SUPERCRITICAL CO_2-EXTRACTION OF FATTY COMPOUNDS OUT OF BIOTECHNOLOGICAL PRODUCTS

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INTRODUCTION

For isolation of substances from biomass the first step to be done is separation of several matrix substances prior to extraction of substances of interest. Degreasing of the feed is a basic upstream extraction step.

The most common method for extraction of fatty compounds out of biomass is the use of liquid organic solvents. After extraction a large amount of solvent containing a small load of fat has to be processed. Distillation is a typical separation method for solvent recycle.

$scCO_2$ extraction offers two advantages: :

a.) Cell structure

High pressure treatment attacks the structure of the biomass during expansion of the "solvent". During expansion of the extractor pressure decreases faster than the CO_2 can diffuse through the cell material. Consequently overpressure inside the cells destroys the cell matrix. This effect results in advantages in extraction of PHA because the cell material is cracked. Figure 1 shows the image of disrupted cells after expansion.

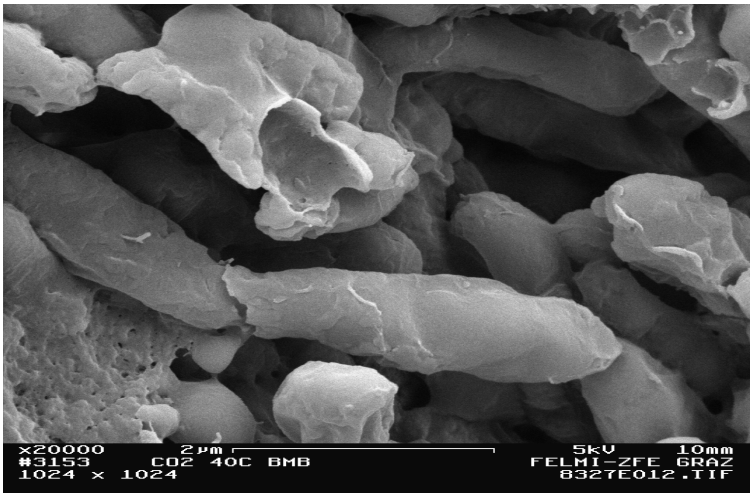

Figure 1: Disrupted Cells after $scCO_2$ Extraction

b.) Solvent recovery

Compared with solvent extraction the solvent recovery of a high pressure extraction step is much less energy consuming. For CO_2 recovery from the extract phase a pressure swing is needed only to decrease solubility of the valuable substances and separation of the solute. In degreasing biomass the pressure of the laden solvent is expanded to ambient conditions. As a consequence the laden solvent is split into the solid bulk solute and the gaseous solvent which is recycled. Further separation steps for removal of the solvent from the extract as well as from the solid residues are not necessary. The advantages of simple process design of $scCO_2$-extraction over conventional solvent extraction can be evaluated from the comparison of Figure 2 and Figure 3.

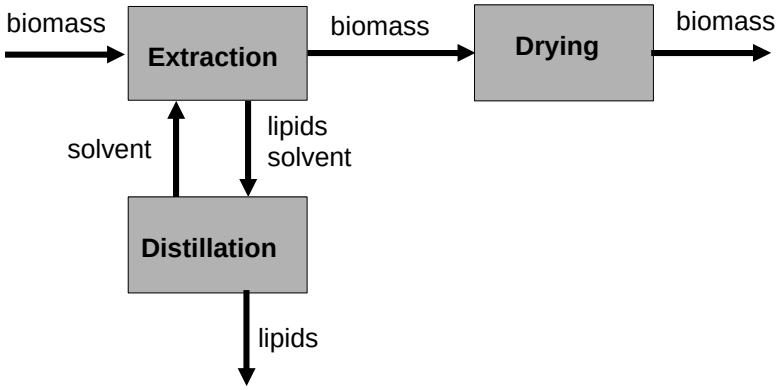

Figure 2: Extraction of Lipids with Organic Solvents

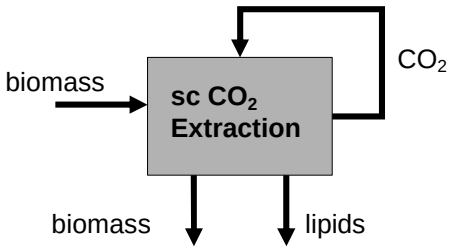

Figure 3: Extraction of Lipids with $scCO_2$

METHOD

The use of supercritical CO_2-extraction for separation of fats from biomass was tested in a 300ml extraction vessel. The extraction cylinder was fed with the biomass powder and after closing the top flange the vessel was set under operation pressure with carbon dioxide. The extraction vessel had a capacity of 15g biomass.
Through depressurisation the fats were collected in a sampling beaker. The CO_2 was not recycled. The experimental set up of the extraction unit is shown in Figure 4 and the schematic of the arrangement is shown in Figure 5.

