EUROPEAN CHITIN SOCIETY

NEWSLETTER

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- Glucosamine for treatment of osteoarthritis – fact or fiction?
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EDITORIAL

In my previous editorial, which also happened to be my first, I pointed out that in order to publish two Newsletters a year it is crucial that the members of the Society contribute to the contents. Perhaps naively I had thought I might end up in the position of having to select some contributions and turn down others due to lack of space, and so inadvertently annoy some members. Unfortunately this has so far not turned out to be the case.

Obviously we are all busy but most people have at least one particular issue that they consider important, I have several, and if these relate to chitin/chitosan the Newspaper is the place to air them and, hopefully, get some responses. So please get on your keyboards and submit them well in advance of our next scheduled publication in July 2006. Two such items are included in this issue.

Later this year the European Chitin Society is host to the 10th International Conference on Chitin/Chitosan which will be held in Montpellier, France as a joint meeting with our own EUCHIS '06. Some additional details are given by the Conference Chairman, Professor Eric Guibal. There is also an outline account of last year's national chitin conference held by Polish Chitin Society.

George Roberts
Honorary Secretary

GLUCOSAMINE FOR TREATMENT OF OSTEOARTHRITIS - FACT OR FICTION?

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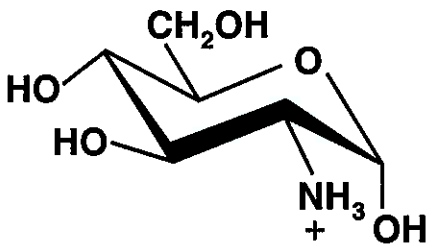
With the large increase in the public interest of glucosamine in relation to its use as a remedy for osteoarthritis in the late 1990's, and chitin producers experienced that their main customers were no longer chitosan producers but glucosamine producers. Many chitosan-researchers, including myself, may be reluctant to accept this shift in the interest from chitosan to glucosamine, perhaps a not so exciting monosaccharide. However, it could be of interest to look into the reasons to the increasing interest in the monosaccharide glucosamine in relation to its application for treatment of osteoarthritis. The following is written from the perspective of a chitosan researcher in relation to the use of our (limited) chitin resources.



Chemical structure of D-glucosamine (α-anomer in its protonated form)

Osteoarthritis is a common problem as people get older and the largest cause of chronic disability in the elderly, with an estimated 21 million adults suffering only in the United States. Osteoarthritis occurs when the cartilage in joints (e.g. knees) wears down and the bones start to rub together, which causes pain and a loss of range of motion in the joint. The increasing percentage of elderly in the developed countries has not escaped the attention of the big pharmaceutical companies, which sell a range of products in this marked, including the Non-Steroidal Anti-Inflammatory Drugs (e.g. ibuprofen, acetylsalicylic acid), commonly referred to by the acronym NSAIDs. There is no doubt that drugs for treatment of osteoarthritis is a very large and increasing marked, and that glucosamine seems to have taken its share of this market. However, there are different views to whether glucosamine is effective and safe in relation to treatment of osteoarthritis, to how it compares with other therapies, and to the quality of the glucosamine sold in health-food stores (for recent literature reviews, see e.g. Anderson et al., *Food and Chemical Toxicology*, 43 (2005) 187-201; Brandt & Mazzuca, *Arthritis & Rheumatism*, 52 (2005) 3349-3359). It has been noted that many of the industry-sponsored trials with glucosamine-sulphate were performed by an Italian pharmaceutical company that manufactures a patent-protected formulation which is distributed in Europe as a drug (McAlindon, *Rheumatic Disease Clinics of North America*, 29 (2003) 789-801)). In the United States, glucosamine preparations are purchased from global suppliers and are sold as nutritional supplements not regulated as drugs and may therefore vary in their content of glucosamine. However, the quality of nutritional supplements in the United States is also regulated (http://www.supplementquality.com/links/dshea.html).

Glucosamine products are sold in different salt forms, and the most common counterions (see figure on the chemical structure of glucosamine) are chloride and sulphate.

This means that the content of glucosamine varies in different products, as the labels state the amount of the actual glucosamine salt per tablet.

