Reaching genetic potential with medium chain fatty acids (MCFAs)

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Due to a worldwide decrease in usage of antibacterial growth promoters (AGP) and even a ban on AGP use in the EU, gut health in poultry is becoming an issue of utmost importance.

With a continuous broiler breeding focus on better growth rate and feed conversion, pressure on gut health becomes immense. Several non-antibiotic, plant-derived antimicrobial substances have been proposed as promising alternatives for AGP use, but lots of them lack scientific proof.

The use of free (i.e. not coated, micro-encapsulated or esterified as mono-, di-, or triglycerides) medium-chain fatty acids (MCFA) as a poultry functional feed ingredient (FFI) is an effective way to overcome the stressors faced by the current poultry industry since they exert lots of beneficial effects along the gastro-intestinal tract (GIT) of poultry animals, both on pathogen level as well as on host level.

MCFA are saturated fatty acids consisting of aliphatic tails of 6-12 carbon atoms and a polar head.

	Control	MCFA
Duodenum		
Villi (µm)	1855	1926
Crypts (µm)	480[a]	304[c]
V/C	4.04[a]	6.53[c]
Ileum		
Villi (µm)	644	752
Crypts (µm)	228[a]	197[ab]
V/C	2.94[a]	3.91[b]

[a,b,c] Numbers on one row with different superscripts are significantly different ($P < 0.05$)

Table 1. Effect of MCFA on intestinal villus morphology of broiler chickens at 42 days of age.

Balancing the microbiota

MCFA have a hydrophilic-lipophilic balance (HLB) that is quite similar to the HLB of the cell membrane of bacterial pathogens. Therefore, when both come in close contact in the low pH environment of the stomach, un-dissociated MCFA molecules are capable of penetrating the phospholipid bilayer, thereby destabilising the cell membrane.

Destabilisation happens through the formation of pores, resulting in cell content leakage on the one hand and MCFA entrance on the other hand.

Inside the bacterial cell, MCFA encounter a near-neutral environment resulting in accumulation of dissociated MCFA molecules and protons in the bacterial cytoplasm.

Intracellular acidification will eventually lead to killing of the bacterium, while dissociated MCFA molecules will intercalate with the bacterial DNA, thereby inhibiting DNA duplication and thus bacterial growth.

Free MCFA therefore provide an early pathogen barrier already in the stomach of the animal, compared to MCFA esters which are only active in the intestinal tract after their release into free MCFA molecules by gut lipases. Due to structural differences of the cell membrane, a different intracellular pH regulation system and the presence of a nucleus (protecting the DNA) in eukaryotic cells compared to bacterial cells, the former are unresponsive against the mechanisms of MCFA, so that the use of MCFA as an FFI in poultry (and other animals) can be regarded as safe.

In contrast to MCFA, short-(SCFA) and long-(LCFA) chain fatty acids have a higher, respectively lower HLB compared to that of the bacterial cell membrane and therefore show less affinity for the phospholipid bilayer, making them less active against bacterial pathogens.

This is confirmed by multiple, independent in vitro trials where MCFA were shown to have significantly lower minimal inhibitory concentrations compared to SCFA for numerous bacteria, including salmonella.

Even at non-bactericidal concentrations, MCFA can have a dramatic effect on pathogen persistence in poultry.

By reducing the virulence of bacterial pathogens, the outcome of disease may be altered and intestinal and systemic colonisation may be reduced.

The combination of these antibacterial actions will eventually result in:
- Growth inhibition and killing of bacterial pathogens in the stomach.
- Reduced virulence of surviving pathogens in the intestine.
- A largely unaffected beneficial microbial ecosystem (for example, acid-tolerant lactobacilli).

Zootechnical performance

In comparison with LCFA, MCFA provide the body cells with a quicker and more efficient source of energy.

In the gut, this energy is used by the crypts to create new intestinal epithelial cells (IEC), which migrate towards the top of the villi resulting in an increased villus height.

Next to directly increasing the number of live IEC, MCFA indirectly reduce pathogen-induced IEC cell death by lowering the infection pressure in the intestinal lumen (due to an antibacterial effect more upstream in the GIT).

Less renewal of epithelial villi cells is therefore necessary, meaning a sparing of energy for growth of the animal.

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Fig. 1. The effect of MCFA on the laying percentage of layers.

