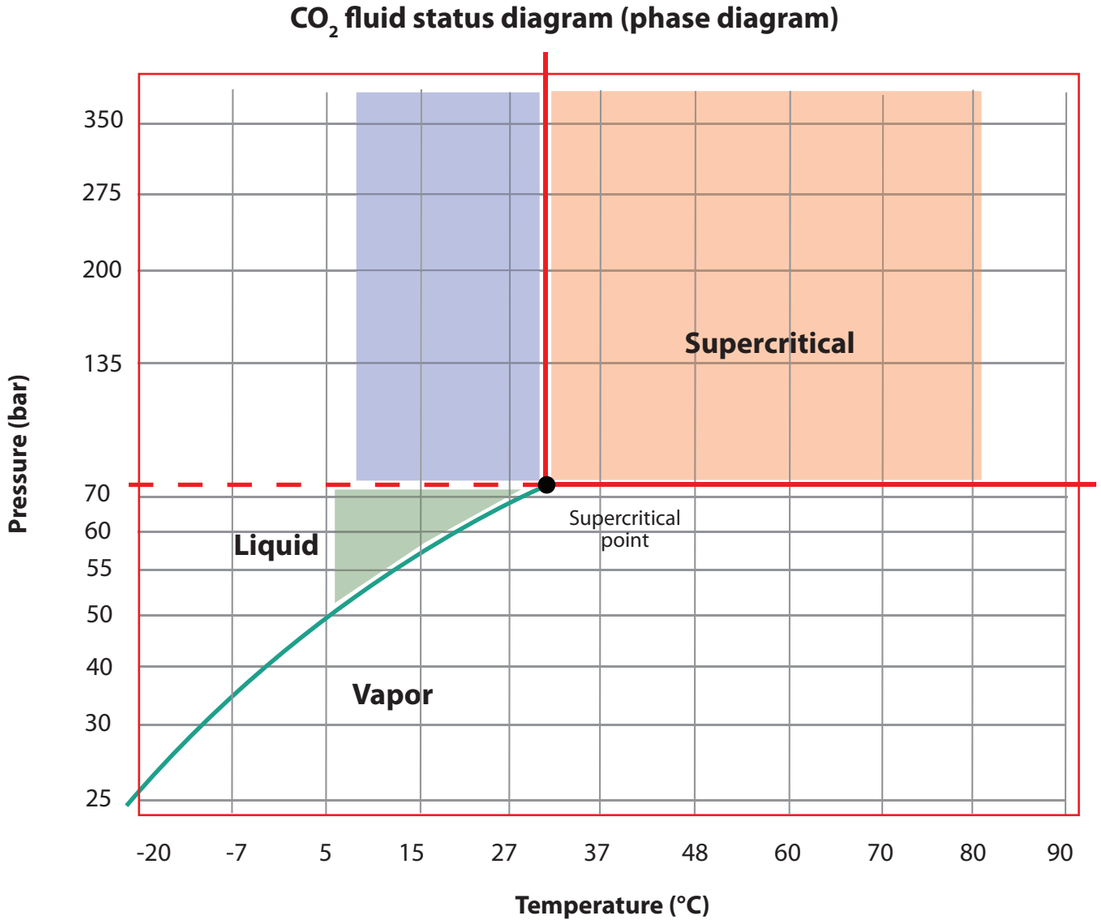

Actual process range in colored areas

Supercritical region: above 73 bar and above 31° C. In this condition CO_2 has the strongest solubility power. Very fast extraction time. With low pressure (75 bar) and low temperature (32° C) conditions, extract composition is mainly concentrated in lighter oils, few resins and waxes. High pressure (350 bar) and high temperature (85° C) conditions allows complete extraction, rich in oils, resins and waxes. Extraction conditions between these two extremes produce very different extract composition.

Subcritical region: above 73 bar and below 31° C. In this condition CO_2 has a low solubility power. Long extraction time. Good for gentle extraction of temperature sensitive products. Extract composition mainly concentrated in light oils and generally poor in resins, paraffin and waxes.

Liquid region: below 73 bar and below 31° C. In this condition CO_2 has a low solubility power. Long extraction time. Best for extraction of temperature sensitive products and aroma compounds. Lowest extract concentration in resins, paraffin and waxes.