A study that was published in The Lancet in 2001 has helped promote glucosamine for treatment of osteoarthritis. This study reported the results of a double-blind clinical trial with osteoarthritis patients who took either glucosamine or a placebo for 3 years, showing that symptoms improved significantly in the glucosamine group while they worsened slightly in the placebo group. Moreover, x-ray examinations of the patients knees suggested progression of the disease (Reginster et al. *Lancet* (2001) 357, 251).

At The American College of Rheumatology Annual Scientific Meeting in San Diego on November 12 - 17, 2005 (see http://www.rheumatology.org), new results from two studies (GAIT % GUIDE) related to glucosamine and osteoarthritis were presented. European researchers reported results (GUIDE) involving 318 patients that received treatment of glucosamine sulfate, acetaminophen (a NSAID) three times a day, or a placebo. Patients could also take another NSAID (ibuprofen) if they needed extra relief. Those taking glucosamine sulfate and acetaminophen both reported improvement in pain, but glucosamine sulfate appeared to deliver the best relief.

Results from the recently completed GAIT Study in the United States, which is sponsored by The National Center for Complementary and Alternative Medicine (NCCAM) of the National Institutes of Health (NIH) and involved 1600 patients with knee osteoarthritis were also presented at the meeting in San Diego in November last year. In this study, patients received either glucosamine hydrochloride or sodium chondroitin sulfate, both supplements, the pain reliever celecoxib (a NSAID), or a placebo. All patients were allowed to take acetaminophen to control severe pain. The researchers concluded in their presentation at the San Diego meeting that glucosamine might help patients with moderate to severe osteoarthritis of the knees in relieving their pain, while mild osteoarthritis patients had no effect of glucosamine. However, when the paper was presented, questions were raised regarding the statistical significance of the results, and the National Institute of Arthritis and Musculoskeletal and Skin Diseases are refraining to comment on the study until the full results are published in the peer-reviewed literature.

It may well be that the commercial marked for glucosamine will continue to increase more rapidly than the chitosan marked, if the new and promising results of glucosamine in relation to treatment of osteoarthritis are published and made available to the growing fraction of elderly people in the developed countries. It can be speculated that the the big pharmaceutical companies are worried about the results suggesting that an inexpensive health product as glucosamine with few side effects is more effective than prescription drugs, and that they will continue to question the effect of a product that is sold from health-food stores. If a significant fraction of the estimated 21 million adults in the United States that live with osteoarthritis can be convinced to take 1.5 grams of glucosamine each day, chitin producers may well see a sudden increase in the value of their chitin.

(The author is grateful to Dr. Paul Sandford for comments and for informations from The American College of Rheumatology Annual Scientific Meeting in San Diego on November 12 -17, 2005)

NOMENCLATURE FOR CHITIN AND CHITOSAN

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Currently there is no standard nomenclature system used with chitin and chitosan although each term is used to describe a series of copolymers covering a range of compositions rather than discrete chemical entities.

- There is no universally accepted distinction between chitin and chitosan with some authors basing this solely on the chemical composition of the sample regardless of its properties and behaviour.
- There is no agreement over the term to be used for one of the most fundamental structural characteristic namely the concentration of *N*-acetyl-**D**-glucosamine residues in the sample. Indeed in a fairly recent volume of "Proceedings" various authors used a total of more than 12 different terms for this parameter.
- There is no agreed 'shorthand' method to describe fully the composition and preparative history of a sample of chitosan.

In issue number 1 of the *European Chitin Society Newsletter* I proposed a system to deal with most of the above problems and while a number of researchers have used some of those proposals there has been no progress towards any consensus. I am therefore putting them forward again, somewhat modified in part, with the intention of starting a serious discussion of the subject. It would be good if the European Chitin Society would take a leading part in establishing a nomenclature system for chitin and chitosan that was acceptable world-wide.

