

"Crustaceutical": A Jargon Term Firstly Used for Scientific Paper

Marife Mustacisa-Lacaba¹, Emmanuel R. de Guia², Ma. Rubi M. Parrocho³,
 Lourdes C. Delmonte⁴, Dolores L. Arteché⁵, Ronnie T. Velasco⁶, Redentor S.
 Palencia⁶

¹Samar State University
 Catbalogan City, Philippines

¹marife.mustacisa@ssu.edu.ph

Article Information

History:

Received 23JAN23

Final Revision 29MAY23

Accepted 21DEC23

Keywords:

Crustacean
 Crustaceutical
 Pharmaceutical
 Carotenoids
 Chitin
 Chitosan

Abstract: This scientific research paper introduces the term "crustaceuticals" to describe crustaceans with potential applications in nutraceuticals, marking the first usage of this terminology. The study aims to conduct a five-year synthesis review to support and validate the coined phrase. Utilizing a synthesis review methodology, the researchers analyze secondary resources from 2017-2022, focusing on two main themes: the nutraceutical potential of crustaceans such as shrimp, crabs, and lobsters, and the designation of these crustaceans as "crustaceuticals." The results reveal that these crustaceans not only possess traditional nutrients but also contain bioactive components with pharmaceutical potential.

Astaxanthin, chitin, chitosan, and fatty acids found in crustaceans exhibit antioxidant, anti-inflammatory, immune-boosting, and health-enhancing effects. The conclusion affirms the appropriateness of the term "crustaceutical" and underscores the biochemical components present in crustaceans, emphasizing their potential value in food technology with medicinal applications. This original research contributes a novel concept to the scientific lexicon and lays the foundation for further exploration of crustaceans in the realm of nutraceuticals.

I. INTRODUCTION

Crustaceans are one of the most important commodities in the food industry. In fact, the crustacean industry produces high-value export goods that allow producers to purchase low-value goods on the global market, favorably affecting food security in both exporting and importing nations (Bondad-Reantso et al., 2012; Nguyen et al., 2019 & Abbott et al., 2021). Asian countries are among the largest producers of crustaceans such as shrimp, crabs, and lobsters (Uderbayev et al., 2017 & Venugopal et al., 2017). In the year 2022, Asian countries currently account for 69% crustacean landings (Boenish et al., 2022).

Among Asian countries, the Philippines is one of the countries with a greater number of fisherfolk involved in crustacean industries (Abduho & Madjos, 2018). The Philippines' production of 826,060 MT of fish, crustaceans, mollusks, etc., contributed 1.01% to the world's total production in aquaculture by principal

producers (BFAR, 2020). In reality, the Philippines is one of the Association of Southeast Asian Nations (ASEAN) countries that exports crustaceans to Japan due to a particular interest in the effects of Acute Hepatopancreatic Necrosis Disease (AHPND). In Japan suggests that ASEAN exporters continue to increase efforts to combat AHPND so that exports to their major market (Japan) will not be affected (Lee, 2020).

The potential to address the economic aspects of other countries is not only one of the benefits of the Philippines' crustaceans; it also has a high nutraceutical potential, aside from the fact that they are a good source of protein-rich foods for human consumption (Li et al., 2021). Nutraceuticals are products that, other than being used for nutrition, are also used as medicine. A nutraceutical product may be defined as a substance that has a physiological benefit or provides protection against chronic disease (Baharlouei & Rahman, 2022). In the case of crustaceans such as shrimp and crabs, it contains chitin, a substance that inhibits the

growth of human cancer cell lines, meaning it has an anti-cancer effect (Rameshthagam et al., 2018; Wang et al., 2020 & Shahbaz et al., 2023). Moreover, in addition to the aforesaid chemical substance found in shrimp and crabs, they also contain chitosan, just like another family of crustaceans, the lobsters. Chitosan is a fibrous substance that reduces cholesterol and fat, making crustaceans very useful in medicine and drug manufacturing (Zhou et al., 2021; Razak et al., 2018 & Dang et al., 2018).

This scientific research paper presents evidence that crustaceans have pharmaceutical potential, and terms linked to them are first used in this study and tagged as "crustaceuticals."

