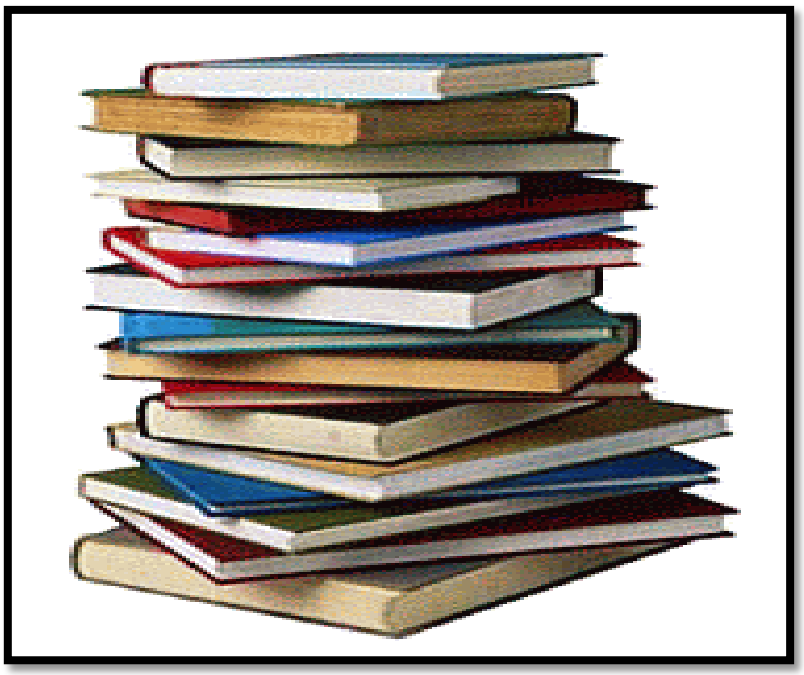
“REFERENCES”



Abdin, A. A., and Saeid, E. M., (2008), “An experimental study on ulcerative colitis as a potential target for probiotic therapy by Lactobacillus acidophilus with or without olsalazine”, Journal of Crohn's and Colitis, 2(4), pp. 296-303.

Agraib, L. M., Yamani, M. I., Rayyan, Y. M., Abu-Sneineh, A. T., Tamimi, T. A., and Tayyem, R. F., (2021), “The probiotic supplementation role in improving the immune system among people with ulcerative colitis: a narrative review”, Drug Metabolism and Personalized Therapy, 37(1), pp. 7-19.

Ahmad, A., Ansari, M. M., Mishra, R. K., Kumar, A., Vyawahare, A., Verma, R. K., and Khan, R., (2021), “Enteric-coated gelatin nanoparticles mediated oral delivery of 5-aminosalicylic acid alleviates severity of DSS-induced ulcerative colitis”, Materials Science and Engineering: C, 119, pp. 111582.

Ahmad, T., Marshall, S. E., and Jewell, D., (2006), “Genetics of inflammatory bowel disease: the role of the HLA complex”, World journal of Gastroenterology, 12(23), pp. 3628.

Akhgari, A., Abbaspour, M., and Moradkhanizadeh, M., (2013), “Combination of pectin and eudargit RS and eudragit RL in the matrix of pellets prepared by Extrusion-Spheronization for possible colonic delivery of 5-amino salicylic acid”, Jundishapur Journal of Natural Pharmaceutical Products, 8(2), pp. 86.

Alsoud, D., Verstockt, B., Fiocchi, C., and Vermeire, S., (2021), “Breaking the therapeutic ceiling in drug development in ulcerative colitis”, The Lancet Gastroenterology and Hepatology, 6(7), pp. 589-595.

Amer, M., Nadeem, M., Nazir, R., Ur, S., Fakhar, M., Abid, F., and Ain, Q. U., (2018), “Probiotics and their use in inflammatory bowel disease”, Alternative Therapies in Health and Medicine, 24(3), pp 16-23.

Ananthakrishnan, A. N., (2013), “Environmental risk factors for inflammatory bowel disease”, Gastroenterology and Hepatology, 9(6), pp. 367.

Asgari, S., Pourjavadi, A., Licht, T. R., Boisen, A., and Ajalloueian, F., (2020), “Polymeric carriers for enhanced delivery of probiotics”, Advanced Drug Delivery Reviews, 161, pp. 1-21.

Atyabi, F., Vahabzadeh, R., and Dinarvand, R., (2010), “Preparation of ethylcellulose coated gelatin microspheres as a multiparticulate colonic delivery system for 5-aminosalicilic acid”, Iranian Journal of Pharmaceutical Research, (2), pp.81-86.

Avachat, A. M., and Shinde, A. S., (2016), "Feasibility studies of concomitant administration of optimized formulation of probiotic-loaded Vancomycin hydrochloride pellets for colon delivery", Drug Development and Industrial Pharmacy, 42(1), pp. 80-90.

Badhana, S., Garud, N., and Garud, A., (2013), "Colon specific drug delivery of mesalamine using eudragit S100-coated chitosan microspheres for the treatment of ulcerative colitis", International Current Pharmaceutical Journal, 2(3), pp. 42-48.

Bagan, J., Paderni, C., Termine, N., Campisi, G., Lo Russo, L., Compilato, D., and Di Fede, O., (2012), "Mucoadhesive polymers for oral transmucosal drug delivery: a review", Current Pharmaceutical Design, 18(34), pp. 5497-5514.

Bardoliwala, D., Baradia, D., Amrutiya, J., and Misra, A., (2021), "Applications of polymers in colon drug delivery", Drug Delivery, pp. 187-220.

Basu, S. K., Kavitha, K., and Rupeshkumar, M., (2010), "Evaluation of ketorolac tromethamine microspheres by chitosan/gelatin B complex coacervation", Scientia Pharmaceutica, 78(1), pp.79-92.

Baumgart, D. C., (2009), "The diagnosis and treatment of Crohn's disease and ulcerative colitis", Deutsches Ärzteblatt International, 106(8), pp.123.

Brusini, R., Varna, M., and Couvreur, P., (2020), "Advanced nanomedicines for the treatment of inflammatory diseases", Advanced Drug Delivery Reviews, 157, pp.161-178.

Caddeo, C., Nácher, A., Díez-Sales, O., Merino-Sanjuán, M., Fadda, A. M., and Manconi, M., (2014), "Chitosan–xanthan gum microparticle-based oral tablet for colon-targeted and sustained delivery of quercetin", Journal of Microencapsulation, 31(7), pp. 694-699.

Cain, A. M., and Karpa, K. D., (2011), "Clinical utility of probiotics in inflammatory bowel disease", Health and Medicine, 17(1), pp 72-79.

Celiberto, L. S., Bedani, R., Rossi, E. A., and Cavallini, D. C. U., (2017), "Probiotics: The scientific evidence in the context of inflammatory bowel disease" Food Science and Nutrition, 57(9), pp. 1759-1768.

Chaudhari, R., and Joshi, A., (2017), "Targeted Drug Delivery for Personalized Cure" Advances in Personalized Nanotherapeutics, pp. 97-115.

Chaurasia, G., (2016), "A review on pharmaceutical preformulation studies in formulation and development of new drug molecules" International journal of Pharmaceutical Sciences and Research, 7(6), pp. 2313.

Chen, F., Liu, Q., Xiong, Y., and Xu, L., (2021), "Current Strategies and Potential Prospects of Nanomedicine-Mediated Therapy in Inflammatory Bowel Disease", International Journal of Nanomedicine, 16, pp.4225.

