

GoldMehl® feather meal: a highly digestible protein source for the Petfood Industry

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INTRODUCTION

In recent years, the proportion of poultry meat consumed by the German population continued to rise, as shown by an increase in the per capita consumption of, for example, 17.2 kg poultry meat in 2005, compared to 20.1 kg in the year 2015 (BMEL 2017). This trend is also reflected in the rising numbers of poultry meat production, with an increase in the mass of slaughtered poultry from 1.12 million to 1.53 million tons between 2007 and 2016 (STATISTISCHES-BUNDESAMT 2017). Since feathers represent about 4–7% of the body weight in domestic fowl, large quantities of feathers are generated as a byproduct at commercial poultry processing plants every day (ONIFADE et al. 1998). On a global scale several million tons of feathers are disposed of or processed for further utilization in the feed industry annually and thus find a meaningful and ecological use (RIFFEL et al. 2003).

The demand for high-quality protein sources will increase in the future, not at least due to the development of the human world population which is estimated at nine billion people in the year 2050. (BONGAARTS 2009). Therefore, the search for

and the use of alternative protein sources is very important to make animal nutrition as sustainable as possible. Due to high protein levels of about 90% (STETTENHEIM 2000), feathers basically represent one of these interesting alternative protein sources.

Keratins, a group of water-insoluble scleroproteins, make up the largest part (85–90%) of the feather-protein (HARRAP u. WOODS 1964). The mechanical stability of the keratin structure and the high content of cross-linking disulfide-bonds of the sulfur-containing amino acid cystine, lead to a resistance to degradation by proteolytic enzymes, which in turn makes feathers almost indigestible in their unprocessed state (GRADIŠAR et al. 2005). To convert this keratinous structure to a more digestible form feathers need to be processed under different conditions (PAPADOPOULOS et al. 1986).

All processing procedures feathers are subjected to are aimed at an increase of the protein-digestibility and thus the nutritive value of feather meal. In order to produce feather meal of high

quality, a balance between too low and too high processing-intensity must be achieved, as excessive physical processing can have negative effects on the nutritive value by influencing the amino acid content and digestibility rate (PAPADOPOULOS et al. 1985; LATSHAW et al. 1994).

In the production of processed animal proteins, the drying conditions (temperature/duration/water content) seem to be of particular importance in respect to the digestibility, e.g. BUREAU et al. (1999) observed a significantly higher protein digestibility of blood products dried by gentle methods.

Since this drying process is also considered to be the most critical point affecting the quality and nutritional value of fishmeal, hot air dryers have already started to attract the interest of the fishmeal producers. The principle of a hot air drying is applied in the low temperature (LT) fishmeal technology, which is a two-step hot air drying characterized by short-term retention and moderate temperatures ensuring that protein quality is maintained at high levels.

In contrast to the fishmeal industry (producing LT fishmeal) indirect drying systems such as rotary disc dryers are still common practice in the poultry-by-product rendering operation. Whereas a slight heating of proteins can make them more susceptible to proteolytic enzymes by changing the tertiary structure and thus increase protein digestibility, excessive heat application leads to the destruction of various amino acids and to the formation of cross-links within or between individual peptides (TRAN et al. 2008). In this case denatured amino acids cannot be recognised physiologically as amino acids and are utilised, after deamination, as a very expensive source for energy only, thus leaving their fullest potential unexploited. The LT fishmeal technology imparts minimal denaturation effects on proteins, thus preserving inherent digestibility and biological value.

In order to use these advantages of a gentle drying technique also in the poultry-by-product rendering operation, GEPRO Geflügel-Protein Vertriebsgesellschaft (Germany/www.ge-pro.de) has launched a new type of feather meal based on the drying system mentioned above. Under the brand name *GoldMehl®*, a

special processed protein from poultry feathers origin has been developed, specifically for the Petfood and Aquafeed Industry.

