Characterizing Developmental Brush Border Enzyme Activity Changes in Early Life Pigs

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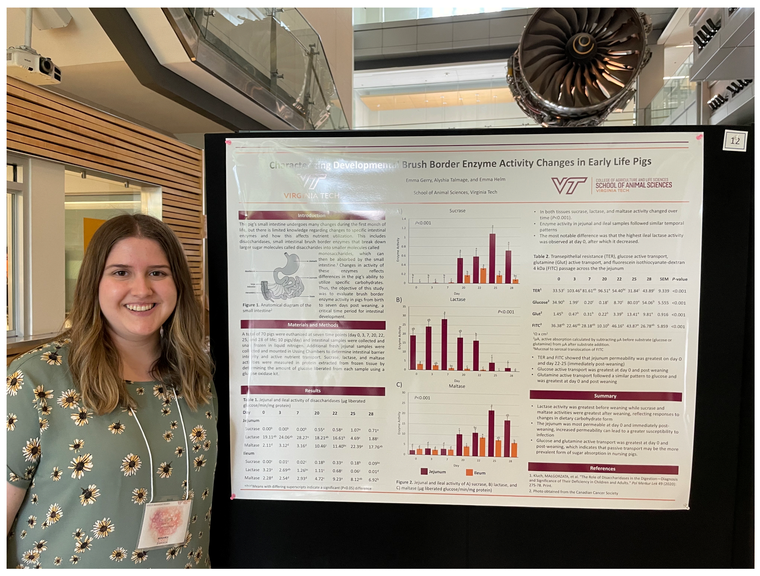
About the Fralin SURF Program

The Fralin Summer Undergraduate Research Fellowship (SURF) is a 10-week research program for undergraduate students interested in learning more about research and gaining hands on experiences working in a lab. Students participate in 40 hours a week of research along with weekly seminars and workshops. I participated in seminars about graduate school, writing personal statements, funding for graduate school/research, and communicating research. Being in lab 40 hours a week really allowed me grow and become more confident in my research skills. At the end of the program there was a symposium where everyone who participated in research over the summer presented their work.



Picture 1. Standing with my poster at the summer undergraduate research symposium

Introduction

The pig's small intestine undergoes many changes during the first month of life, but there is limited knowledge regarding changes to specific intestinal enzymes and how this affects nutrient utilization. This includes disaccharidases, small intestinal brush border enzymes that break down larger sugar molecules called disaccharides into smaller molecules called monosaccharides, which can then be absorbed by the small intestine.[1] Changes in activity of these enzymes reflects differences in the pig's ability to utilize specific carbohydrates. Thus, the objective of this study was to evaluate brush border enzyme activity in pigs from birth to seven days post weaning, a critical time period for intestinal development.

Materials and Methods

A total of 70 pigs were euthanized at seven time points (day 0, 3, 7, 20, 22, 25, and 28 of life; 10 pigs/day) and intestinal samples were collected and snap frozen in liquid nitrogen. Additional fresh jejunal samples were collected and mounted in Ussing Chambers to determine intestinal barrier integrity and active nutrient transport. Sucrase, lactase, and maltase activities were measured in protein extracted from frozen tissue by determining the amount of glucose liberated from each sample using a glucose oxidase kit.

