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ANIMAL HEALTH:
A BREAKPOINT in ECONOMIC DEVELOPMENT?

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The Polyunsaturated Fatty Acids and Skin Health in Horses

Y.M.GOH, J.Y. SIA AND MOHD-AZAM, G.K.

Faculty of Veterinary Medicine, Universiti Putra Malaysia,
43400 UPM Serdang, Selangor, Malaysia.

Abstract

This paper highlighted the importance and contribution of PUFAs (polyunsaturated fatty acid) and their metabolites to the skin health of horses. PUFAs are the major constituents of cellular membrane and regulates membrane fluidity as well as normal skin growth. These are achieved through the presence and balance of their metabolites, which incidentally possess unique anti-inflammatory and/or pro-inflammatory properties. The understanding of the roles and balance of these fatty acids offered an additional approach in the management of skin health in horses.

Keywords: Polyunsaturated fatty acid (PUFA), skin, equine

Introduction

The skin is the body's largest organ and is a natural barrier made up of mainly lipids that protected the organism from infection, ultraviolet radiation, dehydration and other potentially harmful insults. The skin can be affected by local problems but it is also the best indicator of the horse's general health and condition. The coat may become dry and dull if it is not lubricated by normal sebaceous secretions or became hidebound when the skin is tight and does not move freely over the underlying structure. This can be due to dehydration and lack of subcutaneous fat, and is also seen in grass sickness and poorly nourished horses (Pilliner and Davies, 1996). The common horse feeds may contain up to 12% fat (NRC, 1989). Fats present in common grain-based horse feeds are frequently high in linoleic acid, an 18-carbon n-6 polyunsaturated fatty acid (n-6 PUFA). This led some investigators to suggest that well-cared horses are less prone to dermatological conditions as a result of essential fatty acid (EFA) deficiencies (Lewis, 1996). Furthermore, the development of dramatic symptoms as a result of EFA deficiencies, such as substantial hair loss and overt clinical dermatitis would require severe depletion of EFAs over a period of many years (Siguel and Gould, 1998). However, balanced PUFA intake is also important as it has been shown to affect skin and hair coat conditions in horses (Goh *et al.* 2003).

The Fatty Acids

The fatty acids are the basic building blocks of lipids, and therefore important as a key constituent of animal cells and tissues. Fatty acids may be described as saturated, monounsaturated or polyunsaturated on the basis of the number of double bonds in the fatty acid's carbon chain. Saturated fatty acids (SFA) are inert fatty acids without any double bond in their carbon chains, monounsaturated fatty acids (MUFA) had a single double bond, whereas polyunsaturated fatty acids (PUFA) had multiple double bonds within their carbon chains. The fatty acids can also be classified as non-essential fatty acids (NEFA) and essential fatty acids (EFA). The essential fatty acids are those fatty acids that either cannot be biosynthesized or are synthesized in inadequate amounts by animals that require these nutrients for growth, maintenance, and proper functioning of many physiological processes (Cunha, 1991). In mammals, the EFA included fatty acids from the n-3 PUFA family (e.g. alpha-linolenic acid (LNA)) and n-6 PUFA family (linoleic acid, (LA)). However, the concept of EFA is slowly being replaced, in favour of the individual functionalities of each fatty acid (Gunstone, 1996). Apart from structural roles, the fatty acids are also critical for both storage and metabolic functions of the mammalian body (Gurr *et al*. 2002). They also serve other functional roles such as those related to the regulation of membrane structural integrity, chemical signaling of the body functions, immune system modulation, and many others (Vesper *et al.* 1999).

The Essentiality of PUFA

Good nutrition could have a positive effect on an animal's coat and skin. In fact, the dietary PUFA, especially the n-3 fatty acids had demonstrated excellent results in alleviating dermatological conditions in many species of animals (Bauer, 1994). It was also reported that the hair coat score of Thoroughbreds kept under Malaysian conditions benefited greatly from high n-3 PUFA concentration and low n-6:n-3 ratio in their plasma (Goh *et al.* 2003). The essentiality of PUFA in skin health is further underlined by the fact that the linoleic acids and arachidonic acids are major components of the cellular membrane, where both exerted significant influences on the overall skin health (Lauritzen *et al.* 2001). The presence of linoleates are known to down-regulate the hyperproliferation of keratinocytes which contribute to scaly skins (Miller and Ziboh, 1990). The arachidonic acid on the other hand, played a central role in the production of many important pro-inflammatory

n-3 family				**Series-3 PG2** ↻		
Linolenic acid (18:4 n-3)	⇨	Stearidonic acid (20:5 n-3)	⇨	Eicosapentaenoic acid (22:6 n-3)	⇨	Docosahexaenoic acid (18:3 n-3)
n-6 family						
Linoleic acid (18:2 n-6)	⇨	Dihomogammalinolenic acid (20:3 n-6) ↻ **Series-1 PGs**	⇨	Arachidonic acid ↻ (20:4 n-6)	⇨	Docosapentaenoic acid (22:5 n-6)

Figure 1: Metabolism of the n-3 and n-6 PUFA and their metabolites in mammalian liver

substances. Therefore, the PUFAs are critical in the maintenance of epidermal barrier function (Lauritzen et al., 2001), as phospholipid components of cell membranes and as precursors of a variety of potent, short-lived molecules including the prostaglandins (PGs), thromboxanes, leukotrienes and hydroxyeicosatetraenoic acids (HETEs) (Ruzicka and Printz 1984). Figure 1 showed the metabolism of PUFA and their respective metabolites in mammals. Dihomogammalinolenic acid (DGLA, a derivative of linoleic acid) is a precursor of the 1-series PGs that have predominantly anti-inflammatory actions, of particular significance is the PGE1 (Lee, 1993), whereas the 2-series prostaglandins originated from arachidonic acid are mostly pro-inflammatory (Simopoulus, 1999). The 3-series PGs derived from the eicosapentanoic acid (EPA, an n-3 PUFA) had potent anti-inflammatory effects. The n-3 PUFA generally produce metabolites that are less inflammatory, having the potential to modulate hair growth and thus promote better skin health (DeGroot, 1998). The relationship between the various PUFA and their metabolites are often complex. When the tissue is damaged, the liberated arachidonic acids are metabolized by the lipoxygenase and cyclo-oxygenase enzymes to produce substances with potent, predominantly pro-inflammatory properties. However, the release of free arachidonic acid is inhibited by glucocorticoids and also by the action of PGE1, while lipoxygenase is inhibited by 15-hydroxy-dihomogammalinolenic acid, another metabolite of DGLA (Miller et al. 1989). These characteristics led Watkins and German (1998) to propose that dominance of either n-3 or n-6 determines the pro-inflammatory or anti-inflammatory tendencies of the mammalian body, which warrants a balanced intake. It is therefore suggested that dietary PUFA should be supplemented at a recommended ratio of 3 – 5 parts of n-6 PUFA to a part of n-3 PUFA. The balanced intake is also necessary as both n-6 and n-3 PUFA families shared the same enzymatic system in the animal's body (Lee, 1993). The likelihood of these fatty acids being metabolized to their respective anti-inflammatory or pro-inflammatory agents depended on the ratio of n-6: n-3 PUFA in the body.

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