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SeparéCo$_2$

SCFN
The Super Critical Fluid Alliance

Supercritical CO_2 extraction systems

1200 liters SCF extraction system

SCF systems for extraction of natural compounds

Why use supercritical CO_2?

Supercritical fluids (SCFs) are increasingly replacing the organic solvents that are used in industrial purification and recrystallization operations because of regulatory and environmental pressures on hydrocarbon and ozone-depleting emissions. SCF-based processes has helped to eliminate the use of hexane and methylene chloride as solvents. With increasing scrutiny of solvent residues in pharmaceuticals, medical products, and neutraceuticals, and with stricter regulations on VOC and ODC emissions, the use of SCFs is rapidly proliferating in all industrial sectors.
Supercritical fluid extraction (SFE) plants are operating at high throughputs in the foods industry. Coffee and tea are decaffeinated via supercritical fluid extraction and most major brewers in the US and Europe use flavors that are extracted from hops with supercritical fluids.
SCF processes are being commercialized in the polymers, pharmaceuticals, specialty lubricants and fine chemicals industries. SCFs are advantageously applied to increasing product performance to levels that cannot be achieved by traditional processing technologies, and such applications for SCFs offer the potential for both technical and economic success.

CO_2 has several advantages over other extraction mediums, such as hydrocarbons:

- is nontoxic and is Generally Regarded As Safe (GRAS) by the FDA for use in food products
- no toxins, heavy metals or hydrocarbon materials come in contact with the extracted oils
- CO_2 extract are free of solvents. Other extraction solvents, such as hydrocarbon based propellants like propane and butane, hexane and pentane mixtures require additional distillation or purging beyond the extraction process to separate the solvent from the extracted oil.
- CO_2 naturally separates from the extracted oil without any additional process
- exausted raw material is totally free of residual solvent and is generally sold as defatted flavor for diet food.
- CO_2 is non-flammable and don't need expensive explosion proof facilities (ATEX)
- Botanical oil extractions can be done at temperatures that are native to the botanical material, minimizing thermal degradation of the plant material and the extracted oil
- CO_2 is "tunable". The solvency power of CO_2 can be adjusted simply by increasing or decreasing pressures and/or temperatures.

Finallly CO2 is inexpensive. CO2 is readily available and widely used throughout several industries.

Supercritical CO2 behavior

The behavior of CO_2 in the supercritical state can be described as that of a very mobile liquid. The solubility behavior approaches that of the liquid phase while penetration into a solid matrix is facilitated by the gas-like transport properties. As a consequence, the rates of extraction and phase separation can be significantly faster than for conventional extraction processes. Furthermore, the extraction conditions can be controlled to effect a selected separation. Supercritical fluid extraction is known to be dependent on the density of the fluid that in turn can be manipulated through control of the system pressure and temperature. The dissolving power of a SCF increases with isothermal increase in density or an isopycnic (i.e. constant density) increase in temperature. In practical terms this means a SCF can be used to extract a solute from a feed matrix as in conventional liquid extraction. However, unlike conventional extraction, once the conditions are returned to ambient the quantity of residual solvent in the extracted material is negligible.

Solvent power

Fluid phase equilibria of mixtures are very complex, and many types of phase diagrams can be found. The basic principle of SCF extraction is that the solubility of a given compound (solute) in a solvent varies with both temperature and pressure. In all cases, the solubility dramatically decreases when the fluid is depressurized at constant temperature below its critical pressure, with solubility variation of several orders of magnitude. This is the basis of most SCF processes : SCF are used as solvents in the supercritical fluid region to selectively extract some compound(s) before being depressurized to cause the solute(s) precipitation permitting the fluid-solute separation. It is to be noticed that although water is only slightly soluble in SCF carbon dioxide (1-2 g/kg), it plays a very important role as "co-solvent" for many polar molecules ; in fact, water is present in most applications, especially when natural products are processed.
Finally, it is also important to say that, due to their non-polar character, SCF are also used as "anti-solvent" in polar organic solvents where they readily dissolve, leading to a significant decrease of their polar character, and causing precipitation of compounds previously dissolved in these solvents.