Figure 4: Extraction Unit

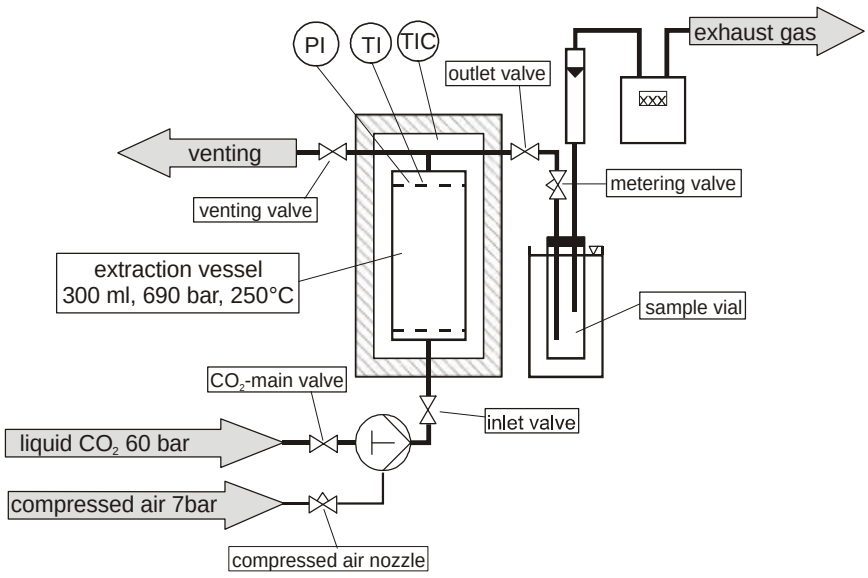

Figure 5: Scheme of the Extraction Unit

RESULTS

The extraction yield depends on the temperature extraction and on the pressure of extraction as well as on the water content of the biomass. For optimizing the degreasing step these parameters were varied. Extraction pressure was varied from 150 bar to 300 bar and extraction temperature from 40°C to 60°C.

