

THE STUDY OF CHITOSAN FROM MARINE CRAB AND ITS APPLICATIONS

Submitted in partial fulfillment of the requirements for the award of Bachelor of Science degree in B.Sc Microbiology

by

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DEPARTMENT OF BIOTECHNOLOGY

SCHOOL OF SCIENCE AND HUMANITY

SATHYABAMA

INSTITUTE OF SCIENCE AND TECHNOLOGY

(DEEMED TO BE UNIVERSITY)

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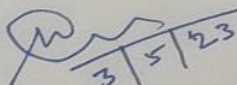
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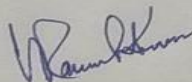
BONAFIDE CERTIFICATE

This is to certify that this Project Report is the bonafide work of VARSHAA. A G (Reg No. 40300073) who carried out the project entitled "THE STUDY OF CHITOSAN FROM MARINE CRABS AND ITS APPLICATIONS" under our supervision from September 2022 to March 2023.

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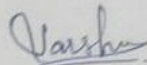
DECLARATION

I VARSHAA A.G hereby declare that the Project Report entitled THE STUDY OF CHITOSAN FROM MARINE CRAB AND ITS APPLICATIONS done by me under the guidance of Dr.

M. MASILAMANI SELVAM (Internal) at SATHYABAMA INSTITUTE OF SCIENCE AND TECHNOLOGY is submitted in partial fulfillment of the requirements for the award of Bachelor of Science degree in Microbiology.

DATE: 02/05/2023

PLACE: CHENNAI



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ABSTRACT

Chitin is naturally abundant polysaccharide and the supporting material of crustaceans, insects, etc., is well known to consist of 2-acetamido-2-deoxy- β -D-glucose through a β (1-4) linkage. It can be degraded by chitinase. Chitin is easily from crab or shrimp shells and fungal mycelia. Chitosan is commercially produced from chitin by alkali deacetylation. It is deacetylated chitin and is polymer of β (1-4) acetyl –D glucosamine. It has been widely used in studies related to coagulation. The natural biocontrol active ingredients, chitin and chitosan are found in the shells of lobsters, crabs and shrimp and many other organisms including insects and fungi. It is one of the most abundant biodegradable materials in the world. Chitosan finds use as a sizing material for rayon and other synthetic fibers, cotton, wool etc. It may also be used in the preparation of cosmetics, pharmaceuticals and also as a water clarifying agent. Treatment of chronic wounds and external ulcers, to arrest or minimize bleeding in neurosurgery. Usage as artificial skin and kidney membrane. Further complex applications in plastic surgery and contact lenses. This sole objective of the study is to carry out water treatment in a most efficient manner, plant growth, fish growth and cosmetics.

Keywords: chitin, chitosan, clarifying agent, biocontrol agent.

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CHAPTER 1

INTRODUCTION

Trash from the shellfish industry is typically dumped in landfills or the ocean. In some cases, leftover shells from crustaceans are turned into fertilizer or low-quality livestock feed. [Gotoh.T2004]. As a source of raw materials for a variety of potentially valuable products, crab shells, specifically chitin and its deacetylated derivative, chitosan, are used. A sequence of boilings and washings with acid, alkali, and detergent that took more than 14 hours were used by [Kaleem, O. and Sabi, A.F.B.S,(2021)] to create deacetylated chitin in 1936–1937. In addition to its numerous other applications, the ion-complexing capacity of deacetylated chitin (chitosan) has been studied and investigated [MI. Nevertheless, many of the techniques documented for extracting chitosan from crustacean shells are time-consuming and need large quantities of chemicals [Doares, Ryan.A (1995)Guibal (2004), Bolto, B., Dixon.D, Eldridge.R (2004)]. Crab shell is a high-quality dry organic source of NPK, calcium (23%), and magnesium (1.33%). Nematode and fungal issues will also be treated by it. Chitin and chitosan are a type of linear polysaccharide that contain different numbers of β -(1,4)-2-acetamido-2-deoxy—D-glucopyranose (GlcNAc) and 2- amino-2-deoxy—D-glucopyranose (GlcN) units[Guan, YJ; (2009)]. Chitin is made up of poly-B-(1-4)-N-acetyl-D'Glucosamine. They are insoluble in water and most common organic solvents because they are a nitrogen-containing polysaccharide that is chemically related to cellulose. Nevertheless, they only dissolve in certain solvents, including N,N-dimethylacetamide, hexafluoroacetone, and hexafluoro-2-propanol. Chitin turns into chitosan, a substance soluble in aqueous acidic solutions (pH 6.0), when the degree of N-acetylation (measured as the average number of N-acetyl-D-glucosamine units per 100 monomers expressed as a percentage) is less than 50%. This indicates that

