



Biocompatible Sodium Alginate Electrospun Nanofiber using Eriobotrya Japonica and Jasmine Sambac leaf extracts

Ayesha Saeed¹, Farzana Kishwar², Ahsan Nazir³ and Muhammad Abiodullah⁴

¹Department of Home Economics, Lahore College for Women University, Lahore, **Pakistan**

²Department of Textile and Clothing, Principal Govt. College for Women Baghbanpura, Lahore, **Pakistan**

³Department of Research Innovation and Commercialization, National Textile University, Faisalabad. **Pakistan**

⁴Department of Educational Research and Evaluation, Institute of Education and Research, University of the Punjab, Lahore. **Pakistan**

*Correspondence: ayeshasaheed82@gmail.com, Ayesha.Saeed@lcwu.edu.pk Received 25-07-2022, Revised: 10-09-2022, Accepted: 11-09-2022 e-Published: 13-09-2022

Sodium Alginate (SA) has earned industrial recognition due to its biocompatibility, biodegradability and especially its water-soluble nature that attracts various important elements to produce electrospun nanofibers. The purpose of this study is to develop optimized uniform bead free biocompatible ecofriendly nanofibers from SA along with *polyvinyl alcohol (PVA)* (which serve as base material) incorporated with plant leaf extracts (water) of *Eriobotrya Japonica (ER)* and *Jasmine Sambac (JS)* through electrospinning with an average diameter of ± 23 to ± 272 nm. The extracts were manipulated at three concentrations (0.5, 1, and 1.5% w/v). Fourier transform infrared spectroscopy confirmed the presence of SA and plant extracts in nanofibers. X-Ray-diffraction results showed that nanofibers lose their crystallinity as the plant extract are loaded into SA/PVA8 nanofibers. Agar disc diffusion method was used to assess the antibacterial properties of nanofibers which showed that SAER nanofibers exhibited good to fair antibacterial properties against *E. coli* than *S. aureus*. The antioxidant capacities were checked through DPPH free radical scavenging assay which showed that SAER nanofibers have excellent antioxidant capacities and it continue to increase as the concentration of the plant extract increased in the SA/PVA8 nanofibers. The developed nanofibers showed excellent biocompatible promising material for biomedical textiles.

Keywords: Electrospinning, Eriobotrya Japonica, Jasmine Sambac, Nanofibers, PVA, Sodium Alginate

INTRODUCTION

Approximately, around the globe more than 450000 plants species present on earth but their use is very limit (Hosseinzadeh et al. 2015). Scientists, doctors, and physicians not only investigating their medicinal values but also exploring advanced ways of its application. Roots, stems, leaves, flowers, fruits and seeds are well known for its pharmacological value and are used as antioxidant and antibacterial agents in contrast with the synthetic antibiotics in medical industry (Salehi et al. 2018). Polyphenols, phenolic acids, flavonoids, flavones, flavanols, quinones, phenols, tannins and coumarins are antibacterial and antioxidant agents responsible for bioactive functioning in medicinal plants which play a critical role in medical, textile and food industry (Aljibory and Chen, 2018). *Eriobotrya Japonica* (Loquat) is an evergreen ornamental fruit tree belonging to the Rosaceae family usually 20-30 feet long (Kumar et al. 2014). Its leaves extract exhibits excellent antioxidant, antibacterial anti-inflammatory and anti-cancerous properties due to the presence of phenolics, carotenoids, flavonoids and terpenoids (Rao and Tang, 2017; Tan et al. 2017; Zar et

al. 2014; Cha et al. 2011). Moreover, *Jasmin Sambac (JS)*, a flowering plant belongs to Oleaceae family, is a small shrub up to 1-3 meters long. As its leaves extract contain phenolic compounds, flavonoids, tannins, and glycosides (Anima et al. 2019).

Sodium Alginate (SA), a natural polymer derived from marine brown algae, is well known for its biocompatible, biodegradable and non-hazardous nature (Aprilliza, 2017). Due to its hydrophilic nature, easily soluble in water. Its polymer inherent the properties of antioxidant and antibacterial (Summa et al. 2018; Liakos et al. 2014). Sometimes it combines with other copolymers to get its maximum benefit in various fields. Electrospinning is one of the versatile techniques of developing nanosized nanofibers (10 to 500 nm) of such material especially for biomedical fields (Thenmozhi et al. 2017). This technique involves various parameters such as solution viscosity, surface tension, conductivity, needle diameter, distance from syringe to collector plate and Voltage (Haider et al. 2018).