Chen, L., Zou, Y., Peng, J., Lu, F., Yin, Y., Li, F., and Yang, J., (2015), "Lactobacillus acidophilus suppresses colitis-associated activation of the IL-23/Th17 axis", Journal of Immunology Research, 2015, pp.909514.

Chen, Y., Wang, Y., and Shen, J., (2019), "Role of environmental factors in the pathogenesis of Crohn's disease: a critical review", International Journal of Colorectal Disease, 34(12), pp. 2023-2034.

Chen, Z., Schuman, T. P., and Bai, B., (2013), "Preparation of microparticle gels and their application", Enhanced Oil Recovery. Abstracts of Papers of the American Chemical Society (ACS), 245th National Meeting of the American-Chemical-Society 2013: Apr. 7-11, New Orleans, LA.

Chey, W. D., Kurlander, J., and Eswaran, S., (2015), "Irritable bowel syndrome: a clinical review", Jama, 313(9), pp. 949-958.

Cioffi, M., De Rosa, A., Serao, R., Picone, I., and Vietri, M. T., (2015), "Laboratory markers in ulcerative colitis: Current insights and future advances", World Journal of Gastrointestinal Pathophysiology, 6(1), pp.13.

Clarke, K., and Chintanaboina, J., (2019), "Allergic and immunologic perspectives of inflammatory bowel disease", Clinical Reviews in Allergy and Immunology, 57(2), pp.179-193.

Collnot, E. M., Ali, H., and Lehr, C. M., (2012), "Nano-and microparticulate drug carriers for targeting of the inflamed intestinal mucosa", Journal of Controlled Release, 161(2), pp. 235-246.

Cui, G., and Yuan, A., (2018), "A systematic review of epidemiology and risk factors associated with Chinese inflammatory bowel disease", Frontiers in Medicine, 5, pp. 183.

Dai, S., Ravi, P., and Tam, K. C., (2008), "pH-Responsive polymers: synthesis,

properties and applications", Soft Matter, 4(3), pp. 435-449.

Dashora, A., and Jain, C. P., (2009), "Development and characterization of pectin-prednisolone microspheres for colon targeted delivery", International Journal of Chem Tech Research, 1(3), pp.751-757.

Desai, N., and Momin, M., (2020), "Colon targeted bioadhesive pellets of curcumin and cyclosporine for improved management of inflammatory bowel disease", Drug Delivery and Translational Research, 10(5), pp.1288-1301.

Deshmukh, R., Harwansh, R. K., Paul, S. D., and Shukla, R., (2020), "Controlled release of sulfasalazine loaded amidated pectin microparticles through Eudragit S 100 coated capsule for management of inflammatory bowel disease", Journal of Drug Delivery Science and Technology, 55, 101495.

Dhillon, P., and Singh, K., (2020), "Therapeutic applications of probiotics in ulcerative colitis: An updated review", Pharma Nutrition, 13, pp.100194.

Di Sabatino, A., Biancheri, P., Rovedatti, L., MacDonald, T. T., and Corazza, G. R., (2012), "Recent advances in understanding ulcerative colitis", Internal and Emergency Medicine, 7(2), pp. 103-111.

Direito, R., Rocha, J., Lima, A., Gonçalves, M. M., Duarte, M. P., Mateus, V., and Figueira, M. E., (2019), "Reduction of inflammation and colon injury by a spearmint phenolic extract in experimental bowel disease in mice", Medicines, 6(2), pp. 65.

Dong, J. P., Zheng, Y., Wu, T., He, Q., Teng, G. G., and Wang, H. H., (2019), "Protective effect of Saccharomyces boulardii on intestinal mucosal barrier of dextran sodium sulfate-induced colitis in mice", Chinese Medical Journal, 132(16), pp. 1951-1958.

Du, L., and Ha, C., (2020), "Epidemiology and pathogenesis of ulcerative colitis", Gastroenterology Clinics, 49(4), pp. 643-654.

Elahi, M., Telkabadi, M., Samadi, V., and Vakili, H., (2012), "Association of oral manifestations with ulcerative colitis", Gastroenterology and Hepatology from Bed to Bench, 5(3), pp.155.

Eom, S. J., Hwang, J. E., Kim, K. T., and Paik, H. D., (2018), "Increased antioxidative and nitric oxide scavenging activity of ginseng marc fermented by Pediococcus acidilactici KCCM11614P" Food Science and Biotechnology, 27(1), pp.

185-191.

Fahmy, A. M., Hassan, M., El-Setouhy, D. A., Tayel, S. A., and Al-Mahallawi, A. M., (2021), "Statistical optimization of hyaluronic acid enriched ultradeformable elastosomes for ocular delivery of voriconazole via Box-Behnken design: in vitro characterization and in vivo evaluation" Drug Delivery, 28(1), pp. 77-86.

Fakhoury, M., Negrulj, R., Mooranian, A., and Al-Salami, H., (2014), "Inflammatory bowel disease: clinical aspects and treatments" Journal of Inflammation Research, 7, pp. 113-120.

Ferri, D., Costero, A. M., Gavina, P., Parra, M., Merino, V., Teruel, A. H., and Martinez-Manez, R., (2019), "Efficacy of budesonide-loaded mesoporous silica microparticles capped with a bulky azo derivative in rats with TNBS-induced colitis", International Journal of Pharmaceutics, 561, pp. 93-101.

Floch, M. H., (2018), "The role of prebiotics and probiotics in gastrointestinal disease", Gastroenterology Clinics, 47(1), pp. 179-191.

Fukuda, T., Naganuma, M., and Kanai, T., (2019), "Current new challenges in the management of ulcerative colitis", Intestinal Research, 17(1), pp. 36-44.

Gagliani, N., and Huber, S., (2017), "Basic aspects of T helper cell differentiation", T-Cell Differentiation, 1514, pp. 19-30.

Ganguly, K., Aminabhavi, T. M., and Kulkarni, A. R., (2011), "Colon targeting of 5-fluorouracil using polyethylene glycol cross-linked chitosan microspheres enteric coated with cellulose acetate phthalate", Industrial and Engineering Chemistry Research, 50(21), pp. 11797-11807.

Ge, C., Lu, Y., Shen, H., and Zhu, L., (2022), "Monitoring of intestinal inflammation and prediction of recurrence in ulcerative colitis", Scandinavian Journal of Gastroenterology, 57(5), pp.513 -524.

Gionchetti, P., Rizzello, F., Habal, F., Morselli, C., Amadini, C., Romagnoli, R., and Campieri, M., (2003), "Standard treatment of ulcerative colitis", Digestive Diseases, 21(2), pp. 157-167.

Glavas-Dodov, M., (2013), "Particulate carriers for local colon drug delivery", J Bioequiv Availab, 5(1), pp. 10000e25.

Gopinath, R., and Naidu, R. A. S., (2011), "Pharmaceutical preformulation studies–current review", International Journal of Pharmaceutical and Biological Archives, 2(5), pp. 1391-1400.

Goyal, N., Rana, A., Ahlawat, A., Bijjem, K. R. V., and Kumar, P., (2014), "Animal models of inflammatory bowel disease: a review", Inflammopharmacology, 22(4), pp. 219-233.

Graff, S., Hussain, S., Chaumeil, J. C., and Charrueau, C., (2008), "Increased intestinal delivery of viable Saccharomyces boulardii by encapsulation in microspheres", Pharmaceutical Research, 25(6), pp. 1290-1296.

