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MARINE BASED CHITOSAN BIOPOLYMER AS POTENTIAL BIOSOAP, ECO-FRIENDLY ALTERNATIVES

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Abstract
Marine-origin polysaccharides have been used in recent research because they are readily available, reasonably priced, biocompatible, and biodegradable. Since it can be made from leftover marine crustaceans, chitosan is becoming more and more valuable in a variety of applications. The structural component of fungi, insects, and crustaceans, chitin is the second most common biopolymer on Earth, behind cellulose. Chitin can be deacetylated to produce chitosan, a deacetylated derivative of chitin. Because the amino groups that give the polymer its many characteristics are present, it is a functionally versatile biopolymer. Though it has been employed in many industrial applications, biodegradable chitosan soap is one of the more recent uses for it. The properties of chitosan have been enhanced through a variety of techniques, including the use of plasticizers and cross-linkers, the embedding of fillers like fibers, whiskers, and nanoparticles, and the blending of the polymer with other natural and synthetic polymers as well as with natural extracts and essential oils. To get this biopolymer to industrial levels for use in biosoap and bioplastic applications, however, a lot more research is still required. Foamability, Total Alkali, TFM, pH, Hardness, and Antimicrobial are the characteristics of biosoap.

Keywords
Chitosan, Biosoap, Marine Biopolymer, Biodegradable, Tissue Engineering.

1. INTRODUCTION

One of the best cleaning agents for water is soap [1]. The saponification reaction is the procedure used to make soaps. Salts of potassium and sodium are utilized in the making of soap. Soaps are frequently used for skin cleansing and washing. The ability of soaps to wash is attributed to the presence of fatty acids, which can be derived from both plant and animal sources. These sources include oleic acid, lauric acid, palmitic acid, and stearic acid, which have both saturated and unsaturated fatty acid chains [2]. The proportion of chloride, free alkali, pH, total fatty acid, and moisture content are among the chemical characteristics of soap [3]. Utilizing renewable biomaterials is one environmentally friendly way to lessen waste generation and environmental deterioration [4-8]. Products manufactured from biopolymers have found innovative and imaginative uses in the bioeconomy and biotechnology throughout the past few decades [9]. Natural resources have played a significant role in human existence as a source of food and therapeutic elements to prolong human life in medicine [10].

Marine-derived biopolymers, utilized in tissue engineering, are among the many materials under investigation that may prove to be useful restorative therapy choices for the regeneration of damaged bone function and/or treatment of bone abnormalities [11-13]. They possess a number of attributes that make them ideal for use in the development of bioengineering-based medical technologies [14]. Among the earliest biodegradable materials utilized in clinical treatment were natural polymeric polymers. The bioactive properties of natural polymers allow them to interact with cells more effectively, enhancing the way that cells behave in biological

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systems [15]. The three primary types of natural polymers are proteins, polysaccharides, and polynucleotides (chitin, chitosan, alginate, gelatin, silk, and elastin) [16]. In tissue engineering applications, the use of natural polymers as architectures makes biological sense. Natural medications derived from marine sources are therefore more targeted and effective in treating a wide range of human illnesses [17]. Simple production and extraction processes are necessary for engineering materials, and polymeric polymers derived from marine minerals meet these criteria [18].

Natural biopolymers have several applications, including the production of implants and surgical equipment as well as medications, because of their intrinsic biocompatibility and biodegradable architectures. Institutions in charge of health control, surveillance, and inspection are also more likely to accept these chemicals [19]. Biological properties of marine biomaterials generally promote the synthesis of novel bioactive compounds with specific pharmacological properties that are important to the pharmaceutical industry. Moreover, they are usually biocompatible and biodegradable [20]. Marine compounds are special because they possess two essential characteristics in the world of pharmacy: a high bioavailability and a target affinity [21]. Tissue engineering, which includes implanting biomaterials and has applications in tissue regeneration, is one of the scientific fields with the most active research presently. The process of enhancing, maintaining, fixing, or regaining different biological tissues' functionality [22].

