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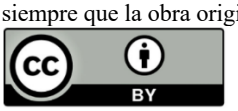

ORIGINAL ARTICLE / ARTÍCULO ORIGINAL

PROXIMAL ANALYSIS OF MALE MANGROVE CRAB, *UCIDES OCCIDENTALIS* (ORTMANN, 1897) AND VALUE-ADDED ALTERNATIVES, ECUADOR

ANÁLISIS PROXIMALES EN MACHOS DE CANGREJO ROJO, *UCIDES OCCIDENTALIS* (ORTMANN, 1897) Y ALTERNATIVAS DE VALOR AGREGADO, ECUADOR

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Titulillo: Proximal analysis in mangrove crabs

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ABSTRACT

The mangrove crab *Ucides occidentalis* (Ortmann, 1897) is a fishery resource in Ecuador regulated only for catching males, which are commercialized mainly in packages of 12 individuals. Our objective was to analyze the meat crab of *U. occidentalis* cooked by two methods (boiling and steaming) as well as show two alternatives of added value (nuggets: aromatic and coconut). Crabs were collected from commercial catches made on Mondragon Island, Gulf of Guayaquil. The meat crab was extracted by hand and the percentages of protein, fat and ash were determined. Consumer preference was evaluated by a sensory panel. A total of 72 male crabs were processed, ranging in size from 75 to 88 mm carapace width. Proximal analysis showed similar values for both cooking methods. Steaming: 21.8% protein, 1.73% fat, 7.24 ash, and boiling: 22.20% protein, 1.95% fat, 6.74% ash. The participants rated the crab nuggets as "good". The aromatic nugget was better than the coconut nugget. Our proximal analysis of male *U. occidentalis* showed values higher than previously reported for the Gulf of Guayaquil (13.38% protein, 0.45% fat, 2.49% ash), but close to those reported for other crab species (16.5-24.38% protein, 0.5-2.09% fat, and 1.02-2.25% ash). It is important to consider food alternatives based on *U. occidentalis* and its derived products, such as chitin, proteins, related molecules (e.g., enzymes, peptides) and nanomembrane production.

Keywords: meat crab – Gulf of Guayaquil – Mondragon Island – sensory profile

RESUMEN

El cangrejo de manglar *Ucides occidentalis* (Ortmann, 1897) es un recurso pesquero en Ecuador, regulado para la captura de individuos machos, los cuales se comercializan principalmente en paquetes de 12 individuos. Nuestro objetivo fue analizar la carne de cangrejo de *U. occidentalis* cocinada por dos métodos (inmersión y al vapor), así como, mostrar dos alternativas de valor agregado (Nuggets: aromáticos y de coco). Los cangrejos fueron recolectados de capturas comerciales realizadas en la Isla Mondragón, Golfo de Guayaquil, Ecuador. La carne del cangrejo fue extraída manualmente y se determinaron los porcentajes de proteína, grasa y cenizas. La preferencia del consumidor fue evaluada mediante un panel sensorial. Se procesaron 72 cangrejos machos, cuya talla varió entre 75 y 88 mm de ancho de carapacho. El análisis proximal mostró valores similares para ambos métodos de cocción, al vapor: 21,8% de proteínas, 1,73% de grasa y 7,24 de cenizas; inmersión: 22,20% de proteínas, 1,95% de grasa y 6,74% de cenizas. Los participantes calificaron los Nuggets de cangrejo como “buenos”. Los Nuggets

aromáticos fueron mejores que los de coco. Nuestro análisis proximal en machos de *U. occidentalis* mostró valores superiores a los registrados anteriormente para el Golfo de Guayaquil (13,38% de proteína, 0,45% de grasa, 2,49% de ceniza), pero cercanos a los encontrados en otras especies de cangrejos (16,5-24,38% de proteína, 0,5-2,09% de grasa y 1,02-2,25% de ceniza). Es importante considerar alternativas alimentarias basadas en *U. occidentalis* y sus productos derivados, como la quitina, las proteínas, las moléculas relacionadas (e.g., enzimas, péptidos) y la producción de nanomembranas.