Gulbake, A., Chashoo, G., Sharma, P. R., Gupta, P. N., Saxena, A. K., and Jain, S. K., (2016), "Polymeric nanocomposite: Development, characterization, ex vivo and in vivo evaluation for ulcerative colitis", International Journal of Polymeric Materials and Polymeric Biomaterials, 65(7), pp. 337-350.

Guo, X. Y., Liu, X. J., and Hao, J. Y., (2020), "Gut microbiota in ulcerative colitis: insights on pathogenesis and treatment", Journal of Digestive Diseases, 21(3), pp.147-159.

Guslandi, M., Giollo, P., and Testoni, P. A., (2003), "A pilot trial of Saccharomyces boulardii in ulcerative colitis", European Journal of Gastroenterology and Hepatology, 15(6), pp. 697-698.

Ham, M., and Moss, A. C., (2012), "Mesalamine in the treatment and maintenance of remission of ulcerative colitis" Expert Review of Clinical Pharmacology, 5(2), pp. 113-123.

Hanauer, S. B., (2004), "Update on the etiology, pathogenesis and diagnosis of ulcerative colitis", Nature Clinical Practice Gastroenterology and Hepatology, 1(1), pp. 26-31.

Harrington, S. G., Nimkin, K., and Gee, M. S., (2020), "Gastrointestinal Tract", Pediatric Body MRI. pp. 311-325.

Hashem, F. M., Shaker, D. S., Nasr, M., and Ragaey, R., (2013), "In vitro and in vivo evaluation of combined time and pH-dependent oral colonic targeted prednisolone microspheres", British Journal of Pharmaceutical Research, 3(3), pp.420.

Hindryckx, P., Jairath, V., and Dhaens, G., (2016), "Acute severe ulcerative colitis:

from pathophysiology to clinical management", Nature Reviews Gastroenterology and Hepatology, 13(11), pp.654-664.

Hirsch, D., Hardt, J., Sauer, C., Heselmeyer-Hadded, K., Witt, S. H., Kienle, P., and Gaiser, T., (2021), "Molecular characterization of ulcerative colitis-associated colorectal carcinomas" Modern Pathology, 34(6), pp. 1153-1166.

Hirten, R. P., and Sands, B. E., (2021), "New therapeutics for ulcerative colitis", Annual Review of Medicine, 72, pp. 199-213.

Hu, T., Wang, H., Xiang, C., Mu, J., and Zhao, X., (2020), "Preventive Effect of Lactobacillus acidophilus XY27 on DSS-Induced Ulcerative Colitis in Mice", Drug Design, Development and Therapy, 14, pp. 5645-5657.

Ibekwe, V. C., Khela, M. K., Evans, D. F., and Basit, A. W., (2008), "A new concept in colonic drug targeting: a combined pH responsive and bacterially triggered drug delivery technology", Alimentary Pharmacology and Therapeutics, 28(7), pp. 911-916.

Isaacs, K., and Herfarth, H., (2008), "Role of probiotic therapy in IBD", Inflammatory Bowel Diseases, 14(11), pp. 1597-1605.

Jagdale, S., and Chandekar, A., (2017), "Optimization of chitosan and cellulose acetate phthalate controlled delivery of methylprednisolone for treatment of inflammatory bowel disease", Advanced Pharmaceutical Bulletin, 7(2), pp. 203-213.

Jain, A., Khare, P., Agrawal, R. K., and Jain, S. K., (2009), "Metronidazole loaded pectin microspheres for colon targeting", Journal of Pharmaceutical Sciences, 98(11), pp. 4229-4236.

Jain, K. K., (2020), "An overview of drug delivery systems", Drug Delivery Systems, 2059, pp. 1-54.

Jin, L., Ding, Y. C., Zhang, Y., Xu, X. Q., and Cao, Q., (2016)' "A novel pH–enzyme-dependent mesalamine colon-specific delivery system", Drug Design, Development and Therapy, 10, pp. 2021-2028.

Kaffash, E., Saremnejad, F., Abbaspour, M., Mohajeri, S. A., Garekani, H. A., Jafarian, A. H., and Nokhodchi, A., (2019), "Statistical optimization of alginate-based oral dosage form of 5-aminosalicylic acid aimed to colonic delivery: In vitro and in vivo evaluation", Journal of Drug Delivery Science and Technology, 52, pp. 177-188.

Kaistha, A., and Levine, J., (2014), "Inflammatory bowel disease: the classic gastrointestinal autoimmune disease", Current Problems in Pediatric and Adolescent Health Care, 44(11), pp. 328-334.

Kamel, S., Ali, N., Jahangir, K., Shah, S. M., and El-Gendy, A. A., (2008), "Pharmaceutical significance of cellulose: A review", Express Polymer Letters, 2(11), pp. 758-778.

Kane, S. V., Brixner, D., Rubin, D. T., and Sewitch, M. J., (2008), "The challenge of compliance and persistence: focus on ulcerative colitis", Journal of Managed Care Pharmacy, 14(1 Supp A), pp. 1-18.

Kang, R. K., Mishr, N., and Rai, V. K., (2020), "Guar gum micro-particles for targeted co-delivery of doxorubicin and metformin HCL for improved specificity and efficacy against colon cancer: in vitro and in vivo studies", Aaps Pharmscitech, 21(2), pp. 1-11.

Kannan, N., and Guruvayoorappan, C., (2013), "Protective effect of Bauhinia tomentosa on acetic acid induced ulcerative colitis by regulating antioxidant and inflammatory mediators", International Immunopharmacology, 16(1), pp. 57-66.

Kany, S., Vollrath, J. T., and Relja, B., (2019), "Cytokines in inflammatory disease", International Journal of Molecular Sciences, 20(23), pp. 6008.

Kaplan, G. G., and Ng, S. C., (2017), "Understanding and preventing the global increase of inflammatory bowel disease" Gastroenterology, 152(2), pp. 313-321.

Kaur, R., Gulati, M., and Singh, S. K., (2017), "Role of synbiotics in polysaccharide assisted colon targeted microspheres of mesalamine for the treatment of ulcerative colitis", International Journal of Biological Macromolecules, 95, pp. 438-450.

Kaur, V., Goyal, A. K., Ghosh, G., Si, S. C., and Rath, G., (2020), "Development and characterization of pellets for targeted delivery of 5-fluorouracil and phytic acid for treatment of colon cancer in Wistar rat", Heliyon, 6(1), pp. e03125.

Kawadkar, J., Meenakshi, K. C., and Ram, A., (2010), "Evaluation of potential of Zn-pectinate gel (ZPG) microparticles containing mesalazine for colonic drug delivery", DARU Journal of Pharmaceutical Sciences, 18(3), pp. 211-217.

Khurana, B., Arora, D., and Narang, R. K., (2020), "QbD based exploration of resveratrol loaded polymeric micelles based carbomer gel for topical treatment of

plaque psoriasis: In vitro, ex vivo and in vivo studies", Journal of Drug Delivery Science and Technology, 59, pp. 101901.

Kotla, N., and Shivapooja, A., (2014), "Recent developments in colon specific drug delivery systems approaches promising in targeting colon", International Journal of Pharmaceutical and Clinical Research, 6, pp. 101-106.

Kulaylat, M. N., and Dayton, M. T., (2010), "Ulcerative colitis and cancer. Journal of Surgical Oncology", 101(8), pp. 706-712.

