Improving the quality of pork – global trends part two

by Darryl D'Souza, Australian Pork Ltd, Canberra, Australia, Bruce Mullan, Royston Consulting, Western Australia, Australia and Cemlyn Martin, Alltech Biotechnology, South East Asia.

The incidence of people consuming vegetarian diets in many countries including Australia is increasing for a number of reasons. One reason is that diets with little or no animal derived foods are considered by many to be a healthier meal option.

However, a number of studies have, in fact, found that the movement towards a plant based diet is not without nutritional risk. Reviews of the scientific literature by Fairfield and Fletcher, Hunt, and Biesalski concluded that plant based diets may be inadequate or have low bioavailability for a number of different micronutrients.

This article will focus on the bioavailability of key micronutrients in meats such as pork and their impact on human health.

Vitamins

Vitamin A refers to a family of fat soluble compounds called retinoids and the recommended dietary intake for adults for vitamin A is 5000IU.

Preformed vitamin A is only found in animal products such as meat, eggs and milk and is essential for vision, immune response, epithelial cell growth and repair.

Plant derived vitamin A (β-carotene) has an extremely poor conversion rate and hence has to be taken in high amounts compared to that found in meat.

Therefore, it is important to consider the source of vitamin A when calculating the daily requirement for particular foods if our requirement is to be met.

Pork is a good source of methyl donors such as folate and vitamin B12. Vitamin B12 is another micronutrient that is found only in meat, but unlike vitamin A there is no plant derived provitamin B12.

It should also be noted that folate derived from meat has a significantly better bioavailability compared to that from fruits and vegetables.

The effect of these micronutrients on the incidence of cancer has been well researched. Studies by Giovannucci et al. and Benito et al. have found that increased intake of folate and vitamin B12 resulted in a reduction in the incidence of colon adenomas. Similarly, the increased breast cancer risk associated with alcohol consumption, was reduced in women who consumed at least 300µg folate per day.

The impact of folate intake on reducing the cancer risk was only evident following a 15 year period suggesting the bioactive ingredient needed to be present in the diet for a very prolonged period.

Therefore, encouraging consumers to increase the intake of foods high in folate, such as pork or folate fortified foods may be a viable way to boost folate intake. If this is the case then it would seem a good case for dietary intake via consumption of meat products as opposed to daily supplements and that this approach would be of far greater benefit to the wider community.

Minerals

Iron and zinc deficiencies are associated with a number of health problems in humans including stunted growth, increased morbidity and reduced neuro-cognitive development and learning capacity.

In Western countries and developing countries, iron deficiency and low iron stores are prevalent in infants, teenagers and women of childbearing age.

This may be due to a diet that provides insufficient amounts of available iron to cover the extra needs for growth and menstrual losses.

Iron and zinc bioavailability is dependant on a number of factors including the mineral's absorption from each food and the inhibitors present in the meal. Plant foods contain a high proportion of mineral absorption inhibitors such as phytic acid, many polyphenols and dietary fibre, with phytic acid perhaps the most potent inhibitor of iron and zinc absorption.

Recent studies have shown that intake of these inhibitors are also more common in diets that contain no animal products.

Pork is a good source of both iron and zinc, with each supplying approximately 10-15% of the recommended daily intake for these minerals.

In addition, muscle protein (beef, veal, pork, lamb, chicken, and fish) has long been known to enhance absorption of non-heme

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Benefit related to	Comment
Immune system/HIV	Se from yeast (200µg/day) proved beneficial in AIDS and ARC.
Cancer prevention	Supplementation with 200µg Se from yeast daily for up to seven years with no toxic effects.
Reduced viral virulence	Se from yeast in a controlled study that indicated inverse relationship between baseline serum Se and mortality from oesophageal/stomach cancer.
Rheumatoid arthritis	Daily supplement of 200 or 600µg Se from Se yeast reduced pain.
Immune stimulation	Daily supplement of 100µg Se from Se yeast restored immune response to mitogen challenge in elderly subjects.
Prevention of cardiovascular disease (CVD)	CVD mortality increases with plasma homocysteine (HC), and Se deficiency hinders conversion of HC to methionine.

