Biotechnology in Animal Husbandry 21 (5-6), p 197-202, 2005 ISSN 1450-9156
Publisher: Institute for Animal Husbandry, Belgrade-Zemun UDC 633.85

# ENZYME ENHANCEMENT OF THE NUTRITIONAL VALUE OF SUNFLOWER MEAL [1]

*Slavica Sredanović, Jovanka Lević, Olivera Đuragić*[2]

*Abstract*: The chemical composition of SFM depends on the variety of the seed, the processing method and the degree of dehulling or decortication. The high variability in quality of sunflower meal due to differing levels of hulls present is the most important limiting factor with the use of this ingredient. Separation of the hull from the kernel is the key to improving the nutritional and commercial values of sunflower protein. Hull removal has not been totally successful, probably because of the tight binding of the hull to the kernel, and thus the feed enzymes may be used to upgrade sunflower meal, so that the maximum benefit may be gained from this feed ingredient in monogastric animals diets. Production of effective enzyme products for use in sunflower meal containing diets will require detailed knowledge of the substrates and their breakdown patterns in the gastro intestinal tract of the target species. The carbohydrate composition of sunflower seeds and sunflower meal is shown in this paper.

The purpose of this paper is to provide an overview of some of our and similar investigation concerned with fibrous component of sunflower meal and enzyme enhancement of the nutritional value of this feed ingredient.

*Key words:* sunflower meal, non-starch polysacharides, enzymes

## *Introduction*

Historically, the major focus of sunflower processing has been the extraction of high quality oil. The meal and other co-products were typically regarded as “by-products” and thus of less interest. To meet the growing demand for protein worldwide, it is essential to improve the efficiency of conversion of proteins and other nutrients from sunflower meal to meat. Processing consideration do have a direct impact on the nutritional value of sunflower meals. Some positive, other negative. It is the job of feed technologist, by-products processors and nutricionists to maximise the economic return on the sunflower meal into the food chain in a safe and efficient manner.

The most apparent disadvantage of sunflower meal is that it contain relatively high level of fiber. Fiber content should be decreased to a minimum by dehulling during processing of the sunflower seed for oil extraction or by different fractionation procedures of sunflower meal after oil extraction based on diametrically opposed physical, chemical and electrical characteristics of the kernel and the hull. Several efficient fractionation procedures and complex systems for separating hulls from kernels and meal, rendered high yields of attractive protein fractions that contained 42-48 % crude proteins and 8-14% crude fibre were developed in our Feed Technology Department *(Delić et. al. 1971; Lević et. al. 1992; Lević et. al. 1994[a]; Lević et. al.1994[b]; Lević et. al.1998).* Our researches in that field rank amongst the top.

Hull removal has not been totally successful, probably because of the tight binding of the hull to the kernel, and thus the feed enzymes may be used to upgrade sunflower meal, so that the maximum benefit may be gained from this feed ingredient in monogastric animals diets *(Lević et. al. 1992; Sencoily et. al. 1999).* The addition of enzyme preparations to feed is not a new concept, but is becoming more fine-tuned with the production of special enzyme preparations specific for the substrate.

## *Sunflower meal dietary fibre*

In our country sunflower seed is the best adapted high protein crop available, and it is useful to use in animal feed as the replacement of other imported protein sources. Sunflower meal if properly processed

1 Review Paper supported by the Ministry of Science and Technology, Project no. TR6877B - Pregledni rad je finansiran od strane Ministarstva za nauku i tehnologiju Projektom broj: TR6877B

2 dipl.ing. Slavica Sredanović, researcher; dr Jovanka Lević, senior research associate; dipl.ing Olivera Đuragić, researcher, University of Novi Sad, Faculty of Technology, Feed Technology Department

has valuable protein with similar amino acids availability to that in soybean meal *(Delić et. al 1992; Lusas 1985; Villiamde 1989; Waldroup et. al. 1970)* but it contain high amount of fiber, and that is the most apparent disadvantage of this feedstuff. Feeding of fiber to monogastric animals has generally been discouraged primarly because of the negative effects that fiber exerts on performance and nutrient utilization (*Sencoily et. al. 1999*).

