# Improving the Nutritive Value of Poultry Feedstuffs: the Rapeseed Products Example

**H. Jeroch and K. Kozlowski, Olsztyn, Poland**

## Introduction

Commercial brown-egg layers have the genetic potential to produce 26.5 kg egg mass per hen housed (405 eggs with 65.5 g average weight) in a prolonged laying period of 16 months, with a feed conversion ratio of 2.1 kg feed per kg egg mass (Lohmann Tierzucht, 2011). Rapid growing broilers reach market weight of 2.1 kg live weight in 5 weeks, with a feed conversion of 1.6 kg feed per kg live weight gain (ROSS, 2012). The genetic potential to convert feed nutrients efficiently into eggs and poultry meat (broiler, turkey, duck) for human consumption can only be fully utilized if the birds are well managed, remain healthy and receive highly digestible, concentrated and well balanced feed rations (Jeroch *et al.*, 2013). The challenge for commercial feed formulation is to optimize feed composition from a reduced choice of raw materials, limited inclusion rates and special attention to anti-nutritive substances.

Table 1 shows the annual use of components currently used in poultry rations in Germany. The dominating raw materials are cereals (mainly wheat and corn) and soybean meal, which are also used for human consumption and the production of bioethanol (cereals).

**Table 1: Annual demand for raw materials of poultry rations in Germany (DVT, 2013)**

| Raw materials | Layer rations | | Fattening rations | | Source |
|---|---|---|---|---|---|
| | Mio t | % | Mio t | % | |
| Cereals (Legumes) | 1.4 | 61 | 1.6 | 62 | Germany, EU, |
| Soybean meal | 0.3 | 13 | 0.5 | 19 | South America, USA, (EU) |
| Other by-products of oil manufacture (Rapeseed meal, sunflower meal) | 0.15 | 6.5 | 0.1 | 4 | Germany, EU |
| By-products of the food industry | 0.15 | 6.5 | 0.15 | 5.5 | Germany, EU |
| Oils and fats | 0.1 | 4.3 | 0.15 | 5.5 | Germany, EU, other |
| Minerals (phosphate) | 0.2 | 8.7 | 0.1 | 4 | Germany, EU, other |
| Total | 2.3 | 100 | 2.6 | 100 | |

DVT= Deutscher Verband Tiernahrung

The available resources are limited and have to be utilized efficiently in animal feed. Poultry nutrition is focused on converting feed protein to egg and poultry meat protein. According to own calculations, feed protein is converted to edible protein at ratios of 33% in eggs, 26% in broiler meat, 24% in turkey meat and 20% in duck meat (Jeroch et al., 2013). In the following outline, we will examine possibilities to improve the conversion ratio further and to include other components.

## Goals and methods to improve feed value

The main **goals** are:
- Species-appropriate feed, higher feed intake, lower mortality
- Higher content of valuable and lower content of indigestible components
- Reduction of antinutritive and undesirable components
- To optimize digestion and intestinal health
- Improved resorption of nutrients and enhanced nutritional value of feed and
- Improved feed hygiene in source components and finished feed

Classical methods have been improved over the years and continue to be used, sometimes with "new" refinements. Of special importance are:
- plant breeding
- biological treatments (e.g., fermentation)
- use of feed additives (e.g., feed enzymes, probiotics, organic acids, phytobiotics)
- chemical treatments (e.g., decontamination)
- technical treatments (e.g., cleaning, milling, shelling, pelleting, toasting, decontamination, extruding, expanding).

## Rapeseed as an example for systematically improved the nutritive value

***Results of successful genetic improvement of rapeseed***

During recent decades, plant breeders in Europe and Canada improved the quality of rapeseed for human and animal nutrition significantly, as shown in Table 2. Starting from technical oil with about 50% of the problematic erucic acid (C 22:1, which is deposited in body fat and may cause heart problems), a valuable product for human consumption and component of animal feed has been developed. The by-products of oil extraction have become useful for monogastric animals after significant reduction of glucosinolate (GLS). The conventional rapeseed varieties had negative effects on thyroid function - glucosinolates inhibit iodine uptake by the thyroid - and performance in poultry if included at low levels of 2-3% rapeseed meal in poultry rations. These by-products could only be used in ruminant rations.