Chitin is a common biopolymer that is present in algae, crustacean exoskeletons, fungi, and insects. A few fungi (Mucoraceae) contain chitosan, which is less common in nature [23]. In the past, chitin obtained from crustacean sources was chemically deacetylated to create the bulk of chitosan samples that are currently sold commercially [24]. Important bioactive compounds, such as chitin and chitosan, offer a wide range of incredibly useful properties, such as antioxidants, wound healing, bacterial resistance, and the removal of certain contaminants. Because chitin and related components are renewable resources, they find application in a wide range of industries, including agriculture, cosmetics, pharmaceuticals, packaging, and nutrition [25]. Chitosan, which is less common in nature, is present in a number of fungi (Mucoraceae). Most commercially available chitosan samples were previously produced by chemically deacetylating chitin derived from crustaceans [26].

To eliminate dirt from surfaces like skin, fabrics, and other substances, soap is a chemical that dissolves in water. In addition to being crucial ingredients in lubricants and utilized in textile spinning, soaps are mostly employed as surfactants for cleaning, washing, and bathing. The process of processing vegetable or animal oils and fats with a strong alkaline solution yields cleansing soaps. A metal radical reacts with fatty acids or fatty glycerides to form soap, which is a chemical compound or mixture of chemical compounds. For washing, bathing, and cleaning purposes, soaps are primarily employed as surfactants [27]. An enormous amount of waste crustacean shell is produced annually as a major by-product of the seafood industry. This waste can be used to make value-added chitin, which can then be turned to chitosan through a relatively straightforward deacetylation process. Chitosan is far less expensive than other biopolymers since it is derived from a bio-waste product utilizing numerous energy-efficient techniques. Still, chitosan is a far better option for food packaging applications due to its unique qualities. Many industries, including natural cosmetics, soap, biomedical, agriculture, textiles, water treatment, photography, chromatography, electronics, paper, and food have already employed chitosan.

After chitin is deacetylated, a white, viscoelastic polymer known as chitosan is created. Chitosan is both biodegradable and biocompatible. Products made from chitosan that have had polymers with distinct properties produced by altering their basic structure [28]. Chitosan has attracted a lot of interest in bone regeneration because to its excellent qualities, which include antibacterial activity, sustained drug release, environmental friendliness, and exceptional biocompatibility [29]. Many skin irritations, such as flaking, dryness, redness, itching, and rash, are more frequently brought on by the chemicals included in commercial soaps; these chemicals can include petroleum compounds and chemical scents. Total fatty matter (TFM), moisture content, caustic alkali, pH, and free alkali were among the physical and chemical characteristics of chitosan-based soaps that were examined in order to assess if they would irritate skin.

2. MATERIALS AND METHODS

2.1 Sources and Structure

The most widely used and cost-effective method for separating chitosan is chitin deacetylation. Knowing that natural compounds, like chitin and chitosan, are derived from the remnants of other natural materials is one of the most crucial things to know. They originate from the trash produced by aquatic life. It should be highlighted as a result that natural resources only come in a certain amount [30, 31]. Many different types of animals and fungi rely on chitin as its structural component. Table 1 lists some popular chitin sources along with their chitin contents.

Table 1: Various sources for chitin extraction with percentage content in each by dry mass. (Hamed, Ozogul, & Regenstein, 2016). [32].

Organism	Chitin Content (%)	References
Crustaceans		Arbia, Arbia, Adour, & Amrane, 2013 [33]; Synowiecki & Al-Khateeb (2003) [34]
Nephro (lobster)	69.8	
Euphausia superb (krill)	24.0	
Homarus (lobster	60.0 -75.0	
Crangoncrangon (Shrimp)	17.8	
Lepas (goose barnacle)	58.3	
Fungi		
Aspergillus niger	42.0	Synowiecki & Al-Khateeb (2003) [34]
Penicillium notatum	18.5	
Penicillium chrysogenum	19.5 - 42.0	
Saccharomyces gutulata	2.3	

Figure 1 depicts the procedures for producing chitin from natural resources. Chitin is made in three steps: the protein is extracted in the first step using an alkaline solution; the minerals are removed in the second step using an acidic solution; and the color is added in the third step. For the substance to acquire specific qualities, each step is crucial. The use of enzymes and acids generated by microorganisms is another method for producing chitin with exceptional quality and purity.

The largest amine polysaccharide polymer after natural cellulose is chitin, which was initially identified in mushrooms in 1811 [36]. As illustrated in Figure 2, chitin is present in the skin and skeleton of snails, invertebrates, crustaceans, and insects, including crab, king crab, crayfish, lobster, and shrimp, despite the fact that it fortifies the cell walls of many fungi. Due to its biological characteristics, practical applications, and biodegradable and biocompatible nature as polymers generated from renewable natural sources, chitin and its derivatives are highly valuable economically [38].

