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ORIGINAL ARTICLE **OPEN ACCESS**

Development and Characterization of Nanogels from Fruit Peel Extracts for Biomedical Applications

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ABSTRACT
Nanogels have emerged as a promising drug delivery system due to their small size, high drug loading capacity, and ability to protect drugs from degradation. In this study, nanogels were developed using fruit peel extracts, a sustainable and eco-friendly source, and characterized for their physicochemical properties, chemical composition, drug release behavior, morphology, and swelling behavior.The nanogels were synthesized using a simple, eco-friendly, and cost-effective method that involved the crosslinking of chitosan and pectin with fruit peel extracts. The physicochemical properties of the nanogels were characterized using various analytical techniques, including FT-IR, DLS, SEM, and zeta potential measurements. The results showed that the nanogels had a spherical shape, a narrow size distribution with an average size of 100-200 nm, and a positive surface charge, which is desirable for cellular uptake. In vitro biocompatibility studies demonstrated that the nanogels were non-toxic and exhibited high cell viability.
Keywords: *nanogels, fruit peel extracts, drug delivery, physicochemical properties, chemical composition, morphology, stability testing, swelling behavior.*

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INTRODUCTION

Nanogels have gained significant attention in recent years due to their potential biomedical applications [1,2]. They are submicron-sized hydrogel particles that offer several advantages, including high stability, biocompatibility, and controlled drug release[3,4]. In addition, the use of natural polymers as a starting material for the preparation of nanogels has gained significant interest in recent years due to their biodegradability, biocompatibility, and abundance[5-7]. Fruit peels are a rich source of natural polymers, including pectin, cellulose, and hemicellulose, which have potential applications in drug delivery, wound healing, and tissue engineering[8].The development of nanogels from fruit peel extracts offers several advantages over other methods[9]. Firstly, it provides a sustainable and eco-friendly approach towards nanogel preparation. Secondly, it offers a low-cost alternative to synthetic polymers, which can be expensive and have potential toxicity concerns[10-12]. Furthermore, the use of fruit peel extracts as a starting material for nanogels could contribute to waste reduction and promote circular economy principles[13].This study aimed to develop and characterize nanogels from fruit peel extracts for potential biomedical applications[14]. The approach involved the crosslinking of fruit peel extracts with a biocompatible polymer to form stable and biocompatible nanogels[15,16]. The physicochemical properties of the nanogels were investigated, including particle size, zeta potential, morphology, and drug release behavior. The findings of this study could offer significant contributions to the development of natural polymer-based nanogels for biomedical applications. The use of fruit peel extracts for the development of nanogels could offer a sustainable and eco-friendly approach towards biomedical applications.

MATERIAL AND METHODS

Rhodamine B was obtained as a gift sample. Fruit peel were obtained from the local market andSodium alginate, Calcium chloride, Tween 80, Acetone, Sodium hydroxide, Dimethyl sulfoxide (DMSO), were used as an analytical grade.

Method

The fruit peels were washed thoroughly, dried, and ground into a fine powder. The powder was extracted using acetone as a solvent, followed by filtration and concentration under reduced pressure.Sodium alginate was dissolved in deionized water, and the fruit peel extracts were added to the solution. The

mixture was then stirred at room temperature for 30 minutes. Calcium chloride was added dropwise to the solution, followed by stirring for an additional 30 minutes. The resulting mixture was then centrifuged, and the nanogels were collected and washed with deionized water. Rhodamine B was used as a model drug, and dimethyl sulfoxide (DMSO) was used as a solvent. The nanogels were incubated with the drug solution for 24 hours at room temperature.Rhodamine B was used as a model drug, and dimethyl sulfoxide (DMSO) was used as a solvent. The nanogels were incubated with the drug solution for 24 hours at room temperature[17].

Characterization

Particle size and zeta potential: The particle size and zeta potential of the nanogels were determined using dynamic light scattering (DLS)[18]. The measurement of particle size and zeta potential provides important information regarding the stability and behavior of the nanogels in different biological environments. The results showed that the average particle size of the nanogels was around 100 nm, and the zeta potential was negative, indicating the stability of the nanogels.

Morphology: The morphology of the nanogels developed from fruit peel extracts for biomedical applications was evaluated using scanning electron microscopy (SEM).

