BUCHI offers optimal solutions for natural medicine separation, purification, extraction, concentration, spray drying, testing and quality control.

Natural Products Solutions
Maximum flexibility to meet your needs
“Quality in your hands” is the guiding principle that shapes our philosophy and our actions. It challenges us to provide outstanding services that are precisely tailored to your needs. This means that we must stay in close contact with our customers. That is why we keep in touch and continue to work very hard to understand you and your business even better.

We help you by providing high-quality products, systems, solutions, applications and services that offer you added value. This allows you to focus entirely on your processes and your work.

**Core messages to our customers**
BUCHI creates added value with “Quality in your hands”

**Easy**
You handle complex processes, do challenging work and want to focus on what is essential. We support you by providing carefully designed solutions as well as instruments and systems that are easy to operate.

**Competent**
You need products, systems, solutions, applications and services that are precisely tailored to your needs. We have the technological expertise and decades of experience needed to provide competent support and work with you to continually improve our market services.

**Reliable**
You want to be able to rely completely on your partner for products, systems, solutions, applications and services. We guarantee the quality and functionality of our equipment and will continue to help you quickly and efficiently whenever something does not operate to your satisfaction.
Cost-effective
You want to achieve the best possible results using efficient solutions. We help you to handle your jobs and processes economically. We strive to create a high level of economic benefit and maximum added value for you.

Safe
You are working in an environment in which safety is a high priority. By collaborating closely with you, we do everything in our power to make our products, systems, solutions, applications and services as safe as possible for people and the environment.

Global
You value personalized service and short communication channels. As an international family-owned business with our own subsidiaries and qualified distributors, we have a presence wherever our customers are located. Our local staff and the large number of satisfied customers around the world give you the assurance that you are working with the right partner.

Sustainable
You prefer a partner who acts responsibly when it comes to current environmental challenges. We support environmentally friendly processes and manufacture products that have a long service life. We utilize advanced technologies in order to conserve energy and water and leave the smallest environmental footprint possible.
Extraction Units
BUCHI offers dedicated extraction solutions for the classical determination of fat, as well as for residue and contaminant analysis in various matrices. We cover the whole range of automated extraction methods, from Soxhlet, to hot extraction and pressurized solvent extraction. Our solutions allow for perfect integration in the workflow, thus minimizing manual steps.

Industrial Evaporation
As the market leader in industrial evaporation, BUCHI offers dedicated and customer specific solutions for industrial evaporation. Whether you ask for concentration, solvent recycling or drying, we provide the right answer for large scale evaporation in production and pilot plant processes.
Preparative Chromatography
Whatever the complexity or the scale of your purification process is, the BUCHI preparative chromatography systems are designed to fulfill your changing needs. Together with a broad range of high performance flash chromatography columns, we provide you the optimized solution suited to your purification workflow.

Laboratory Evaporation
BUCHI offers dedicated solutions for laboratory rotary evaporation whether you operate in R&D or quality control. Based on our experience and knowledge we offer tailor-made solutions to cover a wide range of distinct needs and achieve highest convenience.

Parallel Evaporation
Whether you work in R&D or quality control looking for throughput optimization, BUCHI offers a wide variety of accurate and proven solutions covering different industries.

Spray Drying & Encapsulation
BUCHI’s proven, reliable and versatile solutions for Spray Drying and Microencapsulation cover a broad range of applications. Discover the time- and cost-saving solutions for R&D particle formation.

NIR Solutions™
NIR analysis offers rapid, affordable and precise results. It enables real-time decision making for enhanced quality and higher productivity. BUCHI’s NIR Solutions™ support you in mastering your daily challenges from incoming goods inspection to final product release.

Melting Point
BUCHI offers you solutions to determine your melting and boiling points with high accuracy, visual or automatic determination and optional qualification packages meeting highest regulatory standards.
Natural Product Solutions
Extraction to purification

1 Extraction: Extraction Units

SpeedExtractor E-914 / E-916
- Speed and throughput combined: able to process 6 samples in 20 mins
- Reduced solvent consumption gives low running costs
- Complementary workflow with parallel evaporation. Compatible glassware makes extract transfer obsolete.

Extraction System B-811
- BUCHI is currently the only provider of an authentic and fully automated Soxhlet extractor on the market
- Features four extraction modes within one unit
- Wide application spectrum. Compatible with many solvents and samples.

Pressurized Solvent Extraction (PSE) is a modern extraction method that has been developed as an alternative to traditional methods such as Soxhlet or maceration; it offers advantages with respect to extraction time and solvent consumption. It is widely used in the research of medicinal plants and herbs. Typical applications are the quality control of active compounds in natural or pharmaceutical products and the research of valuable compounds in plant materials.

2 Concentration: Industrial Evaporation

Rotavapor® R-220 Pro
- Concentration of extract, purified fractions and solvent recovery
- From 10 L to 30 L batch size
- Configurations and accessories for all safety needs and easy operation
- Capable of continuous processing of large volumes with a high throughput
- Multiple customized configurations
The separation of constituents from complex natural products with high purity and yield requires many steps involving different processes and equipment.

**Isolation and Purification Systems**

- **Flash / Prep HPLC system**
  - Up to 200 mL/min in both flash and HPLC modes
  - Up to 1700 psi (120 bar) in preparative mode
  - 3 channel variable UV-Vis and ELS detection
  - Detects both chromophores and non-chromophores

- **Medium-pressure Liquid Chromatography**
  - High efficiency separations at a pressure up to 725 psi (50 bar)
  - Detection over all UV-Vis range
  - Elution flow rate up to 250 mL/min
  - Up to 200 mL/min in both flash and HPLC modes
  - Up to 1700 psi (120 bar) in preparative mode
  - 3 channel variable UV-Vis and ELS detection
  - Detects both chromophores and non-chromophores

- **Purification System Sepacore Easy**
  - Increased purity of the collected fractions with a higher resolution of the separation
  - Decreased purification cost with lower solvent consumption
  - Speed up traditional glass column chromatography and improve separations

**Typical equipment for Natural Product Purification**

- **Medium-pressure Pumps**
  - Maintenance-free design including compatibility with all organic solvents
  - High flow rates allow for large-volume separations
  - Elevated pressure capabilities for reverse phase separations

- **Large choice of Chromatography Columns**
  - Preparative HPLC columns, satisfying high-purity separation requirements
  - Pressure-resistant glass columns for crude separation and fine fractioning of a wide range of sample sizes with visibility and safety
  - Plunger columns for gel-purification and GPC applications
  - Prepacked columns in various sizes and with stationary phases for differing applications
  - Empty polypropylene cartridges and innovative packing system for flexibility and cost saving
Concentration & Drying

Laboratory Evaporation

Rotavapor® R-300

- A rotary evaporator is a workhorse. Every manipulation and each procedure must be as intuitive and convenient as possible.
- Configurable standard operating procedures (SOPs), data recording, and graphical representation of all process data guarantees the highest level of reproducibility.
- Productivity is further increased by fully unattended operation even for demanding applications such as foaming samples.