HIV = Human Immunodeficiency Virus; AIDS = Acquired Immune Deficiency Syndrome; ARC = Aids Related Complex

Table 1. Summary of human health benefits from enhanced selenium status (McCartney, 2005).

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and heme iron. Because non-heme iron accounts for 85-90% of the iron content in a typical Western diet, enhancement of non-heme iron absorption from the diet is of particular importance.

Baech et al. reported that the addition of a small amount of pork (50g) significantly increased the non-heme iron absorption in women fed a meal rich in phytic acid.

Minerals and vitamins play an important role in human nutrition. Pork is a good source of many of these, such as iron, zinc, folate and vitamin B12.

On the other hand, some components in plants can reduce the biological availability of minerals in particular.

While supplements are available for each of these compounds, ultimately the greatest potential to improve the health of the general population is via major ingredients such as pork.

In addition, it may be possible to further increase the concentrations of these compounds in pork.

Nutritional enhancement

The food manufacturing industry has in the last five years paid significant attention to the fortification and the nutritional enhancement of a number of functional properties of everyday foods. The premise is that the majority of people would probably prefer to eat food with added functional aspects rather than take supplements.

Given this trend, pork is in a good position for the phrase ‘a pig is what it eats’ due to the fact that the pig is a monogastric and, therefore, pork can be easily fortified with key trace elements or have its nutritional value enhanced to convey functional properties.

An excellent example of this is the way that we are able to increase the selenium (Se) content of pork.

Selenium

In many countries such as Australia and New Zealand, the relatively low level of Se in soils means that primary products from these countries are also low in Se.

While it is generally accepted that Se intakes of Australian and New Zealand consumers are sufficient to ensure that there are no overt signs of deficiency, there is a growing feeling that the relatively low intakes may contribute to elevated levels of risk for some cancers.

The effect of Se on human health has been widely researched and has been the subject of numerous reviews.

The majority of the studies conducted to date indicate that increased dietary Se intakes, particularly in the form of organic Se, confer additional health benefits on the immune system, including reduced viral virulence, reduced cancer risk, reduction in HIV symptoms and progression, reduced risk of cardiovascular disease and reduced pain from rheumatoid arthritis as outlined in Table 1.

In addition to the ever accumulating body of epidemiological data, suggesting that a higher Se intake is linked to lower cancer mortalities, Schrauzer reports that mortality from breast, prostate and skin cancer is much higher in countries with low blood Se (for example, USA and Australasia) and much lower in countries with high blood Se, reflecting higher dietary Se intakes (for example, Japan, Mexico and Thailand). Japan, for example, has a high dietary Se intake and lower cancer mortality than Western countries.

Schrauzer also links longevity with blood Se and calculates that increasing blood Se from 100 to 300μg/l adds four years to life expectancy for both men and women, and recommended a daily Se intake of 200-300μg.

While the conclusions made from studies that associate epidemiological data to, for example, Se status are often challenged as being unscientific, human studies such as those described by Stratton et al. will go a long way to improving our understanding of the role of Se in human health.

Milk, eggs and meat are excellent foods that can be fortified with additional Se. However, as outlined in Table 2, the source (inorganic or organic) can have a significant impact on a range of animal tissue Se levels following Se supplementation.

Mahan and Parrett studied Se content of tissues in a series of studies involving both young growing and finishing pigs. The loin Se content following three dietary Se doses (0.1, 0.3 and 0.5ppm Se) from inorganic (selenite) and organic (Sel-Plex) sources were compared in pigs slaughtered at 105kg live weight.

These data indicate a linear dose response with increasing Se dose from either source resulting in significantly improved muscle Se.

However, Sel-Plex supplementation resulted in significantly higher loin Se at each dose of Se compared to sodium selenite. In addition, more Se was excreted in urine in the case of selenite fed pigs and more Se was retained in muscle in the case of pigs fed Sel-Plex.

This strongly points to the fact that Sel-Plex is a more efficient way of enhancing the Se content of pork, and using inorganic Se leads to excess Se excretion mainly via the urine, and unnecessary environmental loading.