**Table 2: Results of genetic improvement of rapeseed[1]**

| Variety, breeding goal | Quality assessment |
|---|---|
| Traditional varieties | High content of erucic acid in oil, high concentration of antinutritive substances in fat free dry matter, especially glucosinolate, sinapin and others |
| 0-Varieties (improved single quality):<br>1st step in quality breeding:<br>0-Winter variety of rape seed in Germany since 1973 | Varieties of winter rape seed in Europe, summer rape seed (Canola) in Canada and Northern Europe with minimal content of erucic acid (from 50 % down to <1 % of total fatty acids) |
| 00-Varieties (improved double quality):<br>2nd step in quality breeding:<br>00-Winter variety in Germany since 1981;<br>00-Summer variety of rape seed already earlier (Canada and Northern Europe) | Varieties with < 1% erucic acid and reduction of glucosinolate content (from about 100 µmol to <18 mol/g seed) |
| 00-New 00-Varieties for winter and summer rape seed | < 10 µmol glucosinolate/g seed |
| 000-Varieties (triple quality, yellow), available for summer rape seed (Canola) | 20-30% less crude fiber in grain due to reduced shell content, 50% less lignin |

[1] BECKER *et al.*, 1999; RÖBBELEN, 1997 and 2001, Lie *et al.*, 2007; Bartkowiak-Broda *et al.*, 2011

As shown in Table 2, the gucosinolate content has been further reduced in the new double quality varieties. This achievement of plant breeding, combined with the toasting process in modern oil mills, has reduced the content of glucosinolate in the rapeseed meals (RSM) to a relatively low level. A 4-year study (2005-2008) of rapeseed meal quality in Germany showed glucosinulate levels between 6.8 and 9.3 µmol/g RSM (WEBER, 2009). Plant breeders in Poland and Canada are aiming for further reduction of glucosinulate levels in rapeseed and corresponding rapeseed meal. RSM with lower GLS content can be included in poultry rations without any negative effects, as shown by the results in Table 3.

**Table 3: Results with rapeseed meals (RSM) from low glucosinolate (GLS) rapeseed in rations of growing turkeys and laying hens**

| Literature | Birds | RSM-content % | GSL-content µmol/g RSM (88 % DM) | Comments |
|---|---|---|---|---|
| Mikulski *et al.* (2012) | Male turkeys | 0/6/12/18 | 4.4 | Little effect on growth and carcass value; no increase in foot pad lesions |
| Campbell *et al.* (1999) | White-egg Layers | 0/10/20 | 1.8 | Same performance in all groups, no effect on functioning of organs |
| Rodehutscord *et al.* (2012) | Brown-egg Layers[1] | 0/5/10/15 | 6.0 | No negative effects on performance and egg quality |

[1] without tainter gene

A new goal for plant breeders are varieties of rapeseed with reduced total fiber and lignin content (so-called triple quality, shown in Table 2). With this, the digestibility of crude protein and amino acids should be improved and the energetic value of feed increased. In Canada experimental yellow varieties of rapeseed with reduced shell content are currently being tested. They contain less fiber and oligosaccharides per kg dry matter (DM) compared to the conventional black varieties and more crude protein and amino acids. Preliminary results suggest also an improved digestibility of amino acids and a higher content of energy (Table 4).

**Table 4: Feed quality parameters of rapeseed meal from black and yellow rapeseed varieties[1]**

| Parameter | Birds | Rapeseed meal from | |
|---|---|---|---|
| | | Black variety | Yellow variety |
| Fiber-/lignin content (g/kg DM) | | 301/71 | 241/37 |
| Oligosaccharide content (g/kg DM) | | 36 | 21 |
| Crude protein (g/kg DM) | | 438 | 498 |
| Average pc AA-digestibility (%) | broilers | 83 | 89 |
| Metabolizable energy (MJ AME/kg DM) | broilers<br>turkeys | 7.98 (100)<br>8.40 (100) | 9.18 (115)<br>9.08 (108) |

[1] Slominski *et al.* (2007, 2011), Jia *et al.* (2013)

Additional goals for rapeseed breeders are the reduction of other antinutrients, e.g., phenolic substances (sinapin), tannins and phytin acid, while further reduction of glucosinolate continues.

### Positive effects of technical treatments

Several technical solutions have also been developed to reduce the fiber content of rapeseed cake and rapeseed meal. **Peeling the seeds** before processing (Kracht *et al.*, 1998) improves the nutrient composition (Table 5). The fiber content decreases, especially lignin is reduced (by 50%), while the content of crude protein, amino acids and other nutrients is enhanced. The $AME_N$ content depends mainly on crude fiber reduction by peeling and varies with the age of the birds (Table 6).