Chitosan is generally employed in biomaterials, especially drug delivery systems and synergistic applications to augment

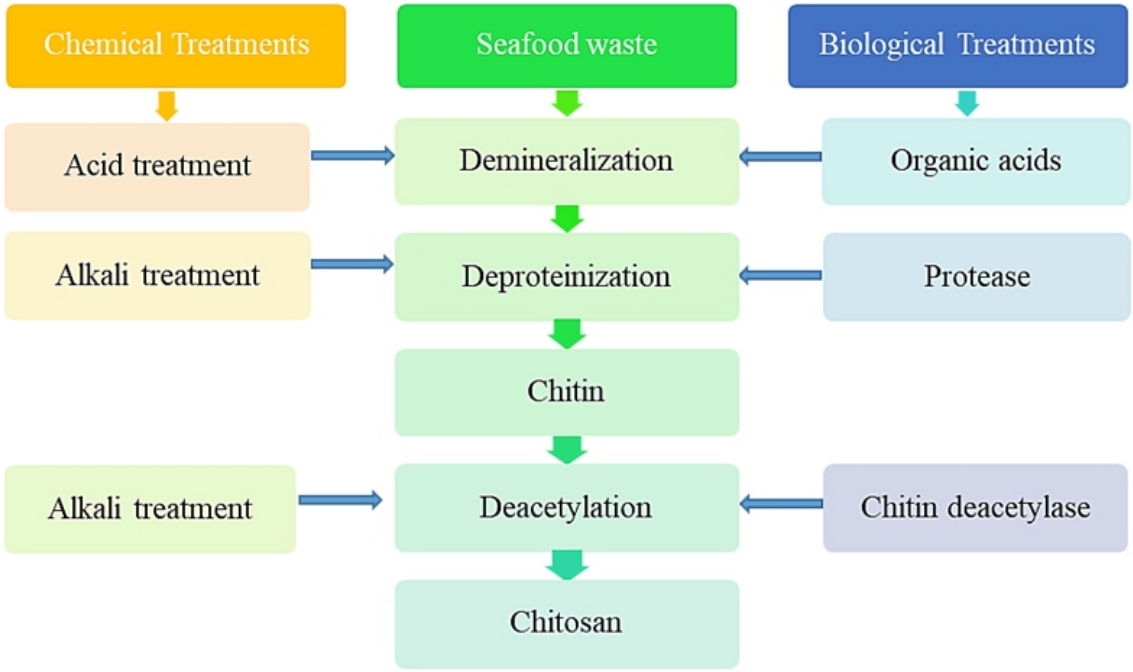

Figure 1: Chemical and biological procedures are used to produce chitin and chitosan. Reproduced with the permission from [38], Copyright 2019 Wiley Periodicals, Inc.

