MEAT AND BONE MEAL, FUTURE NUTRACEUTICALS FOR POULTRY? A REVIEW

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Summary

Food proteins have a wide range of nutritional, functional and bioactive properties. In the last decade, the importance of biologically active peptides in the diet has been recognised, particularly their effect on health (nutraceuticals) for humans and animals. In Australia, meat and bone meal (MBM) is an important feed ingredient for poultry and a possible potential source of bioactive peptides. This review will highlight the current understanding of the potential for bioactives to improve the production and efficiency, health and wellbeing of poultry as well as enhancing food security. Research aimed at improving MBM feeding value (amino acid and mineral retention) and exploring the potential of its bioactive peptides suitable for poultry usage, is thus indicated. An improvement in the feeding value and nutraceutical activity of MBM will give the poultry industry greater confidence in using this by-product, reducing their reliance on imported plant protein ingredients.

I. INTRODUCTION

Biologically active peptides have been identified in many food resources, of both vegetable and animal origin. Peptides are short amino acid segments that have biological activity, providing that they are present at the absorptive site of the gut both “intact” and “active”. In particular, there have been a number of bioactive peptides identified in milk and/or milk products, many of which have a number of nutraceutical (health promoting) activities (Rutherford-Markwick and Moughan, 2005). Of interest to us, is the limited information available on the presence of bioactive peptides in MBM. MBM is a common feed for livestock; however the risk of transferring bovine spongiform encephalopathy (mad cow disease) has limited its use to non-ruminant livestock only (i.e. poultry). Australia produces around 520,000 tonnes of animal by-products annually and relies heavily on its ability to recycle these products back into animal feed; thereby providing both economical and sustainability benefits. Animal protein meals in poultry diets have been proven to produce better growth and feed utilisation efficiency than diets containing only soybean meal as the sole source of protein (Irish and Balnave, 1993). Therefore, studies on the potential usage of bioactive peptides present in MBM as nutraceuticals for poultry are indicated at this time as they are likely to benefit both the industry and the consumer.

II. BIOACTIVE PEPTIDES

Biologically active peptides are specific protein fragments that have influence on metabolic processes and ultimately have a positive effect on health. Bioactive peptides have specific biofunction after they are released from the parent protein source, either by digestion or prior to consumption by food processing. Once liberated, they are capable of affecting a range of physiological and metabolic processes, such as immune response, behaviour, hormonal and neurological response, and gastrointestinal function. Bioactive peptides are normally comprised of 3 – 20 amino acids residues (Clare et al., 2003). Some peptides that have been isolated and identified have specific potential, such as: antimicrobial and

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imunomodulatory function, Angiotensin Converting Enzyme (ACE) inhibition (anti hypertension), antioxidant activity and opioid peptides.

Concerns about the use of chemicals and/or antibiotics in the poultry industry have forced the industry to consider alternatives in disease prevention and/or treatment that are effective and will not contribute to drug resistance or result in residues in poultry products. One of the alternatives might be antimicrobial peptides. The activity of antimicrobial peptides depends on the interaction of the peptides and cell membrane. Some of the peptides that have been identified are glycomacropeptides, immunoglobulins, lactoferrins and lysozyme.

Glycomacropeptides, which are produced from κ-casein in cheese, play an important role as antimicrobial peptides by binding pathogenic bacteria and thereby preventing them from disrupting the mucosal membrane of the gut (Rutherford-Markwick and Moughan, 2005). It also has physiological functions such as the inhibition of bacterial and viral adhesion, promotion of bifidobacterial (i.e. probiotics) growth, and modulation of immune responses through proliferation of splenic lymphocytes (Brody, 2000).

Immunoglobulins (Ig) provide an important defence mechanism against infectious pathogens. Three principal classes of Ig in avian species are IgA, IgG (also called IgY) and IgM. IgA and IgM are transferred into the egg albumen in limited amounts, whereas IgY is transferred across the ovary into the egg yolk during oogenesis, in a similar way to the placental transfer of IgG in mammals, thereby supplying passive immunity to the chick.

Lactoferrin, a glycoprotein that belongs to the transferrin family, has important functions including antibacterial, antiviral, and antifungal activity, while also being identified as an anti-inflammatory, antioxidant and immunomodulatory agent (Lonnerdal and Iyer, 1995). Lactoferrin has been discovered in external secretions, such as saliva, tears, semen, and glandular epithelial cells (Giansanti et al., 2002). It is also present in food products such as milk and milk products, as well as some fish, barley and pumpkin. Ovotransferrin, an analog of lactoferrin in birds, is present in egg white, and it has similar properties to lactoferrin. The antibacterial activity of lactoferrin is associated with its ability to bind free iron, depriving microorganisms of this essential nutrient and inhibiting the attachment of bacteria to the intestinal wall. Lactoferrin also has a direct killing effect by binding to the surface of susceptible microorganisms such as S. mutans, V. cholerae, E. coli, and L. pneumophila (Tomita et al., 2002).

Lysozyme, an antimicrobial peptide found in harvestable amounts in egg albumen, is a potent antimicrobial against certain gram positive microorganisms. It can lyse bacterial membranes and destroys the cell wall. More recently, lysozyme has also been shown to have a bactericidal effect on gram negative bacteria (Mine et al., 2004). Lysozyme has also been reported to have anti-inflammatory, antiviral, antitumor, antihistaminic and agglutinating properties (Mine et al., 2004).