Dietary fiber (DF) is defined as the sum of lignin and polysaccharides that are not digested by endogeneous secretion of the digestive tract of non-ruminant animal species. In this nutrition context, the term DF includes any polysacharide reaching the hindgut and so includes resistant starch and Non-Starch Polysacharides (NSP) *(Johnston et. al. 2003)*. Polysaccharides are macromolecular polymers of simple sugars or monosacharides linked together by glycosidic bonds. NSP have glycosidic bonds other than the bonds of starch which in some case causeed their resistance to starch degrading enzymes *(Smits et. al. 1996).* The NSP found in feedstuffs are primarily components of plant cell walls and it represents a group of heterogeneous compounds differing considerably in chemical composition and physical properties *(Chost 1997)*.

It is convenient to classify five major classes of fibre, according to their chemical structure and to their properties: four classes of water insoluble polymers (lignins, cellulose, hemicelluloses, pectic substances) and one class of various water soluble non starch polysacharides and oligosaccharides (water soluble pectins, β-glucans, arabinoxilans) *(Smits et. al. 1996).* Solubility of fibre components is linked to their effects in digestive tract of animals. NSP are generally defined as water soluble or insoluble. Plants generally contain a mixture of both soluble and insoluble NSP in a ratio that varies according to the type and stage of maturity. The types and levels of carbohydrate polymers and monomers in sunflower seed is shown in table 1. *(Chost 1997)*.

*Table 1. The types and levels of carbohydrate polymers and monomers in sunflower seed (% dry mater)*

| Carbohydrate | Soluble | Insoluble | Total |
|---|---|---|---|
| Starch | | | 1.4 |
| Total NSP | 4.5 | 23.1 | 27.6 |
| Cellulose | | 8.7 | 8.7 |
| Rhamose | 0.2 | 0.3 | 0.5 |
| Fucose | 0.1 | 0.1 | 0.2 |
| Arabinose | 0.6 | 3.0 | 3.6 |
| Xylose | | 5.3 | 5.3 |
| Mannose | 0.1 | 1.1 | 1.2 |
| Galaktose | 0.3 | 0.9 | 1.2 |
| Glucose | | 0.4 | 0.4 |
| Uronic acids | 3.2 | 3.4 | 6.6 |

The types and levels of carbohydrate in sunflower meal depends, to a high degree, on the technology of seed processing and the degree of dehulling or decortication and there is a very different data in literature available. According to literature data sunflower meal with 33% crude proteine contain 1-4% starch, 26-41% DF including 9-11% arabinoxylans, 18-23% cellulose, 9-10% lignins, 2-5% pectins (*Annon 2003; Chost 1997; Lević et. al.1992; Sredanović et. al. 2000)*. In order to develop techniques to counteract the antinutritive effects of soluble NSP, and understanding of their chemistry, physical properties and behavior on ingestion by monogastric is crucial.

No methods are currently available to fractionate DF because of the large diversity of fibre classes. There are two procedures routinely used for the determination of dietary fibre in animal feeds: the Wende method (crude fibre – CF) and the sequential procedure of Van Soest. Wende method is not accurate because CF contains various amount of several fibre classes, depending of the raw material analyzed: cellulose, pentosans (hemycellulose) and lignin. The Van Soest procedure obtains three fibre residues: fibres insoluble in neutral detergent (neutral detergent fibre =NDF), fibres insoluble in acid detergent (acid detergent fibre=ADF) and lignin insoluble in acid detergent (acid detergent lignin =ADL. The main adventage of this method is that from NDF, ADF and ADL it is possible to evaluate the hemicelluloses =NDF-ADF, the cellulose = ADF-ADL and the lignins =ADL *(Van Soest 1983)*.

Further work is required to characterise the type, levels and nutritive activity of the NSP and other DF component found in sunflower meal.