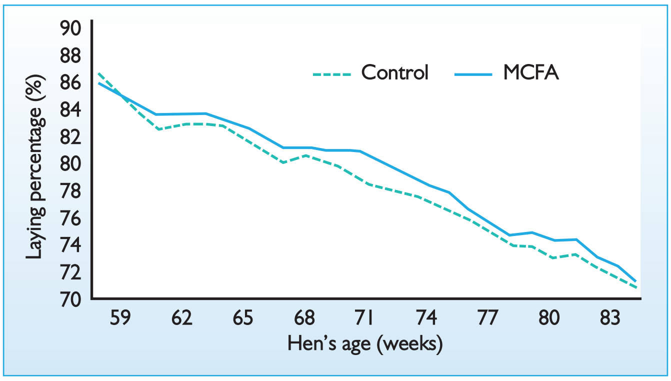
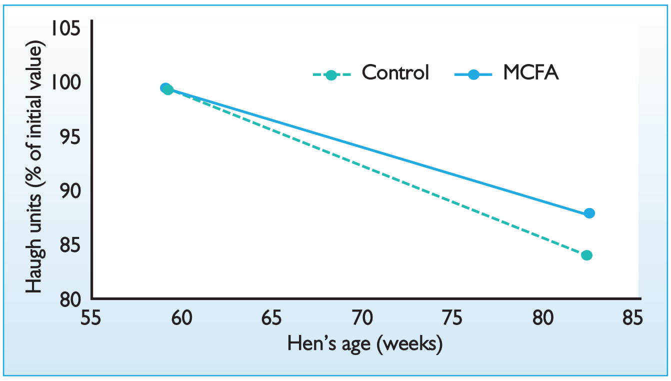


Fig. 2. The effect of MCFA on the evolution of albumen quality.



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Decreased infection pressure also results in a lower crypt depth, which together with increased villus height results in a lower migration and decreased loss of enterocytes along the villi, eventually resulting in more fully mature enterocytes.

Therefore, the increase in villus/crypt ratio that is accomplished by MCFA (Table 1) favours the digestive and absorptive capacities of the small intestine such as nutrient absorption, calcium uptake and working of GIT enzymes, and thus ensures a better gut health.

Next to being absorbed by the intestinal epithelium, MCFA are accumulated in inflammation cells. This results in decreased inflammation, which is an energy-demanding process. MCFA therefore lead to lower energy losses by improving immunity.

The combination of these beneficial effects of MCFA on intestinal morphology and immunity of the host will eventually lead to an increased zootechnical performance (higher feed intake, better feed conversion ratio, etc.) of the chickens.

Functional feed ingredient

Due to their unsaturated and antibacterial nature, MCFA are both chemically and microbiologically stable in feed.
Next to being heat-stable compounds, this ensures a good shelf-life during storage of feed, which is of utmost importance in case of long transports and warm storage conditions.

The use of carefully balanced mixtures of all four MCFA will result in highly synergistic effects and a broad-range mode of action, ensuring an effective widespread use as FFI in all poultry animals.

● **Broiler chicks and turkey poults.**
MCFA reduce the numbers of opportunistic pathogens, resulting in an improved health status, less mortality and improved litter quality. This eventually ensures an improved growth rate, feed conversion ratio and breast meat yield (Table 2).
The use of free MCFA results in reduced Clostridium perfringens counts in the jejunum and ileum, thereby reducing mortality and the amount of necrotic lesions in the small intestinal mucosa. Next to killing clostridial bacteria, MCFA beneficially affect background flora and intestinal health and lead to a quicker recovery by supplying a direct energy source for epithelial cells.

	Control	MCFA
Day 39		
Body weight (g/bird)	2 481^{b} ± 31	2561^{a} ± 61
Feed intake (g/d)	98.4 ± 1.0	100.6 ± 2.5
Average daily gain (g/d/bird)	62.6^{b} ± 0.8	64.6$^{a \pm 1.6}$
Feed conversion ratio (FCR)	1.57 ± 0.01	1.56 ± 0.03
Weight-adjusted FCR (2500g)	1.58^{b} ± 0.02	1.56^{ab} ± 0.03
Mortality and culling (%)	3.8	3.3
Day 42		
Carcase yield (%)	68.8 ± 1.5	69.4 ± 1.5
Breast meat yield (%)	22.6 ± 1.3	23.1 ± 1.1

[a,b] Numbers on one row with different superscripts are significantly different ($P < 0.05$)

Table 2. The influence of MCFA on zootechnical performance and slaughter results of broilers.