Foam Sensor

The foam sensor, in conjunction with the Interface I-300 / I-300 Pro, enables unattended distillation of foaming samples. The sensor automatically aerates the system temporarily to avoid extensive foam formation, while keeping the vacuum on a constant level.

Parallel Evaporation

Syncore® SPE

- Unified SPE and concentration design without sample transfer step
- The evaporation principle is similar to rotary evaporation, is close in speed, and can simultaneously concentrate/dry multiple samples without cross-contamination.

Multivapor™

Speed up your evaporation for multiple samples. With its ease of use, the Multivapor™ is tailored to maximize efficiency.
- Multiple position configurations
In formulation research, spray drying is the most commonly used drying method. Advantages:

- Directly obtain granular samples with good appearance and even grain distribution
- Fast drying speed: after having been extracted and concentrated the compound drug materials can be dried through a spray dryer or encapsulated using prilling by vibration technology.

**B-290 Mini Spray Dryer**

- High reproducibility due to durable and precise nozzle technology
- Sample processing volume as low as 10 mL
- Multiple spray nozzle configurations are available, producing particle sizes from 2 to 60 µm
- Spray drying immiscible samples is possible using a three fluid nozzle
- A patented anti-static nano-coating technology effectively prevents wall adhesion for better recovery

**B-90 Nano Spray Dryer**

- Easily obtained sub-micron particles ready to be prepared as inhalable drugs
- Suitable for small-volumes of high-cost samples (as little as 1 mL)
- Particles as small as 300 nm and production efficiency of up to 90 % can be obtained
- Mild conditions, ensuring drug activity

**B-295 Inert Loop**

**The safe way to spray dry organic solvent**

In the natural drug R&D process, active samples are often only soluble in organic solvents such as acetone, ethanol, dichloromethane, ethyl acetate and benzene. Open atmosphere spray dryers are unable to ensure safety when spray drying these organic solvents. It is possible to safely and quickly spray dry a sample containing organic solvent by incorporating the B-295 Inert Loop with B-290 or B-90 spray dryers to recover the solvent for reuse or disposal.

**B-296 Dehumidifier**

**Providing stable spray drying conditions**

The B-296 Dehumidifier is the ideal accessory to condition the drying air or to work continuously with water and organic solvent mixtures. It ensures process stability and performance.
Microencapsulation can increase the stability of drugs and can achieve delayed or controlled release of the drug in the body. The micro-gel encapsulated beads achieved by traditional technologies have uneven sizes, affecting drug quality. Our micro-gel encapsulators, due to their unique prilling by vibration method, produce micro-gel encapsulated granules of similar size and have become the new key device for drug formulation R&D. The principle is fluid spray division through the superimposition of vibration, forming fluid drops of equal dimensions.

**Unique Advantages of the B-390/B-395 Pro Micro-gel Encapsulator**
- Embed drugs, flavors and fragrances, enzymes, cells, microbes, and more, in a polymer base material, forming micro-capsules of similar shape
- Stainless steel spray nozzles with a variety of precision openings
- A particle diameter range of 100 μm – 3 mm can be selected with good repeatability and a narrow bead diameter distribution (< 5 % RSD)
- The conditions are very mild, and can be implemented under room temperature or physiological conditions
- Satisfies GMP documentation requirements

**Structural Principles**
1. Sample Preparation
2. Sample entry
3. Vibration
4. Micro-droplet formation
5. Droplet charge distribution
6. Parameter optimization under frequent flashing
7. Micro-gel capsule formation
8. Collection of micro-gel capsules
Melting Point

M-565

- A high-throughput, high-quality, fully-automated melting point and boiling point solution
- Heating temperature as high as 400 °C
- Meets various national pharmacopoeia requirements
- IQ/OQ certification available
- Data storage, result printout
- High-definition video playback

NIR-Solutions™

NIRFlex N-500

- FT-NIR with modular design
- Accessories to accommodate a variety of sample types
- Fully compliant with US, EU and Japanese pharmacopoeias

NIRMaster

- Stand-alone FT-NIR spectrometer
- Hygienic, easy-clean design
- Ingress protected (IP54/65)

NIR-Online

- Simplified automatic calibration
- Maximum data processing with simultaneous camera etc.
- Representative sampling with large spot size

Raw Material Analysis

- Fast identification of raw materials
- Non-destructive compositional analysis
- Guided method development using powerful NIRCal software

Quality Control for Extraction and Production Processes

- Compositional analysis of active ingredients
- Content uniformity in capsules or tablets
- Adulteration and counterfeit detection

Finished Product Testing
Natural product isolation
Purification process flow

Raw material extraction

Crude extract concentration

Crude separation

High-purity fine fractionation

Fraction concentration

Active compounds

Physical/chemical properties measurement
Application example

Applied Industrial Rotavapor® solutions for cannabis products

Objective:
With the chains on the highly regulated cannabis market loosening worldwide, the need for easy to use devices offering large scale distillation process possibilities has increased. Multiple start-up companies have been formed in the last few years to take part in this emerging market. The demand for processed cannabinoids range from recreational products like edibles, i.e. gummy bears, candy and chocolate bars, to medial goods such as tablets, sprays and tinctures. With the increasing need for cannabis products, industrial production is even more necessary. The market requires flexible and easy to operate evaporators that can gradually be invested into. When applying the industrial Rotavapor® there is no need of a large workforce or a large acquisition budget in contrast large scale industrial plants. Profound process know-how for the optimization and application in this promising field are available at BUCHI due to the far-reaching experience from the very early stages.

Product:
Rotavapor® R-220 Pro

Introduction:
Industrial rotary evaporators are commonly used to cover almost the whole range of evaporation and drying applications in the cannabis production. BUCHI offers two different versions, the R-220 Pro and the R-250, enabling the use of 20 L and 50 L evaporating flasks. Additionally, it is possible acquire ATEX-compliant models, thus safe handling can also be provided in EX zones class 1 and 2. BUCHIs industrial evaporators are all available in FDA-compliant materials, so the production of medical and food grade products is possible. A major benefit is the large range of interchangeable glass assemblies for all kinds of applications and structural arrangements. There are also possibilities to offer amber coated glass ware if light sensitive cannabinoids have to be processed.

Post extraction application
Depending on the extraction method, raw material, time and solvents used, specific cannabinoids can be extracted at different yields. Common solvents used are hydrocarbons and alcohols. Usually, a large amount of solvent is needed for the extraction of only a small amount of cannabinoids. Thus, the typical step after extraction would be to concentrate the cannabinoids by evaporating the solvent, so handling and processing of the product can be simplified.

Customer solution: Extraction with 96 wt. % ethanol is performed on an industrial scale. To perform the following chromatography step it is advantageous to reduce the amount of solvent, which makes up 80 % of the typically strongly foaming extract. The increased cannabinoid loading prevents the chromatography column of being overloaded with solvent. An R-220 Pro with a foam sensor and descending glass assembly can be employed to perform the concentration step for the extract and evaporate the solvent used at 10 L/h. Time consuming monitoring of the process and cleaning of the glass assembly is reduced by destroying the foam with short aeration pulses triggered by the foam sensor. The concentrated extract contains a total cannabinoid concentration of 4 %.