The NSP content of feedstuffs influences various aspects of animal performance. Their nutritional effects in monogastric animals are diverse and, in some cases, extreme. It is, however, generally conceded that the major detrimental effects of NSP are associated with the viscous nature of these polysaccharides, their phisiological and morphological effects on the digestive tract and the interaction with the microflora of the gut. Soluble fibre increases intestinal transit time, delays gastric emptying, delays glucose absorption, increases pancreatic secretion, and slows absorption, whereas insoluble fibre decreases transit time, enhances water holding capacity and assistt faecal bulking in non-ruminant animals *(Chost 1997; Montagne et.al. 2003)*. These include effects on voluntary feed intake, supply of available energy to the animal, including the digestibility and utilization of nutrients other than NSPs and gut and animal health. These effects can be attributed to the effects of NSPs on gut microorganisms, viscosity and water-holding capacity of the digesta. A high NSP level in the diet will have a diluting effect on the feed because of its low digestibility in monogastric animals *(Smits et. al.1996)*.

*Enzymes and NSP of sunflower meal*

Enzymes make it possible to upgrade the nutritional value of a feedstuff and can be added to feeds as "multi-enzyme" products that contain a variety of different activities or "specific-enzyme" products which are responsible for a single type of enzymatic activity based on a particular dietary substrate, such as NSP *(Acamovic 2001)*. Not only the total fiber content, but also the physical and chemical structure of fibrous polysaccharides and their anatomical arrangement within each specific ingredient, affects the accessibility of enzymes for digestion of nutrients *(Smits et. al. 1996)*. Undoubtedly, a total depolymerisation of the NSP require extremely complex enzyme activities. There are various types of fibre degrading or NSP breaking enzymes as mentioned in the Table 2. along with their individual enzyme activities, their substrates and end products.

*Table 2. Common feed enzymes to tackle NSPs (Annon 2003)*

| Enzyme | Individual Enzyme activities | Acts on | Releases |
|---|---|---|---|
| Cellulases | Endo-1,4-β-Glucanase | β-Glucan | Oligo-saccharides |
| | Exo-1,4-βGlucanase | Amorphous cellulose | Oligo-saccharides |
| (Cellulolytic Enzymes) | Exo-Cellobiohydrolase | Oligosaccharides/ Cellulose | Cellobiose |
| | β-Glucosidase | Oligosaccharides | Glucose |
| | Cellobiase | Cellobiose | Glucose |
| Hemicellulases | Endo-1,4-β-Xylanase | β-Xylan | Xylose |
| | β-Xylosidase | | |
| (Hemicellulolytic enzymes) | Arabinosidase | Branched Xylans | Arabinose |
| | Ferulic acid esterase | Lignified cell wall | Xylan |
| Pectinases | Pectinase | Pectins | |
| Other | Mannanase | Mannan | Mannose |
| | α-galactosidase | Raffinose, Stachyose, Verbascose | Galactose |

The efficacy of feed enzymes depends on their substrate specificity, activity and stability. Therefore, there is often great difficulty in selecting potentially useful enzymes available in the market. Selection of effective enzyme products for use in sunflower-containing diets require detailed knowledge of the substrates and their breakdown patterns in the gastro intestinal tract of the target species *(Malati et. al 2001)*. Commercialy many enzyme formulations are available which differ in their composition with respect to the number of individual enzymes and their activities *(Annon 2003)*. Selected microbial enzymes must degrade NSPs to an extent that can lower the viscosity in the intestine and improve feed utilization. Extensive research has revealed that enzyme usage increases the efficiency of utilization of the feed. It is now well documented that enzymes supplementation breaks NSP polymeric chains into smaller pieces, reduces the gut viscosity, and hence improves the nutritive value of fibrous feedstufs. By degrading the NSPs, enzymes release good amount of energy, protein and small amounts of other nutrients that are trapped in the viscous intestinal digesta *(Johnston et. al. 2003)*.

If the animal is going to benefit from feed enzymes, however, the digestive tract must be healthy so as to maximize the absorption of the released nutrients. The enzyme must also be stable and active at the pH and temperature found inside the digestive tract *(Acamovic 2001)*.

### *Enzyme enhancement of sunflower meal containig diets*

Supplementation of diets for monogastric animals with exogenous enzymes has been increasingly investigated and applied during the past decade as a means of enhansing production efficiency and increasing the effectiveness of nutrient utilisation. It has been demonstrated many times that the supplementation of animal diets with enzymes frequently exerts beneficial effects. The effectiveness of different enzymes in sunflower containing diets on animal production performances are showen in table 3.

