# $CO_2$ APPLIED TO COMMERCIAL EXTRACTION OF PEPPER: PERFORMANCE AND ECONOMICS


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## 1 INTRODUCTION

Pepper conjures flavour and piquancy into foodstuffs. The initiators are essential oils and spicy substances. Pepper contains some 1-4 % of oil and 5-10 % of piperine. As the solubility of the two substances in $CO_2$ differ significantly, aroma and hot components have been separated into two fractions by a commercial $CO_2$-extraction-process at NATECO$_2$. The poster presents the benefits, performance and economics of the extraction with $CO_2$.

## 2 MATERIAL AND METHODES

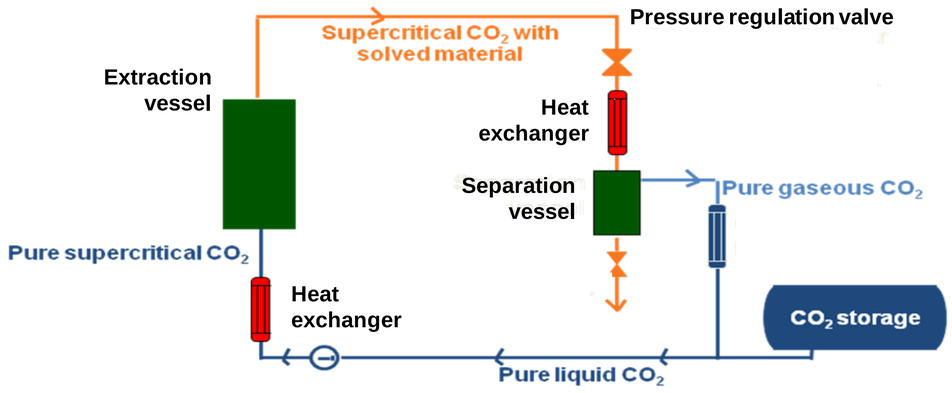


Figure 1: $CO_2$- extraction-plant

Black and white pepper grains were crushed by cold grinding using a hammer mill. Extraction with supercritical $CO_2$ was performed in a plant comprising three extraction vessels of 500 l each. The principal flow sheet of a $CO_2$ extraction plant is demonstrated in figure 1.

The total amount of extractable quantity in the raw material was analyzed by a Soxhlet extraction with Dichloromethane. In the extracts the piperine concentration was determined spectro-photometrically at 304 nm and the oil content was established by a volumetric analysis.

## 3 RESULTS

### 3.1 Performance of the extracts

Applying $CO_2$ as extraction solvent for pepper (fig. 2 and 3) offers multiple advantages.

- By adjusting the extraction and separation parameters high yields can be realised. Thus more than 90 % of the extractable material (compared to extraction with Dichloromethane) is recovered. The yield of the spicy constituent even sums up to 95 %.
- Frequently extracts are implemented to standardize products. Also the two different fractions of pepper enable an accurate standardization of products concerning flavour and piquancy.
- Quality and intensity of the essential oils (fig. 5) and the spicy fraction (fig. 4) at the $CO_2$ process is excellent. Consequently the required amount of $CO_2$-extract to create a peppery aroma is significantly lower in comparison to water distillates.
- Furthermore a decrease of the microbial contamination from high numbers at untreated pepper to nearly sterility in the extract and spent material can be achieved by $CO_2$-extraction.

