How algae and organic minerals influence shelf life and quality of pork

There is a major push globally to improve meat quality in terms of supplying nutrients for human consumers. One such example is the increase in omega-3 fat consumption from meat produced from animals fed specialised feed ingredients, such as algae.

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Algae contain high levels of essential fats like docosahexaenoic acid (DHA), which when eaten by the animal are transferred into its meat. DHA intake is important for the formation of cell membranes, eye and brain development in children, behaviour and emotional stability, support of cognitive function, maintenance of normal brain function and ensuring cardiac health.

In clinical trials, DHA reduced platelet aggregation, decreased triglycerides by 26%, controlled inflammation and increased high-density lipoproteins by 9%.

However, surveys in Western diets have shown that the average intake of DHA for a three-year-old child is only just over 10% of requirements (19mg/day versus RDI 150mg/day) and for adults less than 50% of requirements (60-80mg/day versus RDI 220mg/day). This highlights the importance of increasing DHA intake via transfer from algae.

Recent pig studies have shown that feeding extra DHA from the commercial algae product All-G Rich (Alltech) increased levels of DHA in backfat fourfold (0.026% in control versus 0.109% in algae-fed pigs), in belly meat threefold (0.015% versus 0.047%) and doubled the amounts found in pork loin meat (0.002% versus 0.004%).

Feeding trials

Feeding trials conducted in the USA and Thailand, where pigs were fed 5kg/t or 10kg/t of All-G Rich for the last 28 days of the finisher period, reported between 300-500% increase in DHA concentration in the pork belly (5kg/t raised DHA from 15mg/100g-47mg/100g; 10kg/t supplementation increased DHA from 31mg/100g-175mg/100g).

While increased DHA in meat and fat is useful in terms of heightened human consumption of DHA, this polyunsaturated fatty acid can alter the stability characteristics in final meat products due to the increased susceptibility of unsaturated fats to oxidation from exposure to air and heat during processing or to the presence of oxidising compounds. Hence, the appearance of the meat in packaging, such as its colour or its amount of exudative liquid, may be impaired, and shelf life may be reduced.

Table 1. Effect of feeding DHA plus organic minerals on pork meat characteristics in packaging.

Variable	Days in packaging	Control	DHA + organic minerals	P-value
Water loss (%)	4	12.676[b]	11.68	0.368
	7	14.853[a]	12.979	0.130
Cooking loss (%)	0	24.76	24.18	0.729
	4	23.47	20.44	0.175
	7	23.030[b]	19.840[a]	0.026
pH	0	5.466[b]	5.484[a]	0.037
	4	5.474[b]	5.500[a]	0.028
	7	5.542	5.572	0.062*
Shear force (kgf)	0	3.687[a]	3.203[b]	0.002
	4	3.718[a]	3.190[b]	0.003
	7	3.347	3.134	0.202

Means not sharing a letter differ significantly P<0.05. *denotes trend P<0.1

Retail appearance of meat

The appearance of meat in retail packaging is important in consumer selection. If pork is exuding liquid within packaging or is flaccid or loses water during cooking, this can be perceived as poor quality and may influence purchasing decisions.

Minerals such as selenium are important for the formation in animals of glutathione peroxidase enzyme, which is a major antioxidant involved in protecting cell membranes and in preventing drip loss (exudated liquid) after slaughter and in packaging.

Other important antioxidant minerals include zinc and copper, which are essential components of the antioxidant system in vivo. The importance of using effective antioxidant minerals has been demonstrated, with findings of reduced cooking losses and less toughness of meat from animals provided with antioxidant supplementation.

Traditionally, inorganic mineral ores have been used in animal feeds. Some of these, such as iron, can contribute to higher oxidative status in the animal, damaging tissues and fat. This can lead to poorer meat quality and increased fat rancidity, reducing shelf life and impairing sensory qualities.

Organic forms of minerals, such as Bioplex (Alltech) and Sel-Plex (Alltech), are akin to the natural forms of minerals found in raw feed materials. They are bound to small peptides, which confers more efficient uptake from the gut and increased storage in tissues. They can also be expressed as increased levels in meat, which can improve the quality and shelf life of meat during retail.

