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FEATHER MEAL AND ITS NUTRITIONAL IMPACT AS FEED: A REVIEW

Abstract

Poultry meat consumption and its products processing industry is growing very first to meet the demand of health conscious chicken loving consumers. The huge quantity of by-products especially the feather are also being generated during the completion of this production chain. This feather can be a very good source of valuable high quality protein for animal feed in the form of feather meal (FM), only if they are processed through either hydrolysis or fermentation technology, which can convert the indigestible protein to digestible one and these are very easy and economically viable methods of processing. As the raw materials for production of FM is not so costly, its production cost is also very less, which leads to a feed item in economically viable form, for the poor animals owner/farmers. The higher energy value has made the feather meal a nutritionally important feed ingredient. The easily available amino acid is another component which attracts the animal nutritionist to incorporate FM in animal diet. It has been seen that the FM have the ability to satisfy all the protein demands of milk and meat producing animals, both ruminant and monogastric, poultry, fish etc. efficiently.

Introduction

India is emerging out as a hot spot in the food processing scenario. The huge production of agricultural produces along with the diverse animal resources has brought our country to the summit in food production chain in the world. Newer trend and processing technologies are being taking into account for this purpose. In this regard meat and poultry processing industry is coming out as a boom; especially the poultry production and processing as the growth rate of it is very high. To take care of the safety of chicken meat consumers, an organized processing industry is gradually emerging out. Today the modern broiler processing plants have the potentiality to process 200,000 to 1,000,000 birds per day, therefore tonnage of waste material are also produced.

All of these waste materials (feathers, offal, trims, blood etc.) go through by-products operation for converting this less value product to value added commodities. Processing of this waste as a feedstuff will play a part in solving the world's protein needs by producing more animal protein and recreating a price structure. The by-products are generally converted into animal feed, which is produced by rendering (cooking) the waste materials in hygienic condition. Currently, Feather Meal (FM) is an underutilized protein source in diets for dairy and beef cattle. A major reason for this is lack of use of this product due to very little information exists regarding the nutrient content of the product and its convenience.

Table **1**. Typical compositional components of FM

Dry Matter	90%
Crude Protein	82%
Digestibility	75% min.
Fat	6%
Ash	4%
Crude Fiber	0.6%
Available Lysine	1.8%
Methionine + Cysteine	4.9%
TME_n	07 Kcal/g (12.8 MJ/kg)

(Source: Ewing, 1997)

The most important poultry by-product at a rendering plant is FM. Feathers are rich in protein content called keratin and constitute 7% weight of the live bird, therefore producing a considerable mass as which can be converted to valuable meal. It has been found that addition of FM to blood meal has resulted in improved daily gain and protein efficiency in growing steers, compared with either meal fed alone (Goedeken et al., 1990b). Feather meal is also an excellent source of escape protein. Raw feathers are relatively insoluble and have a very low digestibility of 5% due to the high keratin content and the strong disulphide bonding of the amino acids, but with the controlled technology available today, we are able to convert a relatively insoluble protein into a palatable and highly digestible protein source for the mulching ruminants. To make FM digestible it must first be converted through a hydrolysis process. Hydrolyzation is completed by cooking the feathers with steam. Hydrolyzed feather contents 40% to 65% moisture. This moisture must be reduced to 8% for improving shelf life as an animal feed.