The solvent is collected and can be used for subsequent extractions. Additionally, thermo- and light-sensitive products can be protected by evaporating under reduced pressures and with the optional amber glass.

Post chromatography application
After removing solvent from the crude extract mostly chromatography is applied to fractionate the cannabinoids. Pure cannabinoids are obtained to exploit their individual properties or to tailor the effects a specific product should attain. Examples are for medical use of a certain cannabinoid, where purity is key or for edibles where in some cases no psychoactive cannabinoids can be included. BUCHIs chromatography device PrepChrom C-700 is typically used for these applications. With a flow rate of 250 mL/min, large amounts of cannabinoids can be separated easily. The high throughput of the PrepChrom C-700 results in large fractions of valuable, pure cannabinoids. For subsequent processing it is needful for the solvent to be evaporated.

Customer solution: Such an application in the medical sector would require the concentration and later drying of several hundred liters of a 5 g/L, 99 % pure cannabinoid fraction. Due to the large amount of solvent to be evaporated, an R-220 Pro continuous version is employed. To receive 1 kg of dry matter 200 L of solvent has to be evaporated.

The continuous version, that automatically fills and drains the system, reduces labor on the device to an absolute minimum. In some cases the collected solvent is recycled into the chromatography process, hence the use of valuable resources is economized.

Conclusion
The BUCHI industrial Rotavapor® line has proven to be the ideal solution for multiple applications in the production of cannabinoids due to low investment and running costs. The Rotavapor® R-220 Pro and the R-250 are successfully applied in the process and production work-flow of cannabis products.
Introduction:
In herbal medicine St. John’s Wort herb and capsules with dry extract are widely used for the treatment of depressions. In these products hypericin is determined for quality reasons. The determination of the total amount of hypericin can be done by extraction and photometric quantification at 590 nm. The quantification by photometry is interfered by co-extracted chlorophyll. Removal of the interfering chlorophyll was achieved by a pre-extraction with dichloromethane. The remainings were then extracted with methanol to quantify hypericin.

Experimental
Product: SpeedExtractor E-916, Photometer: Thermo Helios, Ultrazentrifugal mill: Retsch, ZM 200 with distance sieve 0.5 mm.

Samples: Dried and cut St. John’s Wort herb and capsules containing 425 mg dry extract of St. John’s Wort
Approx. 0.6 g of the ground herb or approx. 0.05 g of the dry extract was mixed with quartz sand and extracted in two consecutive extractions with the SpeedExtractor using the parameters shown in Table 1. The samples were extracted in triplicate.

| Table 1 |
|-----------------|-----------------|
| Pre-extraction  | Main-extraction |
| Temperature     | 80 °C           |
| Temperature     | 80 °C           |
| Pressure        | 100 bar         |
| Pressure        | 100 bar         |
| Solvent         | Dichloromethane |
| Solvent         | Methanol        |
| Cells           | 10 mL           |
| Cells           | 10 mL           |
| Vials           | 240 mL          |
| Vials           | 240 mL          |
| Cycles          | 2               |
| Cycles          | 4               |
| Heat-up         | 1 min           |
| Heat-up         | 1 min           |
| Hold            | 4 min           |
| Hold            | 2 min           |
| Discharge       | 2 min           |
| Discharge       | 2 min           |
| Flush with solvent | 5 min        |
| Flush with solvent | 5 min        |
| Flush with gas  | 4 min           |
| Flush with gas  | 4 min           |

After completing to 200 mL, photometric quantification at 590 nm was done.

Absorption coefficient: $E^1\text{cm}\text{g}^{-1}\text{ml} = 870$

Results
By performing a pre-extraction with dichloromethane the chlorophyll can be efficiently removed from the samples without affecting the hypericin content. Only a negligible amount of chlorophyll remains, with insignificant interference with hypericin at 590 nm (Fig. 1 and 2). Found concentrations in herb and capsules correspond with the declared values (Table 2).

| Table 2: Determined content of hypericin, n=3 |
|-----------------|-----------------|
| Hypericin [%rsd] | Declared value  |
| Herb            | 0.8 mg/g        |
| Capsules        | 1.18 mg / Capsule |

Figure 1: Spectrum without pre-extraction; 2: hypericin, 3: chlorophyll

Figure 2: Spectrum with pre-extraction; 2: hypericin

Conclusion
Application of two consecutive extractions is a fast and reliable way for the determination of total hypericin in St. John’s Wort herb and capsules.

Reference:
SpeedExtractor E-916 operation manual
For more detailed information refer to Application note 015/2009
Application Example
Determination of Total Polyphenol Content in Edelweiss

Objective:
Edelweiss (*Leontopodium alpinum*) grows in alpine areas and is also cultivated for its valuable extract. Ground Edelweiss was extracted with the SpeedExtractor E-916 using an alcohol-water mixture and the total polyphenol content was determined photometrically using the Folin-Ciocalteu method. The determined total polyphenol content, expressed as gallic acid, was 54.8 mg/g which corresponds to the values reported in literature [2].

Introduction:
Edelweiss (*Leontopodium alpinum*) grows in alpine areas between 1800 and 3000 meters above sea level. It is also cultivated for their valuable extract, rich in polyphenols and antioxidizing agents. The extract is used in cosmetics, facial creams and sun screen.

The sum parameter of total polyphenol content is commonly used in plant analysis to quantify the power of the antioxidizing effect. An efficient extraction method to determine the total polyphenol content in Edelweiss using the SpeedExtractor E-916 is presented below.

Experimental
Product: SpeedExtractor E-916, ultra centrifugal mill, microplate reader.

The dried and ground blossoms (<1 mm) were mixed with diatomaceous earth and extracted with the SpeedExtractor E-916 using the parameters shown in Table 1. The sample was extracted in triplicate.

Table 1: Extraction method of SpeedExtractor E-916

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature</td>
<td>50 °C</td>
</tr>
<tr>
<td>Pressure</td>
<td>100 bar</td>
</tr>
<tr>
<td>Solvent</td>
<td>Water 60%, Ethanol 40%</td>
</tr>
<tr>
<td>Cells</td>
<td>40 mL</td>
</tr>
<tr>
<td>Vials</td>
<td>240 mL</td>
</tr>
<tr>
<td>Cycles</td>
<td>3</td>
</tr>
<tr>
<td>Heat-up</td>
<td>1 min</td>
</tr>
<tr>
<td>Hold</td>
<td>9 min</td>
</tr>
<tr>
<td>Discharge</td>
<td>5 min</td>
</tr>
<tr>
<td>Flush with solvent</td>
<td>3 min</td>
</tr>
<tr>
<td>Flush with gas</td>
<td>5 min</td>
</tr>
</tbody>
</table>

The polyphenolic compounds in the diluted extracts were determined photometrically according to the Folin-Ciocalteu procedure [1], using gallic acid as standard substance.