*Table 3. Summary of tests with sunflower meal and enzymes in animal feeding*

| Animal species Source | Inclusion % of SFM | Enzymes | Results |
|---|---|---|---|
| Broilers<br>*(Meeusen 1997)* | SFM replaced<br>60 % SBM | Cellulase, protease, Lipase, α-amylase,<br>β-glucanase | BW + 8.3%<br>FCR + 2.7% |
| Broilers<br>*(Lević et.al 1999)* | 15 % SFM<br>(37.8 % CP) | Protease,hemicellulase,<br>Pectinase, β-glucanase | BW + 6.09%<br>FCR + 3.31% |
| Broilers<br>*(Salab 1999)* | 20 % SFM | Protease | SFM =SBM |
| Broilers<br>(*Sredanović et. al. 2000)* | 15 % SFM<br>(44 % CP) | Protease, hemicellulase,<br>pectinase, β-glucanase | BW + 8.36%<br>FCR + 2.84% |
| Broilers<br>*(Sredanović et. al. 2001)* | 10 % SFM<br>(33 % CP) | Cellulase, protease,Lipase, α-amylase,β-glucanase | BW + 10.23%<br>FCR + 8.15% |
| Layers<br>*(Schang et. al. 1998)* | 27.5 % SBM<br>39.6 % | Protease, cellulase | SFM =SBM |
| Layers<br>(Senkoyly et.al.1999) | 20 %SBM | Xylanase, β-glucanase,<br>pectinase | Bigger eggs<br>Less dirty eggs |
| Layers<br>*(Salab 1999)* | SFM replaced<br>35 % SBM | Protease | SFM =SBM |
| Pigs<br>*(Isakov et. al. 1993)* | 13 % SBM<br>44 %CP | Protease, hemicellulase,<br>pectinase, β-glucanase | DWG + 6.2 %<br>FKR + 5.5 % |
| Pigs<br>*(Valchev 1996)* | 15 % SBM<br>37 % CP | β-glucanase, cellulase<br>protease, lipase | DWG + 6.2 %<br>FKR + 3-14 % |
| Pigs<br>*(Meussen 1997)* | 10% SBM | β-glucanase, cellulase<br>protease, lipase | DWG + 7.5 %<br>FKR + 4 % |
| Pigs<br>*(Lević et.al. 2000)* | 8% SBM<br>44%CP | Protease, hemicellulase,<br>pectinase, β-glucanase | DWG + 8.5 %<br>FKR + 2.2 % |

SFM-sunflower meal, SBM-soybean meal; CP-crude protein; BW-body weight;
FCR-feed conversion ratio; DWG-daily weight gain

Investigated enzymes products affects better digestibility of sunflower meal containing diets, upgraded production performances of animals and make it possible to use more sunflower meal in monogastric animals feeding.

### *Conclusion*

In order to develop techniques to counteract the antinutritive effects of soluble NSP, and understanding of their chemistry, physical properties and behavior on ingestion by monogastric is crucial. Further work is required to characterise the type, levels and nutritive activity of the NSP and other DF found in sunflower meal.

It has been demonstrated many times that the supplementation of animal diets with enzymes affects better digestibility of sunflower meal containing diets. The efficacy of feed enzymes depends on their substrate specificity, activity and stability. Therefore, there is often great difficulty in selecting potentially useful enzymes available in the market.

Investigated enzymes products affects better digestibility of sunflower meal containing diets, upgraded production performances of animals and make it possible to use more sunflower meal in monogastric animals feeding.