Industrial applications

Realizing the organization of production platform on agro 's applications, this technology allows the realization of high-quality and high performance products, depending from the features of the technology, features identified as follow:
a) extracts from plants for use in food, cosmetic, nutraceutical and pharmaceutical industry, **b)** fractions of a extracts concentrated of active ingredients (eg palm oil fraction concentrated in tocopherol or vitamin E, **c)** pasteurization processes at room temperature (30° C) for natural drinks and dealcoholization with simultaneous preservation of the aromas characteristic of the alcoholic beverage, **d)** high value ingredients from waste products like polyphenols and antioxidants from vegetable water, tomato waste for highly active molecules, desolate meal for dietary products. Furthermore this technology allows the replacement of conventional processes by reducing environmental impact and significantly improving the life quality of workers (eg: for the removal of toxic substances), product innovation with significant increase in the effectiveness and safety of the products enhancing the penetration in international markets, development of a lot of patents, thanks to innovative features.
This technology can really help to increase the development of the industrial business and raise attention of the markets towards development of a strong correlation between the technology used and the territory around it by several factors: **e)** the versatility of the technology suitable for application in many industrial sectors **f)** its ability to influence the development of entire agricultural value chain for waste products integration and high versatility expressed in many different industrial applications.
In this case, we do not propose a structural intervention in association with the farming systems, but a direct action on the chain of basic foodstuffs for the food, confectionery and nutraceutical industry for: **g)** oils from seeds, wheat germ, soy flour, almonds, characterized in antioxidants (eg beta-sitosterol from almond oil tocopherol from wheat germ), **h)** polar compounds and water-soluble extracts from soy (such as soy isoflavones from supplements for menopausal women), **i)** exhausted meal for healthy-food. If we de-grease a meal with SFE (eg soybean meal) we get a product in which (as opposed to standard meal) caloric intake is reduced by 20-25%. The protein content increased by 35.87%, the fibres increased by 24.30%. This new food is as very interesting in terms of diet and healthy. After desolation, flour may be further treated in supercritical phase together with water as a co solvent to obtain: **j)** Isoflavones from desolated soybean meal (for the treatment of the effects of menopause in women). Also in the soybean meal in addition to isoflavones, there are other substances of interest (lignans for the treatment and prevention of prostatitis in men). From de-grease flour can be obtained after the desolation: **k)** extracts concentrated in glycon isoflavones to be processed in flavonoids aglycones that have a better assimilation. These are phytoestrogens that have a high demand from the market (that consists of women over 50). In addition, the oil extracted is very interesting and may have greater value on the market thanks to the SFE method not only for the highest value given to soybean meal and all products derived from soybean meal but also as a result of the qualitative parameters (acid value, peroxide , iodine) and also the ability to extract components which normally do not go out the matrix with the standard processes (eg beta-carotene and vitamin E).

Briefly, the technological quality of the extract and flour desolate by SFE will promote a series of new products, in line with current market trends, with the following features:

<u>*A. FUNCTIONAL FOOD*</u>
As defined by the Institute of Medicine of the U.S. National Academy of Sciences as foods that include active substances or other materials as soybean oil (especially if organic) extracted with SFE that are able to:
1) provide health benefits
2) vehicle specific nutritional properties **b)**.