Palabras clave: carne de cangrejo – Golfo de Guayaquil – isla Mondragón – perfil sensorial

INTRODUCTION

The production and consumption of seafood has increased in recent decades, making it an important element of food security around the world, and crustaceans were the second group in terms of commercialization importance in 2022, with a representation of 23%. The mangrove crab *Ucides occidentalis* (Ortmann, 1897) is a fishery resource for Ecuador, commercialized mainly in packages (about 12 individuals) sold to intermediaries; in addition, the crab meat is also sold and called "crab pulp" (Mendoza-Avilés *et al*., 2018; Zambrano & Meiners, 2018; Zambrano, 2022).

Ucides occidentalis has been used as food since pre-Columbian times, and there are now micro-enterprises processing and packaging crab meat (Silva & Segovia-Chilinga, 2018). The processing of commercial species brings added value and benefits to the production sector, for example by increasing shelf-life, helping to maintain a high level of quality, opening new market opportunities, and providing a solution to oversupply problems (Morrissey & DeWitt, 2014). However, food acceptability depends on the consumer's sensory perception, which is a complex issue due to different consumption preferences (Assogba *et al*., 2021).

Consumer demand is changing around the world, with consumers looking for food attributes such as convenience, taste, quality, and price (Boughanmi *et al*., 2007). It is important to assess the nutritional quality, processing methods and alternatives for human consumption of aquatic species such as crabs (Galetti *et al*., 2017). In this sense, the main objective of this work was to analyze the meat crab of *U. occidentalis* cooked by two

methods as well as to know the consumption preference over two alternatives of added value.

MATERIAL AND METHODS

Crabs were collected from commercial catches made on Mondragon Island (79°50'; 2°36'), Gulf of Guayaquil, Ecuador, during May and July 2024. The study area was the mangrove swamps within the concession area of the Mondragon Fishing Association (Fig. 1). The sample consisted of adult males due to fishing regulations in Ecuador. In this sense, females cannot be fished and the minimum legal size for males is 75 mm carapace width in accordance with the ministerial agreements #030 from July 04, 2003, and #004 from January 13, 2014, respectively (Zambrano & Meiners, 2018).