Polyvinyl alcohol (PVA) is a biocompatible, non-carcinogenic, nontoxic and more importantly easy to

spinnable characteristics (Jiang et al. 2011) making it useful in various medical fields. SA and PVA both form homogeneous mixture in water (Rafiq et al. 2018) which are suitable for developing electrospun nanofibers through electrospinning. So, the main objective of the study is to develop biodegradable electrospun nanofibers using leaf extracts of ER and JS along with SA/PVA for application in biomedical fields.

MATERIALS AND METHODS

2.1. Material

PVA with MW (Molecular weight) of 72000 (CAS No. 9002-89-5) and SA (CAS No. 9005-38-3) were bought from VWR Chemicals and FMC Biopolymer, Norway respectively. Fresh leaves of ER and JS were taken from botanical gardens of University of the Punjab (PU), Lahore. Pakistan.

2.2. Method

To prepare the water extracts of ER and JS, fresh leaves were washed, dried (for two months) and grinded into fine powdered form, and then soaked in the distilled water. After seven days samples were filtered (Whatman Grade 1 filter paper) and dried on rotary vacuum evaporator. These extracts were used at three concentration levels i.e., 0.5, 1 and 1.5 gram.

Table 1: Experiment detail

| Nanofiber's Name | Polymer Composition (w/v %) | | |
|------------------|-----------------------------|-----|------------------------|
| | SA | PVA | Plant Extract (Leaves) |
| SA/PVA | 2 | 8 | - |
| SA/PVA/ER1=SAER1 | 2 | 8 | 0.5 |
| SA/PVA/ER2=SAER2 | 2 | 8 | 1 |
| SA/PVA/ER3=SAER3 | 2 | 8 | 1.5 |
| SA/PVA/JS1=SAJS1 | 2 | 8 | 0.5 |
| SA/PVA/JS2=SAJS2 | 2 | 8 | 1 |
| SA/PVA/JS3=SAJS3 | 2 | 8 | 1.5 |

Electrospinning solutions were consisting of SA and PVA with ratio of 2:8 w/v % (used as base material which was fixed for all solutions). Optimized nanofibers (detailed of experiment see table 1) were developed after optimizing the solution parameters (viscosity, surface tension and conductivity) and process parameters (Voltage, flowrate, distance from syringe to collector) on electrospinning machine (Fludna Tek LE-10, Bioinicia, Spain; National textile University, Faisalabad, Pakistan).

3. Characterization

Functional group in nanofibers were identified through FTIR spectroscopy (Spectrum two, PerkinElmer, UK) which confirm the presence of polymers and plant extracts

in the nanofibers. The absorbance was measured at the scale of 400 cm^{-1} to 4000 cm^{-1} . XRD (D8 Discover, Bruker, Germany: equipped with a copper tube) analysis of samples mention the crystallinity and amorphous region in the polymer chain of the nanofibers. The diffractogram were found at 2 theta angles between 10-70 degree at a step rate of 0.05-degree sec^{-1} . Origin software was used to measure the intensity of the samples. SEM (Scanning Electron Microscope: FEI Nova Nano SEM) studied the surface morphology of samples. Diameter were measured through Image J software. Agar disc diffusion assay and Free radical scavenging assay were used to determine the antibacterial and antioxidant activities of the samples respectively.

3.1. Agar disc diffusion method

To investigate the antibacterial activity of the nanofiber's agar disc diffusion method AATCC 147-1998 was used against the *E.coli* and *S.aureus*. Nutrient broth agar medium was used to culture bacteria, which were evenly spread with sterilized cotton swab on agar plates. Nanofibers sheets (both with and without plant extracts) were cut according to disc size and placed on it. One disc was of positive control; Penicillin was used. Then, plates were incubated for 24 hours at 37°C. The plates were observed for minimum inhibitory concentration, as clear zone around the disc indicate no growth of bacteria.

3.2. Free radical scavenging assay

Free Radical Scavenging Assay 1, 1-diphenyl-2-picrylhydrazyl (DPPH) was used to determine the antioxidant capacities of nanofibers. Each sample of 50 mg was dissolved in 3 ml methanol solution of 0.1mg of DPPH and then incubates for 30 minutes at 37 °C. Without samples the DPPH solution considered as blank. Absorbance was measured with U.V.-spectrophotometer (Lambda 900, Perkin-Elmer, USA) at 517nm using an air blank.

RESULTS

Fiber morphology was studied through SEM. It was observed that smooth and bead free nanofibers were produced with and without leaf extract.