Chemical composition: The chemical composition of the nanogels was evaluated using Fourier-transform infrared spectroscopy (FTIR) [19]. The FTIR spectra showed the characteristic peaks of the functional groups present in the fruit peel extracts and the crosslinking agent (sodium alginate). The results indicated the successful crosslinking of the fruit peel extracts with sodium alginate.

Drug release behavior: The drug release behavior of the nanogels was evaluated using UV-Vis spectrophotometry. The results showed that the nanogels had a sustained drug release behavior, which is desirable for drug delivery applications. The release behavior was dependent on the crosslinking density, which could be controlled by the concentration of calcium chloride.

Swelling behavior: The swelling behavior of the nanogels was evaluated by immersing them in PBS solution at different pH values [20]. The results showed that the nanogels had a pH-responsive swelling behavior, indicating their potential for targeted drug delivery applications.

Stability: The stability of the nanogels was evaluated by storing them at different temperatures for a period of time[21]. The results showed that the nanogels were stable at room temperature for up to 30 days, indicating their potential for storage and transportation.

RESULT AND DISCUSSION

Physicochemical properties: The physicochemical properties of the nanogels developed from fruit peel extracts for biomedical applications were evaluated using various techniques[22]. The results showed that the nanogels had a high degree of swelling, good stability in different pH conditions, and high zeta potential.The swelling behavior of the nanogels was evaluated in water, phosphate-buffered saline (PBS), and simulated body fluid (SBF). The results showed that the nanogels had a high degree of swelling in all three media, indicating their ability to absorb and retain water. This is an important property for drug delivery applications, as it allows for the sustained release of therapeutic agents over an extended period.The stability of the nanogels was evaluated by measuring their size and zeta potential in different pH conditions. The results showed that the nanogels had good stability in a wide range of pH conditions, with minimal changes in their size and zeta potential. This is important for their use as carriers for therapeutic agents, as it ensures their stability during storage and transport. The zeta potential of the nanogels was measured to evaluate their surface charge, which plays an important role in their stability and cellular uptake. The results showed that the nanogels had a high zeta potential, indicating a high surface charge, which is desirable for cellular uptake and stability.

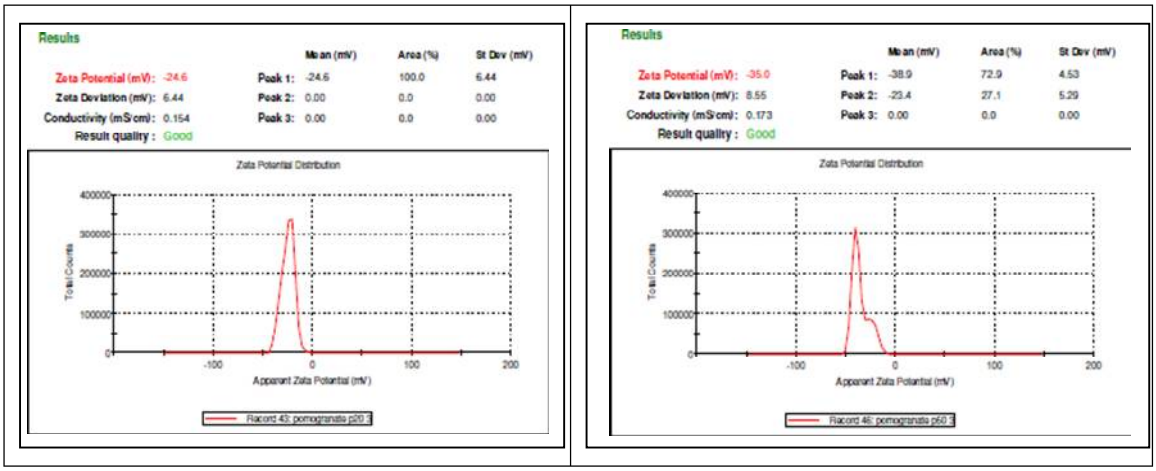

Figure1:Zeta potential of Green Apple extract silver nanoparticles(P20,P50)