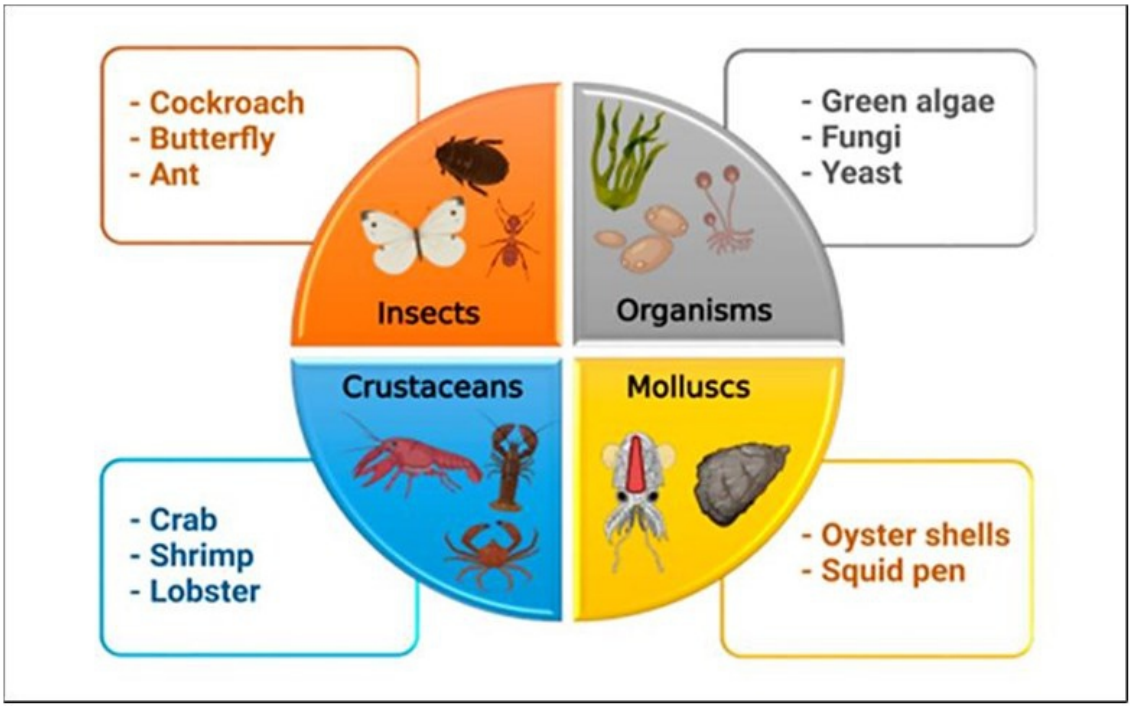

Figure 2: Sources of the chitosan. Reproduced with the permission from [37], Copyright 2014 Elsevier Inc.

the therapeutic advantages of other chemicals. How to make chitosan from chitin is shown in Figure 3.

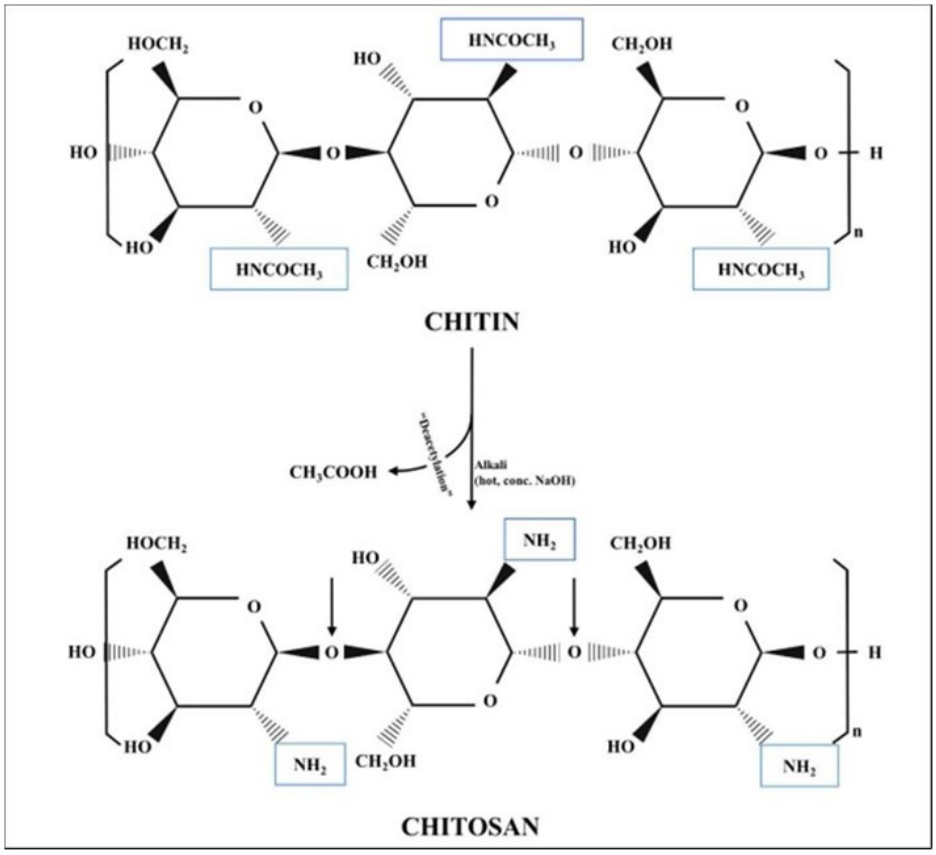

Figure 3: Production chitosan from chitin. Reproduced with the permission from [39], Copyright 2000 American Chemical Society.