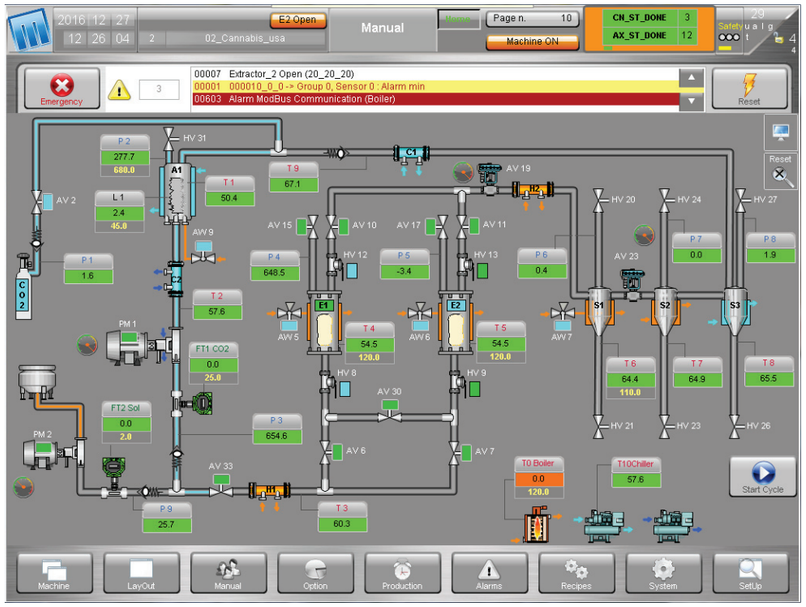
<u>*B. NEW FOOD*</u>
You can define them as foods or food ingredients not used in significant terms for human consumption or produced by other processes that involve:
- A significant change in the composition
- A significant change in the nutritional value
- A significant change in the use expected

And this is the case of de-oiled soy flour (made from SFE) for its high protein concentration (> 46%) and the almost total absence of fat and cholesterol (eg a healthy dessert).
In fact, the quality of these meals for the properties of soy oil extraction with SFE are:
- Good features of desirability and palatability (low temperatures and reducing environment due to mining in environment saturated with CO2 are a mix suitable to inhibit oxidation)
- Organoleptic high quality
- High concentration in fibre and protein as a consequence of desolation
- No fat or low-fat content
- Very low bacteria load and long shelf life due to the high pressures: CO_2 (in the extraction process is brought to 300-350 bar with a simultaneous inactivation of bacteria by the same CO_2 that enters the bacteria and inactive due to differential between internal and external pressure, differential, which destroys the bacteria itself).

The impact on the quality of the soy product chain (extraction made with SFE) is not only about oil and flour-based products but also due to the increased quality of raw materials: as for wheat and almonds, they can be made with similar treatment effects in different sectors.
As for the almonds: oil use has almost exclusively in the cosmetic industry as a base raw material for skin creams, while the flour is a basic element for the production of sweets. In the case of almond de-grease flour is very interesting the use of the flour for the production of fresh and health conscious diet. Moreover, the films of the almonds and hazelnuts for their content of carotenoids and antioxidants (eg gallic acid) are a waste of great interest, both directly extracting the oil from the films and in co-extraction together with flour. As for wheat, wheat germ, which together with the bran is a gap that is typically removed from mills or used as feed for livestock, if treated with supercritical fluids, receives its full value: the oil already extracted is the basis many supplements for its vitamin E and polyunsaturated fatty acids, while the flour, now being quickly eliminated because of its propensity to rancidity due to the presence of oil, may become the basic element for health products for the consistent presence of protein, also considering that the quality of treatment with SCF does not alter the its organoleptic qualities.
resistance in human pathogenic micro-organism.

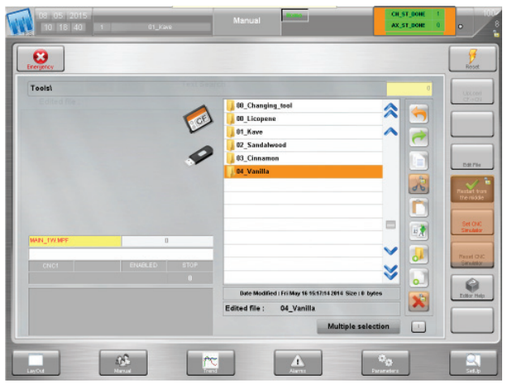
Controls and extractions by recipes

Easy and Clear
Synoptic screen clearly indicates all temperature (°F/ °C), pressure (psi/bar) and flow in liters/hr, and allows the operator a common sense view of the process. Six software buttons are visible in the lower part of the screen. *Layout* is the geneal view, *Manual* is the on line instruction manual, *Trend* shows the real time graphs of the extraction process, *Alarm* shows the real time and hystorical alarms, *Parameters or Recipe* to acces the recipes page and *Setup* for general setup like language (English, Spanish, Italian, German, French) and passwords.