Specifically, this study aims to:

1. introduce the term "crustaceutical" as the first terminology for crustaceans with potential for usage in nutraceuticals.

2. conduct a five-year synthesis review to back up the aforesaid non-technical phrase

II. METHODOLOGY

This study at hand uses "synthesis review" as a method. The researchers read secondary resources from 2017-2022 divided into two themes: the first is on the characteristics of crustaceans such as shrimp, crabs, and lobster, proving their nutraceutical potential. Second, consider how these specific crustaceans are tagged as "crustaceuticals."

III. RESULTS AND DISCUSSION

Prediction Inputs

A. Characteristics of Crustaceans

Shrimp

In terms of overall length, shrimp have been observed to range in size from 8 to 23 cm. The cephalothorax and exoskeleton account for at least 40% of the entire shrimp body, whereas the shrimp muscles are consumed directly (Dang et al., 2018). Shrimp peelability and shell loosening can be improved using enzymatic procedures, microwaves, or ultrasonic treatments. The exoskeleton and head of shrimp are used as by-products to further extract bioactive substances and chitin (Mishyna et al., 2021).

However, accumulating shrimp shell debris causes environmental damage and wastes resources. Utilizing affordable and environmentally friendly methods to recycle shell trash into usable fractions is still difficult (Yang et al., 2019 & Sharma et al., 2021). To find a clean and effective enzymatic procedure to recover the majority of the components of shrimp shell waste, including protein, chitin, astaxanthin, and minerals. Recombinant chitinase, two recombinant aspartic proteases, and ethyl acetate were all employed in the procedure to hydrolyze proteins, hydrolyze chitin, and extract astaxanthin (Deng et al., 2020).

After the removal of the protein and chitin, astaxanthin was easily recovered from the shell remnant due to the fact that deproteinization made the shell chitin accessible to chitinase. High recovery rates of protein (91.4%) and chitin (88.9%) were achieved during the procedure, which was finished in a matter of hours. In contrast to conventional chemical or physical treatments, the N-acetyl group of chitin oligomers, astaxanthin, and amino acids in peptides were all retained in their original states in the final products. Potential uses for the goods include food additives, anti-inflammatory drugs, and antioxidants (Ko et al., 2021; Nirmal et al., 2020 & Kandylis et al., 2020). This enzymatic method improves the environment and the economy by implementing a circular economy in the processing of shrimp (Deng et al., 2020 & de la Caba et al., 2019).

Supplements made from shrimp oil can assist your health more than other fish oils since it contains polyunsaturated fatty acids and carotenoids. By reducing the need for excessive solvent usage and raising the extraction yield, the physical techniques employed for the extraction of oil from shrimp processing by-products (SPBP) have the potential to enhance the extraction procedure (Gulzar et al., 2020 & Du et al., 2022).

Crab

Long-chain omega-3 fatty acids, protein, vital amino acids, and long-chain vitamins and minerals are all abundant in crab meat. Crab meat's distinct flavor and pleasing flavor qualities are a result of its volatile and non-volatile scent and flavor components, which contributes to the high level of customer acceptability (Adetokunbo, 2021; Nanda et al., 2021 & Nadeeshani et al., 2020). To increase the quality, security, and shelf life of crab meat and crab-based value-added goods, various cutting-edge preservation techniques are offered. Crab manufacturing wastes also contain a number of highly valuable bioactive substances (Nanda et al., 2021 & Yadav et al., 2019).

Table 1

Presentation of Biochemical Components

Biochemical Components	Pharmaceutical Description and Used	Presence in the Crustacean Commodity		
		Shrimp	Crab	Lobster
Astaxanthin (AST) (Carotenoids)	A potent lipid-soluble keto-carotenoid with auspicious effects on human health. It has antioxidant and anti-inflammatory effects that protect against inflammatory diseases such as cancer, obesity, hypertriglyceridemia, and hypercholesterolemia, with excellent safety and tolerability (Fakhri et al., 2018; Raza et al., 2021 & Alugoju et al., 2022).	✓	✓	✓
Chitin/Chitosan	These biochemical components are commonly used as antitherapeutics for immune system suppression and host cell toxicity (Safarzadeh et al., 2021). It can exert immune-boosting effects (Chen et al., 2019). Chitosan can even deliver treatment for SARS-CoV-2 infection, while chitin is very useful for having an anti-cancer effect (Tan et al., 2022; Gulati et al., 2021 & Rasul et al., 2020).	✓	✓	
Fatty acids (polyunsaturated)	It controls how the nervous system, blood pressure, hemostatic clotting, glucose tolerance, and inflammatory processes operate. These functions may be helpful in treating all inflammatory disorders. Especially among people who engage in physical exercise, their potential anti-inflammatory and antioxidant actions may offer health benefits and performance enhancement (Gammone et al., 2019; Tobaldini et al., 2019 & Bautista et al., 2019).	✓		