"chitosan" refers to a collection of chitins that have been fully or partially deacetylated, but that a clear nomenclature to describe the distinction in N deacetylation between chitin and chitosan is yet to be established[Huang, R.L.,(2005)]. . Chitosan has some excellent attributes, such as low toxicity and high biodegradability, but it still has some issues with porosity, thermo-mechanical properties, and stability [Crini, G.; 2008]. To overcome these limitations of chitosan, researchers have worked hard to develop various physicochemical modification techniques, such as functionalization of the polymer through various chemical modifications that altered its properties for particular applications in a variety of fields[Escudero-Onate, c.(2018)].

1.1 WATER PURIFICATION:

Water scarcity has grown in importance over the last few decades and demands attention. We are aware that not only is water the most precious and durable resource on the planet, but is also a necessity for human survival. However, this is changing, primarily as a result of our fast industrialisation, where human society is causing the water supplies to decline[Masri,M.S.,(1978)]. The adsorption capacity of chitosan-based membranes is most significantly impacted by the chitosan's physical characteristics. Chitosan has been physically altered into many forms, including hydrogels and beads, for use in the treatment of water[Crini.G.,(2019)]. The source and composition of the chitosan is the second most important aspect to take into consideration while calculating the polymeric membrane's adsorption capacity. Chitosan is known to be extracted from crab shells and lobsters, as well as other natural materials utilized in water filtration. Chitosan is widely used to remove heavy metals from wastewater because of the hydroxyl and amine groups that are present on its surface[Aliabadi,M.; (2013)]. However, due to its limited stability, poor thermo-mechanical capabilities, and porosity, it does have certain drawbacks[Mourya, V.K (2008)].

Scientists created a chitosan-based adsorbent membrane using a variety of techniques to tackle these problems' challenges[Kurita K (1998)]. The purpose of this chapter of the review is to provide an overview of the manufacturing and wastewater treatment uses of chitosan-based polymeric membranes. Various membranes based on chitosan have been developed for using them in multiple applications, but the most special use was to

remove toxic pollutants from contaminated waters[Kurita (2001)]. Chitosan (positively charged) can be applied to create reverse osmosis/ultrafiltration membranes that naturally filter, absorb, and kill bacteria (negatively charged).Chitosan's antimicrobial properties are due to its flocculation and bactericidal properties. Chitosan has been shown to operate as a bridging mechanism for bacterial coagulation [Jimena, B.D., (2017)]. The use of chitin and chitosan as adsorbents in the treatment of wastewater containing organics and heavy metals has received a lot of interest. Chitin is a natural polymer with many hydroxyl and acetamido groups. Chitosan (a chitin derivative) is a hydrophilic polymer composed primarily of hydroxyl and amino groups. The mechanism of adsorption (involving chitin and chitosan) is based on electrostatic attraction (for anionic organic contaminants) and dative coordination (for heavy metal cations). Acetamido and amino groups from chitin and chitosan, respectively, are involved components in such a process[Muzzarelli, R.A.A., (1977)][Anastopoulos. I., Kyzas, G.Z. (2017)].