As shown in figure 1, it was observed that no formation of nanofibers observed with the 100% SA, even when it combined with PVA with the ratios of 50:50, 40:60, 30:70, but 8% w/v of PVA with 2% w/v of SA (ratio=2:8) produced smooth and bead free nanofibers at the flow rate of 0.1ml, 18 KV Voltage and 10cm distance from needle to collector plate.

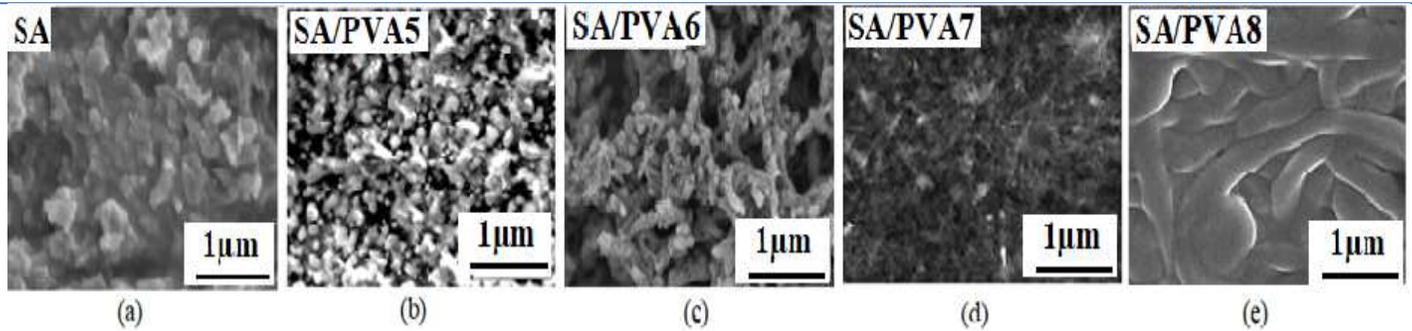


Figure 1: SEM images of nanofibers at different ratios of SA/PVA at magnification level of (a) 10000, (b) 5000, (c) 1000, (d) 5000, (e) 10,000

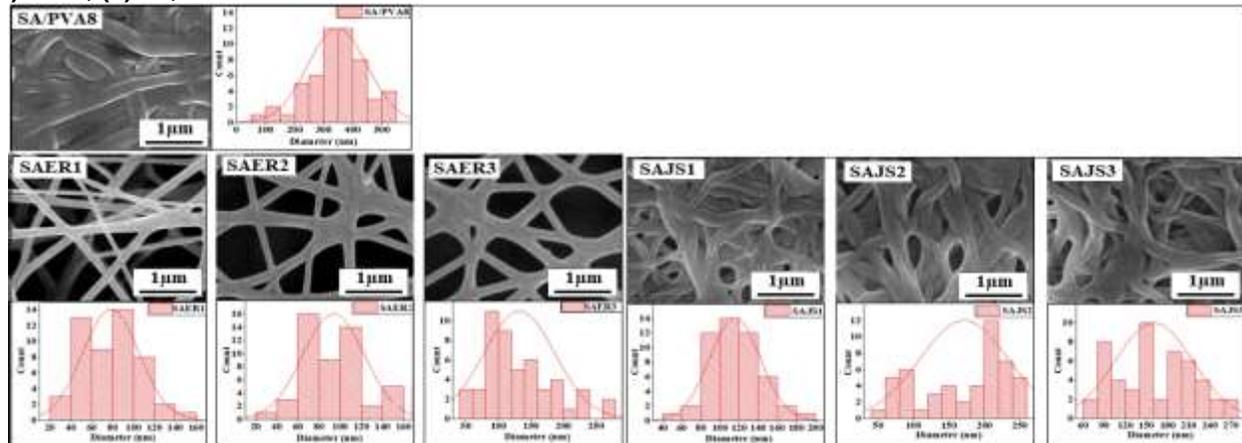


Figure 2: SEM images (magnification level of 30x) of with and without plant extract nanofibers and Diameter distribution

As above figure 2 showed that very thin, smooth nanofibers of SA/PVA8 were developed with diameter ranging from ± 79 to ± 145 nm, this might be due to very low surface tension and high conductivity of the electrospinning solution. It was also observed that as the plant extract loaded into the pure SA/PVA8 nanofibers its diameter increased as ER containing nanofiber showed diameter range from ± 23 to ± 154 nm (SAER1). It was also found that as the concentration of plant extract increased its diameter also increased as ± 32 to ± 158 nm (SAER2) and ± 43 to ± 272 (SAER3) nanofibers at the concentration of 1 and 1.5%. The same trends were also observed in case of JS containing nanofibers as SAJS1 showed diameter ranging from ± 56 to ± 185 nm at 0.5 % concentration, SAJS2 (± 60 to ± 27 nm) at 1% and SAJS3 (± 75 to ± 263 nm) at 1.5%.