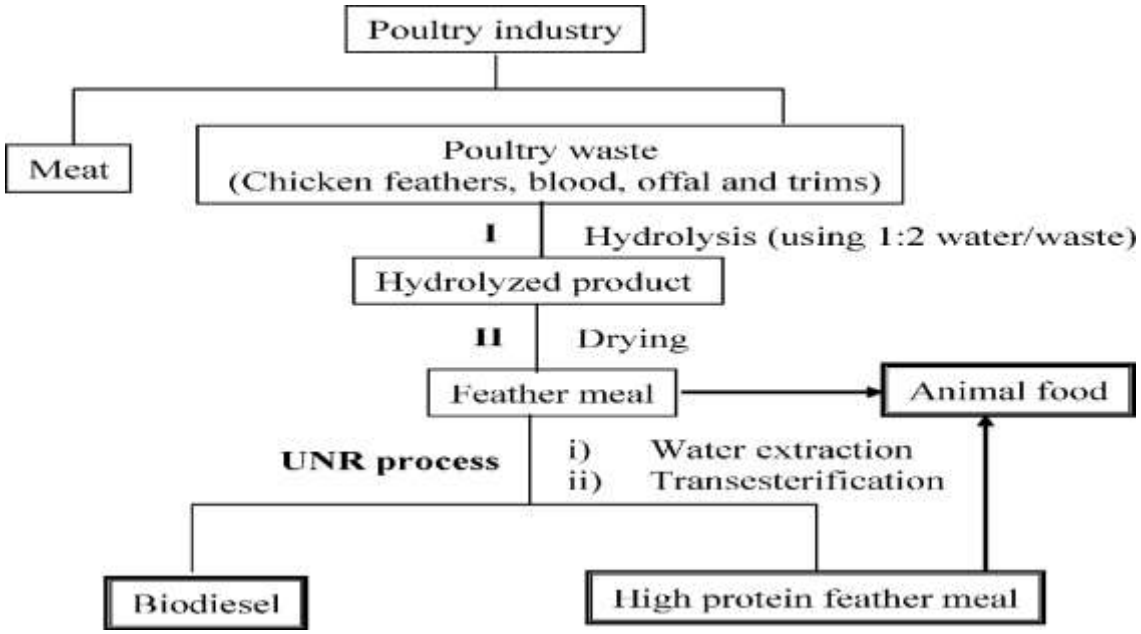
Feather content around 84% protein whereas FM has crude protein, ruminant digestibility and digestible C.P. of around 80.4, 75 and 60.3 percent respectively. The nutritional supplement by FM can fulfill the requirements of ruminants and the hygienic processing and utilization of the poultry byproducts can reduce the chance of environmental pollution effectively.

Production of FM

Feather, produced from freshly slaughtered birds and are collected hygienically from poultry processing plants, then hydrolyzed under high pressure and temperature (140º C) for a period of time required to hydrolyze the chemical bonds between the chemical components of the feathers.

Hydrolyzing can be carried out in batch cookers or continuous hydrolyzers and then make them dry. Different processing conditions such as time, temperature, pressure and moisture can have an effect on the digestibility of the FM protein, therefore are monitored carefully. In batch processing the feather are subjected to steam pressure in a batch hydrolyser at an average pressure of 283 kPa, with less agitation and long residence time of 118 min (Belewu, 2008). The use of enzymes as a 'preconditioning agent' prior to processing has recently been proposed in a pressure vessel to facilitate the process. The aim of this process is to improve amino acid availability and digestibility of the processed protein in the final products.

Figure 1. Schematic representation of poultry waste processing and FM production



(Source: Kondamudi et al., 2009)

Why FM is used

Feather waste from the poultry processing industry can potentially be used as a protein source in animal feeding operations. Improvements in current processing methods that hydrolyze proteins in feathers to make them more digestible for nonruminant animals have led to the availability of high-quality hydrolyzed FM that could provide a viable economic livestock feed (Papadopoulos, 1985). The crude protein content of feather meal does not suffer from the demerits of antinutritional factor like other available counter parts. During 50's and 60's there was considerable prejudice against FM as a result of its low and variable digestibility which at that time was a reflection of the processing conditions. However, a considerable amount of research was carried out by several workers (Fuller, 1967, Naber *et al.* 1961 and Thomas, 1972) which has demonstrated that FM was a useful protein supplement for inclusion in broiler diets too.

Table 2. FM as a source of total sulphur amino acids

Calculated Analysis	Corn-Soya basal ration	5% Fish mea	5% FM
ME (MJ/kg)	12.72	12.72	12.71
Protein %	24.2	24.3	24.2
Methionine added %	0.1	0.04	0.075
Methionine total %	0.484	0.479	0.432
Cystine %	0.373	0.378	0.425
Total Sulphur AA %	0.857	0.857	0.857
LWG (2-8 weeks) g	1660	1687	1683
FCR (feed/gain)	2.25	2.20	2.24

(Source: Fuller, 1967)

It has been demonstrated that at least half of the total sulfur amino acid (TSSA) requirement of animals can be met with cystine and that FM is a good source of this amino acid (Fuller, 1967). An

interesting observation was that when FM was included in rations at a level of 4-6% for 7-14 days prior to slaughter, a significant reduction in abdominal fat was observed, without affecting growth or FCR, which is very economical as it increased the proportion of lean meat obtained, therefore the FM can fulfill all the requirements for the milk, meat producing animals economically.