**Table 5: Contents (g/kg DM) of rapeseed meal from not dehulled (nd) and dehulled (d) seeds of identical rape varieties**

| Authors | | Crude ash | Crude protein | Crude fat | Crude fiber | NDF[1] | Lignin | Lysine |
|---|---|---|---|---|---|---|---|---|
| Kracht *et al.* (2004) | nd | 77 | 396 | 21 | 117 | 268 | 88 | 19 |
| | d | 82 | 424 | 21 | 72 | 193 | 44 | 22 |
| Huang *et al.* (2007) | nd | 79 | 386 | 14 | 118 | n.a. | n.a. | 13 |
| | d | 78 | 468 | 9.5 | 56 | n.a. | n.a. | 21 |

[1] neutral detergent fiber

**Table 6: Effect of dehulling rape seed on energetic feed value of rapeseed meal and rapeseed cake (Jeroch *et al.*, 2001)**

| Feed source | Birds | Not dehulled seed | | Dehulled seed | | $AME_N$-increase % |
|---|---|---|---|---|---|---|
| | | Crude fiber g/kg DM | $AME_N$ MJ/kg DM | Crude fiber g/kg DM | $AME_N$ MJ/kg DM | |
| Rapeseed meal | Broilers | 117 | 6.94 | 72 | 8.27 | 19 |
| | Layers | 117 | 8.08 | 72 | 9.91 | 23 |
| Rapeseed cake | Broilers | 102 | 11.42 | 61 | 13.05 | 14 |

Dehulling before processing also improves the amino acid (AA) digestibility in by-products of rape seed oil production included in rations for fattening pigs and broilers (Kracht *et al.*, 2004; Zuprizal *et al.*, 1992). The results with broilers are shown in Table 7. The digestibility of the meal from peeled rape seed is close to that of soybean meal.

**Tabelle 7: Effect of dehulling rapeseed on digestibility of amino acids of rapeseed meal in broilers (Zuprizal *et al.*, 1992)**

| Amino acid | Rapeseed meal | | Soybean meal |
|---|---|---|---|
| | Not dehulled | Dehulled | |
| Lysine | 76 | 82 | 84 |
| Methionine | 84 | 90 | 89 |
| Cystine | 76 | 80 | 80 |
| Threonine | 78 | 82 | 84 |

Other technical treatments of rapeseed (hydrothermic conditioning, micronising, infrared treatment) and of rapeseed meal (expansion, extrusion) showed no improvement of energetic feed value for broilers (rapeseed, rapeseed meal) and laying hens (rapeseed), whereas treatment of rapeseed with **hot air** (Jet sploding) at 125 °C was successful (Dänicke *et al.*, 1998).

**Chemical-hydrothermal treatment** of rapeseed (Brettschneider, 2006) reduced the glucosinolate content more effectively than toasting of RSM in modern oil mills. This treatment reduced the glucosinolate content from 13.8 µmol/g (91 % DM) to 1.5 µmol/g. It should be pointed out, however, that a very high inclusion rates of expanded rapeseed in layer rations can have negative effects on thyroid function (Jeroch *et al.*, 2008), probably caused by degraded glucosinolates.

Sinapin (in layer feed responsible for the „fishy“ taint of eggs from brown-egg layers with insufficient activity of trimethylamine oxidase) has been treated successfully with a combination of **chemical** (10% sodium bicarbonate solution) and **hydrothermal treatment** (expander) to minimize the negative effects (Jeroch *et al.*, 1999). Rapeseed products have been included up to 7.5 % in rations for brown-egg layers with tainters (Dänicke *et al.*, 2006). Since then, primary breeders have eliminated the tainting gene, which makes the feed treatment unnecessary.

### The potential of added feed enzymes

Rapeseed has essentially no phytase activity in the seeds and therefore low utilization of total phosphorus (with its high content of phytin) in the by-products of oil extraction. Oloffs et al. (2000) estimated 28 % phosphorus (P) utilization in laying hens for meal and 22% for cake, compared to 46-49 % utilization for phytase-rich wheat. **Phytase supplementation** improved the P utilization in broilers und laying hens significantly, as shown in Table 8 (Dänicke *et al.*, 1998). Therefore rations with rapeseed by-products should be supplemented with a microbial phytase preparation.

**Table 8: Effect of phytase supplementation with rapeseed by-products on P-utilization in 43 meat type and egg type chickens** (Dänicke *et al.*, 1998)

| Birds | Rapeseed by-products | Phytase | P utilization (%) |
|---|---|---|---|
| Broilers | Meal | without | |
| | | with | 62 |
| | Cake | without | 35 |
| | | with | 52 |
| Layers | Meal | without | 6 |
| | | with | 32 |
| | Cake | without | 22 |
| | | with | 40 |

The high content of cell wall carbohydrates (non-starch polysaccharides, NSP) and indigestible oligosaccharides suggested testing of products with **NSP degrading enzymes**. The results of different authors (Kocher *et al.*, 2000, 2001; Slominski *et al.*, 2003, 2007; Fang *et al.*, 2007, Zdunczyk *et al.*, 2011) vary and cannot be summarized as a recommendation to add enzymes to feed with rapeseed products. The lack of enzyme effects may be due to the use of preparations developed for NSP in grain rather than rapeseed. Short testing periods may also explain inconclusive results (Table 9).