1.2 PLANT GROWTH

Chitosan affects plant immunity and induces the excretion of resistant enzymes. Furthermore, chitosan not only stimulates cells but also increases disease and pest resistance. Chitosan has a significant impact on agriculture, acting as a carbon source for bacteria in the soil, increasing the transition of organic matter into inorganic matter, and assisting plant root systems in absorbing more nutrients from the soil. Chitosan is absorbed into the root after being degraded in the soil by microorganisms [Cho,M.H.,(2008)]. Chitosan application in agriculture, even without chemical fertilizer, can significantly enhance the microbial population and convert organic nutrients into inorganic nutrients that are easily absorbed by plant roots [Kurita K (2006)][Bittelli M., Nicholas EJ (2001)]. Water resource management is a challenge for agriculture in temperate locations, such as the Mediterranean basin, where dry and hot summers are common, and drought events can have a significant influence on both production and crop quality [Barber, MS (1989)]. They include both film-forming and stomata-closing chemicals that can boost leaf resistance to water vapor loss, hence enhancing plant water consumption in carbon assimilation and, as a result, biomass or yield [Maclean,

N. (2003)]. Plant growth regulators are one of the most essential variables in enhancing leafy vegetable yield. Growth regulators have a positive management effect on field crop growth and production. Hormones govern physiological processes, and synthetic growth regulators may improve field crop growth and development, resulting in higher total dry mass [Chibu, H., Arima. S (2000)]. Chitosan application improves growth and yield characteristics in rice and soybean, sunflower, radish, barley, and wheat, and maize. Chitosan-based research on the growth, yield characteristics, and yield of Indian spinach is still lacking [Bornet,A; (2007)][Broussignac. P., (1968)][Muzzarelli, R.A.A., (1973)]. Considering the above facts, the present research work was undertaken to study the effect of Chitosan on growth, yield attributes and economic yields in broad beans, tomato and brinjal species.

1.3 FISH GROWTH

Aquaculture strives to give fish with stable environmental conditions in which to thrive while also protecting them from stress and disease. Well-balanced diets should be examined to provide a sustainable output of fish species. Fish farming is acknowledged as an important and substantial part of the global fishing industry. The aquaculture industry in Egypt has been developed and well sustained within the last few decades. Fish aquaculture is seen as an essential agricultural activity capable of eradicating nutritional deficiencies and reducing poverty [Das, B.C. and Das, T.K (1996)]. Aquaculture has advanced far faster than capture fisheries in the last few decades. Fish demand is increasing globally, with a shift towards intensive aquaculture systems, particularly in developing nations where fish are an essential source of animal protein and artificial feeding, where fish represent a major component[Abdel-Ghany, H.M.; and Salem, M.E.S.(2020)][Dave D, Routray W (2018)]. Chitosan and its related compounds have been demonstrated to boost fish growth performance, general immunity, and antioxidant benefits in the diet. However, depending on the species and growth stage of the fish, the technique for chitosan supplementation of food in fish requires thorough research [Ahmed,F; (2019)][Abdel-Ghany, H.M (2020)]. The effect of chitosan in feed formulation on the development of sea bass growth, feed utilization, body composition, and histological reaction was studied. At the end of the experiment, the final fish weight,

feed conversion ratio (FCR), specific growth rate (SGR), protein efficiency ratio (PER), protein productive value (PPV), and energy utilization (EU) of sea bass fed chitosan enriched food and the control diet were determined. The data represents the mean SD from a triplicate determination for a three-week feeding trial. For three weeks, different concentrations of chitosan and a control without chitosan were mixed with total fish feed in the form of dry meals. The impact of dietary chitosan on fish growth has received little

investigation. The purpose of this study was to learn more about the effects of dietary chitosan on sea bass growth, feed efficiency, and survival.

CHAPTER 2

LITERATURE SURVEY

2.1 CHITIN AND CHITOSAN

Although chitin is present in many aquatic organisms, many insects, terrestrial crustaceans, mushrooms, and some fungi, from the point of view of production, the raw biopolymer chitin is only commercially extracted from marine crustaceans (Truong et al. 2007; Nwe et al. 2011b, 2014; Dave and Routray 2018). This is because a significant amount of wastes/biowastes are available as low-cost byproducts of the seafood processing industry. Chitin and chitosan are produced on a massive scale using biowaste from the marine industries of prawns, crab, lobster, krill and squid. These marine crustaceans' shells contain 15–40% chitin, 20–40% proteins, and 20–50% calcium carbonate, respectively. Minor elements include lipids, metals, salts, and other minerals such as pigments and lipids. Naturally, the percentages differ greatly depending on the species employed, the quality and freshness of the shell, and the time of year (Peniche et al. 2008; Nwe et al. 2014). Clams and oysters are two additional marine creatures that may produce chitin. Deproteinization, demineralization, and decolorization are the three basic procedures needed to extract chitin from prawns, crab, and squid bone plates and shells. If protein or pigment recovery is not the goal, the order of the first two processes is unimportant (Peniche et al. 2008; Nwe et al. 2011b). The acetamide groups of purified chitin are subsequently hydrolyzed with sodium hydroxide solutions 40%–60% v/v to produce chitosan (No and Meyers 1995; Kurita 1998). The deacetylation procedure renders the N-acetyl bonds non-esterified. To avoid depolymerization and to stop chain deterioration, the procedure is often carried out in the presence of a N₂ atmosphere or a scavenger of oxygen. The precise reaction conditions rely on a number of variables, such as the raw material's origin, previous treatment, and desired level of acetylation. Both homogeneous and heterogeneous techniques are used to deacetylate chitin.