FTIR Spectroscopy

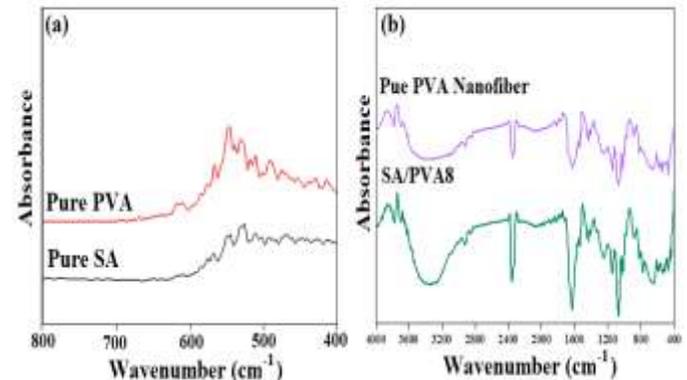


Figure 3: FTIR Spectrum of (a) pure PVA and SA, (b) pure PVA and SA/PVA8 Nanofibers

As figure 3 showed the FTIR pattern of PVA polymer. Its peaks have been observed in the range of $3280-3500$ cm^{-1} , 1690 cm^{-1} , 1081 cm^{-1} and 839 cm^{-1} . These peaks indicated the presence of OH group, CH_2 bond stretching and bending related to the vibrations of atoms within the molecules and movement of electrons within the vibrational energy level. When SA is added in PVA, the similar pattern of peaks had been observed but there was

a difference in the spectrum as shown in figure 3. The FTIR spectrum of SA showed broader and sharper peaks at the same wavelength. This sharpness is due to the more stretching and bending of bonds within *PVA* and now this blend is having a more concise structural formation as compared to *PVA* alone. The broader peaks shows that OH, CH₂ bonds are having intermolecular interactions with SA. There is a possibility of SA to interact with *PVA* and they may be available for the formation of nanofibers for further use (Safi et al. 2007).

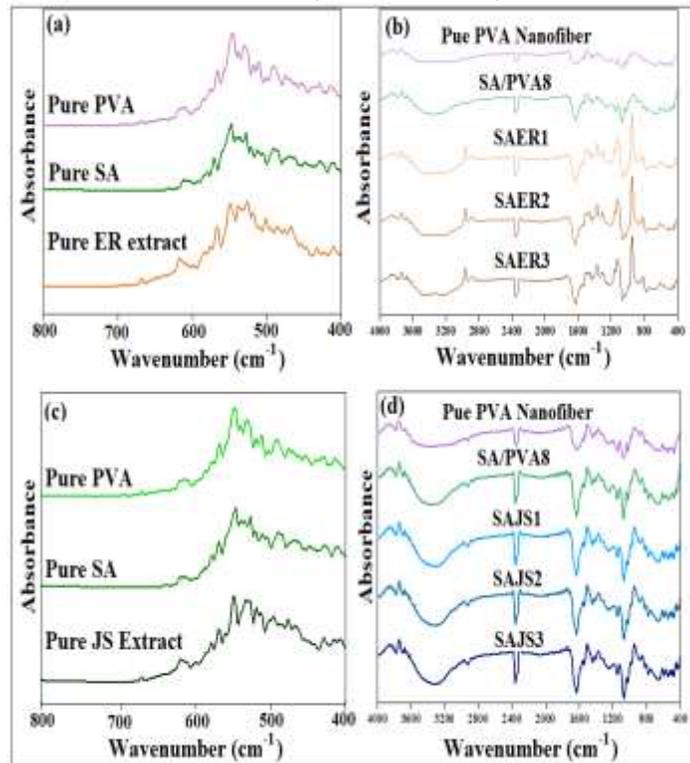


Figure 4: FTIR Spectrum of (a) pure PVA, SA and ER leaf extract, (b) pure PVA SA/PVA8, SAER1, SAER2 and SAER3 nanofibers (c) pure PVA, SA and JS extract (d) pure PVA SA/PVA8, SAJS1, SAJS2 and SAJS3 nanofibers at different concentrations

