

Apparent dry matter and protein digestibility of vegetal and animal ingredients and diets for pre-adult Australian redclaw crayfish *Cherax quadricarinatus* (von Martens 1858)

Digestibilidad aparente de proteínas y de materia seca de dietas e ingredientes vegetales y animales para pre-adultos del acocil australiano *Cherax quadricarinatus* (von Martens 1858)

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Abstract. Apparent dry matter and protein digestibility of four animal and three vegetal ingredients and diets with them included, were evaluated for pre-adult *Cherax quadricarinatus*. The ingredients were: two sardine meals (67% and 58% crude protein), squid meal, red crab meal, soy paste, textured wheat, and sorghum meal. A reference and seven experimental diets were formulated including 14.5% of each ingredient in the reference diet, and 0.5% of chromic oxide as a marker. Vegetal ingredients and the corresponding diets, had higher digestibility than animal ingredients. Textured wheat, soy paste, and sorghum meals showed an excellent dry matter/digestibility (> 86%). The digestibility of protein was better in textured wheat, and soy paste meals (> 87%). Some animal ingredients such as, squid meal, and sardine meal 67% CP, had acceptable dry matter digestibility (over 65%). It is concluded that pre-adult redclaw is omnivorous and able to efficiently consume vegetal and animal ingredients, but they can digest better the vegetal ingredients.

Key words: Crustacean nutrition, *Cherax quadricarinatus*, digestibility, vegetal and animal ingredients, diets.

Resumen. La digestibilidad aparente de proteínas y de materia seca de cuatro ingredientes animales y tres ingredientes vegetales, así como de las dietas en que se incluyeron, fueron evaluados para pre-adultos del acocil australiano *Cherax quadricarinatus*. Los ingredientes probados fueron: dos harinas de sardina (67% y 58% de proteína cruda), harina de calamar, harina de langostilla, pasta de soya, trigo texturizado y harina de sorgo. Una dieta de referencia y siete dietas experimentales fueron formuladas, incluyendo 14.5% de cada ingrediente en la dieta de referencia y 5% de óxido crómico como marcador. Los ingredientes vegetales y sus respectivas dietas, tuvieron más alta digestibilidad que los ingredientes animales y sus dietas. El trigo texturizado, la pasta de soya y la harina de sorgo, presentaron una excelente digestibilidad de materia seca (> 86%). La digestibilidad proteica fue mejor para el trigo texturizado y la pasta de soya (>87%). Algunos ingredientes animales como la harina de calamar y harina de sardina con 67% de proteína cruda, tuvieron una aceptable digestibilidad de materia seca (>65%). Se concluye que el acocil australiano, en su fase de pre-adulto, es un organismo omnívoro capaz de consumir eficientemente ingredientes de origen vegetal y animal, pero que digiere mejor los de origen vegetal.

Palabras clave: Nutrición de crustáceos, *Cherax quadricarinatus*, digestibilidad, ingredientes vegetales y animales, dietas.

Aquaculture in Mexico has focused on two marine groups, oysters and penaeid shrimp. It is important to diversify the activity in order to use continental waters for aquaculture, selecting species with the best aquacultural characteristics, such as a high growth rate, resistance to management and diseases, good food conversion rate, single nutritional requirements, and omnivorous feeding habits (Martínez-Córdova, 1999).

Redclaw, *Cherax quadricarinatus* can reach 70 to 100 g in 6 to 8 months, has a good price and market, and most of the characteristics previously mentioned. These make the species an excellent candidate for farming in Mexico (Hutchings & Villarreal, 1996).

Aquafeeds are formulated with animal and vegetal ingredients. Animal ingredients are mostly used to cover protein requirements. However they are more expensive, scarce, and less available than those from vegetal origin (Chamberlain, 1995).

Many studies on digestibility in crustaceans have been focused on the American lobster (Leavitt, 1983), and penaeid shrimp (Cousin *et al.*, 1996; Sudriyono *et al.*, 1996; & Cruz-Suárez *et al.*, 2000), and few on freshwater crustacean as *Procambarus clarkii* (Reigh *et al.*, 1990), *Orconectes virilis* (Brown *et al.*, 1990), *Cherax destructor* (Jones, 1989; Jones & De Silva, 1997; Hernández, 2001), and *C. quadricarinatus* (Castillo *et al.*, 2002).

The objective of this study was to evaluate the dry matter and protein digestibility of four animal and three vegetal ingredients and corresponding diets on pre-adult redclaw.

The experiment was made at CIBNOR, La Paz, B.C.S., Mexico. A single-factor, completely randomized experimental design with five replicates was performed. Experimental units consisted of 60-L plastic tanks with filtered and sterilized freshwater.

The seven ingredients evaluated were: two sardine meals (67% and 58% crude protein, C.P.), squid meal, red crab meal, soy paste, textured wheat, and sorghum meal.

A reference diet was formulated by means of the MIXIT-4 (MS-DOS software). Seven experimental diets were then made with 85 % of reference diet, 14.5 % of the ingredient to evaluate, and 0.5% chromic oxide as a marker (Leavitt, 1983).

