



Application Bulletin

Increase Filtration Capacity and Reduce Process Time in Citrus Oil De-waxing Applications

Overview

Essential oils extracted from orange, lemon, lime, tangerine, grapefruit and other citrus fruits are important raw materials for multiple uses of growing commercial importance. They are processed further into natural flavoring materials for the food and beverage industry, and have shown promise in additional applications as preservatives or antioxidant agents. Their byproducts are also used in commercial cleaners, aromatic and personal care products, medicinal preparations and more.

Most citrus essential oils are extracted by cold-pressing the rinds of the citrus fruits. Naturally-occurring waxes which originate in the citrus peels are solubilized during extraction and have a negative impact on the quality of the citrus oil, causing cloudiness upon precipitation. Various processors of citrus oils employ a variety of methods to separate the wax solids, including centrifugation, tank settling, diatomaceous earth (DE, Kieselguhr) filtration, and depth filtration with cartridges, lenticular filters or filter sheets. These methods pose some challenges.

Pall SUPRApak™ technology offers a unique and proven solution for cost-effective de-waxing of citrus oils, depending on their wax content. In addition, it has other uses in flavor applications, such as removing trace citrus oil from flavor washes, polishing flavors and flavor blends prior to packaging, and flavor pre-filtration.

The Challenge

Two flavor manufacturers process a variety of citrus essential oils from different sources or from own production, creating citrus flavoring ingredients for the food and beverage industry and citrus oil products for other commercial uses. De-waxing the citrus oils is necessary to optimize downstream conversion into flavors, or to meet the quality specifications of their customers. Batch sizes vary from less than 1,000 to over 10,000 liters (264-2,640 US gallons).

Both producers have employed various disposable filtration products to separate the undesirable waxes, including depth filter cartridges, lenticular

filter modules and filter sheets in plate/frame systems. The drawbacks they experienced were insufficient final product quality, which necessitated reprocessing of the oils in multiple passes through the filters, impacting productivity. Process flow rates were low, or the installations required larger sizing. Filters plugged relatively quickly. Replacing the disposable filters to allow batch completion was time consuming, labor intensive, and costly. As cleaning and reusing the filters is not generally an option especially when processing different batches of oils, filter disposable cost impacted profitability.

Filter sheets used in plate/frame systems had additional drawbacks, as the systems are open and characterized by presence of drip losses and exposure of the filtered fluids to the environment and operators. Sheet replacement was tedious and time-consuming.

Some applications made use of sparkler filters, utilizing DE as a filter aid. The drawbacks involved were similar to those experienced with the disposable filter solutions, with the additional detrimental factors of personnel exposure to the DE and the need for DE waste management.



Figure 1: Each SUPRApak module is a dense package of filter sheet material, providing exceptional throughput and excellent filtrate quality.



As is often the case in citrus flavor-producing facilities, much of the equipment in use must be explosion-proof, which presented a disadvantage when excessive handling of equipment for filter-change-outs was involved.

The primary goal in citrus oil de-waxing is to reduce process time and increase filtration capacity while maintaining superior filtrate quality.

The Solution

In a variety of applications on different oils at both manufacturers, Pall's SUPRAPak technology has met the challenge and overcome all the disadvantages of the conventional depth and DE filtration methods used (Figure 1).

Ambient temperature citrus oil is pumped from totes or tankers directly to the SUPRAPak filter installation. The resulting filtrate quality meets QA requirements, with no to very low need for product reprocessing. Filtrate quality is monitored in the laboratory either by a visual light test method or by in-process, online turbidity measurement.

In one case, which compared the use of depth filter cartridges (Figure 2) versus SUPRAPak modules for de-waxing, on the largest batch sizes of approximately 10,000 liters (2,640 US gallons) of product, process time was reduced by 90% from 29 hours with cartridges to 3 hours with SUPRAPak modules, due to the attainment of the required filtrate quality without a need for multiple re-filtration steps¹.

In a second case, a producer had previously employed several multi-round filter housings containing depth filter cartridges in a series of successively tighter micron ratings for citrus oil de-waxing. In contrast, they are now able to use a single SUPRAPak filter housing containing 2 vertically stacked 16-inch diameter SUPRAPak modules, while achieving an even better filtration

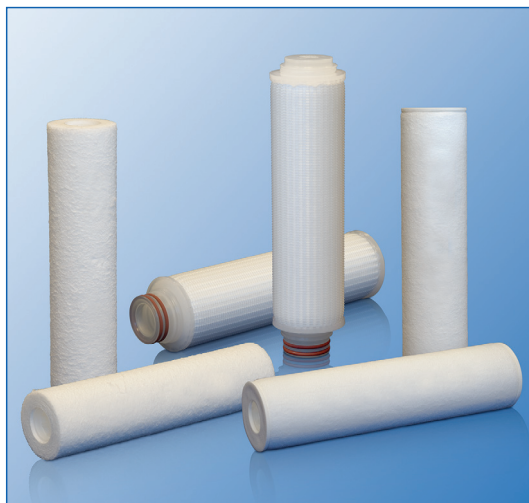


Figure 2: The use of melt blown depth filter cartridges in citrus oil de-waxing was found to require large sizing with in some cases multiple steps in series, and it often meant repeated re-filtration of the oil to achieve desired filtrate quality.