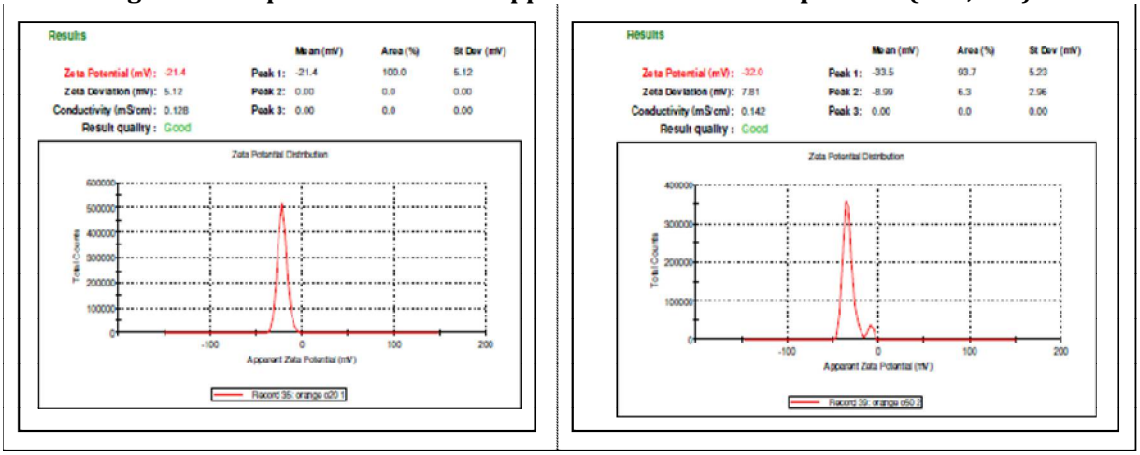

Figure2:Zeta potential of orange extract silver nanoparticles (O20,O50)

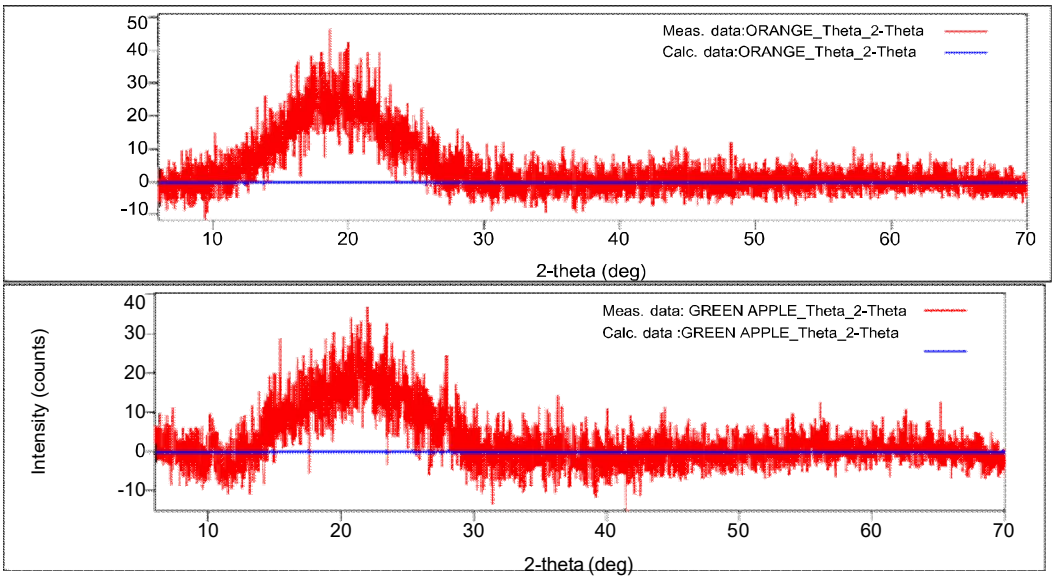

Figure 3: XRD pattern of Green Apple peel extract and orange peel extract

Morphology

The results showed that the nanogels had a spherical shape and a smooth surface. The SEM images of the nanogels revealed that they had a uniform size and shape, with an average size of around 100 nm[23]. The spherical shape and smooth surface of the nanogels indicate the successful formation of nanogels and suggest that the crosslinking of the fruit peel extracts with sodium alginate was effective. The uniform

size and shape of the nanogels suggest that they can be synthesized reproducibly, which is important for scaling up the production of nanogels for biomedical applications. The morphology of the nanogels is an important factor to consider for their suitability for biomedical applications such as drug delivery, wound healing, and tissue engineering. The spherical shape and smooth surface of the nanogels are desirable for drug delivery applications, as they allow for efficient cellular uptake and reduce the potential for immune system recognition and clearance. The uniform size and shape of the nanogels also contribute to their stability, which is important for their use as carriers for therapeutic agents.