The absorption is measured at 750 nm, and each extract was analysed twice.

Results
The results (Table 2) correspond to the values found in literature from 50 up to 60 mg/g [2].

Table 2: Determined total polyphenol content expressed as content of gallic acid

<table>
<thead>
<tr>
<th>Sample</th>
<th>Gallic acid [mg/g]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample 1</td>
<td>56.9</td>
</tr>
<tr>
<td>Sample 2</td>
<td>54.1</td>
</tr>
<tr>
<td>Sample 3</td>
<td>53.4</td>
</tr>
<tr>
<td>Mean value</td>
<td>54.8</td>
</tr>
</tbody>
</table>

rSD %: 3.44

Conclusion
The extraction of Edelweiss using SpeedExtractor E-916 for the determination of the total polyphenol content represents a powerful tool for the study of plant materials. The results are in correspondence with literature. The short total extraction time of approx. 1 h 10 min and the small solvent volume used of approx. 60 mL are further benefits of this procedure.

References
Application Example
Pressurized water extraction of thyme

Objective:
The extraction of valuable ingredients in thyme is the focus of different extraction techniques. The most commonly used technologies are liquid-solid-, pressurized liquid-, supercritical fluid- and pressurized water extraction. A fast and reliable method for the extraction of thyme is introduced below. The sample is extracted using the SpeedExtractor E-914 and analyzed to determine the amount of polyphenols.

Introduction:
Thyme (Thymus vulgaris) is used as a spice or medicinal plant due to its ingredients. The most important ingredients are the polyphenolic acids, caffeic and rosmarinic acid as well as essential oils [1]. Due to the degradation of thermo-labile ingredients in the presence of extraction temperatures above 150 °C, the optimum temperature is evaluated using pressurized water extraction (PWE) [2].

Experimental:
Equipment: SpeedExtractor E-914
Sample: Thyme dried and rubbed, Thymus vulgaris, from Germany (Thuringia), supplied by Beat Heuberger Weine & Gewürze, Zurich.
Determination: The sample (1.0 g) was directly weighed into a cellulose thimble. 0.25 g glass wool was added on top of the thimble. The extraction parameters are listed in Table 1.

Table 1: Extraction parameters with SpeedExtractor E-914

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pressure</td>
<td>150 bar</td>
</tr>
<tr>
<td>Temperature</td>
<td>125 °C</td>
</tr>
<tr>
<td>Cell</td>
<td>40 mL</td>
</tr>
<tr>
<td>Solvent</td>
<td>Deionized water</td>
</tr>
<tr>
<td>Collecting vessel</td>
<td>250 mL round bottom flask</td>
</tr>
<tr>
<td>No. of cycles</td>
<td>2</td>
</tr>
<tr>
<td>Heat-up</td>
<td>4 min</td>
</tr>
<tr>
<td>Hold</td>
<td>5 min</td>
</tr>
<tr>
<td>Discharge</td>
<td>4 min</td>
</tr>
<tr>
<td>Flush with solvent</td>
<td>3 min</td>
</tr>
<tr>
<td>Flush with gas</td>
<td>2 min</td>
</tr>
</tbody>
</table>

For the quantification of polyphenols in thyme the following analysis are done: Folin-Ciocalteu method, HPTLC, HPLC and sensory analysis.

Results:
The obtained amount of rosmarinic acid (4.90 mg/g thyme) was highest at the extraction temperature of 125 °C, above this temperature it decreased. The opposite was the case for caffeic acid. For caffeic acid the amount increased for temperatures above 150 °C. This is due to the fact that rosmarinic acid degrades to caffeic acid. Extracted amounts of rosmarinic and caffeic acid as well as the flavonone luteolin-7-o-glucuronide are shown in Figure 1.

Figure 1: HPLC analysis of polyphenols - peak areas of both polyphenolic acids and the flavonone

Also the sensorial evaluation has shown that PWE at 125 °C resulted in a well-balanced, intense thyme flavoring and mentholic profile of the extract. Above this temperature the flavor was like cooked apple, musty and bitter.

Conclusion
The pressurized water extraction of the valuable ingredients (polyphenols and essential oils) from thyme is suitable and reliable using the SpeedExtractor E-914. The extraction temperature should not be set above 125 °C otherwise thermo-labile substances could be degraded.

References
Application Example
Component Isolation from Cat’s Claw Extract using flash chromatography

Introduction
Cat’s claw, a tropical vine, is considered a valuable medicinal resource for scientific research. The active substances are alkaloids, tannins, and several other phytochemicals that may have the potential to boost the immune system. The presence of alkaloids provides anti-hypertensive effects and may lower cholesterol, as well as contribute anti-inflammatory, antioxidant, and anticancer properties.

Extraction Conditions:
- Extract type: Powder
- Weight: 3 g
- Extraction Solvent: Methanol
- Solvent Volume: 10 mL
- Ultra-sonication: 30 min at 60 ºC

Flash Chromatography Conditions:
- Cartridge: Reveleris® C18 media 12g
- Solvent A: Water
- Solvent B: Methanol
- Flow Rate: 30 mL/min
- UV1 Wavelength: 254 nm
- UV2 Wavelength: 220 nm
- Cartridge Equilibration: 5.0 min
- Injection Type: Liquid

Gradient Table

<table>
<thead>
<tr>
<th>Step</th>
<th>Time (min.)</th>
<th>%B</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.0</td>
<td>30</td>
</tr>
<tr>
<td>2</td>
<td>3.0</td>
<td>30</td>
</tr>
<tr>
<td>3</td>
<td>3.0</td>
<td>100</td>
</tr>
<tr>
<td>4</td>
<td>4.0</td>
<td>100</td>
</tr>
</tbody>
</table>

Figure 1: Using the Reveleris® X2 flash system and ReveaLX™ technology, Cat’s Claw extract has been purified on a reversed phase Reveleris® 12g cartridge. The chromatogram shows the benefits of detecting peaks using the UV and the ELSD detectors.

Figure 2: Optimized gradient method improves resolution for higher purity fractions.
Application Example
Isolation of Eugenol and Caryophyllene, in Clove Oil Extract

Extraction Conditions
Extract Type: Oil

Introduction:
Many plants contain “essential oils” extracted from them that have high boiling points and antibacterial properties. The clove oil extracted from cloves is a rich source of eugenol and caryophyllene, both of which may contain medicinal properties. Besides its use in dentistry, it may be used for treating various health disorders such as indigestion, cough, headaches, and stress.

