Chitosan as Fat-Binder for Lowering Blood Cholesterol Level

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Abstract: Chitosan is a natural polysaccharide produced by the deacetylation of chitin, a significant component of crustaceans' shells such as crabs, shrimp, lobster and crawfish. Chitosan can be modified to become hydrophobic, which means the lack of affinity to water increases hydrophobicity properties. Through hydrophobic bonds, it is claimed to have the ability to bind with neutral lipids such as cholesterol. Cholesterol is a type of fat essential for humans, but too high a cholesterol level can be dangerous. Thus, this study aims to observe the parameters that can enhance hydrophobically modified chitosan's ability to lower cholesterol levels. The monitored parameters include the concentration of chitosan, the different pH values and the type of cooking oil. Another research objective is to study the effect of gamma radiation on samples. The method used to determine how much cholesterol is entrapped by the chitosan is quantifying the entrapped oil method. In contrast, the characteristics of cooking oil droplets formed can be observed through MBI-1600X microscope, UV-visible spectroscopy, Fourier Transform Infrared Spectroscopy (FTIR) and Field Emission Scanning Electron Microscope (FESEM). Finally, the interaction between chitosan and cooking oil at those three parameters, including gamma radiation;s effect on samples, is determined. This book is written to suit the needs of readers who want to know more about the properties characterisation of chitosan.

keyword: Lowering Blood, Cholesterol Level

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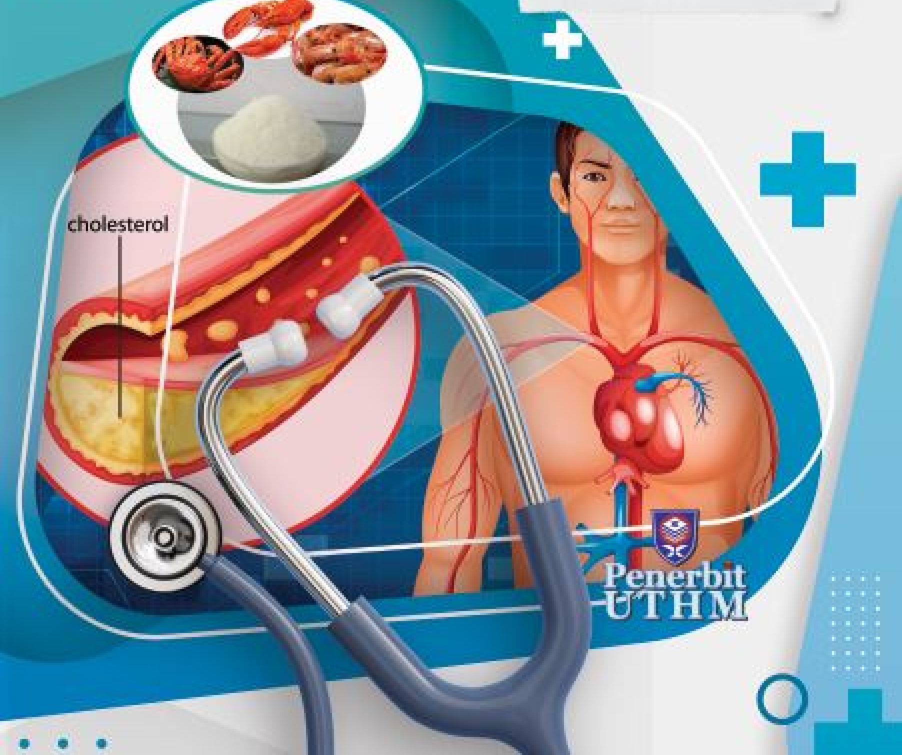

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2024

First Published 2024

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Published by:
Penerbit UTHM
Universiti Tun Hussein Onn Malaysia
86400 Parit Raja,
Batu Pahat, Johor
Tel: 07-453 8698/8529
Fax: 07-453 6145

Website: http://penerbit.uthm.edu.my
E-mail: pemasaran.uthm@gmail. com
http://e-bookstore.uthm.edu.my

Penerbit UTHM is a member of
Majlis Penerbitan Ilmiah Malaysia
(MAPIM)

Cataloguing-in-Publication Data

Perpustakaan Negara Malaysia

A catalogue record for this book is available from the National Library of Malaysia

ISBN 978-629-490-007-3

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PREFACE

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Chapter 1

INTRODUCTION

Chitosan is a linear polysaccharide composed of randomly distributed β-(1, 4)-linked D-glucosamine and N-acetyl-D-glucosamine. It is a compound that can be extracted from the hard exoskeleton of crustaceans including crabs, shrimps, lobster and krill. The process of producing chitosan involving the deacetylation of a chitin that causing the removal of an acetyl groups of chitins and leaving behind a complete amino group (Dutta et al., 2004; Sashiwa & Aiba, 2004).

