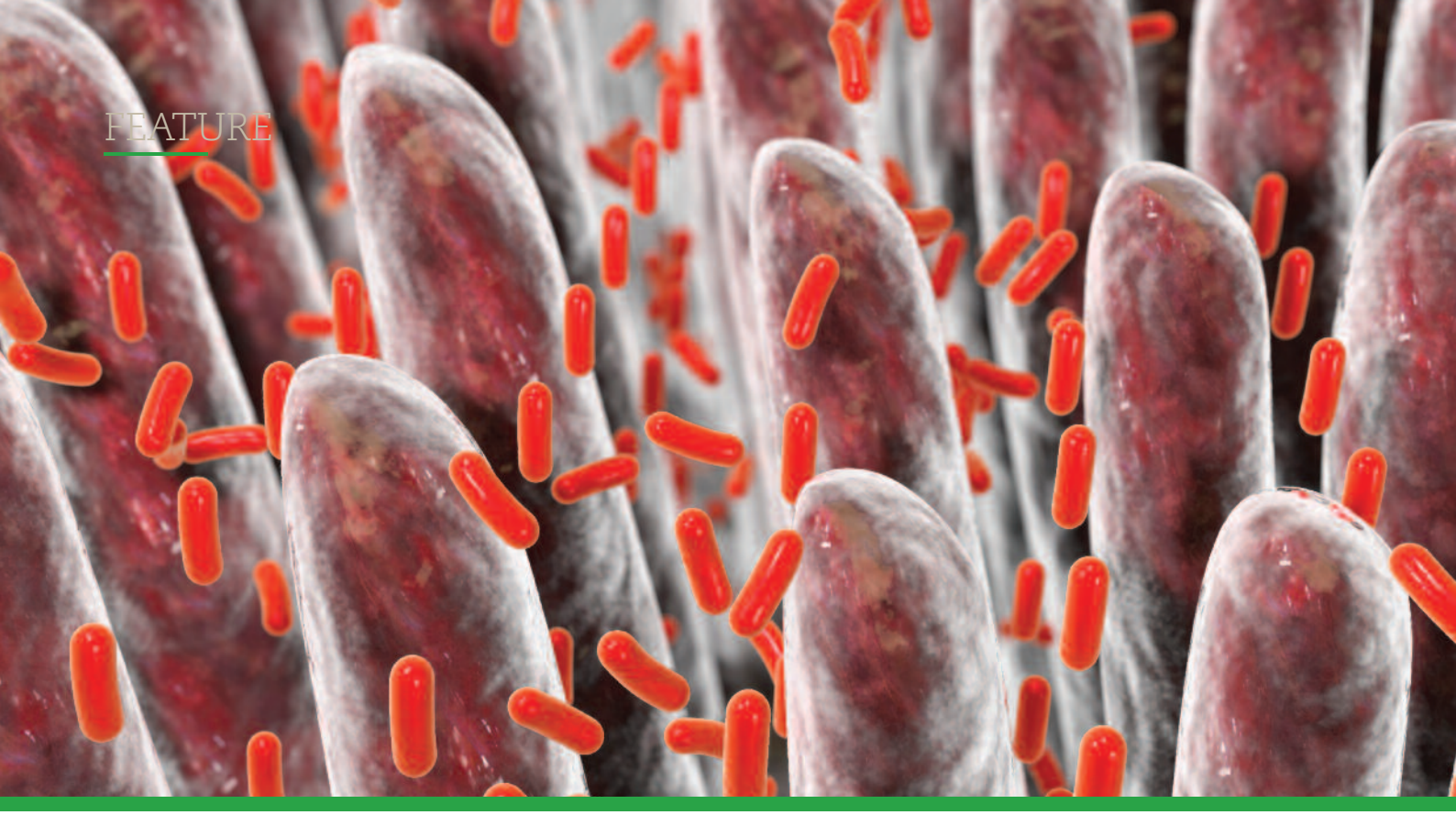

Milkybiotics

Sinead Morrin won Best Oral Presentation and the RDS medal at the recent TEAGASC Walsh Fellowships seminar, along with Best Food Research Presentation, and the Institute of Food Science and Technology Ireland medal, for her presentation on 'Milkybiotics: influencing the intestinal surface to increase colonisation of health-promoting bacteria'.