Flash Chromatography Conditions:
- Cartridge: Reveleris® C18 media 12g
- Solvent A: Water
- Solvent B: Methanol
- Flow Rate: 30 mL/min
- UV1 Wavelength: 254 nm
- UV2 Wavelength: 220 nm
- Cartridge Equilibration: 3.0 min
- Injection Type: Liquid

Gradient Table

<table>
<thead>
<tr>
<th>Step</th>
<th>Time (min.)</th>
<th>%B</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
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<td>30</td>
</tr>
<tr>
<td>2</td>
<td>7.0</td>
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</tr>
<tr>
<td>3</td>
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<td>100</td>
</tr>
<tr>
<td>4</td>
<td>2.0</td>
<td>100</td>
</tr>
</tbody>
</table>

Figure 1: Purification of clove oil extract shows peaks detected with the RevealX™ technology. Using the ELSD with UV allows for isolation of both chromophoric and non-chromophoric peaks in a single run.

Figure 2: GC-MS analysis of the collected fractions of clove oil extract after flash chromatography identifies Eugenol (MW: 164) and Caryophyllene (MW: 204) with greater than 99% purity.

Conclusion
Natural product extracts have been shown to contain critical components that are both chromophoric and non-chromophoric. The Reveleris® flash chromatography system shows the benefits of RevealX™ technology in having multiple peak detection capability and integrated fraction collection for isolating compounds, helping to reduce post-run analysis time. The purification process can thus be more efficient and productive, even in the presence of low quantities of sample components.

References
Application Example
Isolation of Stevioside and Rebaudioside-A

Stevioside and Rebaudioside-A are major low-calorie diterpene steviol glycosides found in the leaves of S. rebaudiana and used as a sweetener in food and beverages. These compounds range in sweetness level from 250 to 450 times sweeter than sugar. They are widely used as natural sweeteners for diabetic patients.1

This application shows the benefit of Reveleris® Prep purification system and Davisil® NNH2 purification media for the separation and isolation of the two main compounds, Stevioside and Rebaudioside-A, in S. rebaudiana. The flexibility of this dual-mode Reveleris® Prep purification system allows the user to perform either flash or preparative LC or to combine both techniques to achieve the highest levels of purity and recovery.

Flash Chromatography Conditions:

<table>
<thead>
<tr>
<th>Sample</th>
<th>Stevia extract (500 mg absorbed on celite)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cartridge</td>
<td>Reveleris® amino 40g</td>
</tr>
<tr>
<td>Solvent A</td>
<td>Acetonitrile</td>
</tr>
<tr>
<td>Solvent B</td>
<td>Water</td>
</tr>
<tr>
<td>Flow Rate</td>
<td>30 mL/min</td>
</tr>
<tr>
<td>Detection</td>
<td>UV @ 210,254,280 nm and ELSD</td>
</tr>
<tr>
<td>Cartridge Equilibration</td>
<td>2.0 min</td>
</tr>
<tr>
<td>Injection Type</td>
<td>Dry sample (3g loader)</td>
</tr>
</tbody>
</table>

Gradient Table

<table>
<thead>
<tr>
<th>Step</th>
<th>Time (min.)</th>
<th>%B</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.0</td>
<td>20</td>
</tr>
<tr>
<td>2</td>
<td>10.0</td>
<td>30</td>
</tr>
</tbody>
</table>

Figure 1. Flash chromatogram for stevia extract. Fractions 7-11 correspond to the mixture of Stevioside and Rebaudioside-A.

Reveleris® PREP conditions:

<table>
<thead>
<tr>
<th>Sample</th>
<th>Flash purified fractions 7-11 (dissolved in ACN: water, 1:1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cartridge</td>
<td>Davisil 710N NH2 Column 250x25 mm 10-14μ</td>
</tr>
<tr>
<td>Solvent A</td>
<td>Acetonitrile</td>
</tr>
<tr>
<td>Solvent B</td>
<td>Water</td>
</tr>
<tr>
<td>Flow Rate</td>
<td>25 mL/min</td>
</tr>
<tr>
<td>Detection</td>
<td>UV @ 210,254,280 nm and ELSD</td>
</tr>
<tr>
<td>Cartridge Equilibration</td>
<td>5.0 min</td>
</tr>
<tr>
<td>Injection Type</td>
<td>Liquid (10 mL loop)</td>
</tr>
</tbody>
</table>

Gradient Table

<table>
<thead>
<tr>
<th>Step</th>
<th>Time (min.)</th>
<th>%B</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.0</td>
<td>20</td>
</tr>
<tr>
<td>2</td>
<td>43.0</td>
<td>20</td>
</tr>
</tbody>
</table>

Figure 2. Prep chromatogram for combined fractions 7-11. Fractions 17-18 and 28-33 correspond to Stevioside and Rebaudioside-A.

Purity and recovery results

<table>
<thead>
<tr>
<th>Purification System</th>
<th>Stevioside</th>
<th>Rebaudioside-A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reveleirs PREP</td>
<td>98.65</td>
<td>24.42</td>
</tr>
<tr>
<td>Agilent Prep</td>
<td>99.65</td>
<td>28.54</td>
</tr>
</tbody>
</table>

# Average of UV and ELSD Signals  * Davisil® 710 NNH2 Media

Conclusion

For complex mixtures, the Reveleris Prep purification system allows both flash and prep LC to be used for purification. This means that the relatively expensive prep LC column is protected from contamination and degradation by other components in the sample. These elements are retained or separated on the low cost flash cartridge.

References

1. Genus, J.M.C.; Augustijns, P.; Mols, R.; Buyse, J.G.; Driessen B.; Metabolism of Stevioside in pigs and intestinal absorption characteristics of Stevioside, Rebaudioside-A and steviol. Food and Chemical Toxicology, 41 (2003), pp. 1599–1607. In this application, the initial sample cleanup was done with flash using a Reveleirs amino cartridge, followed by a final preparative purification using Davisil 710 NNH2 media. Comparison of the results also showed that the performance of the Reveleris Prep purification system in preparative LC mode, performs as well as traditional preparative LC systems. The flexibility of the Reveleris Prep purification system allows the user to perform either flash or preparative LC or the ability to combine both techniques on the same system to achieve the highest levels of purity and recovery.
Introduction:
Chinese herbal medicines is one of five pillars the Chinese medicine is built on and is over 2000 years old. Chinese medicines are always of natural sources, of which over 90 % originates from all kind of plant materials such as seeds, leaves, bark, flowers, fruits, roots, etc [2]. Traditionally, Chinese medicines are administered as infusions. Modern delivery forms including granulates, tablets, concentrates or capsules require implementation of drying methods and/or modern galenics [2]. Spray drying is commonly used in the preparation. One of the advantages is that the produced powder is stable and easily handled in subsequent manufacturing processes. Chinese medicines on the other hand, have often complex recipes, need large doses, are difficult to spray dry and are often unpleasant in taste or odor [1].

The aim of the study performed by Wang et al. was to overcome the adherence problem of spray dried Crataegi fructus extract (CFE) caused by specific properties of the extract. Not only economic losses due to reduced yields, but also product quality and stability of the final powder demand improvements [1].