The valorization of these bioactive substances—derivatives of chitin, protein hydrolysates and enzymes, lipids, carotenoids, etc.—that have numerous uses in the agricultural, environmental, food, textile, pharmaceutical, and other biomedical industries—is advised to be done using green extraction methods (Ozogul et al., 2021 & Suresh et al., 2018).

Lobster

Study on carotenoids present in carapace and abdominal tissue in 5 species of lobsters *T. orientalis*, *P. homarus*, *P. versicolor*, *P. ornatus* and *P. polyphagus* has been carried out. Each carotenoid found in each species was given a separate quantitative and qualitative (HPLC) estimation. Astaxanthin was found to be more prevalent among the carotenoids in the *P. polyphagus* carapace (65.68%). Since astaxanthin predominates, this product is likely a strong source of natural antioxidants, which may enhance users' health (Galasso et al., 2018; Stachowiak & Szulc, 2021). So, it follows that the waste could constitute a valuable source of

natural carotenoid that could be recovered and used later as a pigment source in aquaculture diets.

B. Crustaceal Potentials

Based on the literature reviews, aside from the facts that crustaceans such as shrimp, crabs, and lobsters are rich in proteins, minerals, vitamins, and carbohydrates, there are recently discovered biochemical composition that makes it important in the pharmaceutical areas (Nanda et al., 2021; Suresh et al., 2018 & Nag et al., 2022). The following were the bioactive components present in crustaceans such as crabs, shrimp, and lobster which are abundant in the Philippines. Based on the literature reviews, the following were the bioactive components present in crustaceans such as crabs, shrimp, and lobster, which are in the Philippines (Table 1).

The findings suggest that crustaceans such as shrimp, crabs, and lobsters are not only rich in traditional nutrients but also contain important bioactive components that have

potential applications in the pharmaceutical industry. Astaxanthin, a carotenoid found in these crustaceans, has antioxidant and anti-inflammatory effects that may protect against inflammatory diseases such as cancer, obesity, hypertriglyceridemia, and hypercholesterolemia. Chitin and chitosan, which are commonly found in crustacean shells, have immune-boosting effects and can be used as antitherapeutic for immune system suppression and host cell toxicity. Fatty acids, particularly polyunsaturated fatty acids, found in crustaceans can potentially treat all inflammatory disorders, offer health benefits, and enhance performance among individuals who engage in physical exercise. Overall, these findings highlight the importance of crustaceans in human nutrition and health

IV. CONCLUSION

In conclusion, this study introduces the term "crustaceutical" as a pioneering nomenclature for crustaceans, shedding light on their nutraceutical potential through a comprehensive five-year synthesis review. Employing a synthesis review methodology, the research thoroughly explores the characteristics of shrimp, crabs, and lobsters, uncovering innovative extraction methods for valuable components. The study emphasizes environmentally sustainable practices, such as circular economies in shrimp processing, and explores the diverse applications of by-products.

Additionally, the investigation reveals the abundant bioactive components in crab meat and highlights green extraction methods for various substances, including chitin and chitosan. The prevalence of astaxanthin in lobster waste further underscores its potential as a natural antioxidant source. The multifaceted discussion delves into the rich biochemical composition of crustaceans, with particular emphasis on the immune-boosting effects of chitin and chitosan.

Overall, the coined term "crustaceutical" encapsulates the layered significance of crustaceans in human nutrition, health, and pharmaceutical applications, urging continued exploration of their potential benefits and sustainable utilization.

ACKNOWLEDGEMENT

The researchers deeply appreciate Aptissimi Development Innovations, Inc. (ADII) for facilitating futures thinking training for crustaceans, enhancing the research process.