2.2 AGRICULTURAL USES

Chitin and chitosan, both of which have been investigated for a variety of agricultural purposes due to their documented antiviral, antibacterial, and antifungal characteristics.

They have been applied to treat illness or stop its spread, chelate nutrients and minerals to keep infections from getting to them, or boost a plant's natural defenses. Both monocotyledons and dicotyledons respond to host defense responses when chitin and chitosan are used to strengthen plant defenses. Numerous studies on the use of chitosan to control plant diseases have yielded mixed results depending on the pathosystem, the derivatives employed, the concentration, the degree of deacetylation, the viscosity, and the formulation used. Chitosan improved germination index, shortened mean germination time, increased shoot height, root length, and shoot and root dry weights in two tested maize lines, while having no discernible impact on germination at low temperatures. Chitosan reduced the amount of malondialdehyde in both of the test lines, changed how permeable the plasma membrane was, and elevated levels of proline, soluble sugars, peroxidase, and catalase activities as well as their concentrations. When chitin derivative dressings were applied to damaged tree bark, the wounds healed more quickly [Sharma, R.; (2019)]. A variety of PR-proteins and defense-related proteins, including phenylalanine ammonia-lyase and peroxidase, are said to be produced and accumulated as a result of chitosan's broad elicitor effects. Chitosan appears to expedite wound healing due to its participation in the synthesis and assembly of lignin matrix and the production of tyloses.

2.3 WATER TREATMENT

After cellulose, chitosan is the most abundant natural polysaccharide that is formed by deacetylating chitin. Due to their abundance in nature, bio-renewability, sustainability, low cost, and exceptional performance when compared to other materials used in water treatment, polysaccharides like chitosan received particular attention . Chitosan is a biopolymer that is commercially derived from prawns and other sea crustaceans and is biocompatible, biodegradable, renewable, and non-toxic .Chitosan's adsorption mechanism, particularly for the removal of heavy metals, has received very little research. Understanding the crucial function of the interaction between the hydroxyl group from the chitosan and the amine group of the metal ions could help to improve the sorption capacity of the membrane for the removal of heavy metals. Normally, the electrostatic or chemical interaction (chelation or complexation), ion exchange, and

nonpolar interaction, such as van der Waals forces, can be used to evaluate the amount of heavy metal adsorption through a modified chitosan surface. Water pollution by a variety of harmful substances, especially organic pollutants and heavy metals, has elevated to a severe environmental concern due to the detrimental effects on future generations' access to safe drinking water. In light of these facts, research into creating new and more effective materials and technologies for pollutant removal from wastewaters is increasing steadily.

2.4 FISH GROWTH

Chitosan has become a new candidate as a growth-promoter for farm animals. Aquaculture requires the creation of novel, unconventional fish diets that can support the physiological and biological processes of the cultured fish in order to ensure ongoing growth. Therefore, in order to advance aquaculture, scientists must look for green, eco-friendly, renewable, lucrative, and biologically sustainable materials. Chitosan (CS) and chitosan nanoparticles (CSNP) are regarded as safe, all-natural cationic biopolymers that support fish immunological function and growth[Wan Ngah, W.S., (2011)]. Chitosan production and use represent a globally desired, economically appealing method of disposing of crustacean shell waste. Interest is generated by its

usage in aquaculture due to its minimal risk of side effects, ability to boost immune system performance, and growth performance improvements.