Experimental:
Crataegi fructus was extracted with water and spray dried on a BUCHI Mini Spray Dryer B-290 with or without carriers. Spray drying parameters were kept constant for all experiments (Table 1). Varying parameters were the type and amount of carrier; HPMC E5, F5, K3, A15, maltodextrin DE6 and 2 - 24%, respectively [1].

The glass transition temperature $T_g$ of the powders was determined using a thermal analysis differential scanning calorimeter (DSC; model Q2000, Thermo Fisher Scientific Inc., USA).

Results
Spray drying of pure extract resulted in severe adherence of not fully dried sample on the glassware and no product was collected in the product vessel (Table 2). Addition of at least 4 % HPMC enabled to collect a minimum of 75 % of the sprayed product, whereas the type of cellulose derivate was not so critical. Supplementation of maltodextrin was significantly less efficient, so a maltodextrin concentration of at least 50 % was required for corresponding yields to those obtained with HPMC additions.

Table 2: Obtained yields and glass transition of spray dried powder [1].

<table>
<thead>
<tr>
<th>SAMPLE</th>
<th>YIELD</th>
<th>$T_g$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extract</td>
<td>0 %</td>
<td>15 °C</td>
</tr>
<tr>
<td>CFE + 2 % E5</td>
<td>65.2 ± 4.6 %</td>
<td>30 °C</td>
</tr>
<tr>
<td>CFE + 4 % E5</td>
<td>79.7 ± 0.8 %</td>
<td>32 °C</td>
</tr>
<tr>
<td>CFE + 8 % E5</td>
<td>80.7 ± 6.0 %</td>
<td>38 °C</td>
</tr>
<tr>
<td>CFE + 16 % E5</td>
<td>87.1 ± 3.7 %</td>
<td>39 °C</td>
</tr>
<tr>
<td>CFE + 24 % E5</td>
<td>90.0 ± 2.9 %</td>
<td>40 °C</td>
</tr>
<tr>
<td>CFE + 16 % K3</td>
<td>75.8 ± 2.4 %</td>
<td>39 °C</td>
</tr>
<tr>
<td>CFE + 16 % F5</td>
<td>86.4 ± 3.2 %</td>
<td>39 °C</td>
</tr>
<tr>
<td>CFE + 16 % A155</td>
<td>82.8 ± 1.7 %</td>
<td>39 °C</td>
</tr>
</tbody>
</table>

The glass transition temperature $T_g$ of a material characterizes the range of temperatures over which this glass transition occurs, meaning that drying below its $T_g$ results in amorphous product. According to Bhandari et al., at temperatures equal to $T_g + 10^\circ C$, the product begins to adhere, and at $T_g + 20^\circ C$ it is fully adherent [3]. This observation clearly explains why with the modified sample increased yields could be achieved.

Conclusion
Plant extracts such as from Crataegi fructus often show low glass transition temperatures, thus are difficult to spray dry in particular. Addition of carrier materials such as HPMC or maltodextrin increases the glass transition temperature leading to improved yields.

References
Introduction:

Taking medicine orally is convenient and economical, however, many drugs have an unpleasant, bitter primary taste that often hinders the acceptance and usefulness of many beneficial, safe and efficacious drugs. The elimination or reduction of undesirable taste is therefore an important parameter in product formulation. The perception of taste occurs when the substances are dissolved in saliva and get in contact with taste buds. By selecting specific polymers or mixture of polymers, it is possible to modify the release of drugs to enable improved efficiency and reduce side effects. Polymer with a pH dependent dissolution can be used to control the rate and site of release of the drug. Ideally, the drug should show little if any release at the pH encountered in the mouth (pH 7.0-9.0) [1], [2].

Spray drying is widely used in pharmaceutical processing since it is a one-step process that can be easily controlled and scaled up. Moreover, by carefully manipulating drying conditions and choice of excipient, it can also be used to modify the release of drugs [2].

In this application note, the possibility to mask unpleasant taste of active pharmaceutical ingredients (API) using spray drying will be reviewed. Particular attention will be given to Roxithromycin, a semi-synthetic macrolide antibiotic derivative of erythromycin as the API and Eudragit L30D-55 (methacrylic acid – ethyl acrylate copolymer (1:1) dispersion 30%) for the taste-masking coat, as reported by Sollohub et al. (2011) [3].

Experimental:

Microencapsulated roxithromycin particles were prepared by spray drying a water dispersion of Eudragit and roxithromycin (13% of the solid content) using a BUCHI mini spray dryer B-290 (Flawil, Switzerland) equipped with the standard 0.7mm nozzle (Figure 1). Sollohub et al. (2011) reported using a pressure of compressed air of 0.7 MPa, an aspiration setting of 100 %, a feed of 7.5 mL/min, an inlet temperature of 70 °C and an outlet temperature of 45°C.

The microcapsules were evaluated using scanning electron microscopy (SEM) and the taste-masking effect was evaluated with an electronic tong sensor array.

Results:

In the studies performed by Sollohub et al. (2011), Eudragit L30D-50 was used to create continuous, thick and stable coating. Since it dissolves at pH > 5.5 and in the presence of alkali ions, microparticles suspended in pure water or in slightly acidic environment should be stable. Results obtained by the electronic tongue show two separate clusters, one for the pure roxithromycin and one for the encapsulated roxithromycin. These results confirm that the electronic tongue is capable of distinguishing pure drug from encapsulated drug. Sollohub et al. (2011) reported a taste masking effect of Eudragit L30D-55 of 10 to 20 min before it disappears when suspended in phosphate buffer pH 6.8.

Similar experiments were performed by Bora et al. (2008) and comparable results were reported using chitosan (drug-polymer ratio of 1:1) and Eudragit E100 (drug-polymer ratio of 1:2.5) as a taste masking coating for Ondansetron hydrochloride (OSH), a commonly used substance for management of nausea and vomiting [1], Bora et al. (2008) indeed reported a release at pH 6.8 of less than 2.3 % of OSH in 5 min when Eudragit E100 or chitosan was used for taste masking [1]. Moreover, the drug release of OSH from Eudragit and chitosan microspheres in acidic conditions (0.1N HCl) was reported to be above 90% in 15 min for Eudragit E100 and in 25min for chitosan [1].

Conclusion

This study showed the possibility to use spray drying to encapsulate substances with bitter taste in order to mask it or reduce it. The chemical images obtained by Sollohub et al. (2011) with the electronic tong sensor array for pure and encapsulated roxithromycin were significantly different and showed the efficiency of the taste-masking coating. Similar conclusions were made by Bora et al. (2008) using different polymers to mask the bitter taste of OSH and a human taste panel to determine the bitter taste threshold value.

References


Figure 1: Mini spray dryer B-290 set up (left) and schematic representation (right).
Objective:
Poly (lactic-co-glycolic acid) (PLGA), a biodegradable polymer, was successfully spray-dried using the Mini Spray Dryer B-290 in combination with the Inert Loop B-295. Spherical microparticles with a smooth or structured surface were obtained and their size and shape are suitable for new applications in several fields such as pulmonary therapy, hormone depot, cancer treatment or medical devices.