2.2 Preparation of Soap by Hot Process Method

Chitosan of analytical grade was obtained from Sigma Aldrich and utilized in the purification process. To accelerate the interaction between the alkali and the fat, 3g of the Chitosan powder (A), measured oil, Alovera gel, glycerin, milk protein, flavor, and coloring agents were added to a 250 mL beaker. To make a 0.2 N NaOH solution, a fixed volume of distilled water was combined with a calculated weight of NaOH. The aqueous base solution was gradually added to the oils at a temperature of 33-43 °C, and the mixture was constantly stirred until it started to thicken. After that, the mixture was put into a plastic mold and given time to harden. For sample (B), the sample procedure was repeated. Photographs of Soap A and Soap B, respectively, in Figures 4 (a) and 4 (b), show the computed weights of the two samples in Table 2.

Table 2: Weight of Soap Mixtures.

Samples	Chitosan Powder gm	Oil mL	Caustic lie mL	Gel gm	Glycerine gm	Colouring Agents mL	Flavour mL	Protein gm
Soap A	3	Coconut oil-175	150	5	5	Blue colour-5	5	5
Soap B	3	Almond oil-175	150	5	5	-	5	5

Figures 4 (a) & (b): Photographs of Soap A and Soap B.

3. RESULTS AND DISCUSSION

3.1 Characterization of the Soap Prepared

3.1.1 Foamability Test

Each soap sample weighed around 2.0g. It was then dissolved and transferred to a 250 mL measuring cylinder that held 100 mL of distilled water. To create foam, the liquid was violently agitated for approximately five minutes. For roughly ten minutes, the measuring cylinder was left to stand. After that, a measurement and record of the foam's height in the solution were made [40]. Comparing the manufactured soaps with commercial soap, the same process was performed.

3.1.2 Determination of pH

Around 10 mL of distilled water was added to a beaker containing 5g of each soap combination, which was weighed and dissolved. The pH reading of the pH meter was taken after it was immersed into the solution [41]. The control sample underwent a same treatment.

3.1.3 Determination of Total Alkali

5g of each soap sample were combined with 2.5 mL of 1M H2SO4 solution and 10 mL of neutralized alcohol. The mixture was then heated until the soap sample was completely dissolved. Phenolphthalein was used as an indicator for titrating the solution against 1 M NaOH.

The following relation was used to compute the total alkali:

The total alkali was calculated using the relation:

$$\% \text{ Total alkali} = (VA\text{-}VB)/W \times 100\%$$

Where: V_A = volume of acid used (cm^3),
VB= volume of base (cm^3),
W= weight of soap (g) [40]

3.1.4 Determination of Total Fatty Matter

50 mL of distilled water was used to dissolve around 5g of each soap sample, which was then heated. After the mixture was heated to a transparent consistency, 10 mL of H_2SO_4 was added. After adding 2g of wax, the mixture was heated again until the fatty acid content solidified. The following phrase

was used to determine the outcome when the solution was allowed to cool and solidify into a cake. The cake was taken out, dried, and weighed.

$$\%\,TFM = (A\text{-}Z)/W \times 100\,\%$$

Where, A = weight of the obtained cake,
Z = weight of the wax, and
W = weight of the soap [42].

3.1.6 Determination of Hardness

A needle was inserted into the surface of each soap sample, and a lead fishing weight was fastened to it. In both the manufactured soap blend and the control sample soap, the needle's entry point was measured and noted. Calculate the values of Foamability, pH, Percentage of total alkali (%), Percentage of Total fatty matter (%), Hardness in Table 3.

Table 3: Foamability, pH, Percentage of total alkali (%), Percentage of Total fatty matter (%), Hardness.

Samples Produced	Soap Foam (cm)	pH	Alkali (%)	TFM (%)	Hardness
Soap A	12.1	9.1	0.32	71	0.57
Soap B	13.4	8.8	0.19	66	0.84

3.1.5 Antimicrobial Test for the Soap Produced

The manufactured soap made from neem and soy beans underwent an antimicrobial test in the microbiology lab of Ahmadu Bello University in Zaria's Department of Pharmaceutical Sciences. The test specimen organisms from the lab that were used for this were;

- *Escherichia coli*
- *Staphylococcus aureus*
- *Salmonella typhi*

Sensitivity Test

The isolated bacteria were prepared into Muller Hinton Agar (MHA) glass plates after standardization. Five wells were excavated in the sterile plates using an 8 mm diameter, sterilized cork borer spaced the same distance apart. The labels on the wells were based on the various soap concentrations that were made (100 mg/mL, 50 mg/mL, 25 mg/mL, 125 mg/mL, and the control "CP" mg/mL). The wells were filled with sterilized filter paper and designed to hold approximately 0.1 m of each of the soap's concentrations. The soap was relocated for an 18-24 hour incubation period in an incubator after being left at room temperature for approximately one hour, or the pre-diffusion period. Following the incubation time, when the extract was absorbed into the surrounding media, the plates were closely monitored. It was found that the existence of microbiological activity corrupted the organism and fostered growth. A transparent ruler was used to measure the zone of inhibition, and the findings were obtained and discussed.