Kumar, A., Gulati, M., Singh, S. K., Gowthamarajan, K., Prashar, R., Mankotia, D. and Khursheed, R., (2020), "Effect of co-administration of probiotics with guar gum, pectin and Eudragit S100 based colon targeted mini tablets containing 5-Fluorouracil for site specific release", Journal of Drug Delivery Science and Technology, 60, pp. 102004.

Lamprecht, A., (2003), "Multiparticulate systems in the treatment of inflammatory bowel disease", Current Drug Targets-Inflammation and Allergy, 2(2), pp. 137-144.

Larabi, A., Barnich, N., and Nguyen, H. T. T., (2020), "New insights into the interplay between autophagy, gut microbiota and inflammatory responses in IBD", Autophagy, 16(1), pp. 38-51.

Lee, S. H., Bajracharya, R., Min, J. Y., Han, J. W., Park, B. J., and Han, H. K., (2020), "Strategic approaches for colon targeted drug delivery: an overview of recent advancements", Pharmaceutics, 12(1), pp. 68.

Lee-Kong, S., and Kiran, R. P., (2016), "Ongoing challenges and controversies in ulcerative colitis surgery", Expert Review of Gastroenterology and Hepatology, 10(2), pp. 187-191.

Legaki, E., and Gazouli, M., (2016), "Influence of environmental factors in the development of inflammatory bowel diseases", World Journal of Gastrointestinal Pharmacology and Therapeutics, 7(1), pp. 112.

Lengyel, M., Kállai-Szabó, N., Antal, V., Laki, A. J., and Antal, I., (2019), "Microparticles, microspheres, and microcapsules for advanced drug delivery", Scientia Pharmaceutica, 87(3), pp. 20.

Lin, W. C., Chang, C. W., Chen, M. J., Chu, C. H., Shih, S. C., Hsu, T. C., and Wang, H. Y., (2017), "Challenges in the diagnosis of ulcerative colitis with concomitant

bacterial infections and chronic infectious colitis", PLoS One, 12(12), pp. e0189377.

Liu, L., Yao, W., Rao, Y., Lu, X., and Gao, J., (2017), "pH-Responsive carriers for oral drug delivery: challenges and opportunities of current platforms" Drug Delivery, 24(1), pp. 569-581.

Loftus Jr, E. V., (2016), "Update on the incidence and prevalence of inflammatory bowel disease in the United States", Gastroenterology and Hepatology, 12(11), pp. 704.

López, E. V., Álvarez, A. L., Méndez, J. B., and Espinar, F. J. O., (2017), "Cellulose-polysaccharide film-coating of cyclodextrin based pellets for controlled drug release", Journal of Drug Delivery Science and Technology, 42, pp. 273-283.

Lorenzo-Lamosa, M. L., Remunan-Lopez, C., Vila-Jato L. and Alonso, M. J., (1998), "Design of microencapsulated chitosan microspheres for colonic drug delivery", Journal of Controlled Release, 52(1-2), pp. 109-118.

Luckheeram, R. V., Zhou, R., Verma, A. D., and Xia, B., (2012), "$CD4^+$ T cells: differentiation and functions", Clinical and Developmental Immunology, 2012, pp.60-82.

Mahkam, M., and Vakhshouri, L., (2010), "Colon-specific drug delivery behavior of pH-responsive PMAA/perlite composite", International Journal of Molecular Sciences, 11(4), pp. 1546-1556.

Managlia, E., Katzman, R. B., Brown, J. B., and Barrett, T. A., (2013), "Antioxidant properties of mesalamine in colitis inhibit phosphoinositide 3-kinase signaling in progenitor cells", Inflammatory Bowel Diseases, 19(10), pp. 2051-2060.

Mandlik, D. S., Mandlik, S. K., and Patel, S., (2021), "Protective effect of sarsasapogenin in TNBS induced ulcerative colitis in rats associated with downregulation of pro-inflammatory mediators and oxidative stress", Immunopharmacology and Immunotoxicology, 43(5), pp. 571-583.

Maroni, A., Moutaharrik, S., Zema, L., and Gazzaniga, A., (2017), "Enteric coatings for colonic drug delivery: state of the art", Expert Opinion on Drug Delivery, 14(9), pp. 1027-1029.

Marques-Marinho, F. D., and Vianna-Soares, C. D., (2013), "Cellulose and its derivatives use in the pharmaceutical compounding practice", Cellulose-Medical, Pharmaceutical and Electronic Applications. 14(9), pp. 166-180.

Mehta, T. J., Patel, A. D., Patel, M. R., and Patel, N. M., (2011), "Need of colon specific drug delivery system: review on primary and novel approaches", International Journal of Pharmaceutical Research and Development, 3(1), pp. 134-153.

Messaris, E., and Dassopoulos, T., (2019), "Concepts in inflammatory bowel disease management", Shackelford's Surgery of the Alimentary Tract, 2, pp. 1888-1918.

Morris, G. P., Beck, P. L., Herridge, M. S., Depew, W. T., Szewczuk, M. R., and Wallace, J. L., (1989), "Hapten-induced model of chronic inflammation and ulceration in the rat colon", Gastroenterology, 96(2), pp. 795-803.

Morsy, M. A., Gupta, S., Nair, A. B., Venugopala, K. N., Greish, K., and El-Daly, M., (2019), "Protective effect of Spirulina platensis extract against dextran-sulfate-sodium-induced ulcerative colitis in rats" Nutrients, 11(10), 2309-2316.

Motavallian-Naeini, A., Andalib, S., Rabbani, M., Mahzouni, P., Afsharipour, M., and Minaiyan, M., (2012), "Validation and optimization of experimental colitis induction in rats using 2, 4, 6-trinitrobenzene sulfonic acid", Research in Pharmaceutical Sciences, 7(3), pp. 159-181.

Nascimento, R. D. P.D., Fonseca Machado, A. P.D., Galvez, J., Cazarin, C. B. B., and Junior, M. R. M., (2020), "Ulcerative colitis: Gut microbiota, immunopathogenesis and application of natural products in animal models", Life Sciences, 258, pp. 118129.

Negi, D., Singh, A., Joshi, N., and Mishra, N., (2020), "Cisplatin and probiotic biomass loaded pessaries for the management of cervical cancer", Anti-Cancer Agents in Medicinal Chemistry, 20(5), pp. 589-598.

Nidhi, Dadwal, A., Hallan, S. S., Sharma, S., and Mishra, N., (2017), "Development of enteric-coated microspheres of embelin for their beneficial pharmacological potential in ulcerative colitis", Artificial Cells, Nanomedicine, and Biotechnology, 45(6), pp. 1092-1100.

Niu, (2021), "Polysaccharides from natural resources exhibit great potential in the treatment of ulcerative colitis: a review", Carbohydrate Polymers, 254, pp. 117189.

Noreen, A., Akram, J., Rasul, I., Mansha, A., Yaqoob, N., Iqbal, R., and Zia, K. M., (2017), "Pectins functionalized biomaterials; a new viable approach for biomedical applications: A review", International Journal of Biological Macromolecules, 101, pp.

254-272.

Paharia, A., Yadav, A. K., Rai, G., Jain, S. K., Pancholi, S. S., and Agrawal, G. P., (2007), "Eudragit-coated pectin microspheres of 5-fluorouracil for colon targeting", Aaps Pharmscitech, 8(1), pp. E87-E93.