Immunomodulatory peptides, such as β-casokinins from casein hydrolysate, act by inhibiting ACE, which is responsible for inactivating bradykinin (a hormone with immune enhancing effects). β-casokinins has a role in the stimulation of lymphocyte proliferation including antigen-dependent T-cell proliferation; promotion of antibody development, phagocytic activity of macrophages and neutrophil movement/cellular proliferation; and the inhibition of lipopolysaccharides and phytohemagglutinin-induced propagation of murine spleen cell cultures (Rutherford-Markwick and Moughan, 2005).

ACE plays an important part in regulating blood pressure, fluid, and salt balance by converting the inactive angiotensin I into a powerful vasoconstrictor angiotensin II (Zaloga and Siddiqui, 2004). ACE inhibitory peptides play a significant role in controlling body fluid homeostasis of chicken, such as the circumventricular organs and arginine-vasotocin (AVT, avian ADH) producing systems. It also has an indirect effect on the immune system by preventing inactivation of bradykinin (Yamamoto, et al, 2003) as mentioned previously.
Antioxidant peptides have an important role in preventing damage to the epithelial cells by oxidants (free-radicals) produced by activated immune cells (macrophages). Carnosine, a peptide found in meat and fish products, has a variety of biologic properties in addition to its antioxidant properties (Zaloga and Siddiqui, 2004). It is a precursor of histidine (histidine containing peptides also have antioxidant properties), stimulates maturation of immunocompetent cells, influences modulation of enzymatic activity, and vasodilation of arteries. The latter may have a significant influence in cardiovascular disease (e.g. sudden death syndrome) and in ascites by preventing pulmonary constriction.

Other important peptides that have been discovered are the opioids, such as casomorphins and met-enkephalin, which are known to modulate social behaviour and to have an analgesic effect in humans (Clare et al., 2003). Opioid peptides found in food sources are absorbed intact into the blood circulation and produce their effect when they reach endogenous receptors located in the spinal cord, digestive tract, pituitary and adrenal glands, and hypothalamus. Opioid endogenous receptors of chickens have been identified in the neurohypophysis, and they are important in regulating feeding behaviour, produced either by stimulating feeding which can result in hyperphagia; or by suppressing food consumption by slowing gastric movement (Bungo et al., 2004; Bungo et al., 2005).

III. MEAT AND BONE MEAL

MBM, by definition are rendered products from mammalian tissues, including bone, but typically exclusive of any added blood, hair, hoof, horn, hide trimmings, manure, and stomach or rumen contents. MBM has a crude protein level of approximately 50%, with typical calcium and phosphorus contents of 10 and 5%, respectively. MBM contains a highly balanced source of amino acids; however its quality, in terms of the available or digestible amino acids varies greatly depending on the products rendered and processing conditions (temperature, moisture, pressure and time). There are more than 100 rendering plants in Australia that produce MBM; these plants vary in size, processing capabilities and types of raw materials used. Rendering conditions recognised to minimise protein degradation include: temperatures less than 125°C (Batterham et al., 1986); zero psi pressure (Shirley and Parsons, 2000); and for minimal periods of time (Batterham et al., 1986).

Heat is an essential component in the production of MBM; the critical factors affecting protein quality are the degree of heating and the length of time this heat is applied. When proteins are exposed to higher temperatures, digestibility is reduced as a result of reactions between amino acids and other compounds and intramolecular reactions between amino acids within the protein molecule that cannot be split by digestive enzymes. Cross linking between amino acids, such as cysteine can have a detrimental effect because cysteine or total sulphur amino acid is the first limiting amino acid in MBM for chicks. In addition, inappropriate processing conditions used to produce MBM can significantly (>20%) reduce the digestibility of lysine.

IV. POTENTIAL NUTRACEUTICAL

The interests in “functional food products” (nutraceuticals) have risen considerably in the last two decades (Rutherfurd-Markwick and Moughan, 2005). Our research will examine the potential of MBM to act as a source of bioactive peptides for poultry. In particular we will try to address the following questions: Are there any bioactive peptides in MBM? If so, how much would be available? What will their effect be on the metabolism of poultry? What can be done to improve the activity and quality of the peptides? These questions arise as an increasing number of bioactive peptides are identified and isolated, especially from milk and
milk products. The discovery of carnosine, as well as ACE inhibitory peptides in meat and fish products has led to our hypothesis that MBM may have the potential to be a significant source of bioactive peptides.

There is considerable potential for developing MBM as a source of nutraceuticals for poultry thereby increasing its feeding value. Improved nutrient retention from MBM will reduce the levels of undigested proteins reaching the lower intestine and causing pathogen proliferation (i.e. reducing the incidence of necrotic enteritis). Consequently, this will be beneficial to the poultry industry to reduce the industry reliance on in-feed antimicrobials and to improve the environmental sustainability of the poultry industry by minimising nitrogen excretion and/or recycling it. Better quality MBM will give the industry more confidence to use it which in turn will reduce the usage of imported plant protein ingredients.

REFERENCES