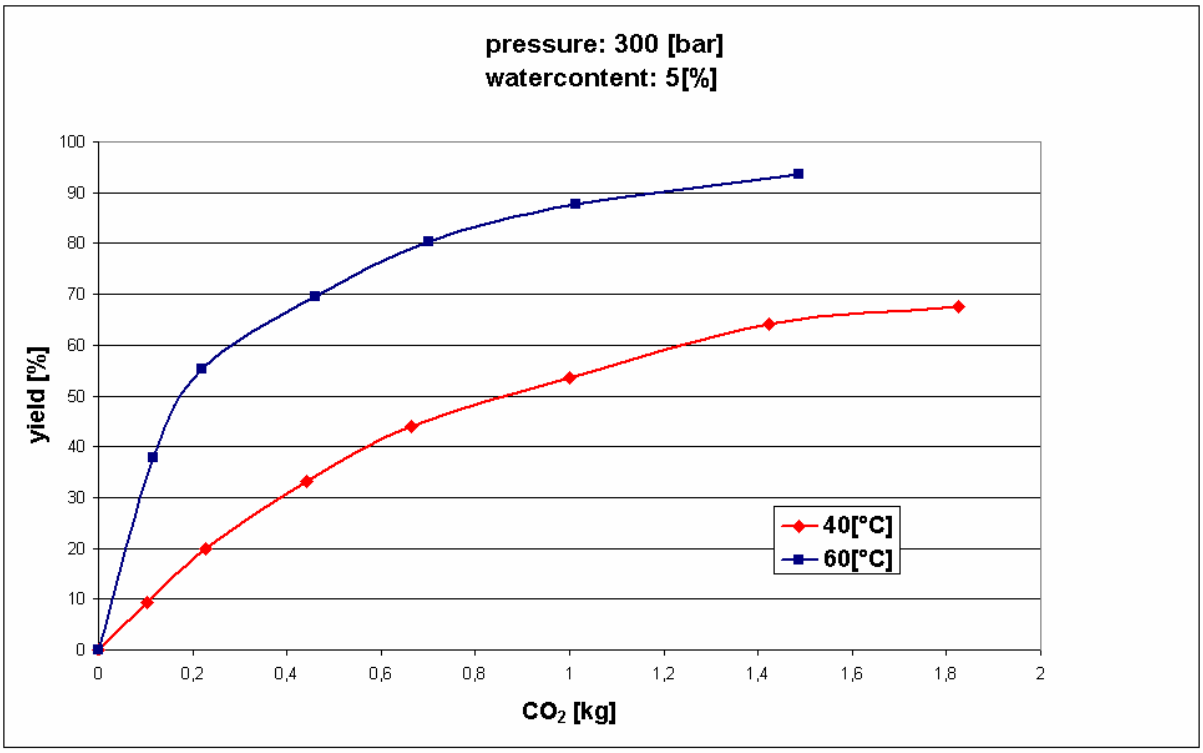

Figure 6: Extraction Yield of Lipids for Operation pressure of p = 300 bar and two Temperature Levels

The solubility and phase equilibrium can be varied in a wide range by changing pressure and temperature. The diagrams of Figures.6 to 8 show a typically trend of extraction yield over extraction time, respectively total CO_2 mass. In Figure 6 the effect of temperature on the extraction yield is compared for two operation temperatures.
Higher solubilities can be achieved by either raising extraction temperature or extraction pressure. As can be seen from Figure 7, the operation pressure has a strong influence on the extraction yield.

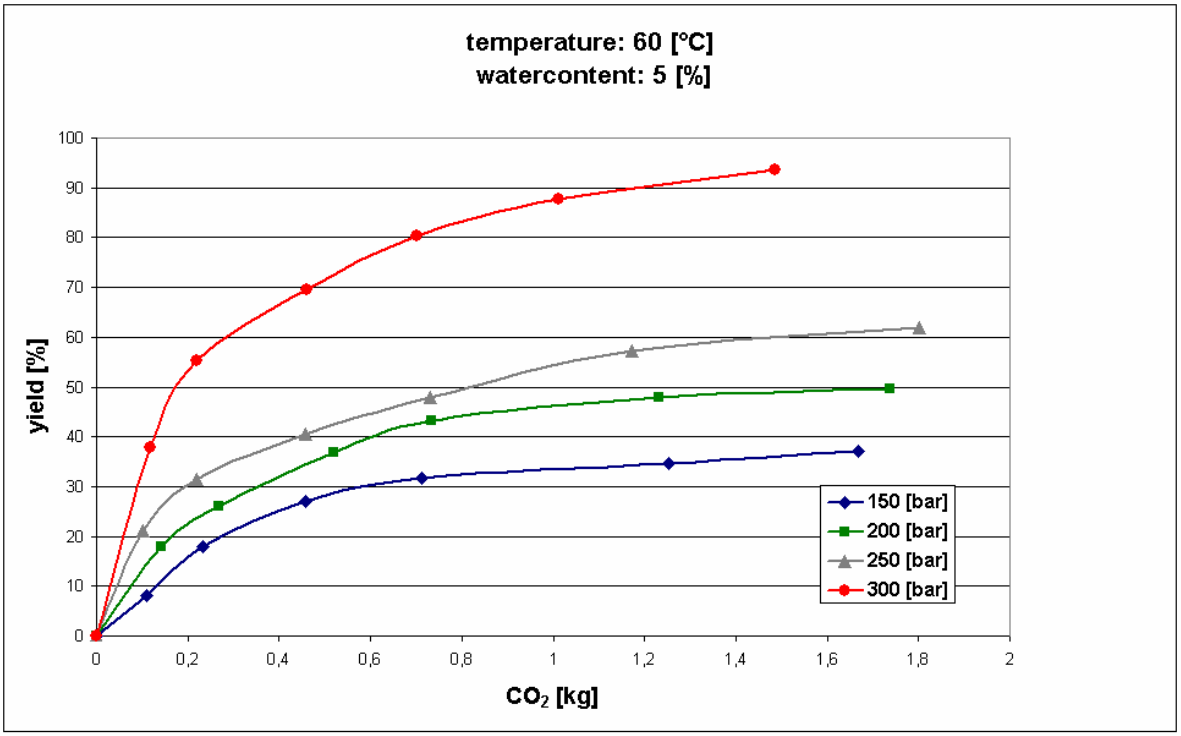

Figure 7: Extraction Yield of Fats; Pressure 300bar; Operation Temperature: 60 °C

The water content of the feed was varied in a next step. Water has a strong influence on the rate of extraction. As shown in Figure 8 increasing humidity seemingly increases CO_2 penetration of the whole matrix, resulting in a significant change of the extraction yield.