Chitosan can be modified to become hydrophobic where the increase of hydrophobicity will increase the enzyme activity of it (Azeman et al., 2015). Hydrophobicity is the physical property of a molecule which known as a hydrophobe that repelled from a mass of water. The word hydrophobic means "water-fearing", where it describes the repulsion interaction between water and nonpolar substances. Through hydrophobic bond, chitosan is said to have ability in binding with neutral lipids for example fat and cholesterol (Philippova & Korchagina, 2012). Recently, chitosan has been widely used in various fields include in biomedical, agricultural, biotechnology and many more. Moreover, its applications have been extensively explored in all aspects of science.

Chapter 2

CHITOSAN

Composition of Chitosan

Chitosan, a natural polysaccharide which can be derived from chitin, a mainly component of the shells of crustaceans has received much attention for its commercial applications in various fields for instances in the biomedical, agriculture, cosmetic products, food and chemical industries as well. Chitosan consists of β-(1→4) linked 2-acetamido-2-deoxy-β-D-glucopyranose (GlcNAc) and 2-amino-2-β deoxy-D-glucopyranose (GlcN) units with the ratio depending on the deacetylation degree as shown in figure 2.1.. It consists of three types of reactive functional groups, an amino ($-NH_2$) or acetamido ($-NHCOCH_3$) group with both primary and secondary hydroxyl (-OH) group at the C-2, C-3 and C-6 positions, respectively (Dutta et al., 2004; Hussain et al., 2013)).

Chapter 3

CHARACTERIZATION WITH UV-Vis

Sample preparation

The stock solutions of different molarities of chitosan (0.1 M, 0.2 M, 0.3 M, 0.4 M and 0.5 M) were prepared. The chitosan powder is weighed to a desired amount of weight depending on molarities which has been determined and dissolved in a beaker with certain volume of distilled water added to it. The solution is then transferred into a 1-L volumetric flask. The beaker is rinsed several times with small portion of distilled water and next is added to the volumetric flask's calibration mark.

For parameter of different concentration, the samples were prepared by adding 10 ml of palm oil into a beaker of 100 ml of 0.1 M chitosan stock solution. The beaker with palm oil and chitosan was stirred at a constant speed with the temperature of 37º C by using hot plate and a magnetic stirrer. It was stirred for about 30 minutes until it form an emulsion. The steps were then repeated by using different molarity of stock solution. There were 5 different samples for this concentration parameter.

Chapter 4

CHARACTERIZATION WITH FTIR

Fourier transform infrared spectroscopy (FTIR) is a technique used to obtain an infrared spectrum of absorption, emission or scattering of a solid, liquid or gas state sample. Also, it is used to measure how well the sample absorbs light at certain wavelength and identify the functional group exist in a molecule. FTIR become as one of the most important technique available to scientist working on chitosan.

Commonly, FTIR spectroscopy records the energy of the electromagnetic radiation which is transmitted through a sample as a function of the wavenumber or frequency. Furthermore, this technique also allowing the qualitative identification of certain bond type present in the sample which is induced by the energy of each peak in the spectrum of the absorption corresponds to the frequency molecular vibration.

In this research, the FTIR is used to obtain and study the different analysis between each of the selected samples where it involved all 3 parameters including concentration of chitosan powder, different of pH values and type of cooking oil. Besides that, the effect of gamma

Chapter 5

CHARACTERIZATION WITH FESEM

Field emission scanning electron microscope (FESEM) is the device that used to study and analyse the morphology of particles. With the energy dispersive X-ray spectroscopy system (EDS), the element contents in that particles or samples can be detected easily. In this study, FESEM is used to observe the different morphology of selected samples including samples before and after gamma irradiation of chitosan and chitosan-oil.

Differs from the previous studies where most of them were used scanning electron microscope (SEM) to study the morphology of the samples, this research used FESEM instead of SEM. The morphology of chitosan and chitosan-oil were determined by a JEOL JSM-7600F. Each of samples were coated with gold (Au) for enhancing the conductivity before the scanning process.

Chapter 6

CONCLUSION

From the findings of the research, it can be concluded that the characteristics and function of chitosan as a fat-binder affected by different parameters including concentration of chitosan, pH values and the type of cooking oil used. The capability of chitosan in entrapping fats could be proved through this research study by preparing the sample of chitosan and cooking oil at those three different parameters. Also through this study, the claims that chitosan helps in lowering blood cholesterol level in body is further strengthened.

For each parameter, chitosan has shown its best condition in entrapping fats where chitosan works best at concentration of 0.5 M, pH 8 and with the adding of palm oil for parameter of different concentrations, pH values and type of cooking oil respectively. The result also shows that the fat binding capability of the chitosan is increases as the sample undergoes gamma radiation. These findings might be due to some logically and theoretically reasons that make those conditions best for chitosan to interact with the cooking oil.

Bibliography

Azeman, N.H., Yusof, N.A., Abdullah, J., Yunus, R., Hamidon, M.H. & Hajian, R. (2015). Study on the Spectrophotometric Detection of Free Fatty Acids in Palm Oil Utilizing Enzymatic Reactions. *Molecules*, 20, 12328-12340.