Energy value of FM

The feeding value of feather meal is affected not only by protein, but also by energy content of it. For poultry and animal nutritionists, the relationship between energy and nutrients is important, if the energy content of feather meal is underestimated, then its inclusion in diets will lead to wider ca1orie-protein ratios, and may contribute to excess fat accumulation in the body. It is reported that the energy content of feedstuffs, especially FM in terms of TMEn, strongly depends on their chemical composition. The metabolizable energy content of well processed feather meal is, to a large extent, dependent on fat content in raw materials.

Initial work to determine the energy value of FM was carried out using broilers birds. It was considered that the NRC values were too low. Pesti (1990), upon investigation of the initial data, found that when FM was included in diets at 40% level in the ration, the energy value was low, as the animals were unable to digest and absorb the amount of protein offered. But when it was used at the levels of 20%, the energy value was much higher than NRC published values (2.36 kcal/g) and it was suggested that a value of 3.07 Kcal/g (12.8MJ/kg) was more appropriate. True Metabolizable Energy (TME_n) values vary from 3092 to 3996 Kcal/kg and mainly depend upon the fat content of FM which varies from 1.8 to 12%. Metabolizable energy can be estimated from the fat content of well processed FM from the equation, TME_n (kcal/kg dry matter) = 2862 + 77(% fat) (Dale, 1992).

Amino acid availability in FM

The direct relationship exists between the quality of an animal protein source and its available amino acids. In recent feed formulation, considerable attention has been focused on the available amino acids content of feed ingredients. Although the animal protein sources have high values of available amino acids and the availability of amino acids can vary greatly with the quality (Johnson and Parsons, 1997). There are many methods for the determination of available amino acids. Indirect assays for determination of availability include physical and chemical analysis method. In case of direct method, considerable attention has been, focused on the precision for determination of digestibility of amino acids (Kessler *et al*., 1981). There is need to determine the relationship between the quality of feed ingredients and their available amino acids. A significant amount of certain sulphur amino acids like cysteine, methionine and sulphur derived component such as cystine are much important for the proper growth and development. These amino acids play an important role on the growth performance. Liu *et al.* (1989) examined 3 samples of FM to determine true amino acid availability (AAA) and found that true AAA ranged from 59.2 (lysine) to 82.8% (arginine).

Table 3. True amino acid Availability of FM

Amino Acid	TAAA %
Lysine	59.2
Methionine	74.4
Cystine	64.2
Leucine	76.9
Phenylalanine	79.2
Arginine	82.8

(Liu et al 1989)

FM can be an integral part of animal and poultry diets

Supplement for dairy animals

India is the largest milk producer in the world, therefore the nutritional maintenance and management of dairy animals is very important. The food should contain appreciable and balanced amount

of all the nutrients. Moderately producing dairy cattle have been able to obtain all of their protein needs from the passage and subsequent digestion of bacterial and protozoal protein but with the increased genetic merit and the need to produce more per cow, ways have been sought to feed both the cow and the rumen microbial population.

Table 4. Effect of various levels of FM on dairy production

	Diet with 14% CP			Diet with 18% CP		
	0% FM	3% FM	6% FM	0% FM	3% FM	6% FM
DMI	ns	Ns	ns	ns	ns	ns
BWt Ý	ns	Ns	ns	ns	ns	ns
MF%	ns	Ns	ns	ns	ns	ns
MY	0	++	+	0	0	0
MP%	0	-	--	0	-	--

(Harris *et al.*, 1997)

Feather meal has been proof to be as good as soybean meal in regards to weigh gain in range dairy animals and responsible for a glossier hair coat than soybean meal (Leme, 1978). Other than that it has been shown that Addition of hydrolyzed feather meal to the concentrate portion of the ration at various levels did not significantly alter the feed intake, milk production, or body weight of dairy cows during the first 12 wk postpartum (Rakes, 2010). Rendered proteins are a source of by-pass protein and in recent times the use of FM has been examined in the diets of high producing dairy cattle, in this concern the nutritionists have examined the need to supply greater amounts of protein post-ruminally by using either chemically treated or naturally occurring by-pass proteins. They concluded that up to 6% FM had no negative effect on intake or body weight, a positive effect upon milk yield at the lower protein diet and a linear negative effect upon milk protein content. They suggested that the imbalance of amino acids (low lysine and methionine), was responsible for lower milk protein synthesis.