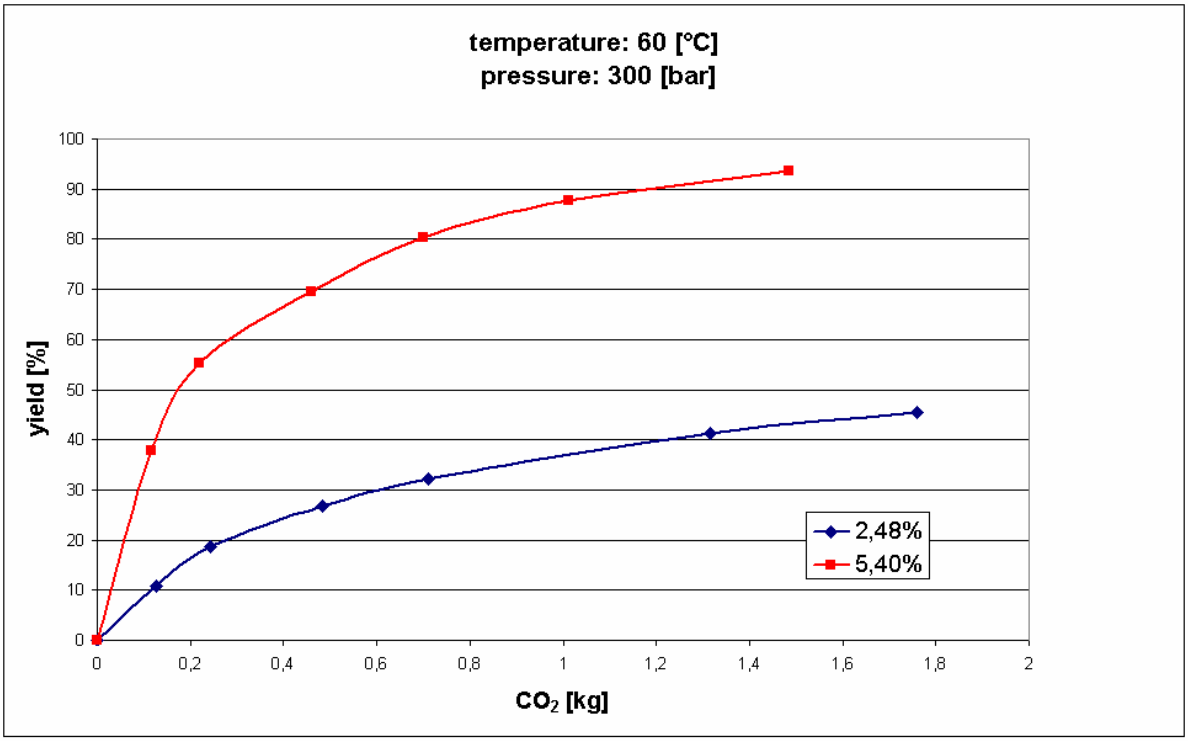

Figure 8: Effect of Feed Humidity on the Yield; Temperature: 60 °C, Pressure: 300 bar

SUMMARY

The solvent properties of CO_2 in extraction of fats from the biomass were investigated. Extraction pressure was varied from 150 bar to 300 bar and extraction temperature from 40°C to 60°C. The influence of feed humidity of the biomass on the extraction process was considered too. The solvent CO_2 has several advantages over conventional hydrocarbon-based solvents. In degreasing biomass rapid depressurization of the solvent supports cell disruption, which is very favourable for any further manipulation. Elevated temperature and high pressure as well as elevated feed humidity accelerate the rate of extraction and the yield of extraction. The advantages of simple solvent recovery finally contribute to the unique properties of the solvent CO_2 too.

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