Development of Quantitative In Vitro-In Vivo Relationships to Understand Food Digestion Processes

BORNHORST G. (1,2), NADIA J. (2)
1 University of California Davis, Davis, United States
2 Riddet Institute, Palmerston North, New Zealand

As development of functional foods has increased, parallel advancement of in vitro model systems has occurred to facilitate food product testing. With the development of novel in vitro digestion systems and methodologies, a quantitative framework is needed to develop appropriate in vitro-in vivo relationships such that results between in vitro and in vivo tests can be easily compared. The Human Gastric Simulator (HGS) was utilized to conduct in vitro gastric digestion of two carbohydrate-based foods of varying structure that were previously studied in vivo using a growing pig model (cooked fettucine pasta and semolina porridge). During in vitro digestion in the HGS, gastric secretions were added at a rate of 4.1 mL/min and gastric emptying was controlled at 5.62 g/min for both meals. Both the gastric emptying and gastric secretion parameters were determined based on average values across six carbohydrate-based meals from a previous in vivo study in growing pigs. During in vitro gastric digestion, samples were taken from the bottom of the HGS at 30 min intervals up to 240 min and the pH, dry matter gastric emptying, texture, particle size distribution, and starch degree of hydrolysis were measured in the emptied digesta. Emptied digesta pH was greater in semolina (4.35 – 1.58) compared to pasta (2.23 – 1.21), likely due to differences in buffering capacity between the meals. During gastric digestion in the HGS, the dry matter half emptying time of semolina was 57.75 ± 1.96 min compared to 163.25 ± 18.28 min for pasta. These trends align with in vivo results, where pasta also had a slower dry matter gastric emptying half time compared to semolina (360 vs. 88 min, respectively). Quantitative correlations between the in vitro and in vivo results were developed to compare dry matter gastric emptying, starch hydrolysis, digesta texture changes, and digesta moisture content, with R2 values ranging from 0.4375 – 0.9955, depending on the measurement and meal type. Information on quantitative in vitro-in vivo relationships will be crucial in engineering the next generation of in vitro model systems that can be utilized to develop future foods with healthy benefits.