1. Polymers covering the composition range between and including the homo-polymers poly[β-(1→4)-2-acetamido-2-deoxy-**D**-glucopyranose] and poly[β-(1→4)-2-amino-2-deoxy-**D**-glucopyranose] are to be named as chitin or chitosan depending on their insolubility or solubility respectively in 0.1 M acetic acid, and not on their composition. Following this rule the water-soluble product obtained when chitin is approximately 50% deacetylated under homogeneous conditions would be called water-soluble chitosan and not water-soluble chitin.

2. In structural terms the emphasis should be on the concentration of *N*-acetyl-**D**-glucosamine residues rather than the concentration of **D**-glucosamine residues. The concentration of the former is expressed as a mole fraction and given the symbol F_A. While a similar concept could be used to describe the mole fraction of **D**-glucosamine residues, and given the symbol F_D, it is preferable to use $(1-F_A)$.

3. The composition of the polymer may be given in 'shorthand' form by a final figure, in brackets, that denotes the F_A value of the sample. This covers the composition range from chitin[1.00] to chitosan[0.00] while recognising that these two homo-polymers are also named systematically as poly[β-(1→4)-2-acetamido-2-deoxy-**D**-glucopyranose] and poly[β-(1→4)-2-amino-2-deoxy-**D**-glucopyranose].
Examples:

a) An acid-insoluble material having 35% of its sugar residues deacetylated would be chitin[0.65].
b) An acid-soluble material having 75% of its sugar residues deacetylated would be chitosan[0.25].

3. If the deacetylation process is carried out under homogeneous conditions this is indicated by an italicised '*h*' immediately after the number giving the mole fraction of the *N*-acetyl-**D**-glucosamine units in the chain.
Examples:
a) A material have 50% of its sugar residues deacetylated under heterogeneous conditions, and hence normally insoluble in 0.1 M acetic acid, would be chitin[0.50].
b) A material have 50% of its sugar residues deacetylated under homogeneous conditions and water-soluble, hence presumably soluble in 0.1 M acetic acid, would be chitosan[0.50*h*].

4. The composition of *N*-acyl derivatives of chitin or chitosan, as defined in (1) above, is given by a figure denoting the mole fraction of *N*-acetylated units in the starting chitin or chitosan, together with a figure, or figure(s), denoting the mole fraction(s) of the *N*-acylated unit(s). The figure for the mole fraction of *N*-acetylated units in the starting chitin or chitosan is given first, followed by the figure(s) for the mole fraction(s) of *N*-acylated unit(s). When there are two or more different types of *N*-acylated units, in addition to any *N*-acetylated units, the numbers denoting the mole fractions are given, after the figure for the mole fraction of *N*-acetylated units, in the same order as the alphabetical order of the *N*-acyl groups. Again any homogeneous *N*-acylations are indicated by *h*.
Examples:
a) A sample of chitosan[0.10], produced by heterogeneous deacetylation and subsequently re-*N*-acetylated under homogeneous conditions to give a product having 48% of its sugar residues *N*-acetylated would be *N*-acetylchitosan[0.10/0.38*h*].
b) A sample of chitosan[0.20], produced heterogeneously and subsequently reacted with propionic anhydride under homogeneous conditions giving a product having in total 55% of it sugar units *N*-acylated would be *N*-propionylchitosan[0.20/0.35*h*].
c) A sample of chitosan[0.15], produced heterogeneously and subsequently reacted with propionic anhydride under homogeneous conditions to give a product having a total of 35% of its sugar units *N*-acylated, then further reacted with hexanoic anhydride under homogeneous conditions to give a product with a total of 60% of its sugar units *N*-acylated would be *N*-hexanoyl-*N*-propionylchitosan[0.15/0.25*h*/0.20*h*]. Note that even if the final product is insoluble in 0.1 M acetic acid it is still designated as a chitosan derivative since the starting material, chitosan[0.15], was soluble in acid.

I hope that this article will lead to a discussion out of which a systematic nomenclature can be developed and eventually taken up by the chitin community world-wide.

