Banatrol® plus

White Paper Summary

The #1 natural antidiarrheal used in healthcare facilities.

Diarrhea is an important problem in critically ill patients [1] [2]. Enteral feeding and medications are common causes of diarrhea in the hospital setting. Fiber-free enteral nutrition can induce diarrhea through abnormal colonic responses and disruption of the colonic microbiota [3] [4] [5] [6]. Antibiotics can also disrupt the gut microbiota resulting in dysbiosis and diarrhea [7] [8] [9].

Dietary fiber has been shown to have a positive impact on diarrhea in acute care patients [2] [10] [11]. In 2016, the Society of Critical Care Medicine (SCCM) and the American Society for Parenteral and Enteral Nutrition (JPEN) published clinical guidelines which included expert consensus that a fermentable soluble fiber additive (module) be considered for routine use in all hemodynamically stable medical and surgical intensive care unit patients placed on a standard enteral formulation [12]. In addition, a dose of 10 – 20 g divided over 24 hours was recommended as adjunctive therapy when there was evidence of diarrhea was while the routine use of a soluble fiber additive (module) was suggested for all ICU patients as a prophylactic measure to help maintain commensal (colonic) microbiota and promote bowel health through the delivery of short chain fatty acids (SCFA).

Soluble, fermentable dietary fiber plays a key role in the management of diarrhea in acute care through the restoration/modulation of the colonic microbiota and serving as a substrate to produce SCFAs. The colonic microbiota is a complex and diverse microbial ecosystem [13]. Beneficial colonic microbiota suppress enteropathogenic organisms through a process called colonization resistance [14] [15]. Mechanisms for colonization resistance include : 1) competition for niches and nutrients, 2) metabolic exclusion by SCFA production, O2 consumption and bacteriocins, and 3) modulation of the host immune system [15]. Disruption of the gut microbiota via antibiotics [8] [16] or enteral tube feeding [17] [18] can reduce colonization resistance and increase the risk of infection by organisms such as Clostridium difficile.

Anaerobic fermentation of dietary fiber by the resident microbiota in the large bowel leads to the production of SCFAs, primarily acetate, propionate and butyrate [19] [20]. SCFAs play an important role in colonization resistance [15] [21] and are a source of energy for the host [22] with butyrate being a preferential energy source for the colon [23]. Another key benefit, as it relates to diarrhea, is the effect of SCFAs on water absorption in the colon [24]. SCFAs are absorbed by colonic epithelial cells and stimulate Na-dependent water absorption via a cyclic AMP-independent process involving apical membrane Na-H, SCFA-HCO3, and Cl-SCFA exchanges [24]. Nasogastric tube feeding of fiber-free formulas induce abnormal secretion of fluid and electrolytes in the ascending colon [25]. However, this effect is reversed when SCFAs are infused into the ascending colon [26]. A reduction in SCFA production during antibiotic use may be the primary reason for antibiotic-associated diarrhea [27] as the mechanism by which the colon absorbs water is compromised. Fermentable dietary fiber, by serving as an indirect source of SCFAs, helps restore the level of these important organic acids in the colon through the fermentative activity of the resident microbiota.

Banatrol Plus is a unique combination of banana flakes, that provide dietary fibers such as pectin and resistant starch [28] [29], and Bimuno GOS (B-GOS). Bananas have a long history of use in the management of diarrhea. In 1950, Fries [30] published a paper on the effect of dehydrated banana flakes on infant diarrhea. Infants treated with dehydrated banana flakes recovered more quickly than did the infants in the control group. Banana flakes have also been shown to control diarrhea in enterally fed patients [31]. Results from treatment with banana flakes were comparable to the control group receiving routine care (ie., antidiarrhea medication and tube feeding rate adjustment). Bimuno GOS is a novel galactooligosaccharide produced by a strain of Bifidobacterium bifidum NCIMB 41171 [32]. B-GOS is highly fermentable and bifidogenic [32]. Clinical studies in healthy elderly volunteers demonstrated a significant increase in the number of beneficial bacteria, especially bifidobacteria, as well as a positive effect on immune response [33] [34]. Also, B-GOS has been shown to reduce diarrhea episodes in healthy subjects at risk of travelers' diarrhea [35].