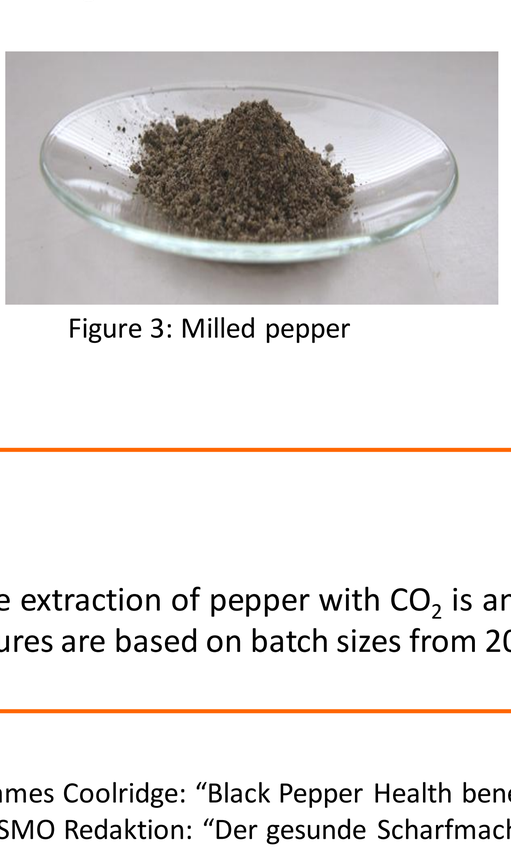

Figure 2: Raw material

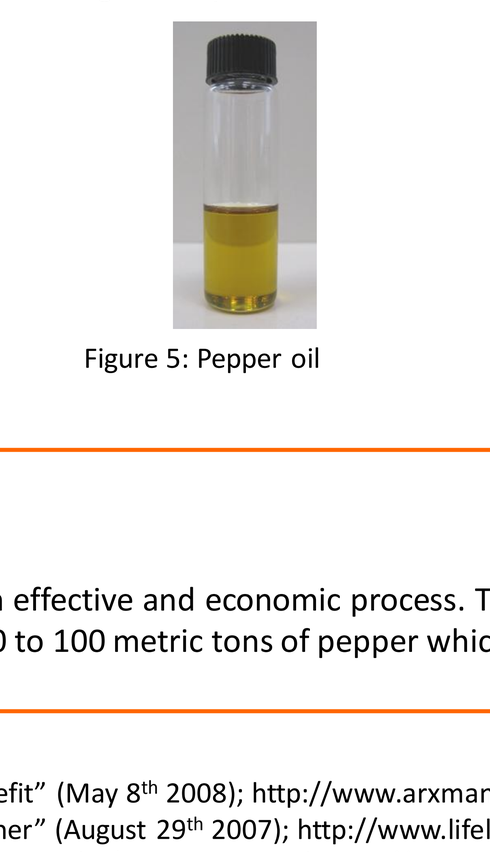

Figure 4: Piperine extract



Figure 3: Milled pepper



Figure 5: Pepper oil

### 3.2 Economics

In average 12 %w/w of piperine extract have been recovered in the first separation step and 7 %w/w of the pepper oil in the second separation step, respectively. For the raw material a pepper price of 2.40 € per kg has been adopted. The economical figures are illustrated in table 1.

Figure 6: Industrial $CO_2$ extraction plant

Table 1: Yield and costs

| Yields and Costs / Quantity [kg] | | **20 tons batch** | **100 tons batch** |
|---|---|---|---|
| Milling costs | [€/kg] | 0.32 | 0.32 |
| Extraction costs | [€/kg] | 2.70 | 2.32 |
| Processing costs | [€] | 60,400 | 264,000 |
| Pepper costs | [€] | 48,000 | 240,000 |
| Total costs | [€] | 108,400 | 504,000 |
| Quantity of piperine extract | [kg] | 2,400 | 12,000 |
| Quantity of oil extract | [kg] | 1,400 | 7,000 |
| Costs of piperine and oil extract | [€/kg] | **28.53** | **26.53** |

As table 1 shows the costs for the production of one kilogram $CO_2$-extract with a piperine content of around 55-60 % are under 30 €. Pepper concentrates with approx. 40 % of piperine obtained from extraction with organic solvents are traded with over 40 €/kg.

### 3.3 Health benefits of pepper extracts

Spices like pepper refine meals but also attribute to well-being and digestion. Particularly the alkaloid piperine provokes healthy influences on the human body.

So piperine improves the digestion by stimulating the secretion of hydrochloric acid in the stomach [1;2]. Showing antioxidant properties piperine prevents the growth of harmful bacteria in the intestinal tract [1;2]. Increasing the melanin-production pigmentary abnormalities can be reduced by piperine [3]. Also piperine is said to be anticancerogenic, because it inhibits some pro-inflammatory substances of tumor cells [1].

## 4 CONCLUSIONS

The extraction of pepper with $CO_2$ is an effective and economic process. The paper shows evidence by presenting the extraction costs and the resulting product prices. The figures are based on batch sizes from 20 to 100 metric tons of pepper which have already been extracted successfully several times at NATECO$_2$.

## 5 REFERENCES


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[3] Focus Online: “Peffer mildert Pigmentstörungen” (2nd February 2008); http://www.focus.de/gesundheit/ratgeber/haut/vitiligo_aid_241011.html; April 6th 2009