Nutritional approach and microbiome in poultry

Irène Gabriel

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Irène GABRIEL

Nutritional Dynamics

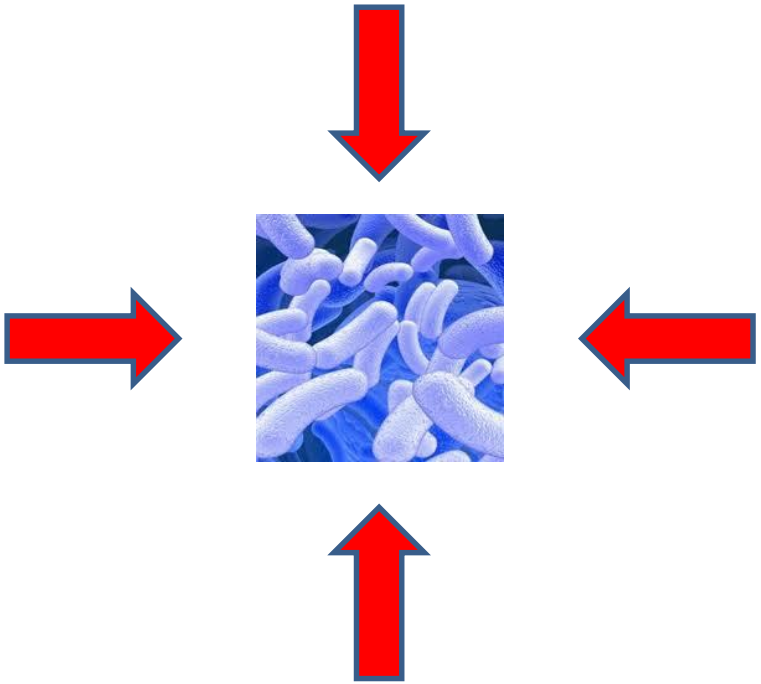
UR83 Recherches Avicoles
INRA Centre Val de Loire
Nouzilly

Meeting INRA/Merial: Probiotic at the hatchery , Immersion Day, Lyon, September 28th 2016

1. Factors regulating microbiota

2. Dietary factors regulating digestive microbiota

1. Factors regulating microbiota

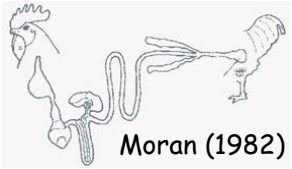


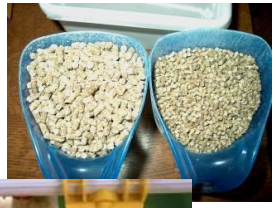
Factors regulating microbiota (1)

- Environment of first days : first contact with bacteria
Hatcher, eggshell
Human handling
Boxes for transportation
First feed and water
Litter

- Age :
Quantitative increase
Increase in complexity

- Digestive segments





- Anticoccidial drugs
- Feed additives
- Feed compounds
- Diet structure / Technological treatments
- Water

Gabriel et al 2006, 2014; Oakley et al 2014; Stanley et al 2014; Shaufi et al 2015

Factors regulating microbiota (2)

- Nervous system

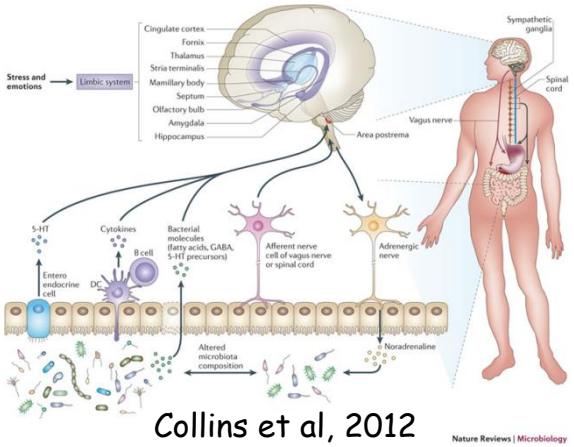
- Stress

- Rearing environment

- Host genetics

- Maternal nutrition

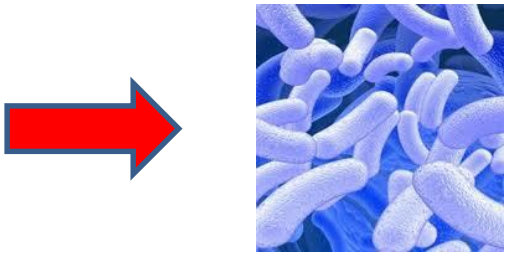
Interactions between
Microbiota
Intestine
Brain