Table 5. Total CP contents and Rumen Undegradable Protein (RUP) fractions of major rendered animal products used as feed ingredients for beef and dairy feeds

	CP, as % dry matter		RUP, % CP	
	Beef[a]	Dairy[b]	Beef	Dairy
Blood Meal	93.8	95.5	75.0	77.5
FM	85.8	92.0	70.0	65.4
Meat and Bone Meal	-	54.2	-	58.2
Meat Meal	58.2	-	55.0	-

(Source: a-From NRC requirements for Beef Cattle, 1996, b-From NRC requirements for Dairy Cattle, 2001).

However, the potentiality of FM to increase milk components can be increased by simultaneous feeding of other high bypass proteins that have complimentary amino acid profiles such as blood meal (BM) which provides more lysine and methionine. Thus, feeding with low cost feather protein could prove to be very economic for high producing dairy cattle.

Beef production

Increasing costs of the conventional protein sources have generated interest in new and less expensive sources of protein for beef cattle. W. M. Beeson *(unpublished data)* found replacing one-third of the soybean meal protein with feather meal in a 32% protein supplement resulted in a slight improvement in daily gain (1.11 *vs* 1.08 kg) and feed efficiency (6.37 *vs* 6.57 kg dry feed per kilogram of gain) with steer calves fed a basal ration of high-moisture corn and corn silage. Feather meal has been shown to replace plant protein supplements in lamb fattening rations with equally good results on a "protein equivalent" basis (Jordan and Jordan, 1955). Klopfenstein (1990) evaluated the protein value of

urea, soy bean meal, FM (FM), blood meal (BM) and a 50:50 combination of FM and BM when fed to 260 kg calves for a 112 day period. The most efficiently used protein sources was FM: BM combination compared to soy bean meal. The excellent performance of the BM: FM combination was suggested as being due to the provision of lysine in the BM. It has also been established from the findings of Thomas and Beeson (1977) that feather meal have potential as new sources of protein for beef cattle.

Poultry feed

A possible means of maintaining supply of broiler meat all year round at cheaper prices is by reducing the cost of production. Feeding of father meal can fulfill the requirements for growth promoting protein in economically viable form. Hydrolyzed feather meal may be added up to 6% of the ration for broilers, 7% for layers and 5% for turkeys in well balanced diets, without harmful effect as far as production or health are concerned. Inclusion of the processed, water boiled feather meal up to 3.0% in the diets did not significantly affect mean body weights, feed intake, and feed conversion ratio of broiler chickens. The carcass data from the slaughtered chickens showed that birds fed diets containing 0, 1.5, and 3% feather meal had higher ($P<0.05$) carcass yields compared to those fed the 4.5% feather meal diet (Ochetim, 1993).

Pig ration

For a successful and sustainable swine production, it is not only important to increase nutrient utilization, but also explore fully the potential of all amino acid sources or finding alternative sources of amino acids as a feed ingredient (Chiba, 2001). One of the potential alternative protein sources is hydrolyzed feather meal (FM) because of its high protein content, in addition, it is highly available, and has no anti-nutritional factors and, apparently, no risks of disease transmission (unlike some of ruminant-based products, which are capable of transmitting diseases such as Bovine Spongiform Encephalopathy), thus, FM can be an attractive alternative protein source for nonruminant diets (Chakravorty Divakala, 2008). Feather meal represents an available source of protein for animal feeds and while its use in poultry rations has been extensively studied, only a limited number of investigations have been conducted with swine. Hydrolyzed feather meal appears to be an acceptable protein source for growing-finishing pigs and can be incorporated at 8% into diets that are properly formulated without negatively affecting growth performance or carcass characteristics (Heugten and Van Kempen, 2002).

Conclusion

FM is excellent source of high quality protein but with the lower digestibility, whereas with the easy application of some modified processing steps the quality of FM can definitely be increased. At low steam pressure, long hydrolysis times are needed to increase FM density and to improve digestibility. The easy availability of raw materials for the production of FM and economically viable processing methods can make it the most promising protein rich feed for both ruminant and monogastric animals. The energy value, amino acid composition and its availability has made it the first preference by animal owners. Based upon the price of FM, nutritionists should consider more regular use of this commodity. The effective utilization of FM can surely increase the animal production in term of milk, meat, therefore surely will secure its position in animal diet in near future as convenient, economically viable, protein rich feed ingredients for all sorts of domesticated animals.

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