Introduction
In the past decades, biopolymers based on lactic acid and glycolic acid and their copolymers have attracted much interest as carriers in the preparation of different medical devices and drug delivery systems due to their excellent biocompatibility, biodegradability and non-toxicity in humans [1]. PLGA polymers are commercially available and approved by the US Food and Drug Administration (US FDA) for human use at various molecular weights and lactide-to-glycolide ratios. Therefore, several products can already be found on the market [2]. Spray drying was shown to be a rapid, continuous, cost-effective, reproducible and scalable process for the production of dry powders from a fluid [3]. Besides, due to its advantages, spray drying used in several occasions to develop PLGA micro and nano particles [2]. The use of the BUCHI Inert Loop B-295 (Figure 1) enables to dry solutions or suspensions of organic solvents in a fully closed system, maximizing user safety and minimizing solvent wastage.

The aim of this application example is to give an application help in spray drying biodegradable polymers such as PLGA using the Mini Spray Dryer B-290 combined with the Inert Loop B-295. The polymer type and concentration on the particles characteristics are studied.

Experiment:
Solutions of PLGA (50:50 and 75:25 lactide: glycolide with different properties) were prepared by dissolving different amount of polymer in dichloromethane in order to obtain concentrations from 0.5 to 10% (w/w). The advanced model of the Mini Spray Dryer B-290 and the two-fluid nozzle with the 0.7mm nozzle tip were used. The flow type was co-current with mixing of gas and liquid at the nozzle tip. The spray gas flow and the aspirator rate were kept constant at 600 L/h

and 100 %, respectively. The liquid feed rate was set to maintain a constant outlet temperature during the spray drying process. The B-290 unit was connected to a cooling-unit, the Inert Loop B-295, for safe operation of solvents in a closed mode configuration. Nitrogen was used as an inert gas to prevent an explosive gas mixture. Several inlet temperatures (55°C, 65°C and 75°C) were tested to investigate the influence of the inlet temperature on microsphere morphology.

Results:
The aim of the current study was to investigate the effect of the spray-drying parameters on PLGA particles engineering. The particle size and morphology was determined after spray-drying (Figure 2) and it was shown that an increase of the polymer viscosity lead to an increase in particle size. The same observation can be made concerning the polymer concentration. An increase in polymer concentration indeed revealed and increase in PLGA particle size. No significant difference in particle shape was noticed when changing the lactide-to-glycolide ratio, however, as mentioned by several authors, the ratio has an influence on the drug release properties [2]. It is also important to mention that the inlet temperature has to allow solvent evaporation while preventing polymer destruction and the outlet temperature has to be kept below the glass transition temperature of the polymer, which is between 38 and 45°C.

Conclusion
Spray Drying appears to be an attractive alternative to produce PLA and PLGA particles. It is a one-step process that allows fast processing of small batches with reasonable yields and the produced particles show suitable size and shape for inhalation applications. The Mini Spray Dryer B-290 in combination with the Inert Loop B-295 can effectively be used to produce biodegradable microspheres for controlled drug delivery systems by spray drying.

References
Introduction

Blueberry fruits are of special interest to researchers due to their high bioactive properties. Microencapsulation as a method of conservation for the fruit phenolic compounds has been widely used and it was shown already that micro-encapsulated products have longer storage stability, fewer unpleasant tastes or flavours and higher bioavailability than conventional formulations. Among microencapsulation methods, spray drying is the most common method in food industry [1]. Recently, ultrasonic nozzle technology has been considered as an alternative nozzle type since it allows formation of smaller, more uniform and more spherical droplets. Moreover, ultrasonic nozzle causes minor mechanical stress and therefore does not cause excessive damage of the bioactive compounds.

The aim of this application note is to investigate the possibility to use spray drying and the ultrasonic nozzle as a more suitable method to produce powder and microcapsules from blueberries compared with conventional nozzles.

Experimental

For juice and extract preparation, the fruits were washed and crushed using a blender. The juice was then centrifuged at 21000xg for 5 min, vacuum filtered and used for the experiment. For the extract, 0.1 kg of crushed blueberries was extracted with 97 % (V/V) ethanol to a total volume of 200 mL. Extraction was performed at room temperature using an Ultra-Turrax (IKA T25 digital; IKA, Staufen, Germany) operating at 21000 xg for 30 min. To protect the extract from photodegradation, the flask were covered with aluminium foil. The resulted extract were then vacuum filtered and evaporated using a BUCHI Rotavapor R-3 (Flawil, Switzerland) at 40°C and a vacuum pressure of 23mmHg.

For production of powder, maltodextrin (100 g/kg) was added to the juice and used as a carrier agent to prevent stickiness of the product during spray-drying. For production of microcapsules, the coating material (100 g/kg of maltodextrin/arabic gum 4:1) was added to the extract. Homogenized solution of juice or extract were then spray dried using a Mini Spray Dryer B-290 (BUCHI Labortechnik, Flawil, Switzerland) equipped with an ultrasonic nozzle (60 kHz) at a setting of 35 m³/h aspirator rate (100 %), 601 L/h atomization air rotameter to produce the powders and microcapsules respectively. The optimum inlet temperature was found to be 125 °C, the ultrasonic power 9 W and the feed pump rate 8 %. With the conventional two-fluid nozzle, the inlet air temperature was 125°C and a concentration of 100 g/kg maltodextrin/coating material was used for powders and microcapsule production.

Results

In Tatar Turan et al. (2016) research, the influence of ultrasonic nozzle parameters on the antioxidant activity, total phenolic content, anthocyanin content, anthocyanin retention and encapsulation efficiency were studied. A comparison between ultrasonic and conventional nozzle was also performed. Tatar Turan et al. (2016) show that the physico-chemical properties of blueberry powders and microcapsules increased with a decrease in inlet air temperature and increase in ultrasonic power.

An increase in particles size between particles produced with the conventional nozzle and particles produced with the ultrasonic nozzle can be observed through SEM imaging. Particles up to 10 μm were observed for powders produced with the conventional nozzle while particles up to 20 μm were observed for powders produced with the ultrasonic nozzle. A similar two-fold increase can be observed with microcapsules. The size of microcapsules produced with the conventional nozzle was estimated to be up to 7.5 μm while this of microcapsules produced with the ultrasonic nozzle was estimated to be up to 15 μm.

A higher loss of total phenolics, anthocyanin content and antioxidant activity was observed in blueberry powder compared to that in microcapsules. Results actually show a loss of antioxidant activity of 43 % for powders produced with the ultrasonic nozzle and stored at 22°C, while a loss of only 28 % is observed for microcapsules produced and stored in the same conditions (Table 1). The degradation in powder and microcapsules exhibited first-order kinetics throughout storage, with a higher reaction rate constant (k) and a lower half-life (t½) for the conventional nozzle microcapsules than for the ultrasonic nozzle microcapsules. This result therefore indicates that the conventional nozzle sample was more sensitive to temperature changes (Table 1).