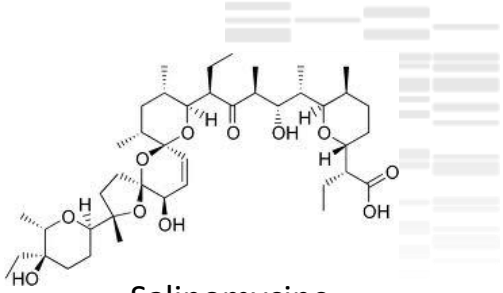


Collins et al, 2012

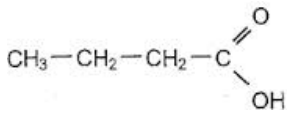
Torok *et al.* 2011; Guardia et al., 2011; Gabriel et al, 2014; Stanley et al. 2014; Mignon-Grasteau et al, 2015

2. Dietary factors regulating digestive microbiota





Salinomycine



2.1. Anticoccidial drugs
2.2. Feed additives
2.3. Feed compounds
2.4. Diet structure / Technological treatments

Feed additives

Additives studied* in poultry

* With publications in Web of Science and PubMed

Organic acids
Carbohydrates (Prebiotic, 'Fibre', MOS)
Probiotic and symbiotic
Enzymes : Digestives (Polysaccharidase, Phytase, Protease)
Plant / Plant extracts

Amino acids
Vitamins

Clay
Charcoal
Minerals, trace elements

Bacteriocin
Bacteriophage and their enzymes (Endolysine, …)
Antimicrobial peptids
…

Seal et al, 2013; Cheng et al, 2014

Effects of additives reported in literature

Alone or in combination (synergy)

Results

Growth performances
- Feed intake
- Growth
- Feed conversion

Mortality

Gut health (whose microbiota)

Immunity

Product quality

Variable responses
- Beneficial effects
- No effect
- Harmful effects

Effects + on microbiota
No effect on animal

According to conditions

Product	Composition / Dose / Mode of application
Animal	Genetic, sexe / Age / Physiological state
Rearing conditions	
Diet composition	

Diet composition

→ Indigestible compounds

→ Substrates for the growth of microbiota

Different bacteria have different substrate preferences

➡ Diet has a great potential impact on the digestive microbiota

Nutrient composition

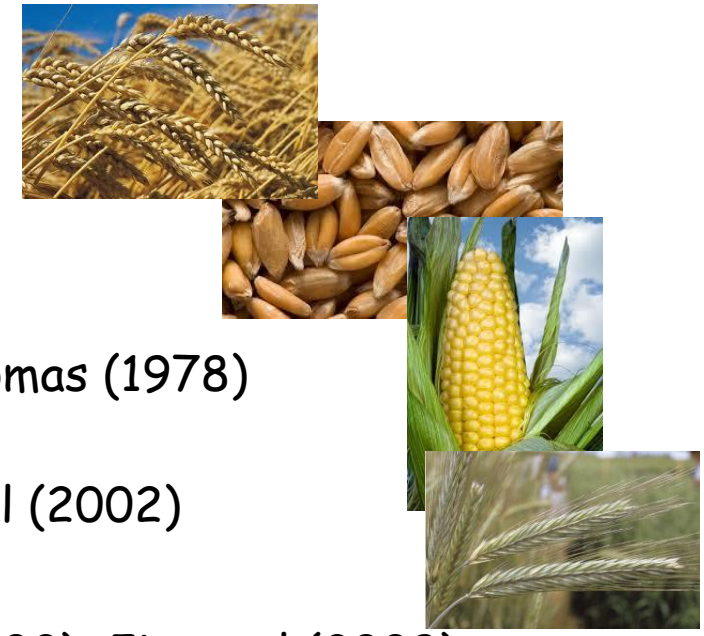
Carbohydrates

Proteins

Lipids

Minerals

Carbohydrates



Water soluble non-starch polysaccharides

Rye / corn

↑ Anaerobe counts Wagner et Thomas (1978)