Thesis Abstract

Gustav VAAJE-KOLSTAD

Title: The chitinolytic machinery of *Serratia marcescens* – the catalytic mechanism of chitinase B and the function of the chitin-binding protein CBP21

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Summary

The annual production of chitin in the biosphere has been estimated to amount to 10^{11} tonnes, however little chitinous material accumulates in the environment. This is mainly due to the existence of highly effective chitin-degrading microorganisms that employ batteries of chitin degrading enzymes (chitinases) for the purpose of chitin utilization. One of the most efficient chitin degraders is the enterobacterium *Serratia marcescens* that uses a combination of three family 18 chitinases (ChiA, ChiB and ChiC), an N-acetyl-β-hexosaminidase and a chitin-binding protein to process chitin. The high chitinolytic activity of *S. marcescens* has made this bacterium a model organism for studying chitin degradation and this has resulted in detailed characterisation of the chitinases, the *N*-acetyl-β-hexosaminidase and the chitinolytic system in general. The goal of the work described in the thesis was to increase understanding of the catalytic mechanism of family 18 chitinases and to unravel the role of the chitin-binding protein, CBP21 in chitin degradation.

Catalysis by family 18 chitinases was studied by X-ray crystallography and enzyme kinetics using ChiB wild type and mutants, as well as various inhibitors. The catalytic domain of family 18 chitinases has a TIM-barrel ($(\beta/\alpha)_8$) fold that contains the characteristic DXDXE sequence motif, which in ChiB includes Asp140, Asp142 and the catalytic acid Glu144. Asp142 has in previous studies been shown to play an important role in catalysis where it is involved in substrate distortion and stabilisation of the transition state of the reaction. The first paper of the thesis (1) describes the structure of the D142N mutant in the apo-form and in complex with allosamidin, a potent chitinase inhibitor (K_i in the nM range). Kinetic and inhibition data obtained for the mutant and wild type at pH values ranging from 3 to 10 showed that inhibition by allosamidin was pH dependent and that the D142N mutant had a generally reduced affinity for the inhibitor. Comparison of wild type and D142N structures in complex with allosamidin showed that the reduction in affinity was mainly caused by alteration of the electrostatic environment in the active site and not by structural changes. As the pH-dependent affinity for allosamidin did not correlate with k_{cat}, it was concluded that allosamidin is a mimic of a reaction intermediate rather than of the transition state. The second paper of the thesis (2) describes the interactions of HM508, a designed inhibitor, with ChiB. HM508 acts as a competitive inhibitor of ChiB with a K_i in the 50 μM range. The structure of ChiB in complex with HM508 showed the two sugar moieties of the inhibitor bound to the -2 and -1 subsites, whereas the designed part of the inhibitor (a phenylcarbamate group) was interacting with the aromatic side chains that line subsites +1 and +2. The interaction of the phenylcarbamate group was shown to be important for inhibitor binding, as Trp→Ala mutations in the +1 and +2 subsites decreased the affinity of the inhibitor. Interestingly, the wild type enzyme hydrolysed the inhibitor upon longer incubations, leaving a degradation product of HM508 (a chitobiono-δ-lactone) bound to subsites -2 and -1. The

conformation of the sugar bound in the -2 subsite was essentially identical to the corresponding sugar in the structure of an inactive mutant of ChiB in complex with an *N*-acetylglucosamine pentamer (3). The sugar bound in the -1 subsite showed the ^4E conformation that has been predicted for the transition state of the hydrolytic reaction. Since the chitobiono-lactone is highly unstable in solution, the observation of this state in the active site shows that the active site is optimised for binding a conformation of the -1 sugar that resembles the proposed transition state of the reaction.