CHAPTER 3

AIM AND SCOPE

AIM

To Study chitosan from marine crabs and its applications.

SCOPE

- Chitosan is used in water treatment to reduce the bacterial count in non-transportable water.
- Chitosan is used in plants to study growth and yields at various concentrations.
- Chitosan is used in fish feed and is fed to the fish to monitor their growth.

CHAPTER 4

METHODS AND METHODOLOGY

1. CONVERSION CHITIN TO CHITOSAN

Materials used are:

- distilled water
- beaker
- sodium hydroxide
- hydrochloric acid
- sodium carbonate
- water bath
- chitin

DEPROTEINIZATION:

- In a beaker, take 250 ml of distilled water.
- Add 7.5 g of NaOH, for 60 g of raw material.
- Allow it to dissolve in water then add chitin.
- Keep it in a water bath for 1 hour at 60 degree celsius.
- Wash the chitin several times.
- Allow the chitin to dry completely.

DEMINERALIZATION:

- Take a beaker and add 200 ml of distilled water.
- Add 6 ml of HCl.
- Add the raw material.
- Stir it until the reaction is complete.
- Leave it for 4 hours.
- Wash it several times.

NOW, OBTAINED PRODUCT IS CHITIN.

DEACETYLATION OF CHITIN:

- Take a beaker and add 200 ml of distilled water.
- Add 60 g of Na_2CO_3 and allow it to dissolve
- add chitin to it.
- Keep it in a water bath for 90 mins at 60 degree celsius.
- Wash it several times to remove the excess alkali.
- Allow it to dry completely.

OBTAINED PRODUCT IS CHITOSAN.

2. WATER PURIFICATION:

MATERIALS REQUIRED

- Polluted water
- Burette
- Beaker
- Chitosan

PROCEDURE

- Collection of polluted water from fish tanks .
- Filter the polluted water in 3 methods.
- Take a clean burette and add 50g of chitosan to it to purify 1l of water.
- Take another burette and add 50g of charcoal to it to purify 1l of water.

- Take a next burette and add 25g of charcoal and 25g of chitosan to it to filter 1l of polluted water.
- Then observed the various changes in filtered water.
- For the microbial count perform serial dilution.
- Sample waters to perform serial dilution are : polluted fish tank water, filter from Chitosan water filter from charcoal water and filter from mix of chitosan and charcoal water.
- Prepare nutrient agar for 500ml and Perform pour plate method to the samples.
- After 72 hrs microbial counts are observed.

3. PLANT GROWTH:

MATERIALS REQUIRED

- Broad bean seeds
- Tomato seeds
- Brinjal seeds
- Pots
- Soil
- Chitosan

PROCEDURE

- Collected broad beans , tomato and brinjal seeds from an organic shop.
- Planted the seeds in 5 pots with different concentrations(2g, 5g, 7g , 10g) of chitosan and one pot for bio-control.
- Planted seeds are observed for 1 month.



**FIG.4.3 SEEDLING OF BROAD BEANS ,
TOMATO AND BRINJAL**

4. FISH GROWTH:

MATERIALS USED FOR FISH FEED:

- Yellow corn meal
- Rice bran
- Crude protein[soybean meal]
- Crude fat[fish oil]
- Crude fiber[green leaf]
- Multivitamins
- Chitosan

PREPARATION

- All dry ingredients are mixed well.
- Fish oil, multivitamins and chitosan were mixed separately and added to the dry mixture.
- Materials are finely grounded in the blender.
- Made with two concentrations that are with and without chitosan.
- Warm distilled water is added.

- Diets were processed by a mincer with 3mm diameter, spaghetti like structure, sun dried and stored airtight.
- Broken into small pellets and stored in the refrigerator.



4.4 FISH FEED PELLETS

PROCEDURE

- The fishes are fed for 2 weeks as adaptation periods.
- Initial weights are recorded.
- Fishes are fed twice a day(6 days a week).
- Fishes are fed for 30 days in total.
- Weights are reweighed every week.



FIG 4.4.1 ALBINO TINFOIL



FIG 4.4.1 ALBINO TINFOIL

CHAPTER 5

RESULTS AND DISCUSSION

5.1 WATER PURIFICATION

The bacterial count was high in raw water sample plates.