Wheat , barley / corn

↑ Bacterial counts Mathlouthi et al (2002)

Wheat , barley, rye / corn

⟶ C. perfringens Annett et al (2002), Jia et al (2009)

Barley, oat, wheat / commercial

Change in dominant microbiota (Seq 16S) Ludvigsen et al (2016)

Rk : Environment modify non-dominant microbiota

High fiber diet

DDGS*, wheat bran / Corn, soybean

*Dry distillers grains with solubles

Changes in microbiota (Seq 16S) Walugembe et al (2015)

Protein source and level (1)

Fishmeal / Soybean meal (protein level : 40%)

→ C. perfringens Drew et al (2004)

Fishmeal (protein level 33%) / Control diet (protein level : 21.5%)

Changes in microbiota (Seq 16S) Wu et al (2014), Stanley et al (2014)

Fishmeal / Soybean meal (protein level : 23%)

→ C. perfringens Drew et al (2004)

Protein level : 40% vs 23% (Fishmeal or Soybean meal)

→ C. perfringens Drew et al (2004)

Protein source and level (2)

Soybean meal

High concentrations of raffinose family oligosaccharides

→ May stimulate gut fermentation Zdunczyk et al (2015)

Rapeseed meal / Soybean meal

Change in SCFA and biogenic amines Qaisrani et al (2014)

Sunflower meal

↓ Caecal SCFA (Turkey) Juskiewicz et al (2010)

Protein source and level (3)

Lupin seed meal

Change in microbiota counts — Rubio et al (1998)

Pea seed meal

Pea (15%) / Control (soybean)

Change in microbiota fingerprint (T-RFLP) — Czerwinski et al (2010)
↑SCFA content

Pea level (15 to 30%)

↓ Butyrate in caeca — Konieczka et al (2014)

Fermented cottonseed meal / Soybean meal

Changes in microbiota counts / Fingerprint — Sun et al (2013)

Lipids

Dietary fat source : animal / vegetal

Beef tallow / Soybean oil

Changes in microbiota counts Danicke et al, 1999

Lard and tallow / soybean oil

→ ↑ C. perfringens Knarreborg et al (2002)

Palm kernel fatty acid distillers or lard / Soybean oil

↑ Total organic acid Jozefiak et al (2014)

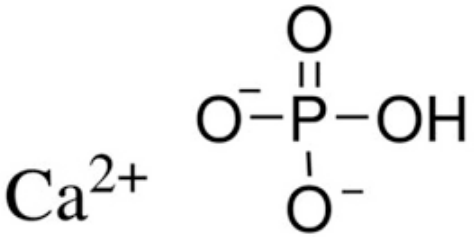
Medium chain fatty acids / Soybean oil, animal fat

Changes in microbiota (Microarray) Van der Hoeven-Hangoor et al (2013)

W-3 fatty acids (alpha-linolenic acid) (Flaxseed oil)

Changes in microbiota (Seq 16S) Lee et al (2016)

Minerals



Ca and digestible P levels

Changes in microbiota counts / SCFA

Ptak et al (2015)

Diet structure : Particule size

Whole wheat / ground wheat

↓ Salmonella Typhimurium — Bjerrum et al (2005)

↓ Clostridium perfringens — Engberg et al (2004)

Change in microbiota counts

Gabriel et al (2003), Engberg et al (2004), Bjerrum et al (2005), Gabriel et al (2008)

Coarse grinding / Fine grinding

↓ Branched chain fatty acids — Qaisrani et al (2014)

Change in microbiota counts — Singh et al (2014)

Technological treatments

Thermal treatments

Change in bacterial counts and SCFA — Boroojeni et al (2014)

Pelleting

↑ SCFA
Change in microbiota counts — Engberg et al (2002)

↑SCFA
↑Salmonella Typhimurium — Huang et al (2006)

Extrusion

Change in SCFA — Konieczka et al (2014)

Regulation of digestive microbiota by diet

Nutrient composition

- Carbohydrates
- Proteins
- Lipids
- Minerals

Diet structure : Particule size

- Whole / ground grains
- Coarse / Fine grinding

Technological treatments

- Thermal treatments
- Pelleting
- Extrusion

Thanks for your attention