

extract, while tannins and triterpenes are absent.

Saha & Verna attributed the inhibitory effects of *Bergenia ciliata* extract on polyphenolics, such as saponins, alkaloids, flavonoids and terpenoids [14]. In a patent, the inhibitory effect of catechins and the compounds present in green tea extract were attributed to chelation of calcium ions and solubilization of crystals [15].

IV. CONCLUSION

Blumea balsamifera extract has a significant effect on the morphology and nucleation of calcium oxalate crystals at varying supersaturation ratios. The extract reduced the crystal size by 38.21±5.65% to 76.47±5.45% across supersaturation ratios of 17.5 to 25 due to a COM to COD shift in crystal morphology. The reduction in size is not significantly affected by supersaturation ratio nor intensity of extract concentration. *B. balsamifera* extract also significantly changed the nucleation behavior of calcium oxalate as the linear dependence of the turbidity slope with supersaturation ratio is lost and overall inhibited by the extract regardless of the concentration.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

AUTHOR CONTRIBUTIONS

All authors contributed equally in this study. CMontealegre conceptualized the topic, analyzed data and wrote the final paper. JTNolasco, JVBautista and RTQuintero conducted the experiment, analyzed the data, and wrote parts of the paper. All authors approved of the final version.

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REFERENCES

[1] C. Thongprayoon, A. E. Krambeck, and A. D. Rule, "Determining the true burden of kidney stone disease," *Nat. Rev. Nephrol.*, vol. 16, no. 12, pp. 736–746, Dec. 2020. doi: 10.1038/s41581-020-0320-7

[2] M. Öner, A. Khan, and S. R. Khan, "Importance of Calcium-based scales in kidney stone," *Mineral Scales and Deposits*, pp. 393–416, 2015. doi: 10.1016/B978-0-444-63228-9.00015-2

[3] F. Rico, "Sambong (*Blumea balsamifera*): Its effect on calcium stone," *Philipp. J. Urol.*, vol. 2, no. 1, pp. 9–13, 1992.

[4] C. M. Montealegre and R. L. D. Leon, "Effect of *Blumea balsamifera* extract on the phase and morphology of calcium oxalate crystals," *Asian J. Urol.*, vol. 4, no. 4, pp. 201–207, Oct. 2017. doi: 10.1016/j.ajur.2016.08.009

[5] C. M. Montealegre, A. C. Ila, R. T. V. Mendoza, R. M. P. Carpio, and R. L. D. Leon, "Effect of *blumea balsamifera* extract in the kinetics of Calcium oxalate crystallisation," *Chem. Eng. Trans.*, vol. 56, 2017. doi: 10.3303/CET1756273

[6] J. Redfern, M. Kinninmonth, D. Burdass, and J. Verran, "Using soxhlet ethanol extraction to produce and test plant material (Essential Oils) for their antimicrobial properties," *J. Microbiol. Biol. Educ.*, vol. 15, no. 1, pp. 45–46, May 2014. doi: 10.1128/jmbe.v15i1.656

[7] S. Chutipongtanate and V. Thongboonkerd, "Systematic comparisons of artificial urine formulas for in vitro cellular study," *Anal. Biochem.*, vol. 402, no. 1, pp. 110–2, Jul. 2010. doi: 10.1016/j.ab.2010.03.031

[8] C. A. Schneider, W. S. Rasband, and K. W. Eliceiri, "NIH image to ImageJ: 25 years of image analysis," *Nat. Methods*, vol. 9, no. 7, pp. 671–675, Jul. 2012. doi: 10.1038/nmeth.2089

[9] B. Hess, S. Jordi, L. Zipperle, E. Ettinger, and R. Giovanoli, "Citrate determines calcium oxalate crystallization kinetics and crystal morphology—Studies in the presence of Tamm-Horsfall protein of a healthy subject and a severely recurrent calcium stone former," *Nephrol. Dial. Transplant.*, vol. 15, no. 3, pp. 366–374, 2000. doi: 10.1093/ndt/15.3.366

[10] T. Jung, W.-S. Kim, and C. Kyun Choi, "Crystal structure and morphology control of Calcium oxalate using biopolymeric additives in crystallization," *J. Cryst. Growth*, vol. 279, no. 1–2, pp. 154–162, May 2005. doi: 10.1016/j.jcrysgro.2005.02.010

[11] D. R. Basavaraj, C. S. Biyani, A. J. Browning, and J. J. Cartledge, "The role of urinary kidney stone inhibitors and promoters in the pathogenesis of Calcium containing renal stones," *EAU-EBU Updat. Ser.*, vol. 5, no. 3, pp. 126–136, Jun. 2007. doi: 10.1016/j.eeus.2007.03.002

[12] E. A. Abdel-Aal, S. Daosukho, and H. El-Shall, "Effect of supersaturation ratio and *Khella* extract on nucleation and morphology of kidney stones," *J. Cryst. Growth*, vol. 311, no. 9, pp. 2673–2681, 2009. doi: 10.1016/j.jcrysgro.2009.02.027

[13] J. J. W. Mullin, *Crystallization*, Elsevier, 2001. doi: 10.1016/B978-075064833-2/50000-0

[14] S. Saha and R. J. Verma, "Inhibition of Calcium oxalate crystallisation in vitro by an extract of *Bergenia ciliata*," *Arab J. Urol.*, vol. 11, no. 2, pp. 187–192, 2013. doi: 10.1016/j.aju.2013.04.001

[15] Y. Benzerara, D. Bazin, M. Daudon, J.-P. Haymann, and J. Rode, "Catechin for treating renal lithiasis," WO 2015025294 A1, 2015.

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