EU-15 Daily consumption	Animals supplemented with selenite		Animals supplemented with Sel-Plex	
	Se conc. (µg/g)	Daily Se cont. (µg)	Se conc. (µg/g)	Daily Se cont. (µg)
Milk (0.7 l/day)	14.3µg/l	10	29.7µg/l	21
Eggs (35g/day)	0.180	60	270	10
Pork (115g/day)	0.124	14	0.272	31
Poultry (57g/day)	0.150	90	350	20
Beef (66g/day)	0.090	60	200	13
Total daily Se from animal foods (µg)		56		107

Table 2. Estimated EU selenium consumption from animal products supplemented with 0.3ppm selenium from either selenite or Sel-Plex (McCartney, 2005).

Conjugated linoleic acid

Conjugated linoleic acid (CLA) is a mixture of positional and geometric isomers of linoleic acid with conjugated double bonds located at positions 7,9-, 8,10-, 9,11-, 10,12- or 11,13- on the carbon chain.

Conjugated linoleic acid was first identified as an anti-mutagenic agent in fried ground beef. The cis/trans-9,11 isomer has been shown to have specific health benefits such as anti-cancer properties and activities against atherosclerosis, the onset of diabetes and obesity.

The effect of CLA in the inhibition of mammary carcinogenesis in both animal and human studies is perhaps the most extensively documented physiological effect of CLA. Conjugated linoleic acids are usually found in ruminant fats, particularly those from grazing animals.

Pork, however, is an ideal candidate for CLA enrichment by feeding synthetic CLA to pigs, because CLA will not be further saturated before absorption.

Therefore, CLA deposits in tissues with relatively high efficiency, meaning that pork could become a physiologically significant source of CLA for human consumption.

In fact, recent studies indicate that the use of CLA as a diet supplement in pigs have resulted in increased CLA concentrations of pork to levels comparable to other major sources of CLA such as milk and beef.

Dietary CLA is incorporated into adipose tissue and to a lesser extent into intramuscular fat of pigs in a dose dependant manner. Numerous pigs studies conducted to date indicate that dietary CLA supplementation had a positive impact on the growth performance of pigs.

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Dietary CLA supplementation in pigs improved feed efficiency, increased lean tissue deposition and significantly decreased fat deposition in pigs, thus making pork a much healthier meat option for consumers.

Lecithin

There is a general consensus within the human health research community that LDL cholesterol is a critical component of both prevention and treatment of coronary heart disease. While therapeutic changes have formed the basis of intervention for lowering LDL, a number of low risk changes in diet are emerging as key long term prevention strategies in the fight to lower LDL cholesterol.

One of these 'new' strategies is the use of soy lecithin. Soy lecithin, a potent emulsifier, has been shown to influence the absorption of fatty acids in the small intestine.

Dietary lecithin supplementation in humans has been shown to reduce cholesterol levels and increases the ratio of polyunsaturated fatty acids (PUFA) to saturated fatty acids (SFA) in both serum and erythrocytes. The most likely rationale for this is that lecithin, an emulsifying agent, allows triglycerides to be digested better.

Therefore, in plant based diets that are higher in PUFA than SFA, a supplement of lecithin should lead to a higher absorption and deposition of PUFAs such as linoleic acid. By contrast, when lecithin combines with cholesterol the resulting micelle is much larger than one formed with bile salts alone. In this case, lecithin is likely to reduce rather than increase the absorption of cholesterol.

Recent studies have shown that dietary lecithin supplementation influenced the collagen properties of pork and improved the eating quality of pork by reducing the chewiness and hardness of pork.

D'Souza et al. also reported that dietary lecithin supplementation at 75g/kg significantly increased the % of linoleic acid and reduced the myristic acid content of pork.

Pigs fed the 75g/kg lecithin supplemented diet also tended to have lower plasma cholesterol at slaughter compared to those fed the control diet and this has the potential to further improve the 'healthiness' of pork. The use of lecithin supplementation to improve the 'healthiness' of pork or pork products, whilst also improving the tenderness of pork, will provide the pork industry with significant marketing opportunities.

Unsaturated fatty acids

There is increasing evidence from animal and in vitro studies which indicates that n-3 fatty acids, especially the long chain polyunsaturated fatty acids eicosapentaenoic acid and docosahexaenoic acid, present in fatty fish and fish oils inhibit carcinogenesis.