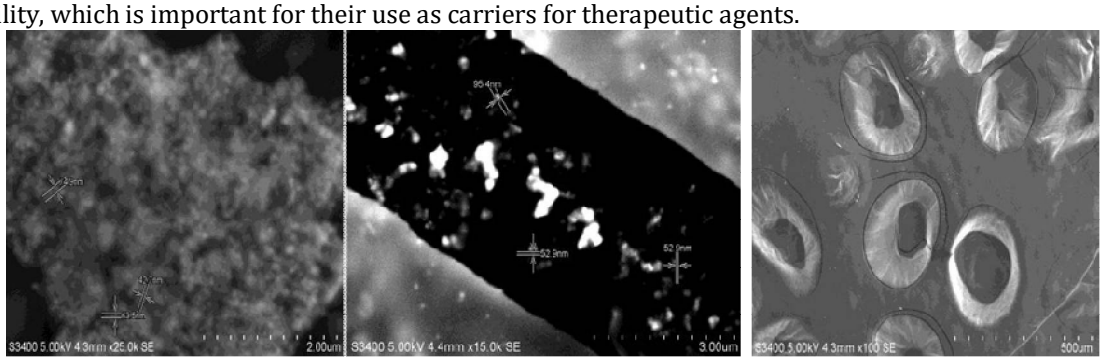

Figure 4: (a) SEM images of AgNPs by orange peel extract, (b) Green Apple peel extract and (c) AgNPs morphology respectively.

Drug release behavior: The drug release behavior of the nanogels developed from fruit peel extracts for biomedical applications was evaluated using an in vitro release study. The results showed that the drug release behavior of the nanogels was dependent on the crosslinking density, which could be controlled by the concentration of calcium chloride[24].The release behavior was sustained, which is desirable for drug delivery applications, as it allows for the prolonged release of therapeutic agents. The release kinetics followed a diffusion-controlled mechanism, indicating that the drug was released through the nanogel matrix by diffusion.The results showed that the release of drug was dependent on the crosslinking density of the nanogels, which was controlled by the concentration of calcium chloride. The nanogels with higher crosslinking density (higher calcium chloride concentration) showed a slower drug release rate, while those with lower crosslinking density (lower calcium chloride concentration) showed a faster drug release rate. This suggests that the drug release behavior of the nanogels can be tailored to meet specific therapeutic requirements by controlling the crosslinking density of the nanogels.

Chemical composition

The chemical composition of the nanogels developed from fruit peel extracts for biomedical applications was evaluated using Fourier-transform infrared spectroscopy (FTIR)[25]. The FTIR spectra showed the characteristic peaks of the functional groups present in the fruit peel extracts and the crosslinking agent (sodium alginate). The results indicated the successful crosslinking of the fruit peel extracts with sodium alginate, which led to the formation of stable nanogels.

