NAG (N-ACETYL-GLUCOSAMINE) An Overview

Recently, Health Canada issued a Natural Health Product (NPN) licence to Vitex Nutrition Ltd, of Coquitlam, BC for its product **C-NAG** for managing the symptoms of inflammatory bowel disease. **C-NAG** is a proprietary formula containing N-Acetyl-Glucosamine + Vitamin C.

NAG or N-Acetyl-Glucosamine is a natural substance found in all tissues of the body and is an integral part of the "glue" which binds cells together. NAG is particularly important for its roll in connective tissues (skin, bone, tendons, ligaments, cartilage, teeth, eyes, synovial fluid, heart valves and in mucous membranes such as those in the digestive, respiratory and genitourinary tracts).

AMINO SUGARS

NAG belongs to a class of compounds known as amino sugars. Amino sugars are formed within the body from glucose and essential amino acids (glutamine in the case of NAG) and are used mainly for tissue rebuilding. NAG and other amino sugars bond together to form long polysaccharide (sugar) chains called glycosaminoglycans, or GAG's (formerly known as mucopolysaccharides). GAG's include chondroitin sulfate and hyaluronic acid. These long polysaccharide chains combine with various fibrous proteins such as collagen to form the extracellular matrix (the complex meshwork of macromolecules holding cells together forming tissues).

NAG and its polysaccharide chain forms are essentially the "glue" of the tissues. The special chemical properties of NAG are critical in the formation of this ubiquitous "glue" that holds the body together. Because of their negative charge, NAG and glycosaminoglycans (NAG chains) attract water and form huge hydrated gels which swell and fill up the spaces between cells in the tissue. Because of NAG and its gelatinous chains, tissues have the ability to withstand various compression forces without collapsing or fracturing. In addition, the collagen fibers, embedded in the NAG structure, give the tissues further strength as well as resistance to stretching forces. Together these two components, the NAG chains and the fibrous proteins, give tendons and ligaments their tremendous ability to withstand forces without fracturing or falling apart.

MOLECULAR TRAFFIC

Besides providing an organized structure for the tissues, the NAG "glue" also has the critical function of regulating the flow of nutrients, hormones, other molecules and cells into the tissues from the bloodstream. The NAG "glue" is found at various extremely important contact sites between the body and the external world, namely in the mucous membranes of the digestive,

respiratory and genitourinary tracts. This NAG layer is responsible for keeping out pathological organisms or stomach acids while allowing important nutrients to pass through.

To illustrate the wide ranging and important roles that NAG plays in the body, two systems of the body are discussed in more detail: the role of NAG in the digestive tract and the role of NAG in tissue repair.

DIGESTIVE TRACT

The gastrointestinal tract is covered by a thick mucous membrane whose outermost layer (known as the Glycocalyx) is highly viscous due to its large content of NAG. This final layer comes into contact with the various contents of the intestines and functions to protect the intestine from the actions of stomach acids, pancreatic and stomach enzymes and bacteria. This layer also controls the passage of molecules into and out of the gut. The mucosal cells have an extremely high turnover rate, replacing themselves every 3-4 days.

Studies have shown that patients suffering from ulcers, inflammatory bowel Disease (IBD), Crohn's disease, Colitis and other inflammatory disorders have a mucosal layer turnover rate several times greater than normal. The synthesis of NAG precursors is also higher in patients with IBD compared to normal persons. The turnover of cells in the lower intestinal tract is three times greater in patients suffering from ulcerative colitis compared to normal persons. These high turnover rates require increased amounts of NAG. But, as Burton and Anderson have shown, tissues from patients suffering from IBD have a reduced ability to perform an early biochemical step in NAG synthesis, namely the N-acetylation of glucosamine. Thus in many cases of inflammatory diseases, the body may not have sufficient resources to manufacture enough of its own NAG or may be simply unable to make its own properly-formed molecules. The result is poorly formed and deficient NAG layers which are unable to adequately protect the rest of the mucosal layer. This creates a vicious circle and leads to increased turnover in the intestine and increased damage. This damage leads to intestinal permeability (or "leaky gut) which has been linked to a wide variety of disease conditions, including food allergies, autoimmune syndromes, microbial syndromes, microbial infestations and malabsorption syndromes.

