Innovations to support genetic improvement in tropical poultry production systems; enteroids to measure gut health.

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Poultry gut health is crucial for performance

Factors affecting gut health

- Location
- Age
- Breed
- Litter
- Gut region
- Temperature
- Maternal factors
- Medication
- Sex
- Hygiene
- Feed
- Housing
Phases of development of the intestine

**Development**
- Gut tissues
- Gut immunity
- Gut microbiota

Development of gut for rest of its life

**Maintenance**
- Mature gut
- Stable microbiota
- Promote barrier integrity

Support gut to conserve homeostasis

Develop *in vitro* technology to determine parameters for gut health and improve survival rate → Intestinal organoids or enteroids
Organoids: miniature in vitro grown organs

Self-organized 3D tissue cultures derived from stem cells

- multiple organ-specific cell types
- cells are grouped together and spatially organized, similar to an organ
- capable of recapitulating some specific function of the organ
Mammalian intestinal organoids and enteroids

- **Organoid**
  - Pluripotent stem cells
  - Small intestine
  - Spheroid culture
  - Lgr5+ stem cell
  - Intestinal crypt

- **Enteroid**
  - Growth factors
  - Matrigel culture
  - Lumen
  - Villus-like domain

3D functional organoid

Incorporate microbes

3D functional enteroid

Incorporate microbes

Collagen matrix

Avian 3D enteroids inside out polarity under floating conditions

Nash et al, 2021
Communications Biology

• Extracellular matrix determines orientation of chicken enteroids
• Easy access to apical side of the enterocytes
Chicken 3D enteroids; representation of gut

- Are all cells present in the intestine represented?
- Are the enteroids functionally similar to the intestine?
Functional characterisation 3D chicken enteroid epithelial barrier function

Epithelial barrier maintained by intercellular junctional complexes

Quantify amount of leakage
Quantification epithelial barrier integrity
Using bio-imaging tools

Functional characterisation 3D chicken enteroid epithelial barrier function
Functional characterisation 3D chicken enteroid
Host pathogen interaction

Parasites
*Eimeria tenella*

Viruses
Influenza virus

Bacteria
*Salmonella enterica serovar Typhimurium*

Do the pathogens induce immune responses?
Functional characterisation 3D chicken enteroid
Host pathogen interaction and immunity

Salmonella enterica serovar Typhimurium – eGFP; wild type and non invasive mutant

Isolate RNA 4 and 8 hpi
Fluidigm RT-qPCR array 96x96 set up
89 immune genes
Borowska et al 2019

samples
genes
3D chicken enteroids

- Represent all cell types found in chicken epithelium and lamina propria
- Bacteria, viruses and parasites enter and replicate
- Immune responses induced similar to *in vivo* responses

- Excellent model for wide range for applications

Nash, Morris, Mabbott, Vervelde
2021 Communication Biology
Chicken 3D enteroids; novel model for gut health

Future applications

• Use the 3D enteroids to compare the inherent gut health of commercial hybrid birds & indigenous breeds (ACGG/TPGS lines).

• Test the ability to resist intestinal disease challenge and resist heat stress.

• Test the importance of nutrition on barrier integrity and immunity.
Thank you

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