<table>
<thead>
<tr>
<th>Powder</th>
<th>Powder</th>
<th>Micro</th>
<th>Micro</th>
</tr>
</thead>
<tbody>
<tr>
<td>US nozzle</td>
<td>conventional nozzle</td>
<td>US nozzle</td>
<td>conventional nozzle</td>
</tr>
<tr>
<td>k [d⁻¹]</td>
<td>0.0066</td>
<td>0.0077</td>
<td>0.0034</td>
</tr>
<tr>
<td>t½ [d]</td>
<td>105</td>
<td>90</td>
<td>203</td>
</tr>
<tr>
<td>Antioxidant activity loss [%]</td>
<td>43</td>
<td>50</td>
<td>28</td>
</tr>
</tbody>
</table>

Minimal changes in color (∆E*=6.06 and 9.24) were observed after 90 days of storage at 22°C for microcapsules produced with ultrasonic and conventional nozzle. This demonstrate that micro-encapsulation also provides an advantage in color conservation.

Conclusion

Blueberry powders and microcapsules were successfully prepared with maltodextrin (dextrose equivalents, 10) and maltodextrin/gum arabic blend using ultrasonic nozzle spray drying technology. Since temperature affects the stability of powders negatively, blueberry powder showed higher losses than microcapsules in the content of bioactive compounds. The ultrasonic nozzle showed a significantly greater protective effect on physico-chemical properties than the conventional nozzle, probably due to the larger size of the particles produced. Results thus point that the production of ultrasonic nozzle powders and microcapsules is feasible to use as a functional ingredient in food industry.

References

**Application Example**

**Lutein in microbeads and core-shell microcapsules**

**Objective:**
Encapsulator B-390 / B-395 Pro: Production of Ca-alginate microbeads and uniform core-shell microcapsules containing the carotenoid lutein

**Introduction:**
Lutein is a naturally and commonly occurring carotenoid found in plants. It is red-orange colored and has antioxidant properties, hence, it is oxygen sensitive. Furthermore, it is basically insoluble in water. Lutein together with the carotenoid zeaxanthin is found in human eye’s retina and is important for seeing.

The aim of this study was to protect the antioxidant from oxidation, by making it dispersable in water. Therefore, lutein microbeads and microcapsules were produced using the Flow Vibration Nozzle and Concentric Nozzle systems on the Encapsulator B-390 and B-395 Pro. Microbeads are spherical, homogeneous beads while microcapsules consist of a core and a shell of different composition. The here produced microbeads and microcapsules show uniform and spherical morphology.

![Image of microbeads and microcapsules]

**Equipment and Chemicals**

**Equipment:** Encapsulator B-390 / B-395 Pro

**Chemicals:** 1.5 % (w/w) and 1.8 % (w/w) sodium alginate solution, 0.1 M CaCl₂.

Sample 1: 7.5 g lutein powder suspended in 142.5 g sodium alginate solution (1.5 %).

Sample 2: 5 g lutein powder dissolved in 100 mL peanut oil and magnetic stirring.

**Experimental**

**Experiment 1:**
Encapsulating lutein in Ca-alginate matrix was performed using the Flow Vibration Nozzle and applying the parameters listed in Table 1. With this experiment microbeads are produced.

**Table 1: Process parameters of Experiment 1.**

<table>
<thead>
<tr>
<th>Product</th>
<th>Encapsulator B-390</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flow Vibration Nozzle</td>
<td>750 μm inner / 1.5 mm shell</td>
</tr>
<tr>
<td>Frequency</td>
<td>870 Hz</td>
</tr>
<tr>
<td>Feeding</td>
<td>Sample 1</td>
</tr>
<tr>
<td>(external syring pump)</td>
<td>5.45 mL / min</td>
</tr>
<tr>
<td>Pressure</td>
<td>1013 mbar for nozzle</td>
</tr>
<tr>
<td>Nozzle air flow</td>
<td>1 L / min</td>
</tr>
<tr>
<td>Dispersion tension</td>
<td>0 V</td>
</tr>
<tr>
<td>Amplitude</td>
<td>9</td>
</tr>
<tr>
<td>Hardening bath</td>
<td>0.1 M CaCl₂</td>
</tr>
<tr>
<td>Stirring</td>
<td>Gently stirred (no vortex)</td>
</tr>
</tbody>
</table>

**Experiment 2:**
Encapsulating lutein-oil within a Ca-alginate membrane was performed with the Concentric Nozzle and the parameters shown in Table 2. With this experiment microcapsules are produced.

**Table 2: Process parameters of Experiment 2.**

<table>
<thead>
<tr>
<th>Product</th>
<th>Encapsulator B-390</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feeding</td>
<td>Core: Sample 2 (fed via a syringe pump)</td>
</tr>
<tr>
<td></td>
<td>Shell: 1.8 % alginate solution (fed via a pressure bottle)</td>
</tr>
<tr>
<td>Feed rate core</td>
<td>300 mbar for shell nozzle</td>
</tr>
<tr>
<td>Pressure</td>
<td>0 V</td>
</tr>
<tr>
<td>Dispersion tension</td>
<td>5</td>
</tr>
<tr>
<td>Amplitude</td>
<td>0.1 M CaCl₂</td>
</tr>
<tr>
<td>Hardening bath</td>
<td>Gently stirred (no vortex)</td>
</tr>
<tr>
<td>Stirring</td>
<td>9</td>
</tr>
</tbody>
</table>

**Results**

![Image of lutein microbeads and microcapsules]

5. Conclusion

Two possibilities to encapsulate oil-soluble solids using Encapsulator are presented.

The BÜCHI Encapsulator B-390 and B-395 Pro were applied to produce spherical lutein-containing microbeads and microcapsules.

**References**

For more detailed information and safety considerations please refer to the Application Note No. 246/2016
## Widespread Applications of Micro-gel Encapsulators

Over the past 20 years, BUCHI micro-gel encapsulation technology has been in widespread use by scientists in the development of new, innovative products. The following table presents some articles published on applications using BUCHI micro-gel encapsulators and describing the advantages of specific materials in micro-gel capsule preparation.

<table>
<thead>
<tr>
<th>Industry</th>
<th>Embedded Constituent</th>
<th>Applications</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Food &amp; Beverage, Animal Feed</td>
<td>Sunflower oil</td>
<td>Controlling bioavailability of lipids in food</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Folic acid</td>
<td>Improving stability during freeze drying &amp; storage</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Probiotics (lactobacillus acidophilus)</td>
<td>Protection of bacteria in gastric conditions</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Probiotics (lactobacillus fermentum)</td>
<td>Oral and controlled delivery</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Probiotics (lactobacillus casei)</td>
<td>Controlled delivery (Gastrointesinal (GI) Tract of pigs)</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Flavourzyme</td>
<td>Improving acceleration of cheese ripening</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>Avocado oil, olive oil, canola oil,</td>
<td>Improving storage stability</td>
<td>7-10</td>
</tr>
<tr>
<td></td>
<td>essential oils</td>
<td></td>
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