Paine, E. R., (2014), "Colonos copic evaluation in ulcerative colitis", Gastroenterology Report, 2(3), pp. 161-168.

Pandey, S., Swamy, S. V., Gupta, A., Koli, A., Patel, S., Maulvi, F., and Vyas, B., (2018), "Multiple response optimisation of processing and formulation parameters of pH sensitive sustained release pellets of capecitabine for targeting colon", Journal of Microencapsulation, 35(3), pp. 259-271.

Patole, V. C., and Pandit, A. P., (2018), "Mesalamine-loaded alginate microspheres filled in enteric coated HPMC capsules for local treatment of ulcerative colitis: in vitro and in vivo characterization", Journal of Pharmaceutical Investigation, 48(3), pp. 257-267.

Perricone, C., Versini, M., Ben-Ami, D., Gertel, S., Watad, A., Segel, M. J., and Shoenfeld, Y., (2016), "Smoke and autoimmunity: The fire behind the disease", Autoimmunity Reviews, 15(4), pp. 354-374.

Philip, A. K., and Philip, B., (2010), "Colon targeted drug delivery systems: a review on primary and novel approaches", Oman Medical Journal, 25(2), pp. 79-87.

Pokorny, C. S., Kneale, K. L., and Henderson, C. J., (2001), "Progression of collagenous colitis to ulcerative colitis", Journal of Clinical Gastroenterology, 32(5), pp. 435-438.

Prisciandaro, L., Geier, M., Butler, R., Cummins, A., and Howarth, G., (2009), "Probiotics and their derivatives as treatments for inflammatory bowel disease", Inflammatory Bowel Diseases, 15(12), pp. 1906-1914.

Rashid, M., Kaur, V., Hallan, S. S., Sharma, S., and Mishra, N., (2016), "Microparticles as controlled drug delivery carrier for the treatment of ulcerative colitis: A brief review", Saudi Pharmaceutical Journal, 24(4), pp. 458-472.

Rawlings, A. V., and Lombard, K. J., (2012), "A review on the extensive skin benefits of mineral oil", International Journal of Cosmetic Science, 34(6), pp. 511-518.

Reji, A., and Vijayan, R. P., (2022), "Formulation and characterization of self microemulsifying sustained release pellets for breast cancer", World Journal of Pharmaceutical Sciences, 10(2), pp.159-175.

Remya, P. N., Pasam, N., Gayathri, H., Saraswathi, T. S., Sangeetha, S., and Kavitha, R., (2020), "Design and characterization of bovine serum albumin and pectin microspheres loaded with mesalamine drug targeted to the colon", Drug Invention Today, 13(6), pp.929-934.

Rizzello, F., Salice, M., Calabrese, C., Mazza, M., Calafiore, A., Calandrini, L., and Gionchetti, P., (2019), "Medical Treatment of Ulcerative Colitis: Does Traditional Therapy Still Have a Role?", In Ulcerative Colitis, pp. 93-104.

Sagiri, S. S., Behera, B., Sudheep, T., and Pal, K., (2012), "Effect of composition on the properties of tween-80–span-80-based organogels", Designed Monomers and Polymers, 15(3), pp. 253-273.

Sardou, H. S., Akhgari, A., Mohammadpour, A. H., Kamali, H., Jafarian, A. H., Garekani, H. A., and Sadeghi, F., (2021), "Application of inulin/Eudragit RS in 5-ASA pellet coating with tuned, sustained-release feature in an animal model of ulcerative colitis", International Journal of Pharmaceutics, 597, pp. 120347.

Sareen, R., Jain, N., Rajkumari, A., and Dhar, K. L., (2016), "pH triggered delivery of curcumin from Eudragit-coated chitosan microspheres for inflammatory bowel disease: characterization and pharmacodynamic evaluation", Drug Delivery, 23(1), pp. 55-62.

Sartor, R. B., (2006), "Mechanisms of disease: pathogenesis of Crohn's disease and ulcerative colitis", Nature Clinical Practice Gastroenterology and Hepatology, 3(7), pp. 390-407.

Serban, D. E., (2015), "Microbiota in inflammatory bowel disease pathogenesis and therapy: is it all about diet?", Nutrition in Clinical Practice, 30(6), pp. 760-779.

Shah, N., Shah, T., and Amin, A., (2011), "Polysaccharides: a targeting strategy for colonic drug delivery", Expert Opinion on Drug Delivery, 8(6), pp. 779-796.

Sharma, A., Kaur, N., Sharma, S., Sharma, A., Rathore, M. S., Ajay, K., and Mishra, N., (2018), "Embelin-loaded guar gum microparticles for the management of ulcerative colitis", Journal of Microencapsulation, 35(2), pp. 181-191.

Sharma, P., Chawla, A., and Pawar, P., (2013), "Design, development, and optimization of polymeric based-colonic drug delivery system of naproxen", The Scientific World Journal, 2013, pp.1-12.

Sheil, B., Shanahan, F., and O'Mahony, L., (2007), "Probiotic effects on inflammatory bowel disease", The Journal of Nutrition, 137(3), pp. 819S-824S.

Shukla, R. K., and Tiwari, A., (2012), "Carbohydrate polymers: Applications and recent advances in delivering drugs to the colon", Carbohydrate Polymers, 88(2), pp. 399-416.

Singh, A., Kaur, K., Mandal, U. K., and Narang, R. K., (2020), "Nanoparticles as budding trends in colon drug delivery for the management of ulcerative colitis", Current Nanomedicine, 10(3), pp. 225-247.

Singh, A., Mandal, U. K., and Narang, R. K., (2022), "Development and In Vivo Evaluation of Pectin Based Enteric Coated Microparticles Loaded with Mesalamine and Saccharomyces boulardii for Management of Ulcerative Colitis", ASSAY and Drug Development Technologies, 20(1), pp. 22-34.

Singh, A., Sharma, A., and Kaur, S., (2014), "A review: micro carrier as colon drug delivery system", International Journal of Pharmaceutical, Chemical and Biological Sciences, 4(4), pp. 899-905.

Singh, M. N., Hemant, K. S. Y., Ram, M., and Shivakumar, H. G., (2010), "Microencapsulation: A promising technique for controlled drug delivery", Research in Pharmaceutical Sciences, 5(2), pp. 65-96.

Sinopoulou, V., Gordon, M., Dovey, T. M., and Akobeng, A. K., (2021), "Interventions for the management of abdominal pain in ulcerative colitis", Cochrane Database of Systematic Reviews, 7(7), pp. CD013589.

Sivananthan, K., and Petersen, A. M., (2018), "Review of Saccharomyces boulardii as a treatment option in IBD", Immunopharmacology and Immunotoxicology, 40(6), pp. 465-475.

Sosnik, A., das Neves, J., and Sarmento, B., (2014), "Mucoadhesive polymers in the design of nano-drug delivery systems for administration by non-parenteral routes: A review", Progress in Polymer Science, 39(12), pp. 2030-2075.

Soyturk, M., Saygili, S. M., Baskin, H., Sagol, O., Yilmaz, O., Saygili, F., and

Akpinar, H., (2012), "Effectiveness of Saccharomyces boulardii in a rat model of colitis", World Journal of Gastroenterology, 18(44), pp. 6452-6460.

Sriamornsak, P., (2011), "Application of pectin in oral drug delivery", Expert Opinion on Drug Delivery, 8(8), pp. 1009-1023.