SUPRAPak – Optimizing Sheet-Based Filtration in a Closed and Compact System

Why the high filtrate quality?

SUPRAPak filter modules are composed of filter sheet media, a component mixture of cellulose fibers, DE, perlites and resin binders, which provide a combination of surface, depth, and adsorptive filtration. Due to the unique flow path of the filtered fluids through the SUPRAPak filter pack the filtration effect achieved is superior, resulting in extremely high filtrate quality.

Why the high flow capacity and throughput?

The sheet media utilized in SUPRAPak modules features an extremely high void volume and adsorptive effect for very high contaminant holding capacity, as compared to depth filter cartridges. In contrast to other sheet-based filters such as lenticulars and sheets, SUPRAPak modules are configured in a unique, high area pack design which results in a special flow configuration called "edge flow". The proven outcome is a much higher flow capacity and throughput than any of the other alternatives.

Why the high degree of flexibility in production?

SUPRAPak modules are available in several product family types in a variety of grades. The choice of the right product depends on the applications.

SUPRAPak modules are available in different diameters, ranging from small (SUPRAPak S), to medium (SUPRAPak M), and large (SUPRAPak L) (Figure 5). The ability to match batch sizes to module sizes enables cost-efficiency.



Figure 5: SUPRAPak modules are available in three sizes, which can be matched to batch volumes to increase cost-efficiency.

SUPRAPak technology is built on the concept of modular design, in that the SUPRAPak housings accommodate from 1 to 4 vertically stacked modules in the SUPRAPak M size range, and from 1 to 6 vertically stacked modules in the SUPRAPak L size range. The housings feature split dome design, which increases flexibility as it is possible to use the same housing for different stack heights of modules (Figure 6).

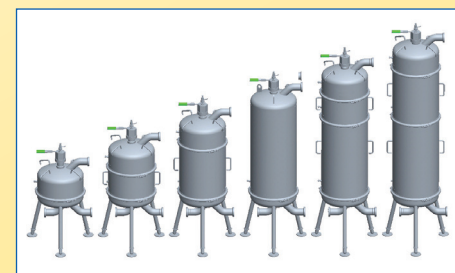


Figure 6: Size options and modularity of housing design enables a high degree of flexibility when processing varied citrus oil types and batch sizes.



effect. A minimum cost savings of 67% has resulted on disposable filters alone¹.

In citrus oil de-waxing, product can be processed at higher flow rates (e.g. 1,000-1,400 liters/hour/ SUPRApak L module) on compact SUPRApak installations, as compared to conventional depth filtration technologies.

In a third case, in which de-waxing was carried out with SUPRApak L modules versus an alternate lenticular module installation (Figures 3a and 3b), the SUPRApak solution demonstrated approximately 5 times higher capacity on the basis of equally dimensioned 16 inch diameter assemblies, before the modules were spent. An 88% disposable filter cost reduction was achieved, with an estimated process time reduction of 82% (Table 1)¹.

As the total volume of citrus oils filtered per SUPRApak module is high, the modules can be discarded on completion of the oil batches. This is in contrast to the lenticular filtration alternative in which multiple filter replacements were required during processing, especially of the larger batches.

Citrus oils typically consist of different amounts of wax depending on fruit type and cultivar, and the extraction process. The higher the wax content, the shorter the life of disposable filter products². Typical wax content in the second and third cases described was estimated to be in the range of 0.5-1%, although exact quantification was not

Why high product yields?

SUPRApak modules are fully enclosed in hygienic SUPRApak housings (Figure 7), which can be supplied in explosion-proof version. Upon completion of the filtration run, any held-up product can be pressurized out of the housing to achieve maximum product yield.

Due to the closed design, product is optimally protected from the surrounding environment and operators are not exposed to the contained fluids.



Figure 7: Cutaway view of SUPRApak housing and modules shows closed design.