Previous studies using organic forms of selenium in animal feed have shown reduced drip loss and increased water holding capacity in poultry meat. For this reason, trials using natural forms of antioxidant minerals in combination with algae-derived DHA have been conducted in growing pigs.

The first trial used a diet containing 5% heated oil, which had undergone oxidation, supplemented with organic antioxidant minerals (Sel-Plex selenium yeast and Bioplex chelated minerals) and DHA from All-G Rich.

DHA was included at a level of 0.5%, and organic minerals at 0.1%, in the treatment diets. Six barrows were randomly allocated to six pens, with three pens per diet treatment. Pigs were fed the diet for the last 24 days of the growing period. The meat was then tested after being packaged for seven days. Results are shown in Table 1.

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Pork from pigs receiving the supplemented diet had lower levels of water loss (hence better water holding capacity), significantly lower cooking losses, higher pH and lower shear force (a measure of tenderness), an indicator of improved tenderness.

This meat would be more acceptable to consumers and more likely to be purchased in retail packaging.

Australian trial

A trial conducted in Australia used 672 pigs in total, randomly allocated to one of four diets: a control diet, a diet supplemented with organic antioxidant minerals, a diet supplemented with DHA alone, or a diet with combined organic antioxidant mineral and DHA supplementation.

Pigs received the test diets for 28 days before slaughter. Meat quality measurements were taken, including tests of loin depth, pH, colour, and drip and cooking losses.

Feeding the combined All-G Rich and organic minerals diet resulted in a 5.4% increase in growth rate (P<0.001) and a 2.7% improvement in FCR (P=0.023).

As seen in the previous study, pigs receiving All-G Rich had deeper loin depth and higher loin pH (hence less acidic meat), and their meat was lighter and less red in colour.

Conversely, pork from pigs fed the inorganic mineral control diet showed signs of increased deterioration over time when packaged.

Despite there being no differences in total lipid content of the pork loin meat, the distribution and character of individual fats changed within the meat depending on the diet.

There was a significant difference in pork from pigs receiving diets containing All-G Rich. The n-3PUFA levels were significantly higher, which further impacted the ratio n-6:n-3.

Fatty acid C22:6n-3 levels were most increased in the meat from the pigs fed All-G Rich, with the control diet group having levels of 0.12%, pork from pigs supplemented with DHA alone containing 0.27%, and those fed both DHA and organic minerals having 0.36% (mineral effect P=0.002; DHA effect <0.0001; interaction P<0.0001).

This suggests that the best way to increase beneficial omega-3 fatty acids in pork loin is to feed a combination of All-G Rich and organic minerals.

During belly fat analysis, the same effects were seen. For both the control diet and the feed supplemented with extra organic minerals, C22:6n-3 levels were 0.05%.

Belly fat from pigs fed DHA alone increased levels to 0.15 (P<0.0001). Fat from pigs fed both DHA and organic minerals contained 0.23% (P<0.0001), the highest level of C22:6n-3 seen in this experiment.

Such a significant interaction between mineral form and DHA supplementation further supports the use of both these ingredients in combination to give not only the best meat quality but the best retention of omega-3 fats.

On average, over the whole monitoring period, drip losses were 5.7% in the control (inorganic minerals, no DHA) group compared to 4.9% in the meat from pigs receiving both the DHA and the organic minerals.

On the day of slaughter, drip loss was 5.8% in the control group versus 5.6% in pork from pigs fed DHA alone, and it was 5.3% in meat from pigs fed DHA and organic minerals.

Cooking losses from fresh meat samples were reduced from 18.4% in meat from the control group to 17.4% in pork from pigs receiving the organic minerals. Losses were reduced further, to 17.2%, in meat from pigs fed both DHA and organic minerals.

Such differences were evident throughout the 28-day storage period, culminating at 28 days with cooking losses in the control group meat of 19.5%, versus 16.9% in meat from pigs fed both DHA and organic minerals.

In addition, shear force data showed that the DHA and organic minerals group's pork had a shear force of 2.28, indicating more tenderness than the control group's meat, which had a shear force of 2.7 (mineral and algae interaction P<0.001).