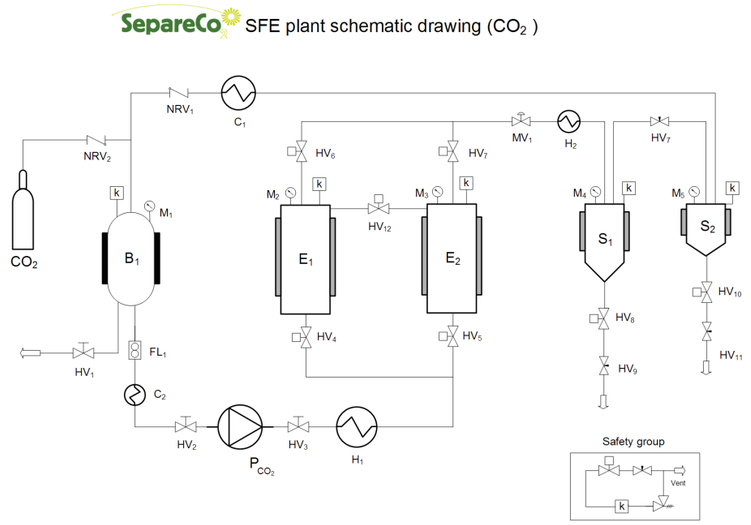
SCF SS10W-PLC single extractor double pump system main screen

Process by recipe
The process cycle is managed by Recipes. A Recipe is an app that automatically controls temperature, pressure, flow, and extraction time and extract collection time interval. These variables dramatically effect the final quality of the extract. These apps are available for download on the SCFN website. If you do not find the recipe you are looking for, simply ask for it. Tailored recipes are avilable on order. Our engineering team will write a new recipe exactly as you need. Load unlimited number of recipes in the software system. A wizard will help you to change main parameters like pressure, temperature, flow to adapt the original recipe to the new raw material.



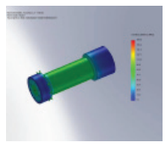
15" touch screen monitor PLC
Wide touch screen 15", the biggest monitor in this class of extraction systems.
Automation Panel 15.0" XGA TFT
- 1024 x 768 pixels (5:4)
- Single-touch (analog resistive)
- IP65 protection (front)
- USB port
- Ethernet port
- Processor: Intel, core i3

Professional equipments

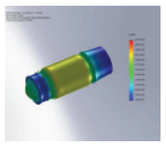


SCF SS10D-PLC scheme

Safety is our mission.
High pressure equipment need to be well designed and safe. Our CAD software helps us to find the right sizing and test the final results before going into production. Your safety is our number one priority.

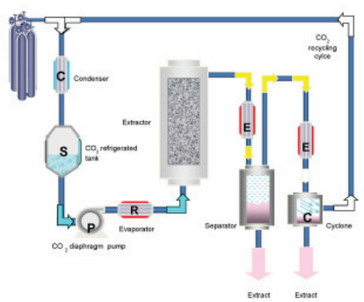


Design simulation



Stress test 10 times working pressure

Full recirculating system
CO_2 is fully recirculated along the process. Thanks to a condenser the gaseous CO_2 is liquefid and delivered again to the reservoir. This process allow to have very clean CO_2 circulating in the raw material.



Use the basket, it's smart!
We use basket in our extractors. Basket provides very even CO_2 flow through the raw material, and completely eliminates clogs. No need to clean the extractor at the end of each cycle. Ask for an additional basket. You will further decrease the down time in between extractions. Just take out the basket from the extractor and insert the new one. Very easy, fast and clean.

Selection of extraction recipes listed in our database and alphabetical sorted per raw materials