The beneficial properties of *GoldMehl®* have already been demonstrated in several studies in the recent years. In feeding trials in fish, it has been determined that *GoldMehl®* is suitable to replace fishmeal at least to levels up to an inclusion-rate of 10% in fish feed. In shrimp diets at least 30% of fish meal could be replaced by *GoldMehl®* without losing performance. Furthermore, in *in-vivo* trials using minks as a model for fish and pet animals, a clear superiority of *GoldMehl®* compared to a regular feather meal (produced with a disc dryer) regarding the digestible rate of protein and the biological available protein in minks could be demonstrated. In addition, *GoldMehl®* has the potential to partly substitute poultry meal in general and, due to its low level of crude ash to serve as replacer for "low ash" poultry meal in specific, helping to reduce costs for protein sources in canine diets.

In order to determine the nutritive value and possible positive effects of *GoldMehl®* palatability, nutrient digestibility and fecal quality, digestibility studies in dogs have been conducted by a total of three authors (SIEBERT 2014; ZEIGER 2015; SCHULTEN 2018). Due to the importance of the praecaecal digestibility of nutrients (especially of crude protein – CP) for the nutritive value, *GoldMehl®* was tested additionally in ileocecalectomized Göttingen mini-pigs.

MATERIAL & METHODS

In all three studies six adult female beagles were used in a cross-over-design to evaluate the apparent total tract digestibility (aD) of nutrients. After five days of adaptation, feces were collected completely for the following five days. Dogs were fed once per day and water was offered *ad libitum*. During the entire trial, dogs were kept separately from each other to ensure individual sampling. Additionally, feces "quality" was assessed daily by an established score for feces consistency modified by ZAHN (2010) with an optimum of score 2. The evaluation of the palatability of diets was performed without any adaptation and was conducted semi-quantitatively by using a score system. In order to avoid energy and nutrient deficiency, the

amount of feed was based on the maintenance requirements of the heaviest dog.

In the study of SCHULTEN (2018) additionally five adult ileoceceally-fistulated Göttingen mini-pigs were used in order to determine the prececal disappearance rate (pc DR) of nutrients, which was tested in a screening test model according to BECKER (2005). In these animals there is an artificially created connection between the small and large intestine, so that chyme can be collected at the terminal *ileum* for examinations. The studies were also conducted in a cross-over-design.

In all studies *GoldMehl*® (GM) was used in comparison to a Regular Feather Meal (FM) which was dried in a disc dryer for 60 min at 160 °C (Table 2). SIEBERT (2014) and ZEIGER (2015) first determined the apparent total tract digestibility of a basic diet in order to subsequently replace it with varying amounts of the respective feather meal as a processed animal (poultry) protein (PAP) without any further heat treatment.

Thus, it was possible to assess the digestibility of both: the whole diet (basic diet + added feather meal) and the feather meal exclusively by applying the difference method for calculation. Both basic diets were commercial dry complete diets for dogs based on poultry meal.

In a “challenge trial”, SIEBERT (2014) added 4 % lignocellulose to a diet in addition to the Regular FM in order to investigate whether a fiber supplement is capable to improve feces quality.

In the study of SCHULTEN (2018) feather meal has been treated thermally by extrusion, thus being part of the test diets for dogs of identical composition, only differing in the type of added feather meal, either as GM or FM. As a result, secondary effects of heat treatment on the nutritive value of feather meal could be identified. The amount of feather meal was set to relatively high levels in order to reveal possible significant differences in the total tract digestibility and feces quality.

Table 1 provides an overview of the composition of all tested diets. Contents of nutrients in feed, chyme and feces samples were determined by using established official standard methods of feed analysis.

Table 1. Composition of the diets used in the studies of SIEBERT (2014), ZEIGER (2015) and SCHULTEN (2018).

Study with associated diets		GM	FM
SIEBERT (2014)	66.7 % basic diet* +	33.3 %	-
	66.7 % basic diet* +	-	33.3 %
	66.7 % basic diet* + 4 % lignocellulose	-	33.3 %
ZEIGER (2015)	95 % basic diet* +	5 %	-
	90 % basic diet* +	10 %	-
	80 % basic diet* +	20 %	-
	80 % basic diet* +	-	20%
SCHULTEN (2018)	extruded diet** containing	25 %	-
	extruded diet** containing	-	25 %

* commercial dry complete diet for dogs based on poultry meal
** based on wheat and meat and bone meal

Table 2. Drying methods used for the production of *GoldMehl*® and the Regular Feather Meal (FM).