The gastrointestinal tract is inhabited by microorganisms and the composition of these microbes can influence our health. Health-promoting bacteria, such as bifidobacteria, are abundant in the breastfed infant gut and are crucial for inhibiting the growth of pathogenic organisms, maintaining barrier function in the gut and promoting immunological and inflammatory responses. To confer these beneficial effects, the health-promoting bacteria must first be able colonise the gut in sufficient numbers (Westermann *et al.*, 2016). Breast milk has been shown through many studies to allow the expansion of a beneficial gut microbiota (Gomez-Gallego *et al.*, 2016). For individuals with lower counts of these health-promoting bacteria, there are products available that promote the growth of these bacteria. However, there are no known products commercially available that increase the initial colonisation of these bacteria in the gut, which is the first and most important step when considering their ability to survive in the gastrointestinal tract. It may be the case that certain diets can modulate the intestinal epithelial cell surface, possibly resulting in changes in the abundance or type of attachment sites for bacteria (Angeloni *et al.*, 2005).

Milk components to enhance gut colonisation

The aim of the study was to investigate the effect of selected milk components on modulating the intestinal cells to allow enhanced colonisation of health-promoting bacteria. After the intestinal cells were exposed to a bovine colostrum fraction, the adherence of a range of commensal bacteria to the cells was dramatically improved (up to 52-fold) when compared to the non-treated control. Increases in colonisation were observed for all five common infant *Bifidobacterium* strains, strains which predominantly reside in the breastfed infant intestine. *Bifidobacterium adolescentis* ATCC 15703 and *Lactobacillus rhamnosus* GG, two adult health-promoting strains, also displayed increased adherence to the intestinal surface in the presence of the colostrum fraction.

Monitoring cellular response

A systems-based approach was subsequently employed to monitor the response of the intestinal cells to the colostrum sample that involved transcriptomic, glycomic and proteomic analyses. Gene microarray analysis demonstrated differential expression of enzymes and proteins associated with glycosylation after exposure to the colostrum fraction. Genes involved in the enzymatic addition of terminal carbohydrate moieties (distinct part of molecule) to proteins such as transporters, transferases, glycosidases and lectins were found to be differentially regulated in the presence of the colostrum fraction. Lectin array studies also revealed an alteration in the abundance of terminal carbohydrate moieties with two monosaccharide moieties, N-acetylglucosamine and N-acetylgalactosamine, specifically present at higher levels on the cell surface when compared to the control. Further correlation was evident from the proteomic analysis, which revealed that proteins encoded by

