 2000).

Finally, the body composition in muscle and liver obtained in this experiment, suggest that the protein requirement for this species could decrease, because similar levels of crude protein in the muscle were calculated between the diets of 45 and 55% crude protein compared with the initial fish. Similar crude protein concentration in muscle was observed by Jover *et al*. (1999) with the Mediterranean yellowtail *Seriola dumerili;* however, higher lipid concentration was used. For liver, this factor was similar between 31% protein level and initial fish. About ether extract in muscle, this factor was higher in fish fed with 31% protein level compared with the rest of diets. In contrast, in liver this value was higher with the protein level at 55%. Liver is an organ with higher energy requirements compared with muscle (predominantly white muscle) (Henderson, 1996). Some authors propose that the use of alternative protein ingredients and optimal protein/energy ratio allows the maximum amount of protein to be available for growth by minimizing the amount used for energy (Espinos *et al*., 2003; Gracia-López *et al*., 2003). In conclusion, our results indicate that the use of practical diets of 55% protein level for rearing juveniles of yellow snapper is appropriated for obtaining an acceptable growth and feed utilization efficiency. However, a great deal of consideration is generally given to reducing feed costs, replacing fish meal by alternative protein sources that are of high quality, but less expensive for aqua feeds.

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