Intestinal targeting of nutrients for specific gene expression

by Dr ir Pim Langhout, Director Nutrition ANH, DSM Nutritional Products Europe Ltd, PO Box 2676, CH – 4002 Basel, Switzerland.

The animal feed industry is facing higher feed prices, leading to increased pressure to improve efficiency in animal performance. Health problems are a main concern in the industry, resulting in significant loss in efficiency.

A disturbance in the physiology of the animals is often the underlying base that results in these health problems. Therefore, an important area of focus for nutritionists is to improve the health status of the animal through balanced nutrition.

Much research in the relation of nutrition and health has been focused on the early life of the animal. This research has shown that nutrition in early age can affect performance and health in older age.

In broilers, effects on early nutrition such as fasting, protein supply and specific additives have also been shown to affect the animals' ability to grow meat or affect the vitality of the birds at an older age. These data indicate that nutrition at a young age can affect the metabolism of the animal throughout the rest of their life.

In humans it has been shown that poor nutrition in young children has resulted in changes in the glucose-insulin metabolism at an older age.

With the new insights into the effects nutrients can have on the gene expression it can be speculated that at least part of these early nutritional effects is created through gene expression patterns.

At this moment nutritional research is still predominantly set up to define deficiencies and reduced health via unbalanced developments in nutritional patterns. During the last decade an enormous amount of information has been revealed, particularly in humans, on the disturbance in the physiology during the development of several diseases.

In addition, genomic technologies have generated data that further improve the understanding of how nutrients affect these physiological patterns of cells and organs.

Therefore, these new areas of research provide interesting opportunities for future nutrition to improve the understanding of how health can be affected through nutrition. The area of research that studies the effect of nutrients on the gene expression is called nutrigenomics. In this article a brief overview will be given on the potential of this field of research for future nutritional concepts.

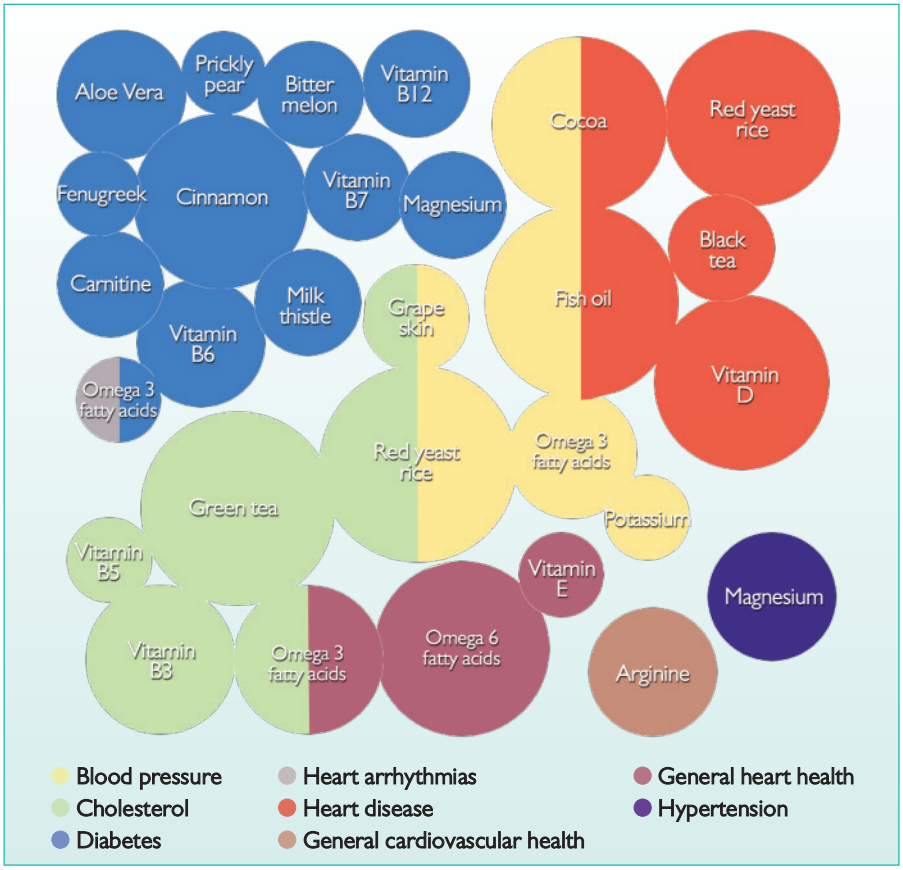

Fig. 1. Overview of the effects of ingredients on gene expression in relation to some human health problems (Adapted from Ahmed 2010). Larger circles indicate greater likelihood that the supplement helps.