These same functional groups were present in SA as the spectrum was broader in the presence of SA. This further broadening and sharpening of peaks were observed in the figure 4 in the presence of ER and JS extract. The phytochemicals present in ER plant were found to be phenols, flavonoids etc. These groups were confirmed by FTIR analysis of extract with SA/PVA8 base. The peaks were broad and sharp, and this showed the molecular interactions with phytochemicals of plant extracts along with nanofibers. Once the intermolecular attractions developed between the polymer base and plant extract then there might be no sharpness in the peaks with increasing concentration of the plant extract as shown in figure 4 b & d (Hari and Nair, 2018; Salomonsen et al. 2008). They all contributed towards the antibacterial, antioxidants and anti-inflammatory activities and that's

why they had many applications in various antibacterial, antioxidants and anti-inflammatory reactions and this will contribute towards the green synthesis of various antibacterial, antioxidants and anti-inflammatory reactions.

X-Ray Diffraction (XRD)

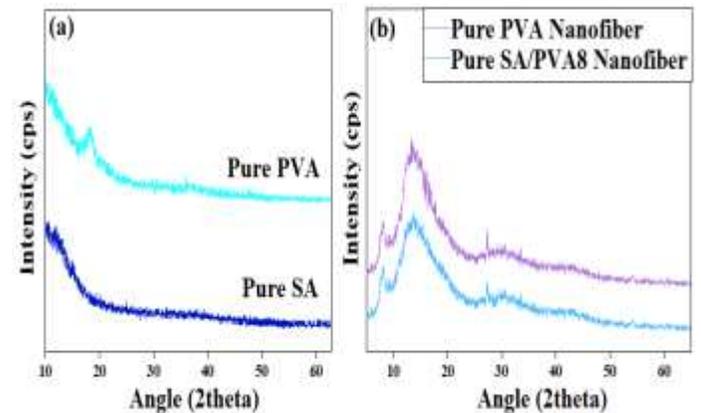


Figure 5: XRD pattern of (a) pure PVA and SA, (b) PVA and SA/PVA8 Nanofibers

The XRD pattern of pure *PVA*, SA with and without plant extract were shown in figure 5a. It was observed that both polymers had sharpening at same places. It would indicate the presence of same structural properties. XRD pattern of *PVA* had shown that it had crystalline structure having $2\theta=19.8$. This value of diffracting angle showed that *PVA* had a crystalline structure. The crystallinity of the polymer might be affected by the presence of the other compounds or leaf extracts. The SA, XRD pattern showed that it had crystallinity at 35.53%. This amount showed that it had little crystallinity but mostly it is an amorphous species having irregular structural arrangements. The nanofibers of *PVA*, SA/PVA8 had shown sharp peaks which indicated *PVA* has more crystallinity with sodium alginate (Nasar et al. 2009).

While The XRD pattern of ER and JS had shown that it had a small value of 2θ that indicated that it had an amorphous structure. In figure 6 b & d, the graphs had shown that with increasing concentration of extract, the crystallinity of SA/PVA8 base was decreased and there were more strong interactions between the SA/PVA8 base and plant extract. The structural changes indicated the presence of interactions between the extract and polymer nanofibers (Aravind et al. 2021; Ibrahim, 2015).

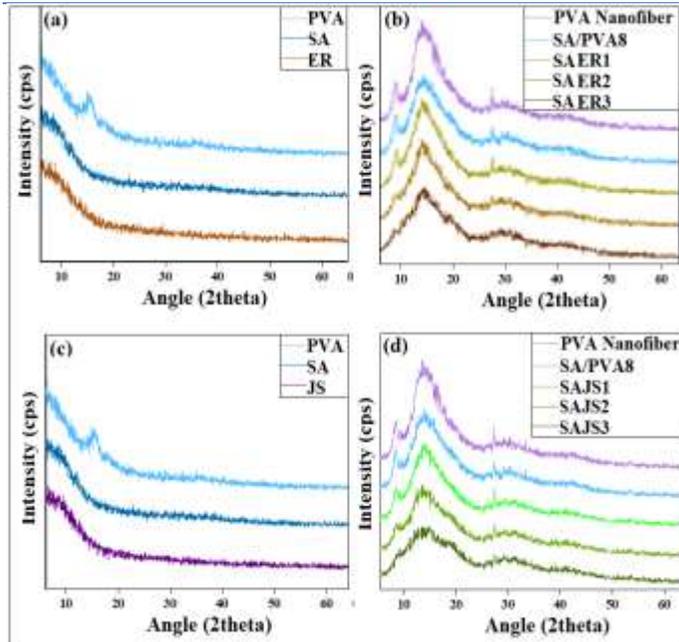


Figure 6: XRD pattern of (a) pure PVA, SA and ER extract, (b) pure PVA SA/PVA8, SAER1, SAER2 and SAER3 nanofibers (c) pure PVA, SA and JS extract (d) pure PVA SA/PVA8, SAJS1, SAJS2 and SAJS3 nanofibers at different concentrations