In addition to secreting chitinases, *S. marcescens* also secretes a small chitin-binding protein (CBP21) when growing on chitin. It had earlier been shown that CBP21 binds specifically to β-chitin, but its role and function in chitin degradation had not yet been revealed (4). The third paper of the thesis (5) describes the crystal structure of CBP21, which is the first structure to be solved of a family 33 carbohydrate binding module. The structure shows a budded fibronectin type-III fold consisting of a compact β-sheet sandwich with a 65-residue bud made up of three short helices (Fig. 1). Several conserved aromatic residues that previously had been postulated to be important for chitin binding were surprisingly found in the interior of the protein, seemingly unable to interact with chitin. Combined sequence and structure analysis revealed a group of conserved, mainly polar residues, on the surface. The role of six residues on the conserved surface patch was probed my site-directed mutagenesis and subsequent binding studies. All mutants showed reduction in chitin affinity (3-8 fold), indicating that the conserved surface area is important for chitin binding and that binding mainly occurs through solvent-exposed, polar side chains. The fourth paper of the thesis (6) describes experiments demonstrating the function of CBP21. Chitin degradation assays using combinations of the *S. marcescens* chitinases and CBP21 showed that the chitin-binding protein strongly promoted hydrolysis of crystalline β-chitin by chitinases A and C, while it was essential for full degradation by chitinase B. Scanning electron microscopy of β-chitin particles incubated in the absence and presence of CBP21 showed disruption of the chitin structure by CBP21, indicating that the function of the protein is to render chitin more accessible for the chitinases, thus increasing chitinase efficiency (Fig. 2). The most efficient conversion of chitin to chitobiose was obtained when all three *S. marcescens* chitinases and the CBP21 protein worked together. Interestingly, homologues of CBP21 occur in most chitin-degrading microorganisms, suggesting a general mechanism by which chitin-binding proteins enhance chitinolytic activity.

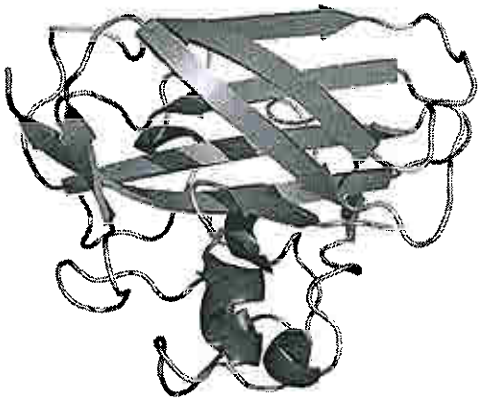


Figure 1. The structure of CBP21 showing a budded FnIII-like fold .

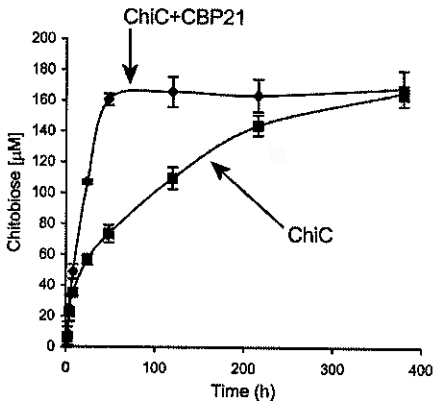
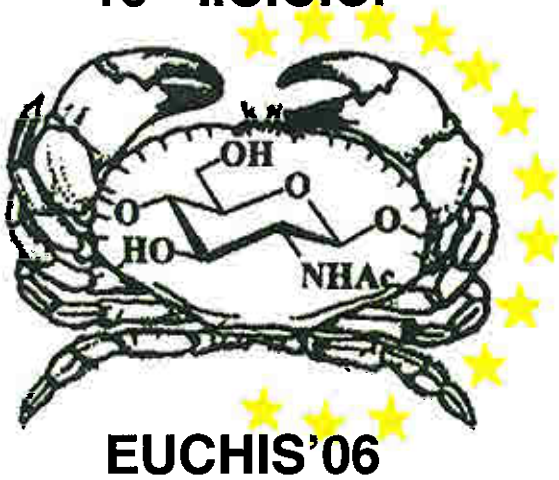


Figure 2. Degradation of β-chitin by ChiC from *Serratia marcescens* in the absence or presence of CBP21.