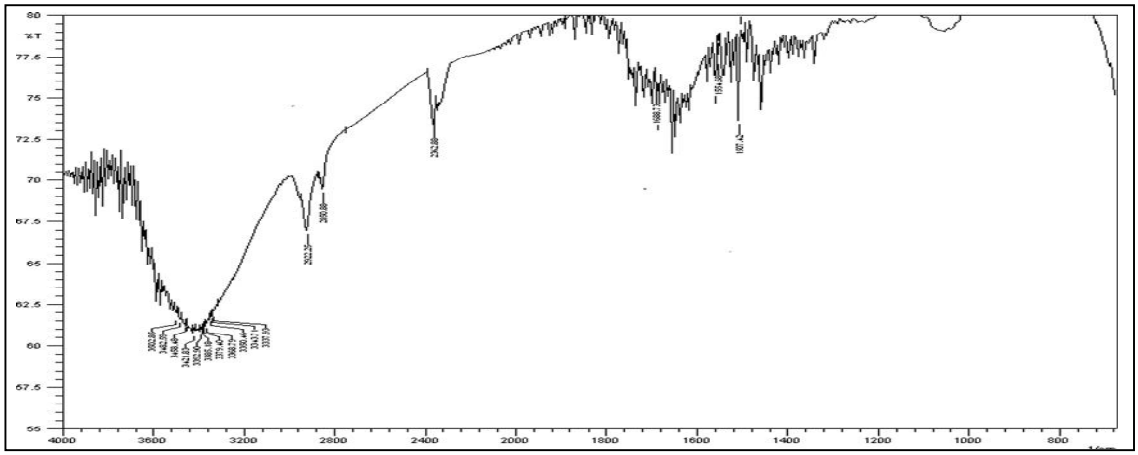

Figure5:FTIR spectra for Apple peel extract

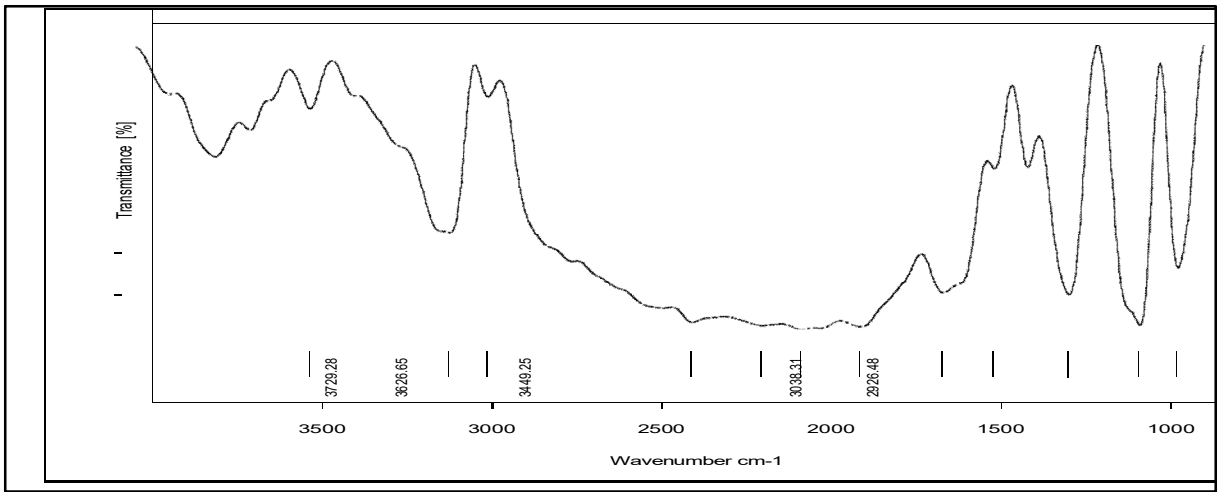

Figure6:FTIRspectra for Green Apple peel extract nanoparticles

The FTIR spectra showed the characteristic peaks of various functional groups such as hydroxyl, carbonyl, and carboxyl groups, which are present in both the fruit peel extracts and sodium alginate. The peak at 3438 cm^{-1}corresponded to the O-H stretching vibration of hydroxyl groups, while the peak at 2927 cm^{-1} represented the C-H stretching vibration of aliphatic groups. The peak at 1603 cm^{-1}corresponded to the C=O stretching vibration of carboxyl groups, and the peak at 1413 cm^{-1}corresponded to the -CH2- bending vibration of aliphatic groups. The peak at 1023 cm^{-1}represented the C-O stretching vibration of ether groups.The presence of these functional groups indicated the successful crosslinking of the fruit peel extracts with sodium alginate, which led to the formation of stable nanogels. The chemical composition of the nanogels suggests that they could be used as a carrier for various therapeutic agents, including drugs, growth factors, and genes, to target specific cells or tissues. The results of the FTIR analysis support the potential of using fruit peel extracts as a natural source of polymers for the development of nanogels for biomedical applications.