Antibacterial activity

Nanofibers with and without plant extract exhibited good to excellent antibacterial property against *E. coli* than *S. aureus*. It was observed that by increasing the ratio of plant extract in nanofibers increased the resistance against bacteria as SAER nanofibers exhibited the highest inhibition zone against *E. coli* than *S.aureus* as SAER1, SAER2 and SAER3 showed inhibition zone of 24.5mm, 25.8 and 28.4 respectively. This might be due to the presence of terpenoids, polyphenols and flavonoids in the leaf extract (water) of *ER* (Rao and Tang, 2017; Tan et al. 2017; Liu et al. 2016). While *JS* containing nanofibers showed slightly higher activity against *S. aureus* than the *E. coli* as SAJS1, SAJS2 and SAJS3 represented the inhibition zone of 16.5mm, 17.9mm and 18.1mm against *S.aureus* (see figure 7).

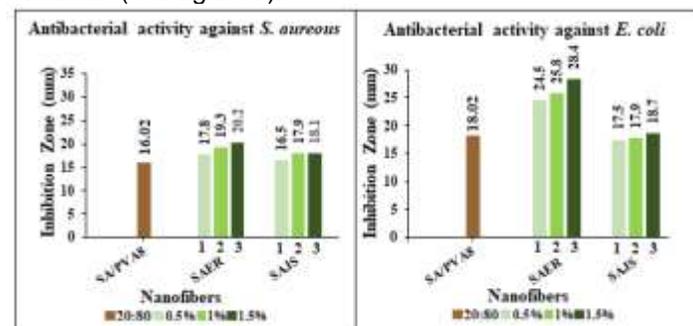


Figure 7: Antibacterial activity (%) of with and without

plant extracts Nanofibers

Antioxidant activity

Antioxidant activities were investigated through DPPH free radical scavenging assay (in vitro). DPPH showed purple color which turns yellow on accepting electron from the antioxidant compound. UV-Vis spectrophotometer was used to measure the absorbance of the samples (Ullah et al. 2020). It was observed the nanofibers pure SA/PVA8 showed moderate activity as compared with the extract containing nanofibers (see figure 8). SAER nanofibers exhibited the slightly higher antioxidant activity than JS containing nanofibers. It may be due to the presence of biological compounds such as tannins, polyphenols, flavonoids and terpenoids in leaves extract of *ER* (Al-Snafi, 2018; Maher et al. 2015). It was important to note that as the conc. (plant extract) increased in nanofibers the antioxidant capacities of nanofibers also increased.

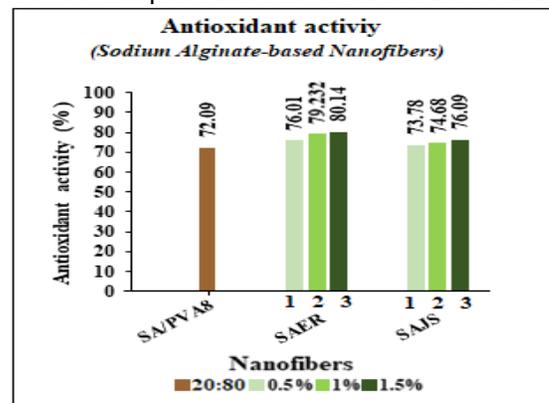


Figure 8: Antioxidant activity (%) of with and without plant extract Nanofibers

CONCLUSION

In this study biocompatible electrospun nanofibers were developed. Natural ingredients were used to develop the nanoscale fibers via electrospinning. All parameters were optimized, SEM results indicated the formation of smooth and bead free nanofibers were developed with diameter range from ± 23 to ± 272 nm. FTIR and XRD showed the successful incorporation of SA and plant extracts into nanofibers mats. Results showed that *ER* loaded nanofibers exhibited good to fair antibacterial properties than pure SA/PVA8 and *JS* containing nanofibers mats against *E. coli*. In relation to antioxidant activities SAER nanofibers showed higher value than *JS* loaded nanofibers (as reported with moderate antioxidant values). Moreover, the conc. of plant extract was directly proportional with the antibacterial and antioxidants properties. So, it was concluded that the developed nanofibers are the excellent biocompatible promising material for biomedical textiles.