Classic Stacked Disc Lenticular Modules



SUPRApak Module

Figure 3a (left) Figure 3b (right): While both lenticular and SUPRApak modules are made of filter sheet media, the SUPRApak solution demonstrates a significantly higher capacity due to its design and pack configuration.

Table 1: Batch Cost Reduction with SUPRApak L versus Lenticular Filtration (Case 3)

Filter Method	% Filter Cost Reduction With SUPRApak Solution	Filter Sets Required to Process Oil Batch	Filter Replacements Required Per Oil Batch	Man Hours for Filter Replacements per Oil Batch	Process Time per Oil Batch and Resulting % Reduction with SUPRApak Solution
Lenticular Modules	88%	5	4	1.5 hours	~ 16.5 hours
SUPRApak Modules		1	0	0	~ 3 hours

82%



available. High wax content may dictate the need for pre-filtration or decanting the oil from some of the wax solids prior to filtration.

Batch sizes vary greatly: the larger the batches, the longer the filtration runs, requiring more filter area to complete the batches. On the other end of the spectrum, very small batch sizes may be inefficient to process on full scale equipment. Finally, different oil types may require different degrees of filtration with tighter or more open grades.

Therefore high flexibility is key to maintaining process cost-effectiveness. A filtration solution that offers both a wide variety of removal ratings and modularity of filtration equipment design is optimal. These features are present in SUPRApak technology, and full advantage of these options is taken by the producers.

Some citrus essential oils have high value. In cases like these, flavor manufacturers have moved from using filter sheets in open plate/frame systems (Figure 4) to closed systems, to avoid losing valuable product to drip losses. The SUPRApak installation is a closed system ideal for preserving product yield.

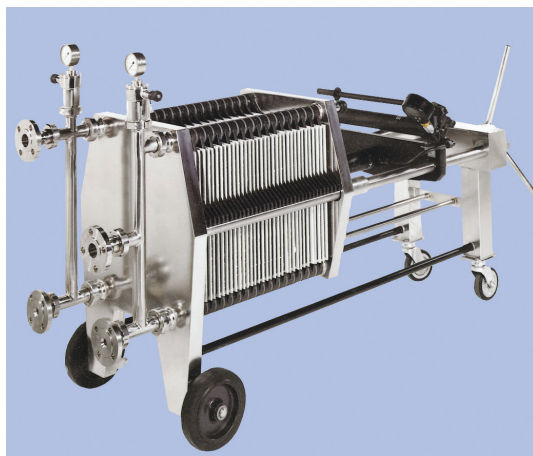


Figure 4: Sheet filters in a plate/frame press configuration pose challenges such as labor-intensive handling, high hold-up volume, and drip losses. They are open systems which expose fluids to the environment.

Other SUPRApak Uses in Flavor Applications

Aside of citrus oil de-waxing, many flavor applications require particle removal or polishing prior to packaging. SUPRApak technology can provide an excellent fit when high filtrate quality, high throughput, flexibility in application and high product yield is desired.

In flavor washes consisting of ethanol/water/citrus oil blends, removal of trace citrus oils within the ethanol/water phase after tank settling is also possible with SUPRApak technology.

In applications wherein flavor ingredients are aseptically dosed into aseptic process pipelines, SUPRApak modules provide an excellent high capacity pre-filtration step prior to sterilizing grade membrane filters, enabling longest possible process runs.

The Benefits

Both flavor manufacturers experienced step-change improvements within their citrus oil de-waxing processes. SUPRApak technology provides a superior alternate option to depth filter cartridges, lenticular modules, sheet filters and sparkler filters.

They presently benefit from:

- Excellent filtrate quality to meet product quality requirements, with limited to no need for multiple re-filtration steps
- Process time reduction by up to 90% for largest batches, resulting in productivity increase
- Low cost per filtered volume due to high capacity of SUPRApak modules when compared to lenticular filters and depth filter cartridges
- High product yield, due to elimination of drip losses from filter sheet systems, and ability to empty the SUPRApak housings by pressurization
- High product protection and low operator exposure to process fluids, due to enclosed system
- Flexibility due to modularity of SUPRApak equipment design, which enables matching batch sizes to equipment capacity
- Negligible labor expenditure due to ease and low frequency of SUPRApak module change-out, compared to conventional filtration methods
- Compact footprint of SUPRApak installation



Footnotes

¹ Batch results will vary based on citrus oil wax content and overall batch volume. Examples shown illustrate individual case comparisons.

² Wax content in citrus oils impacts SUPRApak filter capacity and sizing. Trials can best determine these parameters for each application. SUPRApak filtration will not cost-effectively replace high solids handling equipment such as centrifuges, although limits must be determined based on type and value of citrus oils.

About Pall Corporation

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