Separation of chitin-extracting alkaline processing stream for protein recovery

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Introduction

Chitin owns valuable properties of a biopolymer with plenty of useful applications. High environmental pollution during its production in industrial scale becomes a considerable issue hampering growth opportunities of this industry. By removal of proteins and minerals bound in shrimp shells conventionally using reagents NaOH and HCl, not only chitin will be recovered, but useful proteins accumulate in the alkaline chitin-extracting liquor consequently. This stream contributes a very high organic pollutant and causes highly energetic consumption for aeration systems in wastewater treatment plant. Besides the aspect of a sustainable use of resources, reduction of energetic and chemical loss is taken seriously into account. Is membrane filtration an efficiency process? Will recovered products cover criteria for reuse and respond the need on the market? How does this integrative approach affect the existing production and the wastewater treatment plant?

Material and Method

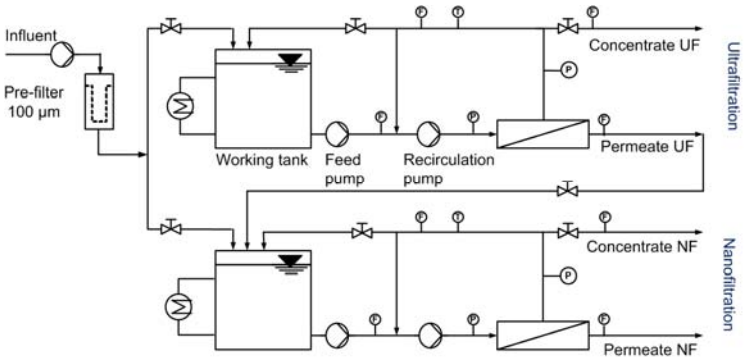

Figure 1 : Layout of investigated filtration in technical scale

For the evaluation of the process efficiency, membrane filtration was tested in a pilot plant (constructed by EnviroChemie, Germany) installed next to the industrial chitin production line (figure 1).

The trials were carried out at 70 °C with multi-channel ceramic membranes: ultrafiltration (UF) 0.1 μm (Atech, Germany), nanofiltration (NF) 450 D and < 300 D (Inopor, Germany). The transmembrane pressure was set to 1.3, 3 and 5 bar for UF, NF 450, NF < 300 respectively. Tangential velocity of 3.5 m/s was applied.

For characterisation of the separated product in view of potential protein supplement for animal feedstuff, concentrate samples were analysed for heavy metals (by AKIZ project laboratory), amino acids composition (by Sac ky Hai Dang Science and Technology JSC), macronutrients and food microbiology (by Can Tho University, Department of Animal Science).

Results and Discussion

Filtration efficiency of the investigated membranes at a volumetric permeate recovery of 80 % was presented in figure 2. Nitrogen content mostly bound to organic compounds, e.g. proteins increased 7 % – 16 % with reducing membrane cut-offs.

A significant retention of total nitrogen bound (TN_b) was observed: 35 %– 56 % rejected from the alkaline process stream and 8 % – 21 % reduced from the entire water volume which must be treated in the local wastewater treatment plant. COD removal appears to have the same tendency.

Among tested membranes, UF retained mostly suspended matter which exhibits an organic mass of 49 % and a nitrogen content of 35 %. It can be concluded that soluble or colloidal organic matter can be effectively accumulated using membranes of lower cut-offs.

NF 450 and NF < 300 exhibited an additional recovery of dissolved nitrogenous compounds of 17 % (52 % NF 450 – 35 % UF) and 21 % (56 % NF <300 – 35 % UF), respectively.

In addition, table 1 shows a high crude protein concentration (based on dry mass) and lysine-methionine ratio (essential amino acids) in concentrate streams of NF 450 and NF <300 compared with protein profile of soybean and fish meal. This predicts a potential reuse of the concentrate stream as protein supplement in animal feeding stuffs.

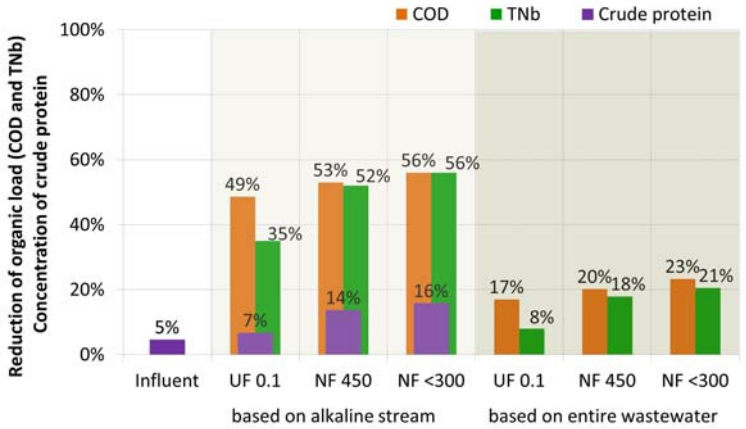

Figure 2: Reduction of organic load and concentration of crude protein concentrated by investigated membranes at a permeate recovery of 80 %

	UF	NF 450	NF <300	soybean	fish meal
Dry matter of liquid phase [%]	11.9	19.3	20.3		
Crude protein in solid phase[%]	59	66	77	43	66
Ratio Lysine/Methionine	4.1	2.7	2.2	4.0	2.5

Table 1: Properties of products extracted by selected membranes compared with conventional protein supplements (adopted from FAO 1997)

Conclusions

Ca. 6.7 – 13.7 – 16 %-wt. of crude protein can be accumulated from nitrogen rich process stream into product by corresponding UF 0.1, NF 450 and NF <300. Protein-rich concentrate is considered as alternative protein source for animal feeding. Furthermore, reuse of sodium hydroxide solution as organic fertilizer or direct utilization in the chitin production line helps reducing chemical and heating cost and limits discharge load to a connected wastewater treatment plant. This concept addresses a nearly zero discharge solution for the chitin industry and contributes to keep the eco-friendliness of chitin based products.

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