The same researchers tested the levels of bacteria in the meat over the 28-day post-slaughter period. Levels increased over time, although the lowest levels of bacteria at 28 days were seen in the meat from pigs receiving DHA supplementation from All-G Rich plus organic minerals.

Such reductions in bacteria levels can prolong the shelf life and quality of the pork within the packaging and during cooking.

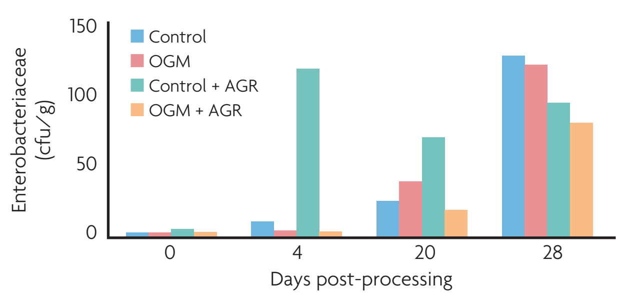

Fig. 1. The effect of dietary supplement treatment on mean enterobacteriaceae log counts of moisture-infused loins (n=36 per treatment per assessment period), where OGM indicates organic minerals and AGR indicates All-G Rich supplementation.

Meat analyses

Animal studies and subsequent meat analyses from various experiments have shown that feeding a high-DHA source such as All-G Rich effectively increases the levels of this important omega-3 fatty acid.

This is important for consumers, especially in young and old people, for the development and maintenance of brain and cardiac functions. However, as omega-3 is polyunsaturated, it requires extra antioxidants to prevent rancidity and shelf life reduction of the meat.

Meat analysis has shown that, while total lipids remained the same, there was a significant shift in the deposition of important omega-3 fats within both loin meat and belly fat when pigs were fed DHA and organic minerals.

However, including organic minerals such as Sel-Plex and Bioplex alongside All-G Rich in the diet for pigs has been demonstrated to prevent such oxidative problems, and it promotes better meat quality for consumers. This increased quality includes reduced drip losses in packaging, reduced moisture losses during cooking and increased tenderness scores.

Pig farmers producing high-quality or value-added meat should use such ingredients in combination to not only be able to claim higher levels of essential omega-3 oils for human consumer benefits, but to improve the quality, sensory characteristics and cooking qualities of packaged pork products. ■

References are available from the author on request

Table 2. Pork loin analysis for meat from pigs fed DHA from All-G Rich and organic minerals alone or in combination.

All-G Rich (kg/t)	0		0.5		P values		
Mineral type	Control	Organic	Control	Organic	Mineral	All-G Rich	Interaction
C18:3n-3	0.48	0.49	0.50	0.49	0.993	0.568	0.453
C18:4n-3	0.02	0.02	0.02	0.02	0.172	0.988	0.888
C20:3n-3	0.09	0.09	0.09	0.09	0.904	0.272	0.830
C20:5n-3	0.08	0.06	0.09	0.09	0.013	0.000	0.045
C22:5n-3	0.25	0.19	0.25	0.24	0.003	0.062	0.110
C22:6n-3	0.12	0.09	0.27	0.36	0.002	0.000	0.000

n-3PUFA (%)

Table 3. Belly fat analysis for meat from pigs fed DHA from All-G Rich and organic minerals alone or in combination.

All-G Rich (kg/t)	0		0.5		P values		
Mineral type	Control	Organic	Control	Organic	Mineral	All-G Rich	Interaction
C18:3n-3	0.57	0.54	0.58	0.58	0.146	0.068	0.266
C18:4n-3	0.02	0.02	0.02	0.02	0.300	0.215	0.426
C20:3n-3	0.09	0.08	0.09	0.09	0.590	0.041	0.023
C20:5n-3	0.02	0.02	0.03	0.03	0.487	0.000	0.017
C22:5n-3	0.10	0.09	0.10	0.11	0.735	0.024	0.155
C22:6n-3	0.05	0.05	0.15	0.23	0.000	0.000	0.000

n-3PUFA (%)