The bacterial count was less in charcoal and chitosan mixture. Hence, chitosan and charcoal maybe an effective source in water purification process.

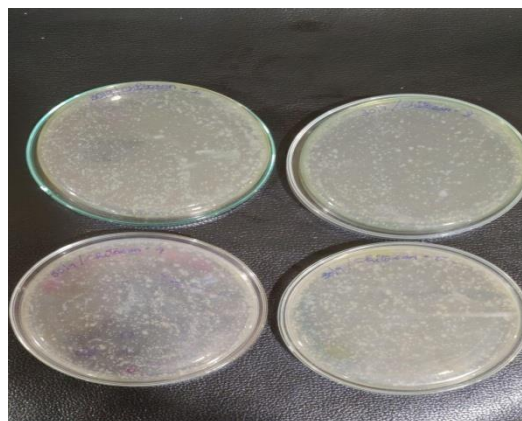
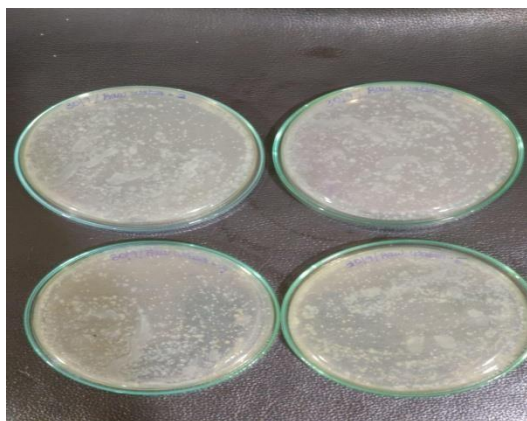


FIG 5.1.1 RAW WATER

FIG 5.1.2 CHITOSAN WATER

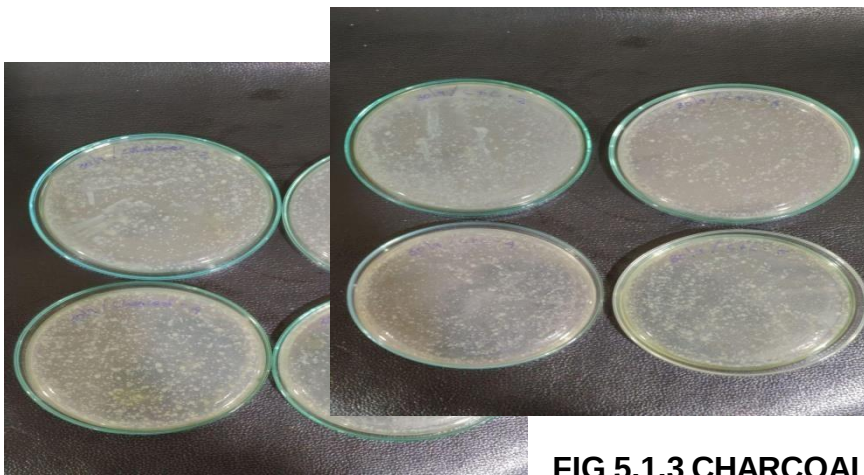


FIG 5.1.3 CHARCOAL WATER

FIG 5.1.4 CHITOSAN

& CHARCOAL

5.2 PLANT GROWTH

Plants usually grow well under suitable environment and soil. Adding right amount of chitosan to the soil improves the plant growth. Plant growth was observed high in 7gm concentration of chitosan pot in every species. further analysis can be done to make chitosan as an effective biofertilizer.



5.2.1 BOARD BEAN SEEDLING



5.2.2 TOMATO SEEDLING



5.2.3 BRINJAL SEEDLING

SEEDLING

3. YIELD

- Yields are obtained in broad bean species only.
- No yields obtained from tomato and brinjal species.
- In 5gm of chitosan pots grows well and produces more amount of yield
- In brinjal and tomato species only plants grow well with a high amount of leaves and the highest high seen in 5gm of chitosan fed pot.