Bimuno GOS and the dietary fiber in banana flakes are highly fermentable serving as an energy source for the microbiota in the large bowel [36] [37] [38]. Bimuno GOS is a highly effective prebiotic serving as preferential energy source for bifidobacteria. These ingredients help maintain/restore the colonic microbiota and subsequently colonization resistance during enteral feeding and following antibiotic therapy. In addition, the SCFAs produced through fermentation drive water and electrolyte absorption in the colon and represents a key mechanism by which

soluble, fermentable fiber helps manage diarrhea in hospitalized patients. There is expert consensus for the routine use of a soluble, fermentable fiber module in all hemodynamically stable medical and surgical intensive care unit patients placed on a standard enteral formula to help maintain commensal microbiota and promote bowel health through the delivery of SCFA. Also, the literature confirms that dietary fiber has a positive impact on diarrhea in acute care patients. The use of a module to deliver dietary fiber represents an approach that allows for a more controlled and consistent dose of dietary fiber to meet the unique needs of the individual patient. Banatrol Plus, a unique combination of banana flakes and B-GOS, represents the ideal soluble dietary fiber module for use in hospitalized patients at risk of or experiencing diarrhea.

Works Cited

[1] P. Wiesen, "Diarrhea in critically ill," *Current Opinion in Critical Care*, vol. 12, pp. 149-154, 2006.

[2] M. Elia, M. Engfer, C. Green and etal, "Systematic review and meta-analysis: the clinical and physiological effects of fibre-containing enteral formulae," *Alimentary Pharmacology and Therapeutics*, vol. 27, pp. 120 - 145, 2008.

[3] T. Bowling and D. Silk, "Colonic responses to enteral feeding," *Gut*, vol. 42, pp. 147-151, 1998.

[4] T. Bowling, "Colonic secretory response to enteral feeding in humans," *Gut*, vol. 35, pp. 1734-1741, 1994.

[5] K. Whelan, "Enteral-tube-feeding diarrhea: manipulating the colonic microbiota with probiotics and prebiotics," *Proceeding of the Nutrition Society*, vol. 66, pp. 299-306, 2007.

[6] K. Whelan, P. Judd, V. Preedy, R. Simmering, A. Jann and M. Taylor, "Fructo-oligosaccharides and fiber partially prevent the alteration in fecal microbiota and short-chain fatty acid concentrations caused by standard enteral formula in healthy humans," *Journal of Nutrition*, vol. 135, pp. 1896-1902, 2005.

[7] D. Leffler and T. Lamont, "Clostridium difficile infections," *New England Journal of Medicine*, vol. 372, pp. 1539-1548, 2015.

[8] M. De La Cochetiere, T. Durand, V. Lalande, J. Petit, G. Potel and L. Beaugeric, "Effect of antibiotic therapy on human fecal microbiota and the relation to the development of Clostridium difficile," *Microbial Ecology,* vol. 56, pp. 395-402, 2008.

[9] V. Young and T. Schmidt, "Antibiotic associated diarrhea accompanied by large-scale alterations in the composition of fecal microbiota," *Journal of Clinical Microbiology,* vol. 42, pp. 1203-1206, 2004.

[10] M. Zaman, K. Chin and V. Rai, "Fiber and prebiotic supplementation in enteral nutrition: A systematic review and meta-analysis," *World Journal of Gastroenterology,* vol. 21, pp. 5372-5381, 2015.

[11] A. Reis, F. A. and S. Loss, "Use of dietary fibers in enteral nutrition of critically ill patients: a systematic review," *Revista Brasileira de Terapia Intensiva*, vol. 30, pp. 358-365, 2018.

[12] S. McClave, B. Taylor, R. Martindale and etal, "Guidelines for the provision and assessment of nutrition support therapy in the adult critically ill patient: Society of Critical Care Medicine (SCCM) and American Society for Parenteral and Enteral Nutrition (ASPEN)," *Journal of Enteral and Parenteral Nutrition*, vol. 40, pp. 159-211, 2016.

[13] V. Mai and J. Morris, "Colonic bacterial flora: changing understandings in the molecular age," *Journal of Nutrition*, vol. 30, pp. 519-525, 2004.

[14] K. Whelan, G. Gibson and P. T. M. Judd, "The role of probiotics and prebiotics in the management of diarrhea associated with enteral tube feeding," Journal of Human Nutrition and Dietetics, vol. 14, pp. 423-433, 2001.

[15] T. Lawley and A. Walker, "Intestinal colonization resistance," *Immunology*, vol. 138, pp. 1-11, 2013.

[16] A. Carignan, C. Allard, J. Pepin and etal, "Risk of Clostridium difficile infection after perioperative antibacterial prophylaxis before and during an outbreak of infection due to a hypervirulent strain.," *Clinical Infectious Diseases*, vol. 46, pp. 1838-1843, 2008.

[17] A. Simor, S. Yake and K. Tsimidis, "Infection due to Clostridium difficile among elderly residents of a long-term-care facility," *Clinical Infectious Disease*, vol. 17, pp. 672-678, 1993.

[18] G. Bleichner, H. Blehaut, H. Mentec and D. Moyse, "Saccharomyces boulardii prevents diarrhea in critically ill tube fed patients," *Intensive Care Medicine*, vol. 23, pp. 517-523, 1997.