CONFLICT OF INTEREST

There is no conflict of interest!

ACKNOWLEDGEMENT

This research paper would not have been possible without the remarkable support of my supervisors, Farzana Kishwar, Muhammad Aboidullah and especially Ahsan Nazir who help me in executing the experiments. Their passion, expertise, knowledge and sensitivity to detail have been an inspiration for me.

AUTHOR CONTRIBUTIONS

AS conceived idea, designed and performed the experiment and also wrote the manuscript, FK and AN critically reviewed, edited the manuscript and contributed reagents, MA analyzed the data. All authors read and approved the final version of this research paper

Copyrights: © 2022@ author (s).

This is an open access article distributed under the terms of the [Creative Commons Attribution License \(CC BY 4.0\)](https://creativecommons.org/licenses/by/4.0/), which permits unrestricted use, distribution, and reproduction in any medium, provided the original author(s) and source are credited and that the original publication in this journal is cited, in accordance with accepted academic practice. No use, distribution or reproduction is permitted which does not comply with these terms.

REFERENCES

- Al-Snafi, A. E. 2018. Chemical Constituents, Pharmacological Effects and Therapeutic Importance of Hibiscus Rosa-Sinensis-A Review. *IOSR Journal Of Pharmacy*, 8(7), 101–119.
- Aljbory, Z., & Chen, M. S. 2018. Indirect Plant Defense against Insect Herbivores: A Review. *Insect Science*, 25(1), 2–23. <https://doi.org/10.1111/1744-7917.12436>
- Anima, P., Arun, M., & Satish, S. 2019. Scientific Validation of Wound Healing Potential of Jasminum Sambac Ait. *South African Journal of Botany*, 121, 584–589. <https://doi.org/10.1016/j.sajb.2018.11.018>
- Aprilliza, M. 2017. Characterization and Properties of Sodium Alginate from Brown Algae used as an Ecofriendly Superabsorbent. In *IOP Conference Series: Materials Science and Engineering*, 188(1), 012019.
- Aravind, M., Ahmad, A., Ahmad, I., Amalanathan, M., Naseem, K., Mary, S. M. M., Zuber, M. 2021. Critical Green Routing Synthesis of Silver Nps using Jasmine Flower Extract for Biological Activities and Photocatalytical Degradation of Methylene Blue. *Journal of Environmental Chemical Engineering*, 9(1), 104877. <https://doi.org/10.1016/j.jece.2020.104877>
- Cha, D. S., Eun, J. S., & Jeon, H. 2011. Anti-inflammatory and Antinociceptive Properties of the Leaves of *Eriobotrya Japonica*. *Journal of Ethnopharmacology*, 134(2), 305–312. <https://doi.org/10.1016/j.jep.2010.12.017>
- Haider, A., Haider, S., & Kang, I. K. 2018. A Comprehensive Review Summarizing the Effect of Electrospinning Parameters and Potential Applications of Nanofibers in Biomedical and Biotechnology. *Arabian Journal of Chemistry*, Vol. 11. <https://doi.org/10.1016/j.arabjc.2015.11.015>
- Hari, N., & Nair, V. P. 2018. FTIR Spectroscopic Analysis of Leaf Extract in Hexane in *Jasminum Azoricum L.* *International Journal of Scientific Research and Technology*, 4(8), 170–172.
- Hosseinzadeh, S., Jafarikukhdan, A., Hosseini, A., & Armand, R. 2015. The Application of Medicinal Plants in Traditional and Modern Medicine: A Review of *Thymus Vulgaris*. *International Journal of Clinical Medicine*, 6(09), 635.
- Ibrahim, H. M. 2015. Green Synthesis and Characterization of Silver Nanoparticles Using Banana Peel Extract and their Antimicrobial Activity against Representative Microorganisms. *Journal of Radiation Research and Applied Sciences*, 8(3), 265–275.
- Jiang, S., Liu, S., & Feng, W. 2011. PVA Hydrogel Properties for Biomedical Application. *Journal of the Mechanical Behavior of Biomedical Materials*, 4(7), 1228–1233. <https://doi.org/10.1016/j.jmbbm.2011.04.005>
- Kumar, S., Ritu, M., & Pallavi, G. 2014. A Critical Review on Loquat (*Eriobotrya Japonica Thunb/Lindl*). *International Journal of Pharmaceutical & Biological Archives*, 5, 1–7.
- Liakos, I., Rizzello, L., Scurr, D. J., Pompa, P. P., Bayer, I. S., & Athanassiou, A. 2014. All-natural Composite Wound Dressing Films of Essential Oils Encapsulated in Sodium Alginate with Antimicrobial Properties. *International Journal of Pharmaceutics*, 463(2), 137–145. <https://doi.org/10.1016/j.ijpharm.2013.10.046>
- Liu, Y., Zhang, W., Xu, C., & Li, X. 2016. Biological Activities of Extracts from Loquat (*Eriobotrya japonica Lindl.*): A Review. *International Journal of Molecular Sciences*, 17(12). <https://doi.org/10.3390/ijms17121983>
- Maher, K., Yassine, B. A., & Sofiane, B. 2015. Anti-inflammatory and antioxidant properties of *eriobotrya Japonica* leaves extracts. *African Health Sciences*, 15(2), 613–620. <https://doi.org/10.4314/ahs.v15i2.39>
- Nasar, G., Khan, M. S., & Khalil, U. 2009. Structural Study of PVA Composites with Inorganic Salts by X-ray Diffraction. *J Pak Mater Soc*, 3(2), 67–70.
- Rafiq, M., Hussain, T., Abid, S., Nazir, A., & Masood, R. 2018. Development of Sodium Alginate/PVA Antibacterial Nanofibers by the incorporation of Essential Oils. *Materials Research Express*, 5(3).