1. Vaaje-Kolstad, G., Houston, D. R., Rao, F. V., Peter, M. G., Synstad, B., van Aalten, D. M., and Eijsink, V. G. (2004) *Biochim Biophys Acta* **1696**(1), 103-111
2. Vaaje-Kolstad, G., Vasella, A., Peter, M. G., Netter, C., Houston, D. R., Westereng, B., Synstad, B., Eijsink, V. G., and Van Aalten, D. M. (2004) *J Biol Chem* **279**(5), 3612-3619
3. van Aalten, D. M. F., Komander, D., Synstad, B., Gaseidnes, S., Peter, M. G., and Eijsink, V. G. H. (2001) *Proc. Natl. Acad. Sci. USA* **98**(16), 8979-8984.
4. Suzuki, K., Suzuki, M., Taiyoji, M., Nikaidou, N., and Watanabe, T. (1998) *Biosci Biotechnol Biochem* **62**(1), 128-135
5. Vaaje-Kolstad, G., Houston, D. R., Riemen, A. H., Eijsink, V. G., and van Aalten, D. M. (2004) *J Biol Chem*
6. Vaaje-Kolstad, G., Horn, S. J., van Aalten, D. M., Synstad, B., and Eijsink, V. G. (2005) *J Biol Chem* **280**(31), 28492-28497

10th I.C.C.C.



EUCHIS'06

The European Chitin Society, the Alès School of Mines and the University of Lyon are happy to invite you to attend the joint meeting 10th International Conference on Chitin & Chitosan (10th I.C.C.C)-Euchis'06 to be held from 6 to 9 September 2006 in Montpellier (France). The 10th I.C.C.C., organized every three years, will take place at Le Corum (the conference center of the City of Montpellier).

This is a unique opportunity for the Chitin & Chitosan Scientific Community to get together and share basic and applied research on these biopolymers. Contributions are invited on topics such as: sources and production, biological and ecological aspects, enzymatic, chemical, physical and physico-chemical aspects, applications in life sciences (food, agriculture, medicine, biotechnology, pharmacy, enzymology, genetics ...), applications in industry (environment, waste-water treatment, paper-making, textiles ...).

Social events provisionally include a visit of the medieval town of Aigues-Mortes (Saint Louis and the Crusades), Salines (salt-production) and a banquet at the Domaine du Grand Malherbes (http://www.camargue.fr/grandmalherbes/)

Deadlines:

Abstracts:	April 30., 2006
Registration at reduced rate:	May 31., 2006
Payment in full:	June 30., 2006

For more details on the organization of this event and for on-line registration and submission of abstracts: http://10thICCC.ema.fr

Eric Guibal, The Alès School of Mines, Eric.Guibal@ema.fr

11TH ANNUAL CONFERENCE OF THE POLISH CHITIN SOCIETY

The Polish Chitin Society must be among the most active national chitin society, certainly in the western hemisphere, and much of the credit for its creation and development must go to the late Professor Henryk Struszczyk. The Society's activities include the holding of an annual conference and the 2005 conference was held on 14-16th September in Kazimierz Dolny, a small town on the Vistula river about 100 Km south of Warsaw. It is a very picturesque town and a great favourite with artists, particularly painters.

Some 40+ researchers attended the conference and 29 papers were presented. These can be divided into four main categories: Biomedical; Agricultural; Degradation; and Physical Properties.

The biomedical papers represent the largest group and can be further divided into two sub-groups: fibrous wound dressings and pharmaceutical applications, together with an overview paper, *Medical applications of chitin and its derivatives*, by M H Struszczyk. The Polish nature of the conference is reflected in this group by the interest in dibutyrylchitin – *Biological assessment of dibutyrylchitin nonwoven dressings produced by polymer solution blowing* by I Krucińska, A Komisarczyk, D Paluch and J Szumilewicz, *Surgical knitted biomaterials with dibutylchitin threads* by E Kornobis, I Krucińska, B Wlodarczyk, L Szosland, J Ledwoń and A Komisarczyk, and *Accumulation of drugs in dibutyrylchitin porous fibres* by A Błasińska and L Szosland - and microcrystalline chitosan – *Influence of microcrystalline chitosan of high degree deacetylation on gene expression of the pyruvate kinase M2 isoenzyme in Ehrlich ascites tumor cells* in vitro, by J Ignacak, J Dulińska, I Palka and H Struszczyk, and *Microctystalline chitosan as pharmaceutical preparation* by K H Bodek. Other papers in the fibrous wound dressings are *Composite biomaterials containing chitosan and fibroin* by G Strobin, M Kucharska, D Ciechańska, D Wawro and S Sobczak, and *Chitosan-Alginate fibres for medical applications* by W Stęplewski, H Struszczyk, D Wawro, D Ciechańska, A Niekraszewicz and E Wesołowska. Other papers covering pharmaceutical applications are *The susceptibility of anaerobic bacteria to Metronidazole and low-molecular-weight chitosan: an* in vitro *study*, A Kędzia, B Kochańska, A Cedro and R Jachowicz; *The susceptibility of* Helicobacter pylori *strains to Metronidazole and low-molecular-weight chitosan: an* in vitro *study*, A Kędzia, M Wierzbowska, A Cedro, R Jachowicz and B Kochańska; In vitro *investigations on chitosan preparations on the digestive tract enzymes*, J Meler; *Investigation of the capacity of binding bile acid salts by various kinds of chitosans*, J Meler and J Pluta; and *The influence of PEG-200 on the release of Metronidazole from gels comtaining lactic acid complexed with chitosan*, K Małolepsza-Jarmołowska.