Each experimental unit was stocked with 15 juveniles (3.6 ± 1.3 g). Feeding was done *ad libitum* twice a day. Three hours after feeding, faeces were collected, washed with distilled water, frozen at -70 °C and lyophilised, for later analysis.

Proteins and chromic oxide in faeces and diets were evaluated simultaneously by a modified Bolin *et al.* (1952), and micro-Kjeldahl method (Nieto *et al.*, 1997).

The percentage of apparent dry matter (ADMD) and protein (APD) digestibility of diets were calculated as:

$$\%ADMD = 100 - 100 * (\% Cr \text{ in diet} / \% Cr \text{ in faeces})$$

$$\%APD = 100 - 100 * (\% Cr \text{ in diet} / \% CP \text{ in diet}) * (\% CP \text{ in faeces} / \% Cr \text{ in faeces})$$

Where Cr is the concentration of chromic acid and CP is the content of protein.

The percentage of apparent dry matter (IADMD) and protein (IAPD) digestibility of ingredients was calculated as:

$$\%IADMD = (100 * \% ADMD \text{ of TD}) - ((100 - \%TI) * \%ADMD \text{ of RD}) / \%TI$$

$$\%IAPD = (100 * \%APD \text{ of TD} * \% CP \text{ in TD}) - ((100 - \%TI) * \%APD \text{ of RD} * \%CP \text{ in RD}) / \%TI * \% CP \text{ in TI}$$

Where ADMD of TD is apparent dry matter digestibility of the tested diet, TI is the tested item, ADMD of RD is the apparent dry matter digestibility of the reference diet.

APD of TD is the apparent protein digestibility of the tested diet, CP in TD is concentration of protein in the tested diet, TI is the tested ingredient, APD of RD is the apparent protein digestibility of the reference diet, CP is the concentration of protein of the reference diet, and CP in TI is the concentration of protein in the tested ingredient.

Data were transformed to arcsen⁻¹ EMBED Equation 3, and then a one-way-ANOVA parametric procedure and a multiple-range test (Tukey P<0.05) were used to compare and rank means.

Textured wheat, sorghum, and soy paste meals, and their respective diets, had the best dry matter digestibility. The lowest percentage was obtained with red crab meal and the corresponding diet (Table 1).

Protein digestibility of diets and ingredients were greater for vegetal ingredients, the better was textured wheat (94.7%), following by soy paste (87.0%) and sorghum (72.6%) meals, and their corresponding diets. To equal that in dry matter digestibility, the lowest percentage of protein digestibility was obtained with red crab meal (40.1%), and the corresponding diet (Table 1).

In general, tested vegetal ingredients and the corresponding diets had a higher dry matter and protein digestibility than animal ingredients and their diets.

These results agree with Reigh *et al.* (1990) who found that vegetal ingredients, such as cereals, had higher digestibility for *Procambarus clarkii* than animal constituent. Smith *et al.* (1985) reported that vegetal ingredients showed an excellent digestibility for *Litopenaeus vannamei*. Brunson *et al.* (1997) found that protein from vegetal origin has similar or higher

digestibility for *Litopenaeus setiferus* than those from animal origin.

Differences between species in protein digestibility are partially related to their feeding habits. Carnivorous organisms (as some crustaceans) are able to degrade animal proteins more efficiently than herbivores or omnivorous organisms (García-Carreño *et al.*, 1994). *Cherax quadricarinatus* is an omnivorous that inhabits rivers and fed mostly on plants such as macrophytes (Brown *et al.*, 1990). The species is able to digest cellulose (Xue *et al.*, 1999). However, redclaw is also an opportunistic carnivore. These conditions make the organism able to efficiently consume vegetal and animal ingredients in its diet (Villarreal, 1996).

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Table 1. Percentages of apparent dry matter (%ADMD) and protein (%APD) digestibility of diets, and apparent dry matter (%IADMD); and protein (%IAPD) digestibility of ingredients for pre-adult redclaw *Cherax quadricarinatus*.

Ingredients and diets	%ADMD	SD	%IADMD	SD	%APD	SD	%IAPD	SD
Red crab	82.2 ^a	0.49	60.9 ^a	3.30	88.0 ^a	0.22	40.1 ^a	1.39
Sardine 58	82.5 ^a	0.91	60.0 ^a	7.08	88.0 ^a	0.55	49.0 ^b	3.76
Sardine 67	85.6 ^{bc}	0.47	83.6 ^b	3.13	90.0 ^b	0.20	66.6 ^c	0.79
Squid	85.4 ^b	0.37	84.4 ^b	2.49	90.1 ^b	0.07	67.2 ^{cd}	0.23
Soy paste	85.6 ^{bc}	0.32	86.0 ^{bc}	2.16	91.6 ^c	0.19	87.0 ^e	2.04
Sorghum	86.1 ^{cd}	0.53	87.1 ^{bc}	3.56	90.5 ^b	0.19	72.6 ^d	0.99
Textured wheat	86.3 ^{cd}	0.46	90.5 ^c	3.04	91.7 ^c	0.20	94.7 ^f	0.18
Reference	86.7 ^{cd}	0.42			91.6 ^c	0.38		

Letters different into the columns, show statistically significant differences (P<0.05). SD = Standard deviation

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