Feather meal	Drying method
GM	two-step hot air drying; short-term retention at moderate temperatures
FM	disc dryer; 160 °C for 60 minutes

RESULTS

During the whole trial the palatability of all diets was high in dogs, which was reflected in a spontaneous and complete intake at the first offer. At any time, feed refusals have not been recorded. The use of diets containing high amounts of feather meal (up to 33.3 %) was associated with a rather soft feces consistency, without any differences between both feather meal used (Table 3). By reducing the proportion of *GoldMehl*® to only 5 % in the diet, the fecal score approached to an optimum of 2 (ZEIGER 2015). Even the addition of a fiber-containing product led to a marked improvement of feces quality (SIEBERT 2014).

Table 3. Results of the fecal scoring depending on the diets used.

Study with associated diets		Feces consistency*
SIEBERT (2014)	66.7 % basic diet + 33.3 % GM as PAP	3.31 ± 0.738
	66.7 % basic diet + 33.3 % FM as PAP	3.18 ± 0.654
	66.7 % basic diet + 33.3 % FM as PAP + 4 % lignocellulose	2.55 ± 0.607
ZEIGER (2015)	95 % basic diet + 5 % GM as PAP	2.60 ± 0.529
	90 % basic diet + 10 % GM as PAP	3.43 ± 0.431
	80 % basic diet + 20 % GM as PAP	3.86 ± 0.161
	80 % basic diet + 20 % FM as PAP	3.63 ± 0.236
SCHULTEN (2018)	diet containing 25 % GM after extrusion	3.23 ± 0.585
	diet containing 25 % FM after extrusion	3.24 ± 0.708

*: 1 = hard, dry feces; 2 = well-formed feces, leaves no residue when removed (optimum); 3 = soft but still formed feces, leaves first residues when removed; 4 = very soft, more or less unformed feces; 5 = watery, liquid feces

As shown in Table 4 and Figure 1, in the studies of SIEBERT (2014) and ZEIGER (2015) the results of the apparent total tract digestibility of protein in dogs substantially depended on the type of added feather meal. Thus, both authors recorded a significantly higher apparent CP-aD of the whole diet (basic diet + feather meal added as PAP without any further heat treatment) when using *GoldMehl*® instead of the regular FM (Table 4). Since both authors previously determined the digestibility of the basic diet, based on these results the digestibility of the feather meal exclusively could be calculated using the difference method. Again, *GoldMehl*® was characterized by a significantly higher CP-aD in comparison to the Regular FM. The results are shown in Figure 1.

Table 4. Apparent protein-digestibility of the whole diets used in the studies of SIEBERT (2014) and ZEIGER (2015).

Study with associated diets		CP-aD
SIEBERT (2014)	66.7 % basic diet + 33.3 % GM as PAP	75.9 ^a ± 3.47
	66.7 % basic diet + 33.3 % FM as PAP	67.4 ^b ± 4.42
ZEIGER (2015)	80 % basic diet + 20 % GM as PAP	81.1 ^a ± 3.47
	80 % basic diet + 20 % FM as PAP	74.6 ^b ± 3.80

^{a, b}: Different letters indicate significant differences between the diets within a study (p<0.05)

Apparent protein-digestibility of both feather meal in the studies of SIEBERT and ZEIGER