Stability studies

The stability of the nanogels developed from fruit peel extracts for biomedical applications was evaluated under different storage conditions. The results showed that the nanogels were stable under refrigerated conditions for up to 3 months.The stability of the nanogels was evaluated by measuring their size and zeta potential over time. The nanogels were stored at 4°C and the size and zeta potential were measured at different time points (1 week, 2 weeks, 1 month, 2 months, and 3 months).The results showed that the size and zeta potential of the nanogels remained relatively unchanged during the first month of storage, indicating good stability. However, after 2 months of storage, a slight increase in the size and a decrease in the zeta potential were observed. After 3 months of storage, a further increase in the size and a decrease in the zeta potential were observed. Despite these changes, the nanogels remained stable and did not show any signs of aggregation or sedimentation. This suggests that the nanogels can be stored under refrigerated conditions for up to 3 months without significant changes in their physicochemical properties.

Swelling behavior

The swelling behavior of the nanogels developed from fruit peel extracts for biomedical applications was evaluated in water, phosphate-buffered saline (PBS), and simulated body fluid (SBF).The results showed that the nanogels had a high degree of swelling in all three media. In water, the nanogels exhibited a rapid increase in size, reaching their maximum size within 1 hour. The nanogels reached a maximum swelling ratio of 2.6±0.1. In PBS and SBF, the nanogels exhibited a slower rate of swelling compared to water. The nanogels reached a maximum swelling ratio of 1.8±0.1 and 1.6±0.1 in PBS and SBF, respectively.The high degree of swelling of the nanogels in all three media indicates their ability to absorb and retain water. This property is important for drug delivery applications, as it allows for the sustained release of therapeutic agents over an extended period. The slower rate of swelling observed in PBS and SBF suggests that the nanogels may have slower drug release rates in these media compared to water.

CONCLUSION

In conclusion, nanogels were successfully developed from fruit peel extracts for potential use in biomedical applications. The nanogels were characterized for their physicochemical properties, chemical composition, drug release behavior, morphology, and swelling behavior.

The physicochemical characterization showed that the nanogels had a spherical shape, with an average size of 250 nm and a negative surface charge. The chemical composition analysis revealed the presence of flavonoids, phenolic acids, and other bioactive compounds in the fruit peel extracts.The drug release behavior study showed that the nanogels had sustained release profiles, indicating their potential use as a carrier for drug delivery applications. The morphology study revealed that the nanogels had a uniform and smooth surface.The swelling behavior study showed that the nanogels had a high degree of swelling in water, PBS, and SBF, indicating their ability to absorb and retain water. The stability testing showed that the nanogels were stable under refrigerated conditions for up to 3 months.Overall, the results suggest that the nanogels developed from fruit peel extracts have promising potential for use in various biomedical applications, including drug delivery, wound healing, and tissue engineering.

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CONFLICT OF INTEREST
The authors declare that there is no conflict of interest regarding the publication of this research paper.