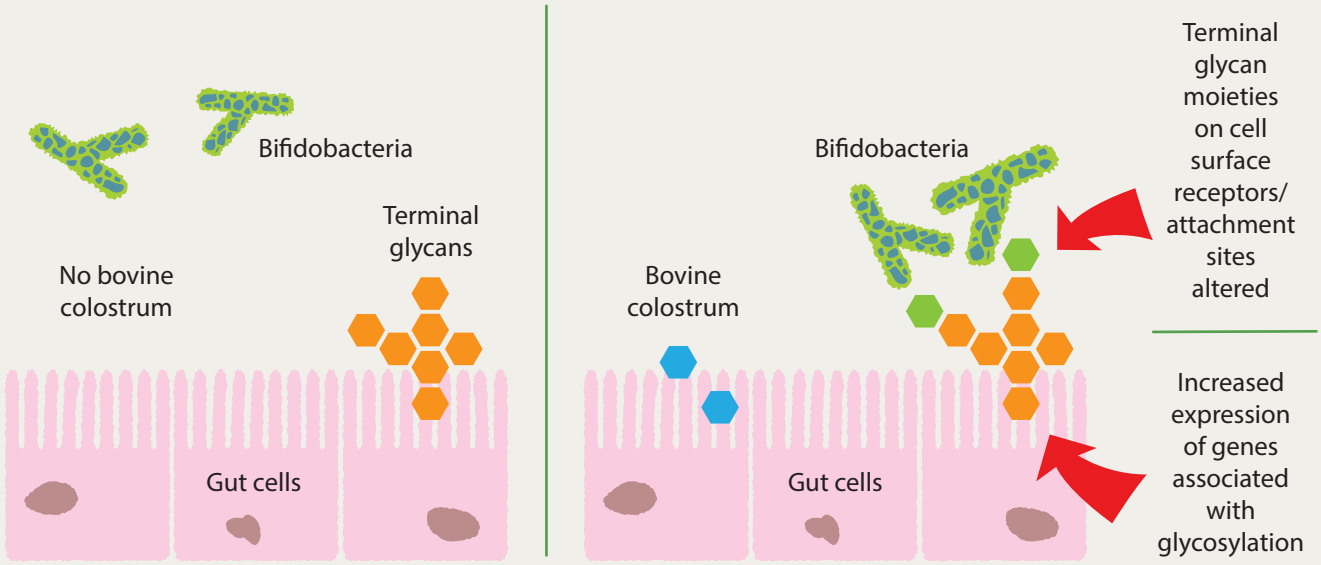

FIGURE 1: Mechanism of action of the bovine colostrum fraction.

these genes were being produced that ultimately confirmed a physical change was occurring at the intestinal surface. Currently, pathway analysis is being performed on the proteomic data, which may indicate the exact intracellular and extracellular cell signalling pathways involved in the response to the colostrum. Overall, the colostrum fraction altered the cell surface sugar pattern, thereby allowing more beneficial bacteria such as bifidobacteria to attach to the cells (**Figure 1**).

New application for whey colostrum

This Teagasc-led research has identified a new application for whey colostrum and its components. This composition has potential for supplementation in infant formula or as food supplements for toddlers, and may improve the discrepancy of *Bifidobacterium* counts found between breastfed and formula-fed infants. It may also have potential as a method for treating or preventing diseases associated with lower counts of commensal bacteria such as inflammatory bowel diseases (Crohn's disease, irritable bowel syndrome, ulcerative colitis), periodontal disease, rheumatoid arthritis, atherosclerosis, allergy, multi-organ failure, asthma, and allergic diseases. Overall, this study provides an insight into how these bacteria colonise the human gut and highlights the potential of milk and other dietary components as functional ingredients that can potentially increase commensal numbers in individuals by conditioning the intestinal surface, allowing subsequent colonisation. A patent application has recently been filed, claiming novel enriched compositions, based on whey colostrum, for supplementation in infant formula, and products for elderly or immune-compromised individuals, or individuals on antibiotics.

Acknowledgements

This work was conducted under the Teagasc Walsh Fellowship Programme. The authors wish to acknowledge Lokesh Joshi and Michelle Kilcoyne (National University of Ireland, Galway) for the use of their lectin array technology. The authors also wish to acknowledge the assistance of the other student supervisors: Jane Irwin, University College Dublin; and, Lars Bode, University of California, San Diego.

References

Westermann, C., Gleinser, M., Corr, S.C. and Riedel, C.U. (2016). 'A Critical Evaluation of Bifidobacterial Adhesion to the Host Tissue'. *Frontiers in Microbiology*, 7 (doi: 10.3389/fmicb.2016.01220).

Gomez-Gallego, C., Garcia-Mantrana, I., Salminen, S. and Collado, M.C. (2016). 'The human milk microbiome and factors influencing its composition and activity'. In: 'Seminars in Fetal and Neonatal Medicine'. WB Saunders, 2016, Vol. 21, No. 6, p. 400-405.

Angeloni, S., Ridet, J.L., Kusy, N., Gao, H., Crevoisier, F., Guinchard, S., *et al.* (2005). 'Glycoprofiling with micro-arrays of glycoconjugates and lectins.' *Glycobiology* 15: 31-41.

Authors

Sinead T. Morrin
Teagasc Walsh Fellow, Teagasc and UCD

Jonathan Lane
Former Research Officer, Food Biosciences Department, Teagasc Food Research Centre, Moorepark, Fermoy, Co. Cork

Mariarosaria Marotta
Research Officer, Food Biosciences Department, Teagasc Food Research Centre, Moorepark, Fermoy, Co. Cork

Rita Hickey
Senior Research Officer, Food Biosciences Department
Teagasc Food Research Centre, Moorepark, Fermoy, Co. Cork
Correspondence: rita.hickey@teagasc.ie