Gratitude is also extended to the Senate Committee on Sustainable Development Goals, Innovation, and Futures Thinking for crucial funding that was vital for completing this study. Their commitment to interdisciplinary research and sustainability has been pivotal in exploring the nutraceutical potential of crustaceans.

REFERENCES

- Abbott, J. K., Willard, D., & Xu, J. (2021). Feeding the dragon: The evolution of China's fishery imports. *Marine Policy*, 133, 104733.
- Abduho, A. T., & Madjos, G. G. (2018). Abundance, supply chain analysis and marketing of crustacean fishery products of Tinusa Island, Sumisip, Basilan Province, Philippines. *Aquaculture, Aquarium, Conservation & Legislation*, 11(6), 1844-1858.
- Adetokunbo, M. A. (2021). *Gravading of mackerel (Scomber sp.): physicochemical and sensory changes during refrigerated storage* (Doctoral dissertation).
- Alugoju, P., Krishna Swamy, V. K. D., Anthikapalli, N. V. A., & Tencomnao, T. (2023). Health benefits of astaxanthin against age-related diseases of multiple organs: A comprehensive review. *Critical Reviews in Food Science and Nutrition*, 63(31), 10709-10774.
- Baharlouei, P., & Rahman, A. (2022). Chitin and chitosan: Prospective biomedical applications in drug delivery, cancer treatment, and wound healing. *Marine Drugs*, 20(7), 460.
- Bautista, R. J. H., Mahmoud, A. M., Königsberg, M., & Guerrero, N. E. L. D. (2019). Obesity: Pathophysiology, monosodium glutamate-induced model and anti-obesity medicinal plants. *Biomedicine & Pharmacotherapy*, 111, 503-516.
- BFAR. Philippine Fisheries Profile (DA, Ed.). 2020. <https://www.bfar.da.gov.ph/wp-content/uploads/2022/02/2020-Fisheries-Profile-Final.pdf>.
- Bondad-Reantaso, M. G., Subasinghe, R. P., Josupeit, H., Cai, J., & Zhou, X. (2012). The role of crustacean fisheries and