What is nutrigenomics?

Nutrigenomics is, in fact, the research area that studies how nutrition can affect the DNA by changing the way the genes are expressed. DNA in the cells is responsible for the expression of physiological processes in those cells via the initiation of the production of various proteins.

This gives these cells their specific function. The production of these proteins can be divided into two main steps.

The first step is the transcription of DNA to RNA, which begins when a protein regulator (RNA polymerase) binds to DNA.

The second step is the translation of RNA towards the synthesis of protein. In general, gene expression begins with controlling the protein regulators (transcription), but can also affect the protein expression (translation).

There are many factors that can affect the expression of the genes in cells. Differences in the environment such as stressors, housing, and climate do influence the expression of genes in various cells. Over the last

Continued on page 25

Continued from page 23
decade, research has shown that nutrients in the diet also play an important role in the expression of the genes.

This nutrigenomics research has shown that understanding the role of nutrients on the expression of genes can play an important role in reducing the development of an imbalance in the animal's homeostasis and consequently reduce the risk for metabolic health problems of the host.

Nutritional factors

The above mentioned trial data on early age nutrition showed clear long term effects of nutrition on animal performance and health, indicate that nutrition might play a role in the expression of genes.

Unbalanced intakes of nutrients in the diet have been shown to promote the onset, progress and severity of diseases.

In particular, correlations between poor nutrition and chronic diseases have been identified. In the last couple of years various studies have been carried out to look into the relationship between nutritional components and the effect on human health via nutrigenomics.

In humans the main focus of nutrigenomics is on the effect of nutrition on several health problems such as obesity, cancer and heart disease. Many of these studies have been carried out with transgenic animal models. Within this research several nutritional factors have been shown to affect the expression of genes and consequently change the homeostatic balance in the animals.

In Fig. 1 a summary is given of the various effects of nutrients on health benefits in humans. In recent years the macronutrient fat and its composition of fatty acids have obtained specific attention in research and this has clearly shown that, in particular, unsaturated fatty acids can modulate gene transcription in humans. In humans, increased intake of fish oil showed protective effects against cardiovascular disease.

These effects are nowadays associated with the positive changes of omega-3 fatty acids in gene expression in relation to inflammation. On the other hand research with various vitamins, in particular that of vitamin D has been carried out several years ago.

Vitamin D has been shown to affect gene expression in several cells and has shown, among others, the ability to reduce the growth of breast cancer cells.

In farm animals so far only a limited number of studies have been carried out in the area of nutrigenomics. It has been shown in poultry that short chain fatty acids, in particular butyrate, can change cellular gene expression through avoiding the release of an enzyme that blocks the onset of salmonella colonisation.

This effect against salmonella colonisation by butyrate was only shown when the butyrate arrives at the cells in the intestinal tract that show the gene expression effect.

Recently in another broiler study it was shown that feeding trace minerals in the first week of life affects gene expression in birds of 21 days of age.

There are also effect of nutrients that indicate that they might affect performance and health through gene expression. For example trial data from transgenic models have shown that protein levels affect gene transcription.

This may explain the fact that low protein diets in early broiler nutrition affects the growth of the birds at an older age. However, the role of protein in gene expression is more complex and not always conclusive due to the high variation within protein composition and stability. For example it is suggested that some yeast protein fractions can affect gene expression.

In piglets it has been demonstrated that a dietary addition of glutamine coordinates alterations in gene expression. This change in gene expression was associated with a reduction in intestinal dysfunction and atrophy in young weanling piglets.

Future perspective

Understanding the effects of different ingredients on the functionality of cells and/or organs may result in new ways of how nutrition can improve the health and productivity of animals. In this way, knowledge of nutrigenomics could help to modulate future dietary concepts, thereby acting as a potential therapeutic tool.

New dietary formulations would then influence genes for digestion or absorption of, for example, proteins, thus optimising digestive function and metabolism. In addition, genes that are also related to immune response, or proliferative processes could be modulated, thereby enhancing mucosal repair through specific nutrients.

This would be of special interest when designing a diet to overcome health problems related to those originated from physiological imbalances such as weaning-associated problems.

However, this nutrigenomics research is still a relatively new area with limited data, thus new developments cannot be expected in the near future.

Although studies in relation to nutrigenomics are still limited, first data clearly show that this research area is able to provide a better understanding in the mode of action of how nutrients can play a role in animal health.

Therefore, insights into the effect of different nutrients on the expression of DNA in specific cells may result in the development of new types of novel ingredients. Thereby the development will focus on identification of dietary components as well as on the targeted delivery system. ■

References are available from the author on request