Results

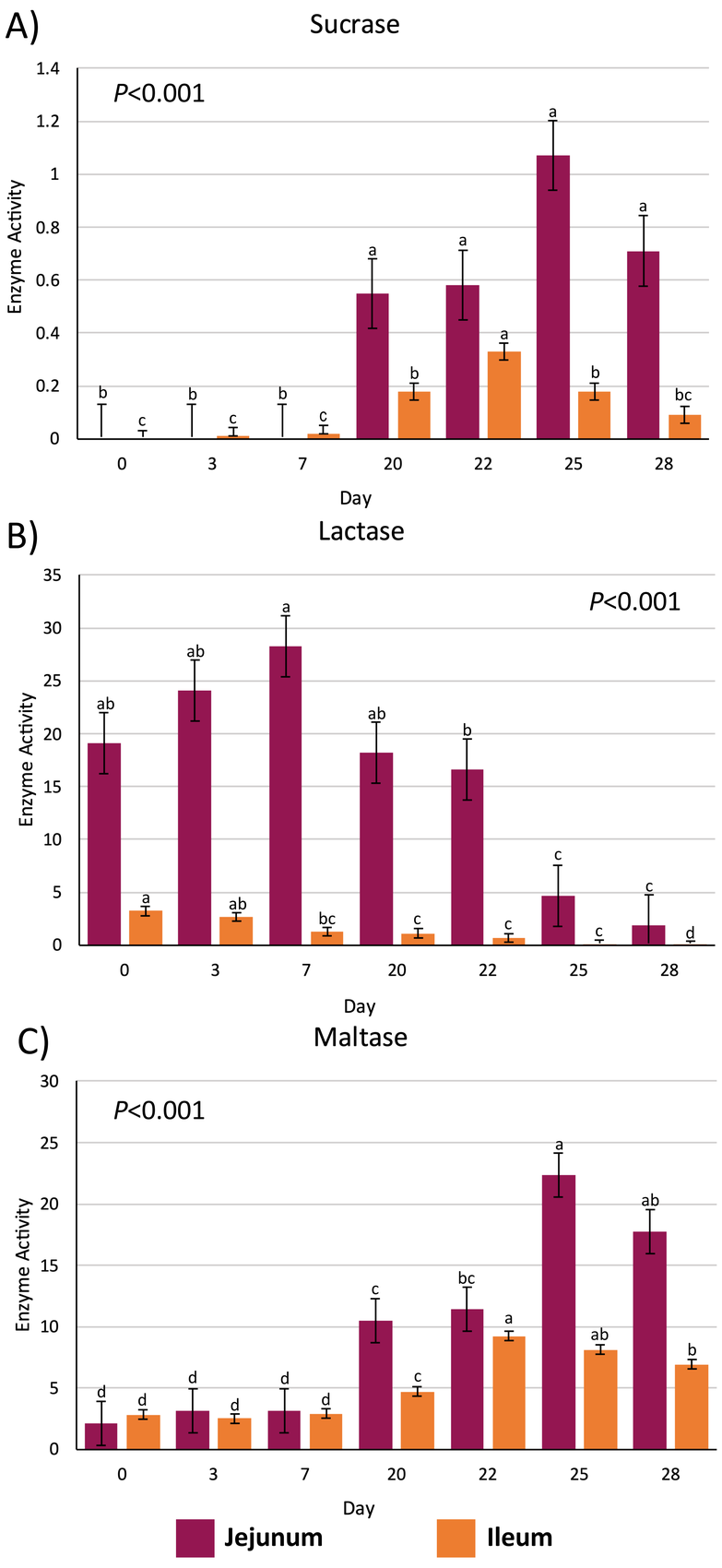


Figure 1. Jejunal and ileal activity of A) sucrase, B) lactase, and C) maltase (µg liberated glucose/min/mg protein)

[a,b,c,d] Means with differing superscripts indicate a significant (P<0.05) difference

- In both tissues sucrase, lactase, and maltase activity changed over time (*P*<0.001).
- Enzyme activity in jejunal and ileal samples followed similar temporal patterns
- The most notable difference was that the highest ileal lactase activity was observed at day 0, after which it decreased.

Table 1. Transepithelial resistance (TER), glucose active transport, glutamine (Glut) active transport, and fluorescein isothiocyanate-dextran 4 kDa (FITC) passage across the the jejunum

	0	3	7	20	22	25	28	P-value
TER[1]	33.53^{c}	103.46^{a}	81.61^{ab}	96.51^{a}	54.40^{bc}	31.84^{c}	43.89^{c}	<0.001
Glucose[2]	34.90^{b}	1.99^{c}	0.20^{c}	0.18^{c}	8.70^{c}	80.03^{a}	54.06^{b}	<0.001
Glut[2]	1.45^{b}	0.47^{b}	0.31^{b}	0.22^{b}	3.39^{b}	13.41^{a}	9.81^{a}	<0.001
FITC[3]	36.38^{ab}	22.46^{ab}	28.18^{ab}	10.10^{b}	46.16^{a}	43.87^{a}	26.78^{ab}	<0.001

[1]Ω x cm^2
[2]µA, active absorption calculated by subtracting µA before substrate (glucose or glutamine) from µA after substrate addition.
[3]Mucosal to serosal translocation of FITC

- TER and FITC showed that jejunum permeability was greatest on day 0 and day 22-25 (immediately post-weaning)
- Glucose active transport was greatest at day 0 and post weaning
- Glutamine active transport followed a similar pattern to glucose and was greatest at day 0 and post weaning

Summary

- Lactase activity was greatest before weaning while sucrase and maltase activities were greatest after weaning, reflecting responses to changes in dietary carbohydrate form
- The jejunum was most permeable at day 0 and immediately post-weaning, increased permeability can lead to a greater susceptibility to infection
- Glucose and glutamine active transport was greatest at day 0 and post-weaning, which indicates that passive transport may be the more prevalent form of sugar absorption in nursing pigs.

Continuing Research

- This fall I continued working on the project and am doing 6 hours a week of research
- Given the results from the Ussing chamber data this summer, I am currently working on an assay to determine Na^+/K^+ ATPase activity to further assess the active transport ability of the small intestine in young pigs

References

1. Kluch, MAŁGORZATA, et al. "The Role of Disaccharidases in the Digestion—Diagnosis and Significance of Their Deficiency in Children and Adults." *Pol Merkur Lek* 49 (2020): 275-78. Print.