Thakur, V., Singh, A., Joshi, N., and Mishra, N., (2019), "Spray dried formulation of mesalamine embedded with probiotic biomass for the treatment of ulcerative colitis: in-vitro and in-vivo studies", Drug Development and Industrial Pharmacy, 45(11), pp. 1807-1820.

Torres, J., Billioud, V., Sachar, D. B., Peyrin-Biroulet, L., and Colombel, J. F., (2012), "Ulcerative colitis as a progressive disease: the forgotten evidence", Inflammatory Bowel Diseases, 18(7), pp. 1356-1363.

Tozaki, H., Fujita, T., Komoike, J., Kim, S. I., Terashima, H., Muranishi, S., and Yamamoto, A., (1999), "Colon-specific delivery of budesonide with azopolymer-coated pellets: therapeutic effects of budesonide with a novel dosage form against 2, 4, 6-trinitrobenzenesulphonic acid-induced colitis in rats", Journal of Pharmacy and Pharmacology, 51(3), pp. 257-261.

Tripathi, K., and Feuerstein, J. D., (2019), "New developments in ulcerative colitis: latest evidence on management, treatment, and maintenance", Drugs in Context, 8, pp. 212572-212597.

Valcheva-Kuzmanova, S., Kuzmanov, A., Kuzmanova, V., and Tzaneva, M., (2018), "Aronia melanocarpa fruit juice ameliorates the symptoms of inflammatory bowel disease in TNBS-induced colitis in rats", Food and Chemical Toxicology, 113, pp. 33-39.

Van De Walle, J., Hendrickx, A., Romier, B., Larondelle, Y., and Schneider, Y. J., (2010), "Inflammatory parameters in Caco-2 cells: Effect of stimuli nature, concentration, combination and cell differentiation", Toxicology in Vitro, 24(5), pp. 1441-1449.

Vancamelbeke, M., and Vermeire, S., (2017), "The intestinal barrier: a fundamental role in health and disease", Expert Review of Gastroenterology and Hepatology, 11(9), pp. 821-834.

Vanitha, K., Venkataswamy, M., Niharika, S., and Ramesh, A., (2018), "Formulation development and evaluation of Mebeverine extended release pellets", Asian Journal

of Pharmacy and Technology, 8(2), pp. 71-77.

Varshosaz, J., Ahmadi, F., Emami, J., Tavakoli, N., Minaiyan, M., Mahzouni, P., and Dorkoosh, F., (2011), "Microencapsulation of budesonide with dextran by spray drying technique for colon-targeted delivery: an in vitro/in vivo evaluation in induced colitis in rat", Journal of Microencapsulation, 28(1), pp. 62-73.

Varum, F. J., McConnell, E. L., Sousa, J. J., Veiga, F., and Basit, A. W., (2008), "Mucoadhesion and the gastrointestinal tract", Therapeutic Drug Carrier Systems, 25(3), pp. 207-258.

Veerappan, G. R., Betteridge, J., and Young, P. E., (2012), "Probiotics for the treatment of inflammatory bowel disease", Current Gastroenterology Reports, 14(4), pp. 324-333.

Verma, S., Kumar, V., Mishra, D. N., and Singh, S. K., (2012), "Colon targeted drug delivery: current and novel perspectives", International Journal of Pharmaceutical Sciences and Research, 3(5), pp. 1274.

Viana, M. T., Perez, M. C., Ribas, V. R., Martins, G. D. F., and Castro, C. M. M. B. D., (2012), "Leukocyte, red blood cell and morphological adaptation to moderate physical training in rats undernourished in the neonatal period", Revista Brasileira de Hematologia e Hemoterapia, 34(4), pp. 285-291.

Vishwakarma, N., Ganeshpurkar, A., Pandey, V., Dubey, N., and Bansal, D., (2015), "Mesalazine–probiotics beads for acetic acid experimental colitis: formulation and characterization of a promising new therapeutic strategy for ulcerative colitis", Drug Delivery, 22(1), pp. 94-99.

Wang, C., Li, W., Wang, H., Ma, Y., Zhao, X., Zhang, X., and Li, J., (2019), "Saccharomyces boulardii alleviates ulcerative colitis carcinogenesis in mice by reducing TNF-α and IL-6 levels and functions and by rebalancing intestinal microbiota", BMC Microbiology, 19(1), pp. 1-12.

Wang, Q. S., Wang, G. F., Zhou, J., Gao, L. N., and Cui, Y. L., (2016), "Colon targeted oral drug delivery system based on alginate-chitosan microspheres loaded with icariin in the treatment of ulcerative colitis", International Journal of Pharmaceutics, 515(1-2), pp. 176-185.

Wang, W., Yan, X., Li, Q., Chen, Z., Wang, Z., and Hu, H., (2020), "Adapted nano-carriers for gastrointestinal defense components: surface strategies and

challenges", Nanomedicine: Nanotechnology, Biology and Medicine, 29, 102277.

Wang, Z., Li, S., Cao, Y., Tian, X., Zeng, R., Liao, D. F., and Cao, D., (2016), "Oxidative stress and carbonyl lesions in ulcerative colitis and associated colorectal cancer", Oxidative Medicine and Cellular Longevity, 2016, 9875298.

Wei, H., Li-Fang, F., Min, B., Yong-Zhen, C., Bai, X., Qing, D., and De-Ying, C., (2010), "Chitosan/Kollicoat SR 30D film-coated pellets of aminosalicylates for colonic drug delivery", Journal of Pharmaceutical Sciences, 99(1), pp. 186-195.

Windsor, J. W., and Kaplan, G. G., (2019), "Evolving epidemiology of IBD", Current Gastroenterology Reports, 21(8), pp. 1-9.

Xavier, P., Belo, L., Beires, J., Rebelo, I., Martinez-de-Oliveira, J., Lunet, N., and Barros, H., (2006), "Serum levels of VEGF and TNF-α and their association with C-reactive protein in patients with endometriosis", Archives of Gynecology and Obstetrics, 273(4), pp. 227-231.

Xiao, B., Si, X., Zhang, M., and Merlin, D., (2015), "Oral administration of pH-sensitive curcumin-loaded microparticles for ulcerative colitis therapy", Colloids and Surfaces B: Biointerfaces, 135, pp. 379-385.

Xu, C. T., Meng, S. Y., and Pan, B. R., (2004), "Drug therapy for ulcerative colitis", World Journal of Gastroenterology, 10(16), pp. 2311.

Xu, M., Sun, M., Qiao, H., Ping, Q., and Elamin, E. S., (2014), "Preparation and evaluation of colon adhesive pellets of 5-aminosalicylic acid", International Journal of Pharmaceutics, 468(1-2), pp. 165-171.

Yadav, H. K., Usman, S., Ramesh, K. V. R. N. S., and Islam, Q., (2021), "Formulation and evaluation of pellets of natural okra gum prepared by extrusion and spheronization", Research Journal of Pharmacy and Technology, 14(6), pp. 3290-3294.

Yadav, P. K., and Liu, Z., (2009), "Current strategies for the treatment of ulcerative colitis", Inflammation and Allergy Drug Discovery, 3(1), pp. 65-72.

Yang, G. Y., Taboada, S., and Liao, J., (2009), "Inflammatory bowel disease: a model of chronic inflammation-induced cancer", Inflammation and Cancer, 511, pp. 193-233.