Table 4: Sensitivity test of the each of the organisms on various concentrations of the biosoap extract.

Organisms Test	Zone of inhibition (mm) at varying concentrations (mg/mL)			
	100	50	25	12.5
E. coli	13.00	10.00	0.00	0.00
S. aureus	12.40	11.00	0.00	0.00
S. typhi	13.00	12.00	10.00	0.00
Control	33.00	31.00	30.00	30.00

4. CONCLUSION

Soap made with chitosan Using the hot process approach, soap B was effectively made. The results showed that compared to branded soaps, chitosan soap was better suited for human skin. Consequently, chitosan-based soap has favorable physicochemical qualities that make it suitable for usage as medicinal or cosmetic soap. Therefore, chitosan soap may also help to prevent acne and protect the skin. Chitosan is proving to be a low-cost and safest alternative to the use of chemical fungicides and bactericides against various plant pathogens. It is user and eco-friendly in nature. It can be incorporated with bio-control agents owing to its compatibility.

REFERENCES

1. **C.D. Joseph and D.D. Desal.** 1991. Liquid laundry detergents based on soap and a-sulfo methyl esters. *J. Am. Oil Chem. Soc.*, 68: 59-6.
2. **Ainie, K., K. Hamirin and I. Peang-Kean**. 1996. Chemical and Physical Characteristics of Soap Made, from Distilled Fatty Acids of Palm Oil and Palm Kernel Oil. *Journal of American Oil Chemists' Society*. 73: 105-108.
3. **Girgis, A.Y.,** 1999. Using of mucilage palm oil in the toilet soap production. *Grasas y Aceites*. 50(3): 185-192.
4. **B. Al-Zubaidy, N. S. Radhi, Z. S. Al-Khafaji**. Study the effect of thermal impact on the modelling of (*titanium-titania*) functionally graded materials by using finite element analysis, *International Journal of Mechanical Engineering and Technology*, 2019, 10, 776-784.
5. **N. S. Radhi, Z. S. Al-Khafaji**. Preparation and Investigation composite coating (Ni-nano hydroxyapatite) on low carbon steel samples, 6th Int Sci Conf Nanotechnology, *Adv Mater Its Appl.*, 2018.
6. **N. S. Radhi, M. Marza, Z. S. Al-Khafaji**. Modification of nickel-phosphor electroless coatings by adding particles of Zirconia. *Solid State Technology*, 2020, 63, 1179-1186.
7. **N. M. Dawood, N. S. Radhi, Z. S. Al-Khafaji**, Investigation corrosion and wear behavior of nickel-nano silicon carbide on stainless steel 316L, *Materials Science Forum*, 2020, 1002, 33- 43, doi: 10.4028, www.scientific.net/msf.1002.33.
8. **S. S. Radhi, Z. S. Al-Khafaji, M. W. Falah**. Sustainable heating system by infrared radiators, *Heritage and Sustainable Development*, 2022, 4, 42-52, doi: 10.37868/hsd.v4i1.82.
9. **L. F. Călinoiu, L. Mitrea, G. Precup, M. Bindea, B. Rusu, K. Szabo, F. V. Dulf, B. E. Ştefănescu, D. C. Vodnar**. 76. Sustainable use of agro-industrial wastes for feeding 10 billion people by 2050Professionals in food chains. Vienna, Austria. The Netherlands: Wageningen Academic Publishers, 2018, doi: 10.3920/978-90-8686-869-8_76.
10. **W. Appeltans, S.T. Ahyong, G. Anderson, M. V Angel, T. Artois, N. Bailly, R. Bamber, A. Barber, I. Bartsch, A. Berta**. The magnitude of global marine species diversity, *Current Biology*, 2022, 22, 2189-2202, doi: 10.1016/j.cub.2012.09.036.
11. **Tjprc**, Investigation biomedical corrosion of implant alloys in physiological environment, *International Journal of Mechanical and Production Engineering Research and Development*, 2018, 8, 247-256, doi: 10.24247/ijmperdaug201827.
