

Early infant diet impacts infant rhesus monkey metabolism

A. O'sullivan¹, E. M. S. McNiven³, N. W. Haggarty⁴, B. Lönnerdal³, C. M. Slupsky^{2,3}

¹UCD Institute of Food and Health, UCD, Belfield, Dublin 4 Ireland, ²Department of Food Science and Technology, ³Department of Nutrition, UC Davis, CA, USA, ⁴Fonterra Ingredients Innovation, Fonterra Co-operative Group, Palmerston North, New Zealand

Epidemiological research has indicated a relationship between infant formula feeding and increased risk of chronic diseases later in life including obesity, type-2 diabetes, and cardiovascular disease^(1,2). However, the underlying mechanisms and metabolic states that define these outcomes are poorly understood, partly due to limitations imposed when designing human infant studies. Consequently, studies investigating infant feeding practices can benefit from the use of appropriate animal models⁽³⁾. A recent metabolomics investigation confirmed the relevance and importance of the rhesus monkey as a model for infant nutrition research⁽⁴⁾. The present study used an infant rhesus monkey model to compare the metabolic implications of formula- and breast-feeding practices using ¹H NMR metabolomics techniques to characterize metabolite fingerprints from urine and serum.

Ten infant rhesus monkeys (*Macaca mulatta*) were recruited to this study from the California National Primate Research Center (CNPRC) at the UC, Davis. Infants were randomly assigned to two diet treatment groups and were either exclusively breastfed or bottle-fed a standard infant formula from birth until 3 months of age. Weight and length were recorded and urine and blood samples were collected weekly. ¹H NMR spectra were acquired for all samples, metabolites were identified and quantified using targeted profiling techniques and multivariate statistical procedures were applied⁽⁵⁾.

Formula-fed infants weighed significantly more and were longer than their breast-fed counterparts at all experimental time points starting from week 4 and continuing to 12 weeks of age ($p < 0.05$). Analysis of serum insulin concentrations showed a significant effect of diet, which was particularly pronounced in the early weeks of life ($p < 0.01$). Multivariate data analysis revealed distinct separation between breast-fed and formula-fed infants for serum and urine metabolomic profiles. In serum, metabolites differentiating breast-fed from formula-fed infants included amino acids, ketones and other compounds. Urinary metabolite differences included those associated with the gut microbiome, as well as sugar, amino acid, and protein metabolism.

Our findings support the contention that early infant diet profoundly influences metabolism in developing infants and suggest that the choice of infant feeding practice may hold future health consequences.

This work was supported by Fonterra Inc.

1. Owen CG, Martin RM, Whincup PH, *et al.* (2006) *Am J Clin Nutr* **84**, 1043–1054.
2. Singhal A, (2006) *Nutr Rev* **64**, S44–S49.
3. Lönnerdal B, (2012) *Ann Nutr Metab* **60**, 196–199.
4. O'Sullivan A, He X, McNiven EMS, *et al.* (2013) *J Pediatr Gastroenterol Nutr* 10.1097/MPG.0b013e31827e1f07.
5. Weljie AM, Newton J, Mercier P, *et al.* (2006) *Anal Chem* **78**, 4430–42.