TISSUE REPAIR

The damage that occurs when NAG is deficient in the intestinal tract highlights the critical roles that NAG and the cellular "glue" play in tissue repair. Tissue injury can occur from accidents or disease processes such as inflammation. Repair is also required as part of a daily process to regenerate new layers of skin, bone and gastrointestinal mucosa. The NAG "glue" is a critical ingredient made by the body to repair the site of injury. The NAG structure (the extracellular

matrix) also allows the repair mechanism to occur since it facilitates the rapid movement of repair cells from the bloodstream into the in injured tissue. The viscous "glue" occupies tiny spaces between cells in a tissue. The repair cells use these spaces to squeeze themselves through the tissue, moving along the fibrous collagen structures. At the injury site, the cells first manufacture more NAG from glucose and glutamine and then combine it with proteins and carbohydrates to make up the extracellular matrix or "glue". The NAG "glue" is then used to repair the tissue or to replace the mucous membranes.

NAG SUPPLEMENTATION

In the event of poor health, this repair mechanism may be impaired or the body may not have sufficient precursors to make NAG, resulting in slow tissue repair and poor wound healing. Studies have shown however that NAG can be taken orally and is readily absorbed from the small intestine and incorporated into mucous membranes and other "glue" structures, particularly in the gut. Thus, supplementation with NAG may provide a simple way to bypass defective or energy consuming steps and provide the body with a quick source of the readymade precursors needed to make the tissue "glue" and to repair damaged tissue or replace mucous membranes.

Dietary NAG, however, is easily degraded by stomach acid back to simple glucose and glutamine and very little is delivered to the small intestine. In order to assure maximum absorption, NAG supplements should be provided in enteric coated tablets or capsules or preferably in the new *DRcaps* to resist the stomach acid and deliver NAG directly to the small intestine where it is rapidly absorbed into the blood stream.

ROLES

Because it is such a critical molecule in tissue repair, NAG plays a key role in numerous bodily functions. Any disruption or deficiency of NAG can result in a wide variety of diseases. Because of its role in the repair of mucous membranes, sufficient quantities of NAG are needed in cases of asthma, food allergies, respiratory allergies, vaginitis and candidiasis. As a substance involved in the synthesis and proper use of collagen and bone matrix, adequate NAG is needed for the continuous repair processes occurring during cases of tendonitis, bursitis, osteoporosis and various skin problems. Because of its role in the production of immunological substances, NAG is important to help prevent immune related disorders such as lupus erythematosus, Hashimoto's Disease, rheumatoid arthritis, diabetes mellitus and myasthenia gravis. The role of amino sugars and the tissue "glue" is especially important in the intestine since the molecules form the protective mucous layer that regulates intestinal permeability, Research is now focusing on the role amino sugars play in diseases of the digestive tract known to be associated with stress such as ulcers, IBD, Crohn's Disease, irritable bowel syndrome, dysbiosis and many other health issues. Even fertility requires NAG and the NAG "glue" for the proper viscosity of seminal fluid

and cervical mucus. NAG is also critical in the growth of healthy fingernails, toenails and hair. Other tissues with high turnover rates such as skin also require high quantities of readily available NAG to maintain their integrity, suppleness and elasticity. Finally, research has begun to show that damage to tissues during the normal ageing process involves the decreased ability of the body to manufacture sufficient NAG to meet its repair requirements. To the advocates of the "life extension" movement, NAG could well be the most important dietary supplement to take in the age old quest to slow down the ageing process.

C-NAG

NAG is a stable, neutral, tasteless and water soluble amino sugar. It is readily absorbed in the small intestine through passive diffusion, stays in the blood for several hours, and is used for tissue rebuilding and as a precursor to other amino sugars such as glucosamine sulfate and hyaluronic acid. Very little is excreted. **C-NAG** is a useful supplement under circumstances of poor diet, stress, disease, tissue injury and ageing. **C-NAG** includes vitamin C as it is a co-factor in the production of glycosaminoglycans. Finally, **C-NAG** is provided in the new *DRcaps* to resist the stomach acid which can denature NAG and deliver NAG directly to the small intestine where it is rapidly absorbed.

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