- aquaculture in global food security: past, present and future. *Journal of invertebrate pathology*, 110(2), 158-165.
- Boenish, R., Kritzer, J. P., Kleisner, K., Steneck, R. S., Werner, K. M., Zhu, W., ... & Mimikakis, J. (2022). The global rise of crustacean fisheries. *Frontiers in Ecology and the Environment*, 20(2), 102-110.
- Chen, Y. H., Lai, K. Y., Chiu, Y. H., Wu, Y. W., Shiau, A. L., & Chen, M. C. (2019). Implantable microneedles with an immune-boosting function for effective intradermal influenza vaccination. *Acta biomaterialia*, 97, 230-238.
- Dang, T. T., Gringer, N., Jessen, F., Olsen, K., Bøknæs, N., Nielsen, P. L., & Orlén, V. (2018). Emerging and potential technologies for facilitating shrimp peeling: A review. *Innovative Food Science & Emerging Technologies*, 45, 228-240.
- de la Caba, K., Guerrero, P., Trung, T. S., Cruz-Romero, M., Kerry, J. P., Fluhr, J., ... & Newton, R. (2019). From seafood waste to active seafood packaging: An emerging opportunity of the circular economy. *Journal of cleaner production*, 208, 86-98.
- Deng, J. J., Mao, H. H., Fang, W., Li, Z. Q., Shi, D., Li, Z. W., ... & Luo, X. C. (2020). Enzymatic conversion and recovery of protein, chitin, and astaxanthin from shrimp shell waste. *Journal of Cleaner Production*, 271, 122655.
- Du, Q., Zhou, L., Li, M., Lyu, F., Liu, J., & Ding, Y. (2022). Omega-3 polyunsaturated fatty acid encapsulation system: Physical and oxidative stability, and medical applications. *Food Frontiers*, 3(2), 239-255.
- Fakhri, S., Abbaszadeh, F., Dargahi, L., & Jorjani, M. (2018). Astaxanthin: A mechanistic review on its biological activities and health benefits. *Pharmacological research*, 136, 1-20.
- Frank, J., Fukagawa, N. K., Bilia, A. R., Johnson, E. J., Kwon, O., Prakash, V., ... & Williamson, G. (2020). Terms and nomenclature used for plant-derived components in nutrition and related research: efforts toward harmonization. *Nutrition reviews*, 78(6), 451-458.
- Galasso, C., Orefice, I., Pellone, P., Cirino, P., Miele, R., Ianora, A., ... & Sansone, C. (2018). On the neuroprotective role of astaxanthin: new perspectives?. *Marine drugs*, 16(8), 247.
- Gammone, M. A., Riccioni, G., Parrinello, G., & D'orazio, N. (2019). Omega-3 polyunsaturated fatty acids: Benefits and endpoints in sport. *Nutrients*, 11(1), 46.
- Gulati, N., Dua, K., & Dureja, H. (2021). Role of chitosan based nanomedicines in the treatment of chronic respiratory diseases. *International journal of biological macromolecules*, 185, 20-30.
- Gulzar, S., Raju, N., Nagarajara, R. C., & Benjakul, S. (2020). Oil and pigments from shrimp processing by-products: Extraction, composition, bioactivities and its application-A review. *Trends in Food Science & Technology*, 100, 307-319.
- Khanh Nguyen, H. T., Nang Thu, T. T., Lebailly, P., & Azadi, H. (2019). Economic challenges of the export-oriented aquaculture sector in Vietnam. *Journal of Applied Aquaculture*, 31(4), 367-383.
- Lee, S. M. (2020). Revealed comparative advantage of selected ASEAN countries' crustacean export to Japan. In *IOP Conference Series: Earth and Environmental Science* (Vol. 414, No. 1, p. 012010). IOP Publishing.
- Li, X., Han, T., Zheng, S., & Wu, G. (2021). Nutrition and functions of amino acids in aquatic crustaceans. *Amino Acids in Nutrition and Health: Amino Acids in the Nutrition of Companion, Zoo and Farm Animals*, 169-198.
- Kandyli, P., & Kokkinomagoulos, E. (2020). Food applications and potential health benefits of pomegranate and its derivatives. *Foods*, 9(2), 122.
- Ko, K., Dadmohammadi, Y., & Abbaspourrad, A. (2021). Nutritional and bioactive components of pomegranate waste used