## POVEĆANJE NUTRITIVNE VREDNOSTI SUNCOKRETOVE SAČME ENZIMIMA

*Slavica Sredanović, Jovanka Lević, Olivera Đuragić*

*Rezime*

Nutritivna vrednost suncokretovih proteinskih hraniva umnogome zavisi od tehnoloških procesa prerade (izdvajanje ulja, pritisak, temperatura) koji se koriste za dobijanje ulja. Ukoliko se radi o tehnologiji dobijanja ulja koja kao nuzproizvod daje suncokretovu sačmu unapređenjem tehnološkog postupka prerade moguće je postići da ona sadrži 44%, pa čak i više sirovih proteina, ali i dalje ostaje problem visokog sadržaja sirove celuloze (12 %) i nesvarljivosti neskrobnih polisaharida (NSP) suncokretove sačme od strane monogastričnih životinja i smanjene svarljivosti ostalih sastojaka zarobljenih u vlaknastoj strukturi ćelija ljuske i ćelijskih zidova jezgra suncokreta.

Upotrebom različitih kombinacija enzima prilagođenih specifičnom obroku moguće je razbiti ugljenohidratne polimere suncokretove sačme i povećati njihovu svarljivost. Enzimi su ekstremno moćni katalizatori, ali visoko specifični u pogledu vrste supstrata i opsega temperature i pH u kome deluju, pa se na izbor vrste i kombinacije enzimskih preparata mora obratiti posebna pažnja, uzimajući u obzir fiziološke karakteristike životinja i karakteristike sirovina i aditiva u obroku.

U radu su, pored osnovnih hemijskih karakteristika, prikazani rezultati ispitivanja sastava ugljenohidratnog kompleksa i sadržaja NSP suncokretovog semena i suncokretove sačme. Dat je i pregled rezultata naših istraživanja i podataka iz literature vezanih za efekte dodavanja različitih enzimskih preparata i njihovih kombinacija u obroke sa suncokretovom sačmom. Ispitivani enzimski kompleksi utiču na povećanje svarljivosti suncokretove sačme, odnosno njenih sastojaka, poboljšavaju proizvodne karakteristike hranjenih životinja i pružaju mogućnost uključivanja veće količine suncokretove sačme u smeše za ishranu monogastričnih životinja.

*Literature*

19. ACAMOVIC, T. (2001): Commercial Application of Enzyme Technology for Poultry Production, Worlds Poultry Science Journal, 57, 225-242.
20. ANON.: Maximising Profits in Poultry Farming, www.vetcareindia.com
21. CHOCT, M. (1997): Feed Non-Starch Polysaccharides: Chemical Structures and Nutritional Significance, Feed Milling International, June Issue, 13-26.
22. DELIĆ, I., RAC, M., STOJSAVLJEVIĆ, T., DUTINA, B., IVIĆ, M., VUČUREVIĆ, N., MILIĆ, B., VLAHOVIĆ, M. (1971): Fizička svojstva, hemijski sastav i hranljiva vrednost suncokretovih sačmi sa visokim sadržajem proteina Savremena poljoprivreda, posebno izdanje br.10, 1-37.
23. DELIĆ I., LEVIĆ, J. SREDANOVIĆ, S., (1992): Standard and improved sunflower meal containing 44% crude protein-production, chemical composition, nutritive value, 33. Savetovanje Proizvodnja i prerada uljarica, Sutomore, Zbornik radova, 268-287.
24. ISAKOV, V., LEVIĆ, J., SREDANOVIĆ, S., IVIĆ, M. (1993): Enzimi kao korektiv hranljive vrednosti suncokretove sačme u smešama za prasad, Savetovanje o unapređenju uljarstva Jugoslavije, Lepenski Vir, Zbornik radova, 341-351.