- Rao, B., & Tang, R. C. 2017. Green Synthesis of Silver Nanoparticles with Antibacterial Activities using aqueous *Eriobotrya Japonica* Leaf Extract. *Advances in Natural Sciences: Nanoscience and Nanotechnology*, 8(1). <https://doi.org/10.1088/2043-6254/aa5983>
- Safi, S., Morshed, M., Hosseini Ravandi, S., & Ghiaci, M. 2007. Study of Electrospinning of Sodium Alginate, Blended Solutions of Sodium Alginate/Poly (Vinyl Alcohol) and Sodium Alginate/Poly (ethylene oxide). *Journal of Applied Polymer Science*, 104(5), 3245–3255.
- Salehi, B., Anil Kumar, N. V., Şener, B., Sharifi-Rad, M., Kılıç, M., Mahady, G. B., Sharifi-Rad, J. 2018. Medicinal Plants used in the treatment of Human Immunodeficiency Virus. *International Journal of Molecular Sciences*, 19(5). <https://doi.org/10.3390/ijms19051459>
- Salomonsen, T., Jensen, H. M., Stenbæk, D., & Engelsen, S. B. 2008. Chemometric Prediction of Alginate Monomer Composition: A Comparative Spectroscopic Study using IR, Raman, NIR and NMR. *Carbohydrate Polymers*, 72(4), 730–739. <https://doi.org/10.1016/j.carbpol.2007.10.022>
- Summa, M., Russo, D., Penna, I., Margaroli, N., Bayer, I. S., Bandiera, T., Bertorelli, R. 2018. A Biocompatible Sodium Alginate/Povidone Iodine Film Enhances Wound Healing. *European Journal of Pharmaceutics and Biopharmaceutics*, 122, 17–24. <https://doi.org/10.1016/j.ejpb.2017.10.004>
- Tan, H., Sonam, T., & Shimizu, K. 2017. The Potential of Triterpenoids from Loquat Leaves (*Eriobotrya japonica*) for Prevention and Treatment of Skin Disorder. *International Journal of Molecular Sciences*, 18(5). <https://doi.org/10.3390/ijms18051030>
- Thenmozhi, S., Dharmaraj, N., Kadirvelu, K., & Kim, H. Y. 2017. Electrospun nanofibers: New Generation Materials for Advanced Applications. *Materials Science and Engineering B: Solid-State Materials for Advanced Technology*, 217, 36–48. <https://doi.org/10.1016/j.mseb.2017.01.001>
- Ullah, A., Ullah, S., Khan, M. Q., Hashmi, M., Nam, P. D., Kato, Y., Kim, I. S. 2020. Manuka Honey Incorporated Cellulose Acetate Nanofibrous Mats: Fabrication and in vitro evaluation as a potential wound dressing. *International Journal of Biological Macromolecules*, 155, 479–489. <https://doi.org/10.1016/j.ijbiomac.2020.03.237>
- Zar, P. P. K., Morishita, A., Hashimoto, F., Sakao, K., Fujii, M., Wada, K., & Hou, D. X. 2014. Anti-Inflammatory Effects and Molecular Mechanisms of Loquat (*Eriobotrya Japonica*) Tea. *Journal of Functional Foods*, 6(1), 523–533. <https://doi.org/10.1016/j.jff.2013.11.019>