**Table 9: Effect of carbohydrase in a broiler ration with 30% rapeseed meal from a yellow variety[1]**

| in parameters | Enzyme addition[2] | |
|---|---|---|
| | without | with |
| Viscosity of digesta (mPaos) | 1.73 | 1.66 |
| 8-week body weight (kg) | 3.68 | 3.77 |
| FCR (kg feed/kg gain) | 2.19 | 2.08 |

[1] Zdunczyk *et al.* (2011),
[2] enzyme mix of pectinase, cellulase, xylanase, glucanase, mannanase and galactanase

## Comparison of Rapeseed vs. Soybean

The differences in nutritional value compared to soybean meal have become smaller and are now almost negligible (Table 10). The dominating share of soybean meal in poultry rations could be largely replaced by rapeseed products.

**Table 10: Feed quality comparison of rapeseed meal vs. soybean meal (based on data in previous tables)**

| Parameter | Rape seed meal | | Soybean meal |
|---|---|---|---|
| | Yellow variety | Dehulled 00-variety | |
| Crude protein (g/kg DM) | 498 | 450 | 510 |
| Crude fiber (g/kg DM) | -[1] | 65 | 67 |
| Lignin (g/kg DM) | 37 | 44 | |
| Lys-digestibility (%) | 88 (chicks) | 82 (chicks) | 84 (chicks) |
| AMEN (MJ/kg DM) | 9.18 (chicks) | 9.91 (hens) | 11.55 (cocks) |

[1] not analyzed

Improvements of the nutritive value have also been achieved in other feedstuffs as a result of plant breeding and a variety of feed treatments. Current knowledge should be fully utilized to optimize modern feed formulation (Jeroch *et al.*, 2013).

## Conclusions

Rapeseed meal and its by-products from oil mills are good examples to illustrate the importance and benefit of improving the nutritive value of feed components for poultry rations. Even small inclusion rates of rapeseed products from conventional varieties resulted in compromised thyroid function and reduced productivity forty years ago, but up to 25% of products from improved double and triple varieties can be included in poultry ration today without any problem.

The following possibilities are suggested:

- Reduction of additional antinutritive components using conventional and molecular genetic methods in plant breeding and use of new feed additives
- New generation of carbohydrases for effective degradation of NSP-fraction in protein feedstuffs
- Development of phytase with significantly improved efficacy and consistency
- Application of new protease enzymes in order to improve protein and amino acid utilization from the raw materials – with the final target to reduce crude protein in diets
- Utilization of the NSP-fraction in raw materials as source of energy by enzymatic disintegration within and outside the intestinal tract in order to release additional nutrients for poultry.

## Zusammenfassung

### Möglichkeiten der Futterwertverbesserung beim Geflügel am Beispiel Rapsprodukte

Im vorliegenden Beitrag werden zunächst Ziele und Methoden der Futterwertverbesserung beim Geflügel vorgestellt. Am Beispiel von Rapssaat und Rapsfuttermitteln wird der Nutzen von verschiedenen Maßnahmen demonstriert. Der Pflanzenzüchtung ist es in wenigen Jahrzehnten gelungen, den Gehalt an antinutritiven und futterwertmindernden Inhaltsstoffen so stark zu reduzieren, dass die Nebenprodukte aus der Rapssaatverarbeitung inzwischen wertvolle Proteinfuttermittel geworden sind und in Geflügelrezepturen in beachtlichen Anteilen eingesetzt werden können. Deutliche Futterwertverbesserungen lassen sich auch durch technische Behandlungen, z.B. durch Schälen der Rapskörner, erreichen. Ein weiteres Potenzial liegt im gezielten Einsatz von Enzympräparaten (Phytasen, Carbohydrasen, Proteasen). Auf diesem Gebiet der Futterwertverbesserung gibt es noch beachtliche Entwicklungsmöglichkeiten und somit auch Forschungsbedarf.

References to the literature cited can be obtained from the corresponding author:

Prof. Dr. Dr. h.c. Heinz Jeroch
Department of Poultry Science
University of Warmia and Mazury
Oczapowskiego 5
10718 Olsztyn, Poland
E-Mail: heinzjeroch@hotmail.com