Several mechanisms have been proposed whereby n-3 fatty acids may modify the carcinogenic process and n-3 fatty acids suppressing AA-derived eicosanoid biosynthesis; influencing transcription factor activity, gene expression and signal transduction pathways; modulate oestrogen metabolism; increase or decrease the production of free radicals and reactive oxygen species; and influence insulin sensitivity and membrane fluidity.

In pigs, the amount of fat increases rapidly during growth and originates both from the diet and from de novo synthesis.

Madsen et al, reported that 75% of carcase fat resulted from de novo synthesis indicating that it is relatively easy to manipulate the fatty acid composition of pork. Fish meals and oils used in pig diets contain high concentrations of polyunsaturated long-chain fatty acids, C18:2 and C18:3 (>50% of total fatty acids), with a significant number of them having more than 20 carbons with four or more double bonds.

Fatty acids C18:2 and C18:3 predominate in some oils, whereas eicosapentanoic (C20:5), docosapentanoic (C22:5) and C22:6 occur in high concentrations in others, particularly in fish species from cold waters. All of these fatty acids are readily absorbed by pigs and are deposited in fatty tissues as triacylglycerols where they significantly alter the overall fatty acid composition. Feeding fish oils to pigs is, therefore, an effective way of increasing the concentrations of these acids in their tissues with the aim of having a beneficial effect on reducing cardio-vascular disease and atherosclerosis.

Whilst enrichment of pork can be achieved by adding flaxseed, fish oil, or fishmeal to pig feeds, it should be noted that use of these sources, particularly fishmeal, has been limited by concerns about adverse effects on sensory qualities.

However, Howe et al. evaluated the use of PorcOmega (POM), a stabilised tuna fishmeal formulation, as a source of DHA for enrichment of pork products.

The results indicate that the LC n-3 PUFA (mainly DHA content) of pork products including chops and sausages, were substantially increased (up to sevenfold) by including up to 10% POM in rations.

More importantly however, the increases were retained after cooking without any adverse effect on the sensory qualities of pork. Most oilseeds and feed grains also contain highly unsaturated lipids (Table 3) which, when fed to pigs, can have a marked effect on the fatty acid composition of pork resulting in a beneficial effect on cardio-vascular disease and atherosclerosis.

It should, however, be noted that the oils of plant origin do not contain the very long chain polyunsaturated fatty acids that are present in fish products.

Conclusion

There is more pork consumed in the world than any other meat, yet there is still intense competition for the pork industry worldwide to attract and retain even more consumers.

Food safety, price, nutritive value, meal convenience and appearance play an important role in determining whether consumers purchase pork, but the pork industry must also ensure that the end product also meets the consumers' requirements for tender, juicy pork that is free of any off taints and aromas.

The implementation of eating quality pathways is one way to ensure that all the consumers' needs for high quality pork are consistently being met.

There is good evidence to show that pork can also form a very important part of a dietary programme to reduce the incidence of obesity and of some human diseases.

A growing demand for functional foods, rather than relying on dietary supplements, has seen pork emerge as a very worthy candidate as a vehicle for delivering essential micronutrients such as Se, iron, folate and other functional supplements such as DHA, CLA that in many instances are absent or inadequate in vegetarian diets.

However, the success of functional pork will ultimately depend on how well we promote and market such foods to the consumer. ■

References are available from the author upon request.

Table 4. Fat content and the fatty acid composition (% distribution) of pig feed ingredients (Madsen et al. 1992).

Ingredient	Fat (%)	C16:0	C18:0	C18:1	C18:2	C18:3
Barley	3.5	19.8	0.7	10.4	44.2	4.5
Oats (conventional)	5.8	14.7	1.0	27.7	35.2	1.6
Oats (naked)	11.0	13.8	0.9	36.4	34.7	1.0
Soybean meal	3.1	18.3	4.4	15.9	51.8	6.8
Animal fat	100	23.6	13.3	38.8	6.0	0.5
Soya oil	100	10.0	2.0	29.0	51.0	7.0
Rapeseed	41.1	4.7	1.6	50.2	21.8	9.1
Sunflower seed	31.2	7.0	6.3	22.2	61.6	0.4
Linseed oil	100	6.6	4.9	20.5	14.6	51.9
Palm oil	100	8.3	2.2	23.6	4.0	0.1
Corn oil	100	10.4	1.6	30.7	54.6	1.7