Zafar, A., Afzal, M., Quazi, A. M., Yasir, M., Kazmi, I., Al-Abaasi, F. A., and Kaur, R., (2021), "Chitosan-ethyl cellulose microspheres of domperidone for nasal delivery: Preparation, in-vitro characterization, in-vivo study for pharmacokinetic evaluation and bioavailability enhancement", Journal of Drug Delivery Science and Technology, 63, 102471.

Zhao, H., Zhao, L., Lin, X., and Shen, L., (2022), "An update on microcrystalline cellulose in direct compression: Functionality, critical material attributes, and co-processed excipients" Carbohydrate Polymers, 278, 118968.

Zipporah, I. E., Lakhbir, K., Morris, G., Patricia, B., and Anthony, A., (2019), "The use of probiotics in the maintenance of remission in ulcerative colitis: A systematic review", Official Journal of the American College of Gastroenterology, 114, pp. S1.

“APPENDIX”

List of Publications

Research Articles

1. **Amandeep Singh**, U K Mandal, R K Narang. Development and characterization of enteric coated pectin pellets containing mesalamine and *Saccharomyces boulardii* for specific inflamed colon: In vitro and in vivo evaluation. **Journal of Drug Delivery Science and Technology**. **2021 Apr.**
   DOI: 10.1016/j.jddst.2021.102393
   Indexed: SCI/SCIE, SCOPUS, UGC CARE list
   Impact factor: 5.06

2. **Amandeep Singh**, U K Mandal, R K Narang. Development and In Vivo Evaluation of Pectin Based Enteric Coated Microparticles Loaded with Mesalamine and *Saccharomyces boulardii* for Management of Ulcerative Colitis. **ASSAY and Drug Development Technologies. 2021 Nov**.
   DOI: 10.1089/adt.2021.052
   Indexed: SCOPUS, UGC CARE list
   Impact factor: 2.8

3. **Amandeep Singh,** U K Mandal, R K Narang. Development of Cellulose Acetate Phthalate Coated Pectin Microparticles Loaded With Mesalamine and *Saccharomyces Boulardii* Intended for Specific Colonic Drug Delivery. **Journal of Advanced Scientific Research. 2021 Mar.**
   Indexed: UGC CARE list

Review Articles

Amandeep Singh, Kirandeep Kaur, U K Mandal, R K Narang. Nanoparticles as budding trends in colon drug delivery for the management of ulcerative colitis. **Current Nanomedicine, 2020 Nov.**
Indexed: SCOPUS

Book Chapter :

Amandeep Singh, Arpna Devi, U K Mandal. Role of probiotics in wound healing. **Springer, Singapore. 2021 Feb.**

Contents lists available at ScienceDirect

Journal of Drug Delivery Science and Technology

journal homepage: www.elsevier.com/locate/jddst

Research paper

Development and characterization of enteric coated pectin pellets containing mesalamine and *Saccharomyces boulardii* for specific inflamed colon: *In vitro* and *in vivo* evaluation

Amandeep Singh [a, b, *], Uttam Kumar Mandal [a], Raj Kumar Narang [b]

[a] Department of Pharmaceutical Sciences and Technology, Maharaja Ranjit Singh Punjab Technical University, Bathinda, 151001, Punjab, India
[b] Department of Pharmaceutics, ISF College of Pharmacy, Moga, 142001, Punjab, India

ARTICLE INFO

Keywords:
Ulcerative colitis
Mesalamine
Probiotic (*Saccharomyces boulardii*)
Pectin
Pellets

ABSTRACT

The objective of this study was to develop and characterize enteric-coated pectin pellets containing mesalamine and *S.bulardii* for specific colon targeted drug delivery for ulcerative colitis management. Pellets of mesalamine and *S.bulardii* were produced by extrusion-spheronization technique by using pectin and microcrystalline cellulose and coated with Cellulose acetate phthalate. The pellets were evaluated for morphology, micromeritic properties as well as through fourier transform infrared spectroscopy, differential scanning calorimetry and X-ray diffraction techniques and the results confirmed that all the ingredients of the pellets were compatible with each other without revealing any specific interaction. The dissolution profiles of uncoated and coated pellets were examined at pH 1.2, 6.8 and 7.4 with and without rat cecal content. Further pharmacokinetic studies revealed a lower value of maximum concentration in the case of cellulose acetate phthalate coated pellets formulation in comparison to uncoated ones which, evidenced the lower systemic exposure of the drug. Finally, to ensure the therapeutic activity of the selected formulation, a 2,4,6-trinitrobenzene sulfonic acid-induced colitis model was used. Colon/Bodyweight ratio, myeloperoxidase, lipid peroxidase level, glutathione activity and histological evaluation were performed in the colitis model. Animal experiments revealed that coated pellets of mesalamine and *S.bulardii* significantly improved the diseased conditions in Wistar rats. The confirmation of which was done by the gain in weight, clinical improvement in macroscopic and microscopic factors of induced colitis. These findings ensure that coated pellet formulation has promising potential for targeted drug delivery of mesalamine and *S.bulardii* to the colon as well as to improve the viability of probiotics and enhancement in the effectiveness of mesalamine in management of ulcerative colitis.

Development and *In Vivo* Evaluation of Pectin Based Enteric Coated Microparticles Loaded with Mesalamine and *Saccharomyces boulardii* for Management of Ulcerative Colitis

Amandeep Singh,[1,2,] *Uttam Kumar Mandal,[1]* *and Raj Kumar Narang[2]*

[1] *Department of Pharmaceutical Sciences and Technology, Maharaja Ranjit Singh Punjab Technical University, Bathinda, India.*
[2] *Department of Pharmaceutics, ISF College of Pharmacy, Moga, India.*
[] *ORCID ID (https://orcid.org/0000-0003-1994-1487).*

ABSTRACT

Mesalamine is the first-line choice of drug for ulcerative colitis management. However, due to the nontargeted delivery of mesalamine, it shows side effects. The possible impact of mesalamine can be improved by coated microparticles in combination with S. boulardii *for targeted delivery to the colon with the prevention of unwanted side effects. In this work, pectin-based mesalamine and* S. boulardii *loaded microparticles were prepared by dehydration technique and coated by an oil-in-oil solvent evaporation method and characterized by Scanning electron microscopy (SEM), X-ray diffraction, and zeta analysis. 2, 4, 6-Trinitrobenzenesulfonic acid was used for the induction of colitis. The anti-inflammatory effects of coated microparticles on Caco-2 cell were assessed by the determination of interleukin (IL)-8 protein (CRP), were assessed. SEM data revealed that all the prepared coated microparticles had an almost spherical shape. The X-ray powder diffraction analysis of uncoated and coated microparticles showed maximum stability without any interaction. The particle size of uncoated and coated microparticles was 9.14 and 15.61 μm, respectively. The zeta potential of uncoated and coated microparticles was observed to be −26.78 and −29.36 mV, respectively. The prepared coated microparticles decreased the levels of lipid peroxides, MPO, and GSH significantly in colitis. In the Caco-2 cell culture model, the concentration of IL-8 is decreased significantly. The hematological observations confirmed that the prepared formulation showed a promising decrease in the levels of WBC, CRP, and ESR in diseased animals. Animal experiments revealed that cellulose acetate phthalate coated microparticles of mesalamine and* S. boulardii *significantly improved the colitis disease conditions of Wistar rats. Hence, cellulose acetate phthalate-coated microparticles of mesalamine and* S. boulardii *could be recommended as adjuvant therapy to achieve a synergistic effect in the management of UC.*