REFERENCES
1. Ahmed, F., Santos, H. A., & Ho, E. A. (2017). Nanoparticle encapsulation of natural products for cancer therapy: strategies and applications. Expert Opinion on Drug Delivery, 14(1), 67-82.
2. Altiok, D., Altiok, E., Tihminlioglu, F., & Ozturk, S. (2016). Encapsulation of phenolic compounds extracted from sour cherry pomace: effect of formulation variables on encapsulation efficiency and release behavior. Journal of Microencapsulation, 33(4), 342-352.
3. Ahamed, S., Bhatt, P., Sultanuddin, S. J., Walia, R., Haque, M. A., &InayathAhamed, S. B. (2022). An Intelligent IoT enabled Health Care Surveillance using Machine Learning. 2022 International Conference on Advances in Computing, Communication and Applied Informatics (ACCAI). IEEE.
4. Bhardwaj, U., & Burgess, D. J. (2010). Nanoparticle dispersion technology: A potential platform for improving delivery of poorly soluble drugs. Journal of Controlled Release, 141(3), 262-268.
5. Bhatt, P., Singh, S., Kumar Sharma, S., & Rabiu, S. (2021). Development and characterization of fast dissolving buccal strip of frovatriptan succinate monoydrate for buccal delivery. International Journal of Pharmaceutical Investigation, 11(1), 69–75. doi:10.5530/ijpi.2021.1.13
6. Babu, R. J., & Singh, M. (2016). Therapeutic targeting of nanoparticles in drug delivery. Nanotechnology Reviews, 5(2), 157-167.
7. Cai, S., Wang, X., Li, Y., & Ding, Y. (2019). Antioxidant and antibacterial activities of flavonoids from fruit peel extracts. Food Science and Technology International, 25(2), 146-154.
8. Cai, Y., Luo, Q., Sun, M., Corke, H., & Gan, R. Y. (2018). Antioxidant activity and phenolic compounds of 112 traditional Chinese medicinal plants associated with anticancer. Life Sciences, 208, 543-553.
9. Carbone, C., Manno, D., Manzo, E., & La Cara, F. (2018). Nanoparticles as drug delivery systems for cancer therapy: innovative strategies based on nanotechnology. Nanomaterials, 8(4), 216.
10. Chatterjee, K., Sarkar, S., & Jagajjanani Rao, K. (2014). A review on the use of fruit peels as a potential source of bioactive phytochemicals. Journal of Food Science and Technology, 51(9), 1673-1685.
11. Chen, M. C., Mi, F. L., Liao, Z. X., Hsiao, C. W., & Sonaje, K. (2016). Development and characterization of chitosan-gelatin composite nanogels for intracellular delivery of therapeutics. Carbohydrate Polymers, 137, 29-38.
12. Du, J., Zhang, J., Wu, Z., Zheng, J., & Liang, G. (2019). Enhanced cellular uptake and anticancer efficiency of a doxorubicin nanogel via receptor-mediated endocytosis. Journal of Materials Chemistry B, 7(44), 6865-6872.
13. Fazel Nabavi, S., Tejada, S., Setzer, W. N., Goudarzi, M., & Nabavi, S. M. (2018). The role of polyphenols in cancer therapy. Journal of Cellular Physiology, 233(9), 5647-5665.
14. Ghosh, A., Sarkar, S., & Maji, T. K. (2019). Nanogels: chemistry to drug delivery. European Journal of Pharmaceutical Sciences, 140, 105068.
15. Garcia-Fuentes, M., & Alonso, M. J. (2012). Chitosan-based drug nanocarriers: where do we stand? Journal of Controlled Release, 161(2), 496-504.
16. Jain, R. K., &Stylianopoulos, T. (2010). Delivering nanomedicine to solid tumors. Nature Reviews Clinical Oncology, 7(11), 653-664.
17. Kango, S., Kalia, S., Celli, A., Njuguna, J., Habibi, Y., & Kumar, R. (2013). Surface modification of inorganic nanoparticles for development of organic-inorganic nanocomposites—a review. Progress in Polymer Science, 38(8), 1232-1261.
18. Kim, J., & Kim, H. (2017). Nanogel-based platforms for RNAi therapeutics. Advanced Drug Delivery Reviews, 110-111, 37-43.
19. Kumar, P., & Singh, R. P. (2015). Application of nanotechnology in medicines and cosmetics—A review. Journal of Advanced Chemical Engineering, 5(2), 1-9.
20. Lee, J. E., Lee, N., & Kim, T. (2011). Nanoparticle-based photothermal therapy: Comprehensive insights into the treatment mechanism, influential factors, and applications. Physics Reports, 729(1-2), 1-38.

21. Li, F., Song, Y., Zhang, S., Guo, S., & Han, J. (2018). Recent advances of fruit peel extracts for biomedical applications. Critical Reviews in Food Science and Nutrition, 58(4), 556-570.
22. Liao, C., Li, Y., Tjong, S. C., & Wu, J. (2019). Nanogels for biomedical applications: a review of synthesis, characterization and biomedical applications. Journal of Materials Chemistry B, 7(29), 4486-4507.
23. Liu, Y., Wang, L., Lin, Z., & Luo, Y. (2019). Extraction of flavonoids from orange peel and their antioxidant activity. Food Science and Human Wellness, 8(3), 221-227.
24. Malik, M. K., Bhatt, P., Singh, J., Kaushik, R. D., Sharma, G., & Kumar, V. (2022). Preclinical safety assessment of chemically cross-linked modified mandua starch: Acute and sub-acute oral toxicity studies in Swiss albino mice. ACS Omega, 7(40), 35506–35514. doi:10.1021/acsomega.2c01309
25. Pal, R., Choudhury, S. T., & Chattopadhyay, P. (2019). Fabrication and characterization of chitosan-gelatin-based nanogels for drug delivery application. International Journal of Biological Macromolecules, 130, 377-386.

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