Bani, K., Montazeri, M. & Hashemi, M. (2006). Effect of Palm Oil on Serum Lipid Profile in Rats. *Pakistan Journal of Nutrition*, 3, 234-236.

Copikova, J., Taubner, T., Tuma, J., Synytsya, A., Duskova, D. & Marounek, M. (2014). Cholesterol and Fat Lowering with Hydrophobic Polysaccharide Derivatives. *Carbohydrates Polymers*, 116, 207-214.

Desbrieres, J., Martinez, C. & Rinaudo, M. (1996). Hydrophobic Derivatives of Chitosan:Characterization and Rheological Behaviour. *International Journal of Biological Macromolecules*, 21-28.

Dutta, P.K., Dutta, J. & Tripathi, V.S. (2004). Chitin and Chitosan:Chemistry, Properties and Applications. *Journal of Scientific & Industrial Research*, 20-31.

Fray, M.E., Niemczyk, A. & Parbin-Szafko, B. (2012). Chemical Modification of Chitosan with Fatty Acids. *Progress on Chemistry and Application of Chitin and Its Derivatives*, Volume XVII.

Guan, L., Chung, H.Y. & Chen, Z.Y. (2011). Comparison of Hypocholesterolemic Activity of Tea Seed Oil with Commonly Used Vegetable Oils in Hamster. *Journal of Food Biochemistry*, 859-876.

Hettiarachchi, M.A. & Wickramarachchi, P.A.S.R. (2011). Synthesis of Chitosan Stabilized Silver Nanoparticles using Gamma Ray

Irradiation and Characterization. *Journal Science of University Kelaniya*, 6, 65-75.

Hussain, M.R., Iman, M. & Tarun, K.M. (2013). Determination of Degree of Deacetylation of Chitosan and Their Effect on the Release Behaviour of Essential Oil from Chitosan and Chitosan-Gelatin Complex Microcapsules. *International Journal of Advanced Engineering Applications*, 4-12.

Joyce, C.C.S., Alexandra, A.P.M. & Herman, S.M. (2013). One-Step Biofunctionalization of Quantum Dots with Chitosan and N-palmitoyl Chitosan for Potential Biomedical Applications. *Molecules*, 18, 6550-6572.

Kumirska, J., Mirko, X.W., Czerwicka, M., Kacyzynski, Z., Bychowski, A., Thoming, J. & Stepnowski, P. (2011). Influence of the Chemical Structure and Physicochemical Properties of Chitin-Chitosan-Based Materials on Their Biomedical Activity. *Biomedical Engineering, Trends in Materials Science*.

Kumirska, J., Mirko, X.W., Thoming, J. & Stepnowski, P. (2011). Biomedical Activity of Chitin/Chitosan Based Materials:Influence of Physicochemical Properties from Molecular Weight and Degree of N-Acetylation. *Polymers*, 3, 1875-1901.

Philippova, O.E. & Korchagina, E.V. (2012). Chitosan and Its Hydrophobic Derivatives:Preparation and Aggregation in Dilute Aqueous Solutions. *Polymer Science*, 7, 552-572.

Rahman, A.A.E. & Badawy, H.A.A. (2006). Ultraviolet, Visible and Infrared Wavelenghts for Determination of Palm Oil Quality. *Process Engineering*, 777-793.

Rashid, T.U., Rahman, M.M., Kabir, S., Sayed, M.S. & Mubarak, A.K. (2012). A New Approach for the Preparation of Chitosan from Gamma Irradiation of Prawn Shell:Effects of Radiation on the Characteristics of Chitosan. *Society of Chemical Industry*, 61:1302-1308.

Rodriguez, M.S. & Albertengo, L. (2005). Interaction Between Chitosan and Oil Under Stomach and Duodenal Digestive Chemical Conditions. *Bioscience, Biotechnology and Biochemistry*, 69(11), 2057-2062.

Sashiwa, H. & Aiba, C.-I. (2004). Chemically Modified Chitin and Chitosan as Biomaterials. *Progress in Polymer Science*, 29, 887-908.

Sionkoswa, A., Planecka, A., Lewandowska, K., Kaczmarek, B. & Szarszewska, P. (2013). Influence of UV-Irradiation on Molecular Weight of Chitosan. *Progress on Chemistry and Application of Chitin and Its Derivatives*, Volume XVIII.

Sun, Y., Neelakantan, N., Wu, Y., Lote-Oke, R., Pan, A. & Rob, M.V.D. (2015). Palm Oil Consumption Increase LDL Cholesterol Compared with Vegetable Oils Low in Saturated Fat in a Meta-Analysis of Clinical Trials. *American Society for Nutrition*.

Xia, W., Liu, P., Zhang, J. & Chen, J. (2010). Biological Activities of Chitosan and Chitooligosaccharides. *Food Hydrocolloids*, 1-10.

Zhang, J., Xia, W., Liu, P, Cheng, Q., Tahirou, T., Gu, W. & Li, B. (2010). Chitosan Modification and Pharmaceutical/Biomedical Applications. *Marine Drugs*, 8, 1962-1987.

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ISBN 978-629-490-007-3

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