Raw material	Origin	Extract	Basic informations	Active principle	Use
Almond	Asia, Europe, North America	Oil	PUFA	Betasitosterol	Nutraceutical, cosmetic
Argania	Africa	Oil	Antioxidant 5000 orac		Cosmetics
Artemisia	Africa	Oil	Antimalarial, antitumor	Artemisinin	Pharmaceutical
Artichoke	Europe	Hydroalcoholic	Rich in polyphenols	Cynarine	Nutraceutical
Baobab	Africa	Oil	High antioxidant activity		Cosmetic
Basil	Europe	Essential oil	Antibacterial activity		Pharmaceutical cosmetic
Bergamot	Europe	Oil	Antibacterial activity		Cosmetic
Blueberry	Europe	Alcoholic	Antioxidant activity	Lutein	Nutraceutical
Boswuellia	Africa, South America	Resin oil	Anti-inflammatory activity	Boswellic acid	Pharmaceutical
Cacao (skins)	Africa South America	Oil	Aantioxidant activity	Polyphenols	Cosmetic, nutraceutical
Calendula (flower)	Europe	Oil	Antioxidant and anti-inflammatory	Faradiole	Cosmetic
Cannabis	Wolrld wide	Oil	Cannabinoids	CBD, THC, etc.	Cosmetic, pharmaceutical
Carrot	Europe	Alcoholic	Antioxidant activity	Beta carotene	Cosmetic
Chamomile (flower)	Europe	Oil	Relaxing activity		Cosmetic, nutraceutical
Cinnamon bark from	Africa	Oil from bark	Antioxidant and anti-inflammatory	Polyphenols	Food, nutraceutical
Cloves	Europe, Asia	Essential oil	Antioxidant activity		Food, cosmetic
Coffee	America	Oil	Rich in polyphenols		Cosmetics, food, nutraceutical
Devil's claw	Africa, South America	Resin oil	Anti-inflammatory activity		
Echinacea	North America, Europe	Oil	Antibacterial activity, healing	Echinacoside	Nutraceutical, cosmetic
Fishmeal	Wolrld wide	Oil	PUFA	Omega 3	Nutraceutical
Ginseng	Asia	Oil	Rich in ginsenosides	Phytosomes	Nutraceutical, cosmetic
Grapeseed	Europe	Oil	Rich in polyphenols		Nutraceutical
Hazelnuts	Europe	Oil	Rich in polyphenols		Nutraceutical, food
Helichrysum	Europe	Oil	Anthistaminic, anti-inflammatory		Nutraceutical
Hypericum	Europe	Oil	Antibacterial activity	Hypericin	Nutraceutical
Lavender	Europe	Essential oil	Aroma		Cosmetic
Linen	Europe, Asia,North America	Oil	PUFA	Omega 6	Cosmetic, nutraceutical
Microalgae	Wolrld wide	Oil	Rich in carotenoids and omega-3	Carotenoids, LPS	Nutraceutical, cosmetic
Mint	Wolrld wide	Essential oil	Aroma		Cosmetics, food
Neem	Asia and Africa	Oil	Terpenoid	Azadiractine	Nutraceutical, organic farming
Nettle	Europe	Hydroalcoholic	Rich in polyphenols		Biological agriculture
Olive	Europe	Oil	Rich in polyphenols	2000mg/Kg poliphenols in oil	Nutraceutical, food
Perilla	Asia	Oil	PUFA	Omega6	Nutraceutical
Pine needles and bark	Europe	Oil	Rich in tannins		Nutraceutical
Polygon	Asia, Europe	Oil	Rich in resveratrole		Nutraceutical
Propolis	Europe, America, Asia	Waxes	Rich in flavonoids		Nutraceutical
Pyrethrum	Africa	Oil	Insect killer	Pyrethrins	Biological agriculture
Rice (chaff)	Asia Europe	Oil	Sterols	Gamma oryzanol	Nutraceutical
Rosemary	Europe	Essential oil	Antibacterial activity		Nutraceutical
Serenoa repens	Africa, South America	Oil	Anti-inflammatory activity	Fitosterols	Nutraceutical, pharmaceutical
Soy	Asia, Europe	Oil	Rich in isoflavones		Nutraceutical
Tobacco	Europe, North America,Asia	Oil	Aroma		Cosmetic, nutraceutical
Tomato	Europe, North America,Asia	Oil	Rich in carotenoids	Lycopene	Nutraceutical, cosmetic
Turmeric	Asia	Oil	Antioxidant, antitumoral	Curcuminoids	Nutraceutical, food
Vanilla	South America and Africa	Oil	Aroma		Alimentary
Wheat germ	Europe	Oil	PUFA	Vitamin E	Nutraceutical, food