- in food and cosmetic applications: A review. *Foods*, 10(3), 657.
- Mishyna, M., & Glumac, M. (2021). So different, yet so alike Pancrustacea: Health benefits of insects and shrimps. *Journal of Functional Foods*, 76, 104316.
- Nanda, P. K., Das, A. K., Dandapat, P., Dhar, P., Bandyopadhyay, S., Dib, A. L., ... & Gagaoua, M. (2021). Nutritional aspects, flavour profile and health benefits of crab meat based novel food products and valorisation of processing waste to wealth: A review. *Trends in Food Science & Technology*, 112, 252-267.
- Nadeeshani, H., Rajapakse, N., & Kim, S. K. (2020). Traditional and novel seafood processing techniques targeting human health promotion. *Encyclopedia of Marine Biotechnology*, 3041-3084.
- Nag, M., Lahiri, D., Dey, A., Sarkar, T., Pati, S., Joshi, S., ... & Ray, R. R. (2022). Seafood discards: a potent source of enzymes and biomacromolecules with nutritional and nutraceutical significance. *Frontiers in Nutrition*, 9, 879929.
- Nirmal, N. P., Santivarangkna, C., Rajput, M. S., & Benjakul, S. (2020). Trends in shrimp processing waste utilization: An industrial prospective. *Trends in Food Science & Technology*, 103, 20-35.
- Ozogul, F., Cagalj, M., Šimat, V., Ozogul, Y., Tkaczewska, J., Hassoun, A., ... & Phadke, G. G. (2021). Recent developments in valorisation of bioactive ingredients in discard/seafood processing by-products. *Trends in Food Science & Technology*, 116, 559-582.
- Rameshthangam, P., Solairaj, D., Arunachalam, G., & Ramasamy, P. (2018). Chitin and Chitinases: biomedical and environmental applications of chitin and its derivatives. *Journal of Enzymes*, 1(1), 20-43.
- Raza, S. H. A., Naqvi, S. R. Z., Abdelnour, S. A., Schreurs, N., Mohammedsaleh, Z. M., Khan, I., ... & Zan, L. (2021). Beneficial effects and health benefits of Astaxanthin molecules on animal production: A review. *Research in Veterinary Science*, 138, 69-78.
- Razak, M. A., Pinjari, A. B., Begum, P. S., & Viswanath, B. (2018). Biotechnological production of fungal biopolymers chitin and chitosan: their potential biomedical and industrial applications. *Current Biotechnology*, 7(3), 214-230.
- Rasul, R. M., Muniandy, M. T., Zakaria, Z., Shah, K., Chee, C. F., Dabbagh, A., ... & Wong, T. W. (2020). A review on chitosan and its development as pulmonary particulate anti-infective and anti-cancer drug carriers. *Carbohydrate polymers*, 250, 116800.
- Safarzadeh, M., Sadeghi, S., Azizi, M., Rastegari-Pouyani, M., Pouriran, R., & Hoseini, M. H. M. (2021). Chitin and chitosan as tools to combat COVID-19: A triple approach. *International journal of biological macromolecules*, 183, 235-244.
- Shahbaz, U., Basharat, S., Javed, U., Bibi, A., & Yu, X. B. (2023). Chitosan: a multipurpose polymer in food industry. *Polymer Bulletin*, 80(4), 3547-3569.
- Sharma, A., Sharma, R. K., Kim, Y. K., Lee, H. J., & Tripathi, K. M. (2021). Upgrading of seafood waste as a carbon source: nano-world outlook. *Journal of Environmental Chemical Engineering*, 9(6), 106656.
- Stachowiak, B., & Szulc, P. (2021). Astaxanthin for the food industry. *Molecules*, 26(9), 2666.
- Suresh, P. V., Kudre, T. G., & Johny, L. C. (2018). Sustainable valorization of seafood processing by-product/discard. *Waste to wealth*, 111-139.
- Tan, R. S. L., Hassandarvish, P., Chee, C. F., Chan, L. W., & Wong, T. W. (2022). Chitosan and its derivatives as polymeric anti-viral therapeutics and potential anti-SARS-CoV-2 nanomedicine. *Carbohydrate Polymers*, 290, 119500.

- Tobaldini, E., Fiorelli, E. M., Solbiati, M., Costantino, G., Nobili, L., & Montano, N. (2019). Short sleep duration and cardiometabolic risk: from pathophysiology to clinical evidence. *Nature Reviews Cardiology*, 16(4), 213-224.
- Uderbayev, T., Patoka, J., Beisembayev, R., Petrýl, M., Bláha, M., & Kouba, A. (2017). Risk assessment of pet-traded decapod crustaceans in the Republic of Kazakhstan, the leading country in Central Asia. *Knowledge & Management of Aquatic Ecosystems*, (418), 30.
- Venugopal, V., & Gopakumar, K. (2017). Shellfish: nutritive value, health benefits, and consumer safety. *Comprehensive Reviews in Food Science and Food Safety*, 16(6), 1219-1242.
- Wang, S. L., Nguyen, V. B., Doan, C. T., Tran, T. N., Nguyen, M. T., & Nguyen, A. D. (2020). Production and potential applications of bioconversion of chitin and protein-containing fishery byproducts into prodigiosin: A review. *Molecules*, 25(12), 2744.
- Yadav, M., Goswami, P., Paritosh, K., Kumar, M., Pareek, N., & Vivekanand, V. (2019). Seafood waste: a source for preparation of commercially employable chitin/chitosan materials. *Bioresources and Bioprocessing*, 6(1), 1-20.
- Yang, H., Gözaydın, G., Nasaruddin, R. R., Har, J. R. G., Chen, X., Wang, X., & Yan, N. (2019). Toward the shell biorefinery: processing crustacean shell waste using hot water and carbonic acid. *ACS Sustainable Chemistry & Engineering*, 7(5), 5532-5542.
- Zhou, J., Wen, B., Xie, H., Zhang, C., Bai, Y., Cao, H., ... & Su, Z. (2021). Advances in the preparation and assessment of the biological activities of chitosan oligosaccharides with different structural characteristics. *Food & Function*, 12(3), 926-951.