25. JOHNSTON, L.J., NOLL, S., RENTERIA, A., SHURSON, J. (2003): Feeding By-Products High in Concentration of Fiber to Nonruminants, Third National Symposium on Alternative Feeds for Livstock and Poultry held in Kanzas City, November 4, 2003. Email:johnstlj@mrs.umn.edu
26. LEVIĆ, J., DELIĆ, I., IVIĆ, M. STEFANOVIĆ, S., (1992): Removal of cellulose from sunflower meal by fractionation JAOCS, 69, 890-893,
27. LEVIĆ, J., RADOJIČIĆ, D., LEVIĆ LJ., SREDANOVIĆ, S.(1994)[a]: Separation of sunflower meal with 38% of raw proteins in a special procedure (ball mill + centrifugal screen), International conference "Modern feedmilling – prospects for development", Moscow, Russia, Proceeding 38.
28. LEVIĆ JOVANKA, RADOJIČIĆ D., SREDANOVIĆ SLAVICA, PRODANOVIĆ OLIVERA (1994)[b]: Electrostatic separation of sunflower meal, International conference "Modern feedmilling–prospects for development", Moscow, Russia, Proceeding 14.
29. LEVIĆ, J., RADOJIČIĆ D., SREDANOVIĆ, S., LEVIĆ LJ. (1998): Technological procedures for enhancing the production of high protein content sunflower meal, Advances in Oils and Fats, Antioxidants and Oilseed By-Products, S.S. Koseoglu, K.C. Rhee, and R.F. Wilson (eds.), AOCS Press, Champaign, Ilinois, USA, 104-107.
30. LEVIĆ, J., SREDANOVIĆ, S.(1999): Enzymes in Broiler Chichen Feeding, Biotehcnology in Animal Husbandry, 15, 5-6,.297-302.
31. LEVIĆ, J., SREDANOVIĆ, S. (2000): The use of enzymes in pig diets containing sunflower meal, 3rd European Symposium on Feed Enzymes, Noordwijkerhout, Netherlandes, 68.
32. LUSAS,E.(1985): New protein food sunflower seed protein, Acad.Press, 393-433.
33. MALATHI, V., DEVEGOWDA, G. (2001): In Vitro Evaluation of Nonstarch Polysaccharide Digestibility of Feed Ingredients by Enzymes, Poultry Science 80, 302-305.
34. MEEUSEN, A. (1997): Enzymes, 3rd.East/West Feed Industry Conference and Exhibition, Prague, Czech Republic, June 25, Proceeding,1-4.
35. MONTAGNE, L., PLUSKE, J.R., HAMPSON, D.J.(2003) : A review of interactions betwen dietary fibre and the intestinal mucosa, and their consequences on digestive health in young non-ruminant animals, Animal Feed Science and Technology, Vol.108, 1-4, 95-117.
36. SALAB, E. (1999): Feeding Sunflower Meal, Poultry International, 11, 48-50.
37. SCHANG, M. J., AZCONA J.O.(1998): Performance of Laying Hens Fed a Corn-sunflower Meal Diet Supplemented with Enzymes, Biotechnology in the Feed Industry, Proceeding of Alltech`s annual Symposium, 405-409.
38. SENKOYLU, N., DALE, N. (1999): Sunflower meal in poultry diets: A review. World Poltry Science Journal, 56, 153-174.
39. SMITS, C.H.M., ANNISON, G. (1996): Non-starch plant polysaccharides in broiler nutrition – towards a physiologically valid approach to their determination, World`s Poultry Science Journal, Vol 57, s. 204-221.
40. SREDANOVIĆ, S., LEVIĆ, J.(2000): Dodavanje enzima u obroke sa suncokretovom sačmom, 41. Savetovanje Proizvodnja i prerada uljarica, Miločer, Zbornik radova,133-147.
41. SREDANOVIĆ, S., LEVIĆ, J.,ŠANTA Š., RAC M, HARTING, E. (2001): "Dijaprot 33 F" i "Dijaprot 33 E" u ishrani pilića, , 42. Savetovanje industrije ulja "Proizvodnja i prerada uljarica", Herceg Novi, Zbornik radova, 107-111.
42. VALTCHEV,G.(1997):Uticaj dodavanja multienzimskih preparata"Kemin" u ishrani svinja, VII Simpozijum tehnologije stočne hrane, Tara, Zbornik radova, 43-45.
43. VAN SOEST, P.J. (1983): Definition of fibre in animal feeds. In: Recent Advances in Animal Nutrition, Butterworts, London, 71-86.
44. VILLIAMDAE, M.J. AND SAN JUAN, L.D. (1989): Effect of chemical composition of sunflower seed meal on its true metabolizable energy and amino acid digestibility, Poultry Science, 77, 1884-1892.
45. WALDROUP, W., HILLARD, C.M., MITCHELL, R.J. (1970): Sunflower meal as a protein supplement for broiler diets Feedstuffs, Vol. 42, 43, p. 41.