5.3.1 OVERALL YIELD OF BROAD BEAN:

No.of pots	Chitosan concentrations	1st week yield	2nd week yield	3rd week yield	Total Yields	Total yield weight	Height of the plant
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1	2 grams	1	3	2	6	25 grams	60cm
2	5 grams	0	2	1	3	10 grams	65cm
3	7 grams	3	6	5	14	100 grams	72cm
4	10 grams	2	1	2	5	20 grams	60cm
5	bio control	1	3	0	4	15 grams	64cm



FIG.5.3.1.BROAD BEANS GROWTH

FIG.5.3.2.OVERALL YIELD OF BROAD BEANS



5.4 FISH GROWTH

Fish growth rate usually slow down when they grow, They require enormous nutrients in their feed. Chitosan added fish feed is used and it resulted in increasing the weight and length of the fishes. Fish feed with chitosan has greater result measurements of the fishes. Further study can be done to make chitosan infused fish feed.

Fish growth rate of first 3 weeks that are fed with chitosan and without chitosan are observed and a data was prepared. The graphical representation is given.

5.4.1 FISH GROWTH 1ST WEEK STUDY [8TH MARCH 2023]:

WITHOUT CHITOSAN			WITH CHITOSAN		
No. of fishes	Weight	Length	No. of fishes	Weight	Length
1	2.234g	3.5cm	1	2.475g	4.5cm
2	2.364g	4cm	2	1.88g	4cm
3	1.206g	4.2cm	3	2.043g	4.3cm
4	2.100g	4.5cm	4	2.590g	4.5cm
Mean	1.976g	4.05cm	Mean	2.248g	4.2cm

5.4.2 FISH GROWTH 2ND WEEK STUDY [17TH MARCH 2023]:

WITH CHITOSAN	WITHOUT CHITOSAN
---------------	------------------

No.of fishes	Weight	Length	No.of fishes	Weight	Length
1	2.59g	5.5cm	1	2.65g	4.8cm
2	2.42g	4.5cm	2	2.73g	4.7cm
3	1.93g	4.2cm	3	2.36g	4.5cm
4	2.54g	5cm	4	2.02g	4.3cm
Mean	2.45g	4.67cm	Mean	2.35g	4.5cm

5.4.3 FISH GROWTH 3RD WEEK STUDY [24TH MARCH 2023]:

WITH CHITOSAN	WITHOUTCHITOSAN
----------------------	------------------------

No of fishes	Weight	Length	No of fishes	Weight	Length
1	2.433g	5cm	1	2.653g	4.8cm
2	2.219g	4.2cm	2	2.738g	4.7cm
3	1.409g	4cm	3	2.343g	4.5cm
4	2.310g	4.5cm	4	2.083g	4.3cm
Mean	2.920g	4.425cm	Mean	3.050g	4.575cm

5.4.4 OVERALL AVERAGE WEIGHT & LENGTH

WITHOUT CHITOSAN		WITH CHITOSAN	
Average weight	Average Length	Average weight	Average Length
2.147g	4.3cm	2.382g	4.5cm

The overall calculation is given by calculating the mean value of weight and length of the fishes. The graph is made for three weeks of observation with average of weight and length.