● **Layers.**
MCFA are highly antimicrobial against Salmonella and reduce the bacterium's virulence by almost completely blocking its invasive potential, which is necessary for full and persistent colonisation. Next to an antibacterial effect, MCFA supplementation results in an increased absorptive capacity. Therefore, MCFA induce an increased availability of nutrients for egg and egg shell production.

These favourable effects of MCFA on intestinal health and egg production are further strengthened by the positive effects of lactic acid. Lactic acid acts as a potentiator of the effects of MCFA, thereby further improving the beneficial/pathogenic ratio of the gut microbiota of the animal. As the hen ages, this results in a better laying persistency (Fig. 1), better albumen quality (Fig. 2) and less cracking of eggs, eventually ensuring more first grade eggs. In addition, feed conversion of layers is significantly improved.

● **Broiler and layer breeders.**
As in layers, MCFA have a long-term effect by maintaining better laying persistency, ensuring a larger number of eggs as the hen ages (Table 3), and a short-term effect by improving both albumen and shell quality.

This latter effect results in a higher hatch of fertile percentage and an increase in hatchability and day-old chick quality, including a higher weight, better relative growth and higher survival rate. As for broilers and layers, MCFA also improve the feed conversion of breeders and day-old-chicks.

Conclusion

With strongly increasing insights in genetic selection, today's poultry animals possess an enormous genetic potential which cannot be kept up by standard nutrition. This makes the use of FFI indispensable in the actual poultry industry.

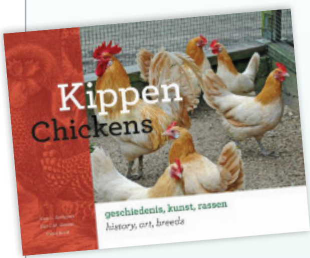
MCFA have been shown to exert a wide range of beneficial activities in all poultry animals, both on pathogen and on host level, aiding in reaching the full genetic potential of these animals. ■

Table 3. Effect of MCFA on production and hatchability parameters in a breeder field trial.

		Control	MCFA
Production data			
Average HD(%)	at week 46	72.97	72.09
	after week 46	61.46	62.19
	after week 62	43.52	46.85
Hatchability data			
Hatch of fertile (%)	before week 46	90.29	90.42
	after week 46	85.30	85.76
Hatchability (%)	before week 46	83.64	83.56
	after week 46	68.46	69.05

Book Review

Chickens – history, art, breeds



The idea for this intriguing book, which is written in Dutch and English, germinated following the discovery of a large and fascinating collection of glass negatives. These had been taken between 1930 and 1940, but publication had never occurred because of World War II. These plates depicted the role of chickens in agriculture, the food supply chain and economy through the ages, as well as in religion, art, culture and literature. They show how different breeds evolved, gained in popularity and formed the basis of today's modern poultry industry. This intriguing book describes the history of chickens in words and images, with some being over 4,000 years old. This book is an enthusiastically written and uniquely illustrated reference tome on chickens.

Photographs are used to great effect to show the changes that have occurred, whether in incubation, breeds or processing lines. You will be intrigued to see what the equipment from companies like Pas Reform looked like in the 1920s and Big Dutchman in the 1960s, not to mention Barneveld poultry market around 1920. On the historical front the role of chickens in Egyptian, Greek, Chinese and other cultures is examined before the evolution of chickens from jungle fowls to today's modern breeds is considered.

All is revealed about Dutch Booted Bantams, North Holland Blues, Bearded Polands, Friesian Fowls, Transylvanian Naked Necks and Jersey Giants and you can also find out about 'Rooster Riders'.

There is a thought provoking passage quoted from an encyclopaedia from 1660 on eggs . . . 'In spring and autumn high productive animals direct their rear ends towards the wind, which excites them as if the tail is being stimulated by a cock. This way the semen flows towards the uterus as the wind itself causes fertilisation and produces 'wind eggs'. Fortunately, our knowledge in reproductive physiology has progressed somewhat over the intervening 350 years!

Anyone with an interest in poultry will be fascinated by this book and, having read it, will be enlightened and a much more knowledgeable poultry person! At under €35 this is the book you will want to enhance your bookcase and enrich your mind!

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