The papers on chitosan and agriculture are mainly studies on the effects of Biochikol 020 PC, a chitosan-based commercial product, on a variety of plants: *The effect of Biochikol 020 PC on microorganism communities in the rhizosphere of papilionaceous plants,* E Patkowska, D Pięta, A Pastucha, H Struszczyk and A Niekraszewicz; *Healthiness and yield of papilinaceous plants after applying Biochikol 020 PC*, D Pięta, E Patkowska, A

Pastucha and A Niekraszewicz; *Effect of Biochikol 020 PC, Tytanit and other preparations on the growth, healthiness and the yield of tomatoes cultivated in peat substrate,* J Borkowski, B Dyki and A Niekraszewicz; *Effect of Biochikol 020 PC, Tytanit and other preparations on the healthiness and the yield of Chinese cabbage,* J Borkowski, A Felczyńska, J Stępowski and A Niekraszewicz; *Role of chitosan in activation of* Trichoderma Viride *in soil*, C Skrzypczak and L Orlikowski; and *The effect of chitosan in American ginseng* (Panax Quinquefolium L.) *protection*, B Kołodziej.

The papers on degradation include studies on aspects of biodegradation, including deacetylation, as well as chemical and physical degradation and again the strong interest in Poland in dibutyrylchitin is apparent: *Study on catalytic ability of* Mucor *in the process of chitosan biodegradation*, K Struszczyk, M Szczęsna-Antczak, T Antczak, M Rzyska, S Bielecki and H Struszczyk; *Stability of chitin deacetylase*, M M Jaworska and E Konieczna; *Complex degradation of chitosan*, S Trzciński; *Alkaline treatment of dibutyrylchitin fibres: Fluorescence microscopy studies*, D Biniaś, S Boryniec, A Włochowicz and W Biniaś; *The impact of the thermal degradation of chitin on the deacetylation process*, A Wojtasz-Pająk; and *Ultrasonic degradation of dibytyrylchitin*, J Szumilewicz and B Pabin-Szafko.

The last group deals with a variety of physical properties: *Heat effects of water sorption by chitosan and its blend with HPC*, M Mucha, K Wańkowicz, S Ludwiczak and J Balcerzak; *Optical properties of chitosan in aqueous solution*, M Koralewski, H K Bodek, and K Marczewska; *The effect of plasticization on the degree of ordering of hydrogel structures in chitosan membranes*, W Maniukiewicz and Z Modrzejewska; *Efficiency of reactive dye adsorption onto chitin*, U Filipkowska.

The collected papers are to be published, **in English**, under the title "Progress on Chemistry and Application of Chitin and its Derivatives, vol. XI" and should be available from the Polish Chitin Society by September 2006. The anticipated cost will be about US$25 but will be free to all attendees at the 12th annual conference of the Polish Chitin Society to be held in Szczyrk in September 2006.

On a more personal note, not only is the late Professor Henryk Struszczyk a co-author of several papers presented at the conference but his son and his daughter were author and co-author respectively of papers, and his widow also attended the conference. This suggests that the Struszczyks have a very strong claim to being 'the First Family' of chitin science.

George A F Roberts