12. **N. S. Radhi, N. E. Kareem, Z. S. Al-Khafaji, N. M. Sahi, M. W. Falah**. Investigation mechanical and biological properties of hybrid PMMA composite materials as prosthesis complete denture, *Egyptian Journal of Chemistry*, 2022, 65, 681-688, doi: 10.21608/ejchem.2022.110545.5034.
13. **Z. S. Al-khafaji, N. S. Radhi, S. A. Mohson**, Preparation and modelling of composite materials (polyester-alumina) as implant in human body, *International Journal of Mechanical Engineering and Technology*, 2018, 9, 468-474.
14. **K. Su, C. Wang**. Recent advances in the use of gelatin in biomedical research, *Biotechnology Letters*, 2015, 37, 2139-2145. doi: 10.1007/s10529-015-1907-0.
15. **E. Sharifi, S. Ebrahimi-Barough, M. Panahi, M. Azami, A. Ai, Z. Barabadi, A.-M. Kajbafzadeh, J. Ai.** *In vitro* evaluation of human endometrial stem cell-derived osteoblast-like cells' behavior on gelatin/collagen/bioglass nanofibers' scaffolds, *Journal of Biomedical Materials Research Part A*, 2016, 104, 2210-2219, doi: 10.1002/jbm.a.35748.
16. **B. D. Ratner, A. S. Hoffman, F. J. Schoen, J. E. Lemons**. Biomaterials science: an introduction to materials in medicine, Elsevier, 2004.
17. **G. Zhang, J. Li, T. Zhu, Q. Gu, D. Li**. Advanced tools in marine natural drug discovery, *Current Opinion in Biotechnology*, 2016, 42, 13-23, doi: 10.1016/j.copbio.2016.02.021.
18. **D.-X. Kong, Y.-Y. Jiang, H.-Y. Zhang**. Marine natural products as sources of novel scaffolds: achievement and concern, *Drug Discovery Today*, 2010, 15, 884-886. doi: 10.1016/j.drudis.2010.09.002.
19. **L. P. Gomes, V. M. F. Paschoalin, E. M. Del Aguila**. Chitosan nanoparticles: production, physicochemical characteristics and nutraceutical applications, *Revista Virtual De Química*, 2017, 9, 387-409, doi: 10.21577/1984-6835.20170022.
20. **M. Cardoso, R. Costa, J. Mano**. Marine origin polysaccharides in drug delivery systems, *Marine Drugs*, 2016, 14, 34. doi: 10.3390/md14020034.
21. **V. Ghormade, E. K. Pathan, M. V. Deshpande**. Can fungi compete with marine sources for chitosan production? *International Journal of Biological Macromolecules*, 2017, 104, 1415-1421, doi: 10.1016/j.ijbiomac.2017.01.112.
22. **T. Sukpaita, S. Chirachanchai, A. Pimkhaokham, R. S.** Ampornaramveth, Chitosan-based scaffold for mineralized tissues regeneration, *Marine Drugs*, 2021, 19, 551, doi: 10.3390/md19100551.
23. **Z. Limam, S. Selmi, S. Sadok.** A. El Abed, Extraction and characterization of chitin and chitosan from crustacean by- products: Biological and physicochemical properties, *African Journal of Biotechnology*, 2011, 10, 640-647.
24. **I. Leceta, P. Guerrero, S. Cabezudo, K. de la Caba**, Environmental assessment of chitosan-based films, *Journal of Cleaner Production*, 2013, 41, 312-318, doi: 10.1016/j.jclepro.2012.09.049.

25. **L. Deressa Tolesa, B. S. Gupta**, M.-J. Lee, Chitin and chitosan production from shrimp shells using ammonium-based ionic liquids, *International Journal of Biological Macromolecules*, 2019, 130, 818-826, doi: 10.1016/j.ijbiomac.2019.03.018.

26. **E. B. Ibitoye, I. H. Lokman, M. M. Hezmee, Y. M. Goh, A. Z. Zuki, A. A. Jimoh**. Extraction and physicochemical characterization of chitin and chitosan isolated from house cricket, *Biomedical Materials*, 2018, 13, 025009, doi: 10.1088/1748- 605x/aa9dde.