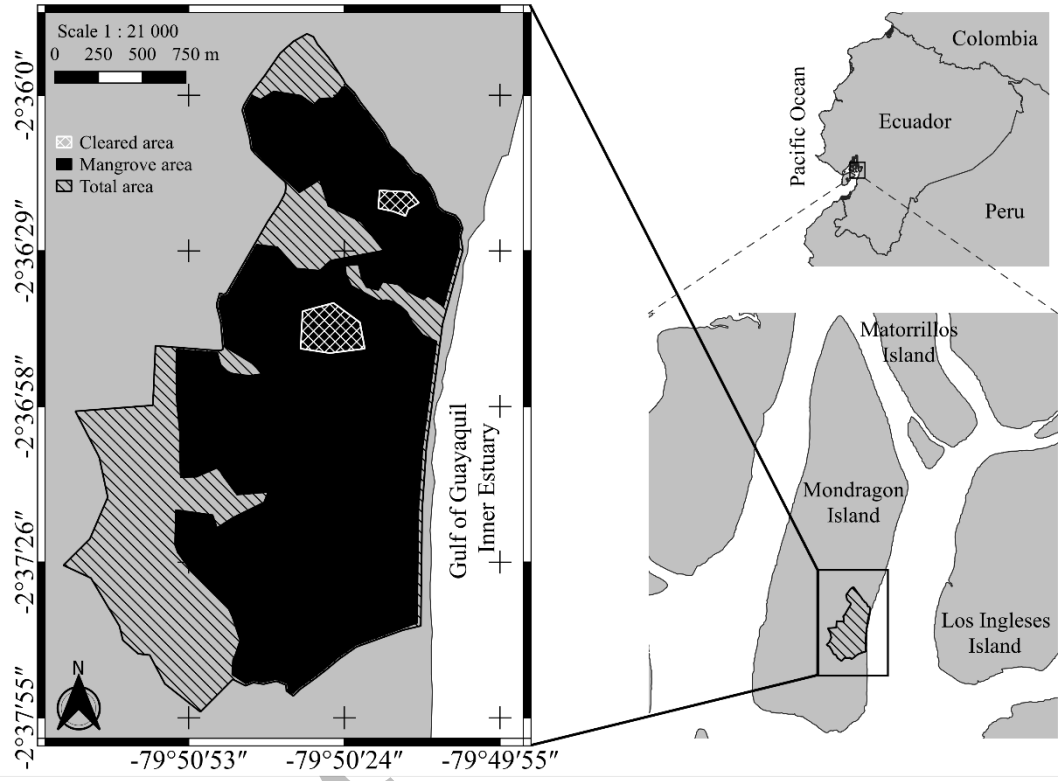

Figure 1. Total area concessioned to the Mondragon Fishing Association, including its mangrove area, and cleared area (no forest), located in the Gulf of Guayaquil, Ecuador. Taken and modified from Troya-Castro & Zambrano (2023).

Crabs were frozen (< 10°C), measured (CW: carapace width) and weighed (W: weight) using a plastic caliper (0.1 mm) and a digital balance (0.1 g). Data (CW vs W) were analyzed using Pearson correlation, power regression and coefficient of determination.

Crab processing and proximal analysis

The crabs were cleaned and processed by two methods: boiling and steaming. In the first case, the crabs were immersed in water at 100 °C for 10-12 min, while in the second case the crabs were exposed to steam (105 °C) for 20-25 min. The crabs were then exposed to cold air (7-10°C) for 15 min to avoid overcooking. Crab meat was extracted manually from the body (i.e., perion) and chelipeds. Proximal analysis was performed according to the official methods of analysis of AOAC International for protein (AOAC 981.10), fat (AOAC 960.39) and ash (AOAC 923.03) (Latimer, 2023).

Two options of crab nuggets were considered as value-added alternatives: "aromatic" and "coconut". In both cases, pre-cooked crab meat (using two extraction methods), salt and pepper, garlic powder, eggs, wheat flour and olive oil were used. In addition, the aromatic nuggets contained dehydrated fine herbs (common thyme, rosemary, oregano), while the coconut nuggets contained coconut flour and dehydrated coconut. The ingredients were mixed and homogenized for 10 min, the nuggets were formed by hand and fried in olive oil at 160°C-180°C for 2 min.

Consumer preference was assessed by a sensory panel and a hedonic test (Cox, 2013; Marques *et al*., 2022). The sensory panel consisted of 24 people, 54% men and 46% women, including an equal number of regular consumers of crab meat and non-consumers. The age range was mainly young adults (18-37 years old), and it included older adults. (Table 1). The selection was done by opportunity method.

Table 1. Percentage of people by age and gender participating in crab nugget tasting panel.

Age group (years)	Women (%)	Men (%)
18-27	45	46
28-37	36	31
38-47	9	15
48-57	9	8

Participants rated the attributes of smell, color, taste, and texture as "excellent," "good," or "regular" for each type of crab nugget coded. In addition, participants indicated their favorite crab nugget alternative. The attribute values were presented using a radial graph (Naqvi, 2024). That analysis was done by Stata software ver MP 16.0, Stata Corp, USA. The best crab nugget was selected by the participants' preference in percentages.

Ethic aspects: The authors point out that all national and international ethical aspects have been respected.

RESULTS

A total of 72 crabs were processed. Crab sizes ranged from 75 to 88 mm CW, while weights ranged from 90 to 200 g. The relationship CW vs. W showed an acceptable correlation value ($r = 0.71$), but the power was low ($r^2 \leq 0.5$). Power regression showed negative allometry ($b < 3$) (Fig. 2).