Keywords: ulcerative colitis, mesalamine, pectin, probiotic (*Saccharomyces boulardii*), microparticles, TNBS

LAY SUMMARY

ScienSage

Journal of Advanced Scientific Research

Available online through http://www.sciensage.info

ISSN 0976-9595

Research Article

DEVELOPMENT OF CELLULOSE ACETATE PHTHALATE COATED PECTIN MICROPARTICLES LOADED WITH MESALAMINE AND *SACCHAROMYCES BOULARDII* INTENDED FOR SPECIFIC COLONIC DRUG DELIVERY

Amandeep Singh*[1,2], Uttam Kumar Mandal[1], Raj Kumar Narang[2]

[1]*Department of Pharmaceutical Sciences and Technology, Maharaja Ranjit Singh Punjab Technical University, Bathinda, Punjab, India*

[2]*Department of Pharmaceutics, ISF College of Pharmacy, Moga, Punjab, India*

**Corresponding author: ad4singh@gmail.com*

ABSTRACT

The present work was focused on delivering mesalamine along with probiotic, specifically to the colonic site. Mesalamine and probiotic were encapsulated in natural polysaccharide pectin microparticles and coated with the Cellulose acetate phthalate (CAP) as an enteric-coated polymer. The major concern of this research is to protect the drug and probiotic release from the gastric environment and target to colonic region. By using nitric oxide assay, the IC_{50} value of both probiotics (*Saccharomyces boulardii* and *Lactobacillus acidophilus*) was determined. Pectin microparticles were prepared by dehydration technique followed by coating with oil-in-oil solvent evaporation. For the drug and polymer compatibility, FTIR determination was done. The release of drug and probiotic was determined with and without rat cecal content. Furtherly pharmacokinetic studies were done to assess the drug concentration in Wistar rat's blood fluid. The nitric oxide assay confirmed that *Saccharomyces boulardii* has high nitric oxide scavenging ability. The FTIR graphs confirmed that no chemical reaction was observed within the drug and polymer. The observed *in-vitro* results of coated microparticles release have been confirmed that the coated formulation has the potential to release the drug and probiotic at the colonic site. Further pharmacokinetic studies revealed a lower value of C_{max} in the case of CAP coated microparticles formulation in comparison to uncoated ones which evidenced the lower systemic exposure of the drug.

Keywords: Ulcerative colitis, Probiotic, *Saccharomyces boulardii, Lactobacillus acidophilus,* Pectin, Colon targeted drug delivery.

Purchase PDF

Review Article

Nanoparticles as Budding Trends in Colon Drug Delivery for the Management of Ulcerative Colitis

Author(s): Amandeep Singh*, Kirandeep Kaur, Uttam Kumar Mandal, Raj Kumar Narang

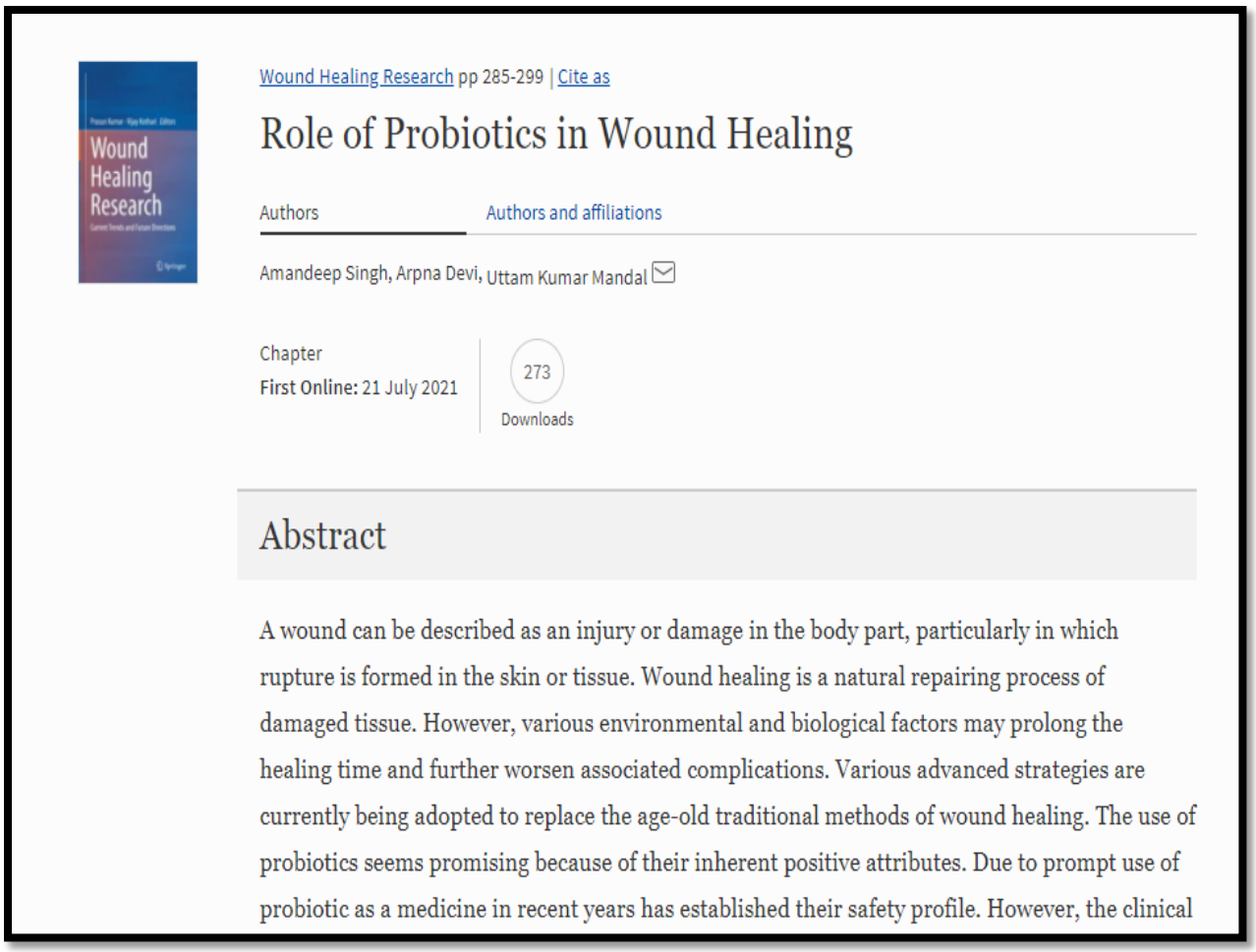
Journal Name: Current Nanomedicine

(Formerly Recent Patents on Nanomedicine)

Volume 10 , Issue 3 , 2020

DOI : 10.2174/2468187310999200621200615

Journal Home



Papers Presented in National/International Conferences

- Presented Paper on Development and characterization of enteric-coated pectin pellets containing mesalamine and *Saccharomyces boulardii* for specific inflamed colon: *In vitro* and *in vivo* evaluation presented in an international webinar organized by advisory board members on Gut-2021.
- Presented Paper on Preparation and characterization of mesalamine and probiotic loaded CAP coated microparticles presented in an international conference organized by Shri Ramatpura Sarkar University, Rajpur, Chattisgarh, India.
- Presented Paper on Development and characterization of CAP coated pectin pellets for the management of ulcerative colitis presented in National e-Conference organized by GRD Institute of technology and management, Dehradun, Uttrakhand.