[19] J. Wong, R. de Souza, C. Kendall, A. Emam and D. Jenkins, "Colonic health: fermentation and short chain fatty acids," *Journal of CLinical Gastroenterology*, vol. 40, pp. 235-243, 2006.
[20] G. den Besten, K. van Eunen, A. Groen, K. Venema, D.-J. Reijingoud and B. Bakker, "The role of short chain fatty acids in the interplay between diet, gut microbiota, and host energy metabolism," *Journal of Lipid Research*, vol. 54, pp. 2325-2340, 2013.
[21] T. May, R. Mackie, G. Fahey, J. Cremin and K. Garleb, "Effect of fiber source on short-chain fatty acid production and on the growth and toxin production by Clostridium difficile," *Scandinavian Journal of Gastroenterology*, vol. 29, pp. 916-922, 1994.
[22] E. Bergman, "Energy contributions of volatile fatty acids from the gastrointestinal tract in various species.," *Physiological Reviews*, vol. 70, pp. 567-590, 1990.
[23] W. Roediger, "Utilization of nutrients by isolated epithelial cells of the rat colon," *Gastroenterology*, vol. 83, pp. 424-429, 1982.
[24] H. Binder, "Role of colonic short-chain-fatty-acid transport in diarrhea," *Annual Review of Physiology*, vol. 72, pp. 297-313, 2010.
[25] T. Bowling, A. Raimundo and G. S. D. Grimble, "Colonic secretory effect in response to enteral feeding in humans," *Gut*, vol. 35, pp. 1734-1742, 1994.
[26] T. Bowling, A. Raimundo, G. Grimble and D. Silk, "Reversal by short chain fatty acids of colonic fluid secretion induced by enteral feeding," *Lancet*, vol. 342, pp. 1266-1268, 1993.
[27] M. Clausen, H. Bonnen, M. Twede and P. Mortensen, "Colonic fermentation to short-chain fatty acids is decreased in antibiotic associated diarrhea," *Gastroenterology*, vol. 101, pp. 1497-1504, 1991.
[28] A. Tapre and R. Jain, "Study of advanced maturity stages of bananas," *International Journal of Advanced Engineering Research and Studies*, vol. 1, no. 3, pp. 272-274, 2012.
[29] R. Zhang and B. Hamaker, "Banana starch structure and digestibility," *Carbohydrate Polymer*, vol. 87, no. 2, pp. 1552-1558, 2012.
[30] J. Fries, N. Chiara and R. Waldron, "Dehydrated banana in the dietetic management of diarrheas of infancy," The Journal of Pediatrics, vol. 37, pp. 367-372, 1950.
[31] E. Emery, S. Ahmad, J. Koethe and etal, "Banana flakes control diarrhea in enterally fed patients," Nutrition in Clinical Practice, vol. 12, pp. 72-75, 1997.
[32] G. Tzortzis, A. Goulas and G. Gibson, "Synthesis of prebiotic galactooligosaccharides using whole cells of a novel strain, Bifidobacterium bifidum NCIMB 41171," Applied Microbial and Cell Physiology, vol. 68, pp. 412-416, 2005.
[33] J. Vulevic, A. Drakoularakou and P. Yaqoob, "Modulation of the fecal microglora profile and immune function by a novel trans-galactooligosaccharide mixture (B-GOS) in healthy elderly volunteers," American Journal of Clinical Nutrition, vol. 88, pp. 1438-1446, 2008.
[34] J. Vulevic, A. Juric, G. Walton and etal, "Influence of galacto-oligosaccharide mixture (B-GOS) on gut microbiota, immune parameters and metabonomics in elderly persons," British Journal of Nutrition, vol. 114, pp. 586-595, 2015.
[35] A. Drakoularakou, G. Tzortzis, R. Rastall and G. Gibson, "A double-blind, placebo-controlled, randomized human study assessing the capacity of a novel galacto-oligosaccharide mixture in reducing travellers' diarrhea," European Journal of Clinical Nutrition, vol. 64, pp. 146-152, 2010.
[36] R. Grimaldi, J. Swann, J. Vulevic, G. Gibson and A. Costabile, "Fermentation properties and potential prebiotic activity of Bimuno galacto-oligosaccharides (65% galacto-oligosaccharide) on in vitro gut microbiota parameters," British Journal of Nutrition, vol. 116, pp. 480-486, 2016.
[37] E. Titgemeyer, L. Bourquin, G. Fahey and K. Garleb, "Fermentability of various fiber sources by human fecal bacteria in vitro," American Journal of Clinical Nutrition, vol. 53, pp. 1418-1424, 1991.
[38] A. Bird, I. Brown and D. Topping, "Starches, Resistant Starch and the Gut Microflora and Human Health," Current Issues in Intestinal Microbiology, vol. 1, no. 1, pp. 25-37, 2000.