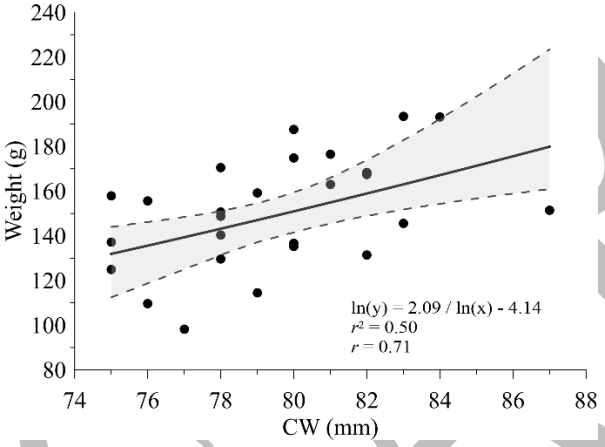

Figure 2. Carapace width (CW) vs. weight of male *Ucides occidentalis* collected in Mondragon Island, Gulf of Guayaquil. Solid line: linear regression; segmented line: confidence intervals; r^2: determination value; r: correlation value.

Proximal analysis results were for steaming: 21.8% protein, 1.73% fat, 7.24 ash; boiling: 22.20% protein, 1.95% fat, 6.74% ash. Participants primarily rated the crab nuggets as "good"; in addition, the attributes were better for the aromatic crab than for the coconut, considering the scores between excellent and regular (Figure 3). Aromatic crab nuggets were selected as the favorite by most participants (75%).

Figure 3. Sensory panel qualification (%) of attributes of two crab nuggets.

DISCUSSION

The mangrove crab (*U. occidentalis*) samples in this study corresponded to adult males (size at physiological sexual maturity = 61.3 mm CW) with sizes similar to those reported for 2009-2013 (83-86 mm CW) in the Gulf of Guayaquil (Zambrano & Meiners, 2018). The determination value and correlation for the relationship CW vs. W were low compared to those reported for male *U. occidentalis* ($r^2 = 0.82$; $r = 0.91$) collected in the Panamanian Pacific (De León *et al*., 2023).

The differences due to the size sample, in Panama (230 crabs) was larger than in Ecuador, which affects the correlation value and determination (Bujang & Baharum, 2016). The size range was wider in Panama (50-80 mm CW), it produces an allometry values different between localities, but the same interpretation (negative) because the data plot follows the same trend. A similar case was demonstrated by morphometric relationships in the semiterrestrial crab *Cardisoma crissum* Smith, 1870, in Ecuador, less data produces the same allometry values when the trend remains (Álvarez, 2022).

Our proximal analysis of males *U. occidentalis* showed values higher than reported by De Cock *et al.* (2023) for some sampling sites in the Gulf of Guayaquil (13.38% protein,

0.45% fat, 2.49% ash). The differences could be related to the method applied. De Cock *et al*. (2023) worked with fresh meat, while we cooked it (by two methods).

Compared to other crab species processed by cooking method, males *U. occidentalis* show a nutritional content close to the reported. *Portunus pelagicus* (Linnaeus, 1758), *Portunus sanguinolentus* (Herbst, 1783), *Cancer pagurus* Linnaeus, 1758*, Callinectes pallidus* (de Rochebrune, 1883), *Callinectes sapidus* Rathbun, 1896, *Cardisoma armatum* (Herklots, 1851), *Eriphia verrucosa* (Forskål, 1775) present ranges of 16.5-24.38% protein, 0.5-2.09% fat, and 1.02-2.25% ash (Ayas & Ozogul, 2011; Maulvault *et al*., 2012; Elegbede & Fashina-Bombata, 2014; Zotti *et al*., 2016; Rangasamy *et al*., 2024).