27. **Kuntom, A., Kifli, H. and Lim, P.K.** (1996): Chemical and Physical Characteristics of Soap Made from Distilled Fatty acids of Palm oil and Palm-kernel oil. *J. Am. Oil Chern Soc*. 73, 105-108.

28. **S. M. Bashir, G. Ahmed Rather, A. Patrício, Z. Haq, A. A. Sheikh, M. Z. U. H. Shah, H. Singh, A. Alam Khan, S. Imtiyaz, S. B. Ahmad, S. Nabi, R. Rakhshan, S. Hassan, P. Fonte**. Chitosan nanoparticles: A versatile platform for biomedical applications, *Materials*, 2022, 15, 6521, doi: 10.3390/ma15196521.

29. **S. Satitsri, C. Muanprasat**. Chitin and chitosan derivatives as biomaterial resources for biological and biomedical applications, *Molecules*, 2020, 25, 5961, doi: 10.3390/molecules25245961.

30. **J. Chakravarty, C.-L. Yang, J. Palmer, C. J. Brigham,** Chitin extraction from lobster shell waste using microbial culture-based methods, *Applied Food Biotechnology*, 2018, 5, 141-154.

31. **T. Philibert, B. H. Lee, N. Fabien**. Current status and new perspectives on chitin and chitosan as functional biopolymers, *Applied Biochemistry and Biotechnology*, 2017, 181, 1314-1337, doi: 10.1007/s12010-016-2286-2.

32. **Hamed, I., Özogul, F., & Regenstein, J. M.** (2016, February 1). Industrial applications of crustaceanby-products (chitin, chitosan, andchitooligosaccharides): A review. *Trends in Food Science and Technology*. Elsevier. http://doi.org/10.1016/j.tifs.2015.11.007

33. **Arbia, W., Arbia, L., Adour, L., & Amrane, A.** (2013). Chitin extraction from crustacean shells using biological methods-a review. *Food Technology and Biotechnology*, *51*(1), 12.

34. **Synowiecki, J., & Al-Khateeb, N. A.** (2003). Production, properties, and some new applications of chitin and its derivatives. *Critical Reviews in Food Science and Nutrition*, *43*(2), 145–171.

35. **F. Arrouze, J. Desbrieres, M. Rhazi, M. Essahli, A.** Tolaimate, Valorization of chitins extracted from North Morocco shrimps: comparison of chitin reactivity and characteristics, *Journal of Applied Polymer Science*, 2019, 136, 47804, doi: 10.1002/app.47804.

36. **A. Muxika, A. Etxabide, J. Uranga, P. Guerrero, K.** de la Caba, Chitosan as a bioactive polymer: processing, properties and applications, *International Journal of Biological Macromolecules*, 2017, 105, 1358-1368, doi: 10.1016/j.ijbiomac.2017.07.087.

37. **T. Jiang, R. James, S. G. Kumbar, C. T.** Laurencin, Chitosan as a biomaterial, *Natural and Synthetic Biomedical Polymers*, Amsterdam: Elsevier, 2014, 91-113, doi: 10.1016/b978-0-12- 396983-5.00005-3.

38. **D. Raafat, H.-G. Sahl**. Chitosan and its antimicrobial potential - a critical literature survey, *Microbial Biotechnology*, 2009, 2, 186-201, doi: 10.1111/j.1751-7915.2008.00080.x.

39. **Y.-W. Cho, J. Jang, C. R. Park, S.-W. Ko**, Preparation and solubility in acid and water of partially deacetylated chitins, *Biomacromolecules*, 2000, 1, 609-614, doi: 10.1021/bm000036j.

40. **Taiwo, A. A., Oluwadare, I., Shobo, A. O. and Amolegbe, S. A.** (2008). Extraction and potential application of caustic potash from kolanut husk, ugwu pod husk and plantain peels. *Scientific Research and Essay*. 3: 515- 517.

41. **Umar, M.** (2002). Cosmetics, Soaps, Detergents and NAFDAC's Regulatory Requirements. A paper presented at a Training workshop for Small and Medium Scale Enterprises.

42. **Ara, I., Siddiqui, B.S. and Faizi, S.** (2 010). Tricyclic diterpenes from the stem bark of *Azadirachta indica*. Photochemistry. 53: 816-820.

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CONFLICT OF INTERESTS

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