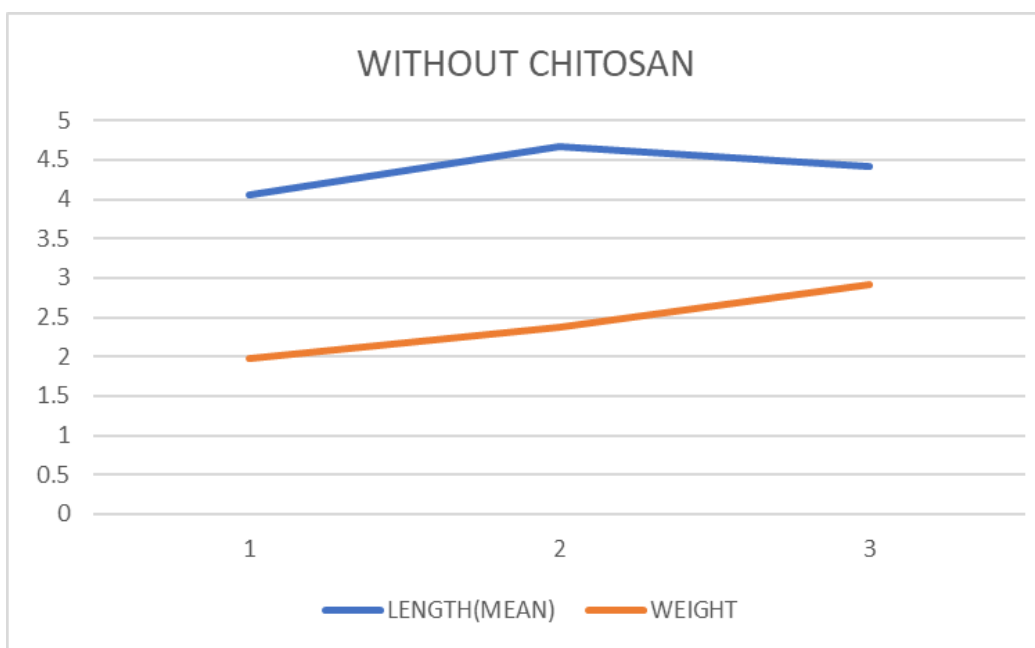


FIG 5.4.1 WITHOUT CHITOSAN GRAPH REPRESENTATION

X axis denotes the number of weeks (week 1,2,3)

Y axis denotes the length and weight of the fishes fed without chitosan.

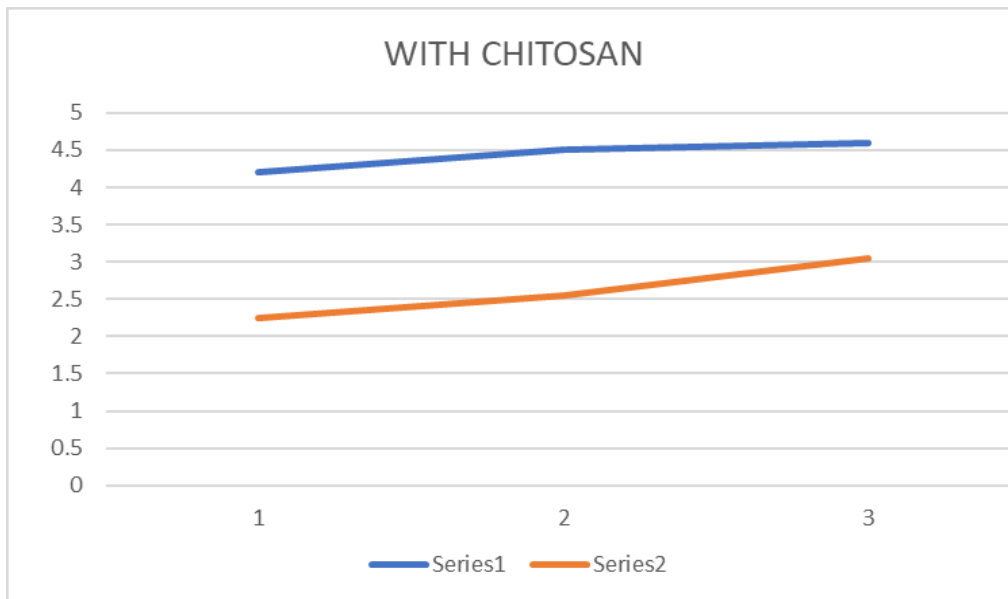


FIG 5.4.2 WITH CHITOSAN GRAPHICAL REPRESENTATION

X axis denotes the number of weeks (week 1,2,3).

Y axis denotes the length and weight of the fishes fed with chitosan.

**FIG.5.4.3.FISH
CHITOSAN**



WITHOUT



FIG.5.4.4.FISH WITH CHITOSAN

CHAPTER 6

SUMMARY AND CONCLUSION

Chitosan derived from the exoskeleton of marine crabs are applied in various applications such as water treatment , agricultural use , fish growth, cosmetics, gene therapy and much more. chitosan in fish feed diet supplements for fishes are helpful in improving growth, good movement, and better environment like less microbes and less pH level. Chitosan acts as an absorber in water treatment . Chitosan absorbs the impurities in water and filters it with less microbial count. Chitosan in agriculture helps in better growth of the plants and with the right amount of chitosan ,it produces more yield. Chitosan is widely used in various industries because of its efficiency , they are abundantly available and they are low in cost.

CHAPTER 7

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