We can assume as nutritional reference in crab species, 20% protein, 1.3% fat and 1.7% ash. However, it is necessary to consider the variations caused by the sampling site, the method of proximal analysis applied, the biological fitness and the intrinsic characteristic of the species. De Cock *et al*. (2023) showed differences in the nutrient content of male *U. occidentalis* between two sampling sites (i.e., Churute and Salado) in the Gulf of Guayaquil. *Portunus pelagicus* and *P. sanguinolentus* show the highest values of fat (5.33 and 6.43%), while in *C. pallidus* and *C. armatum*, the ash (13.41 and 14.96%) (Ayas & Ozogul, 2011; Elegbede & Fashina-Bombata, 2014; Rangasamy *et al*., 2024).

Biological aspects such as the reproductive period (December-May) and moulting (July-October) as well as seasonality could change the chemical characteristics of *U. occidentalis*. This has been demonstrated in *Cancer pagurus* Linnaeus, 1758. The proximate composition showed differences between seasons in raw meat (Maulvault *et al.*, 2012; Zambrano, 2016; Zambrano & Meiners, 2018).

Cooking of crabs is necessary for meat extraction; the heat causes denaturing of muscle proteins (solidification of the meat) and breaks connective tissues with the exoskeleton. However, the method used could affect the nutritional quality (e.g., free amino acids) as reported for the swimming crab *Portunus trituberculatus* (Miers, 1876) in China (Shi *et al*., 2020). On the other hand, the method used could affect the taste of the crab meat as in the case of the spanner crab *Ranina ranina* (Linnaeus, 1758) or be indifferent as in the case of the swimming crab *P. trituberculatus* (Slattery *et al.,* 1992; Shi *et al*., 2020).

Immersion methods can dissolve nutrients (e.g., proteins and minerals) and alter organoleptic qualities. This is avoided by the steaming method, but it requires more equipment. Both alternatives are effective for extracting crab meat from male *U.*

occidentalis because the nutritional contend was similar. Therefore, the choice of method depends on the facilities economically, and the cost-benefit associated with the production.

The nutritional quality of *U. occidentalis* allows to recommend its regular consumption, considering the possible presence of heavy metals (e.g., Cr, Cd, Zn) in the meat that do not exceed the ecotoxicological reference values (De Cock *et al*., 2021, 2023). This species has been a source of food since pre-Columbian cultures, and currently the value chain includes many links from fishermen to consumers (Flores, 2012; Silva & Segovia-Chilinga, 2018). In our study, we considered two dietary alternatives with high ratings of taste attributes by a broad focus group (i.e., women, men, juveniles, adults).

Nuggets are an easy-to-prepare food alternative with a wide variety of ingredients, including gluten-free options (da Silva & Silva, 2019). Nuggets could be industrialized by pre-cooking in olive oil not exceeding 180°C (it develops a crunchy and golden texture, low in fat), quick freezing at 3°C and vacuum packaging, minimizing the risk of microbiological contamination (e.g., *Clostridium botulinum* van Ermengem, 1896 and *Listeria monocytogenes* (E. Murray *et al*., 1926) Pirie, 1940). In this case, the shelf life is six months in frozen conditions and seven days in refrigerated conditions.

It is important to consider food alternatives based on *U. occidentalis* and products derived from it, such as chitin, proteins, related molecules (e.g., enzymes, peptides), and nanomembrane production (de Andrade *et al*., 2012; Zhang *et al*., 2024). Adding value to fishery resources could contribute to sustainable management and poverty alleviation in fishing communities (van de Walle *et al*., 2011 Searles et al., 2018). Red crab meat is a nutritious alternative for human consumption that can be given an added value that facilitates its preparation and meets the nutritional needs of modern society.

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Conceptualization: RZ, LS, MU, RP

Data curation: LS, MU

Formal Analysis: RZ, RP

Funding acquisition: RZ, LS

Investigation: RZ, LS, MU, RP

Methodology: RZ, LS, MU, RP

Project administration: LS

Resources: RP, MU

Software: RZ

Supervision: RZ, LS

Validation: RZ, LS

Visualization: RZ

Writing – original draft: RZ, LS, MU, RP

Writing – review & editing: RZ

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