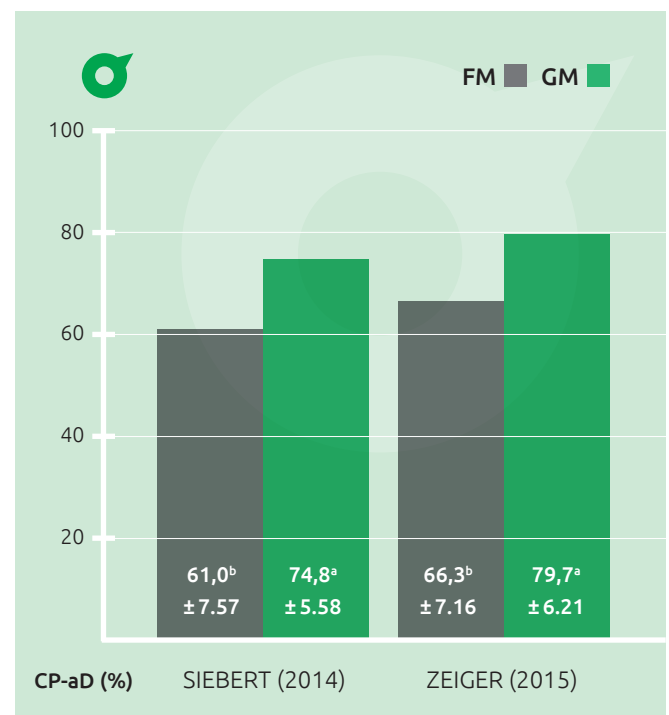


Figure 1. Apparent protein-digestibility of both feather meal calculated by difference method.

^{a, b}: Different letters indicate significant differences between the feather meal within a study (p<0.05).

If both feather meal were additionally treated by extrusion and thus used as components of a compound feed, the apparent total tract digestibility of nutrients remained unaf-

ected by the drying method of the added feather meal. This was reflected in a quite high but identical CP-aD of 78.2 % of both diets used. Comparable results were determined in the studies in ileocecally-fistulated Göttingen mini-pigs. Again, no differences between the two diets could be found after an additional extrusion process of the feather meal, which was reflected in a high but almost identical apparent prececal disappearance rate of crude protein (Table 5).

Table 5. Apparent total tract CP-digestibility in dogs and apparent prececal disappearance rate of CP in ileocecal-fistulated Göttingen mini-pigs of the diets used in the study of SCHULTEN (2018).

SCHULTEN (2018)	GM	FM
Total tract digestibility (%) of crude protein in dogs	78.2 ± 2.54	78.2 ± 3.91
Prececal disappearance rate (%) of crude protein in mini-pigs	74.6 ± 1.99	74.4 ± 1.56

CONCLUSION

As a high level of palatability has been achieved in dogs, even with amounts up to one-third of feather meal in the diet, feather meal seems to be well suited as a protein source in canine diets.

Due to the problems with the collection of soft feces, a maximum level of about 5 % of feather meal should not be exceeded. Specific feed ingredients such as certain types of fibres may help to improve feces quality.

GoldMehl® is characterized by a significantly higher digestibility of crude protein in dogs compared to a regular feather meal when added as PAP to a dry complete diet, which can be attributed to the more gentle drying process using the LT-technology. The Regular FM has been probably affected by greater heat damage due to drying at 160 °C for one hour. It is well known that high temperatures can lead to the formation of cross-linkages of amino acid within heat-labile proteins, which in turn causes a lower digestibility. A comparison of the results of SIEBERT (2014) and ZEIGER (2015) suggests that reducing the level of *GoldMehl*® in diets for dogs may result in a further increase in protein digestibility.

Even after an additional heat exposure during an extrusion process, a compound feed containing *GoldMehl*® shows a very

high digestibility of crude protein. In spite of the high level of *GoldMehl*® used in the study of SCHULTEN (2018), these results are almost comparable to the crude protein-digestibility of established dry feeds for dogs belonging to the super premium sector (DAUMAS et al. 2014). For this reason, losses in nutrient-digestibility does not seem to be the limiting factor for the use of such large quantities (up to 25 %) in extruded compound feeds for dogs.

Another positive aspect is the high prececal digestibility of crude protein, which is markedly higher (74.5 %) compared to previous studies (60.7 %) on prececal digestibility of diets containing feather meal in ileum-fistulated dogs (HÖHMANN 1994). This is probably attributed to the further development of the processing technology for feather meal in recent decades.

It can be concluded that the use of *GoldMehl*® is not limited to aquaculture but is also a potential highly digestible protein source for the Petfood Industry. Looking to the future and to a possible repeal of the restriction on the use of processed animal proteins from poultry slaughter in pig feeding, *GoldMehl*® also represents a valuable protein source for these purposes. Applying a state-of-the-art drying process in the production of feather meal not only adds value to feathers, but also provides sustainable protein production as poultry production increases.

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