The Application of Sheet Filtration for the Production of High-quality Spirits

Powering Business Worldwide

Structure

- Introduction
- Which components can cause hazing in spirits?
- Significance of filtration during the production of spirits
- Requirements for filter systems
- Filtration characteristics of depth filter sheets
- Effect of depth filter sheets on fatty acid esters
- Summary of results
- Practical recommendations
- Application options for depth filter sheets

Introduction
Appearance+Aroma+Taste = Enjoyment

Important quality characteristics of clear spirits

- Appearance: Clarity
- Aroma: Volatile flavors
  (300 – 500 different known volatile substances)
- Taste: Flavor, alcohol content
- The sum of the overall impression leads to acceptance or rejection by the customer
- The goal of the distillery master: Maximum customer satisfaction, only satisfied customers will make repeat purchases

The Cornerstones of Quality

Influence factors for the overall flavor of spirits (Bartels 1996)	
1. Fruit	Degree of ripeness, internal and exterior quality
2. Mashing procedure	Such as crushing stones in stone fruit
3. Mash additives	Pure yeast; Enzymes; acid
4. Fermentation process	Temperature, duration
5. Secondary fermentation phase	None, short or long
6. Distillation process	Distillation speed, separation of first and last runnings
7. Drinking strength	Degree of redilution
8. Type of filtration	Filter medium; filtration temperature; filtration speed
9. Storage of the spirit	Time, temperature

Components Causing Hazing

Order of significance of the main "hazing culprits" K. Malinowsky, Nordhausen workshop	
Calcium, magnesium, silicates	25%
Iron	23%
Polysaccharides, pectins, dextrins	21%
Micro-organisms	18%
Higher fatty acids	13%
Copper	7%
Polyphenols	5%
Machine contamination	3%
Coal dust abrasion	1%
Terpenes	1%
Oil emulsions/varnish/urine	1% each
Corks	1%
Volatile S compounds	1%

Components Causing Hazing
Hardening agents (Ca and Mg ions)

Cause:

- Hard blending water, mainly with exhausted demineralization systems and ion exchangers

Identification in the distillate:

- Floccular hazing, crystalline precipitation

Avoidance:

- Adjustment with softened or distilled water
- Monitoring of the water treatment systems

Elimination:

- Sharp, cold filtration after appropriate storage; re-distillation

Components Causing Hazing
Heavy metals in combination with tannins

Cause:

- Storage in copper or iron containers; processing technology; blending with water containing heavy metals

Identification in the distillate:

- Discoloration; hazing

Avoidance:

- No contact with blank metal parts during processing

Elimination:

- Re-distillation; cation exchanger; sharp filtration with depth filter sheets or membrane filtration

Components Causing Hazing
Fusel oils

Cause:

- Fermentation by-product; mainly from spontaneous flora

Identification in the distillate:

- Hazing after adjustment to drinking strength

Avoidance:

- Use of pure yeast

Elimination:

- Cold acerbic filtration with depth filter sheets at 5% percent by volume below drinking strength, reduced filtration speed

Components Causing Hazing
Essential oils

Cause:

- Natural flavor-determining fruit components

Identification in the distillate:

- Fat droplets on the distillate surface

Avoidance:

- Optimization of the distillation technology

Elimination:

- Cold sharp filtration with depth filter sheets at 5% percent by volume below drinking strength
- Reduced filtration speed

Components Causing Hazing
Terpenes

Cause:

- Natural flavor-determining fruit components

Identification in the distillate:

- Bluish milky opalescence; precipitation at low temperatures

Avoidance:

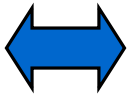
- Optimization of the distillation technology

Elimination:

- Fining of raw brandies (bentonite; magnesium oxide)

Components Causing Hazing
Fatty acids/fatty acid esters:

- Chemically, esters are compounds of acids and alcohol
- Fatty acid esters play a significant role in the flavor characteristics of spirits

Acid + Alcohol  Ester + Water

Origin

- Raw material/fruit: in peel and pulp
- Fermentation
- Natural or artificial maturing

Components Causing Hazing
Fatty acids/fatty acid esters:

Cause:

- Yeast metabolites created during fermentation

Identification in the distillate:

- Precipitation at low temperatures

Avoidance:

- Optimization of the distillation technology

Elimination:

- Fining of raw brandies (bentonite; magnesium oxide)

Components Causing Hazing

Sensory properties of significant fatty acid esters occurring in spirits			
Compound	Chain length	Substance causing hazing	Sensory characteristics (Arctander, 1969/ Ziegler, 1982)
Caproic acid ethyl ester	6 C atoms	+	Very fruity; vinous; somewhat flowery
Caprylic acid ethyl ester	8 C atoms	+	Fruity, vinous, sweet
Capric acid ethyl ester	10 C atoms	++	Sweet, oily, vinous, nutty
Lauric acid ethyl ester	12 C atoms	++	Fatty, fruity, oily, foliaceous
Myristic acid ethyl ester	14 C atoms	++	Slightly oily, slightly estery
Palmitic acid ethyl ester	16 C atoms	++	Oily, fatty

Components Causing Hazing

Sensory properties of significant fatty acids occurring in spirits			
Compound	Chain length	Substance causing hazing	Sensory characteristics (Arctander,1969/ Ziegler, 1982)
Caproic acid (hexanoic acid)	6 C atoms		Fatty, rancid, sharp
Caprylic acid (octanoic acid)	8 C atoms		Oily, rancid, sweat-like odor
Capric acid (decanoic acid)	10 C atoms		Sour-fatty, rancid odor
Lauric acid (dodecanoic acid)	12 C atoms		Fatty, wax-like
Myristic acid (tetradecanoic acid)	14 C atoms		Wax-like, oily odor
Palmitic acid	16 C atoms		

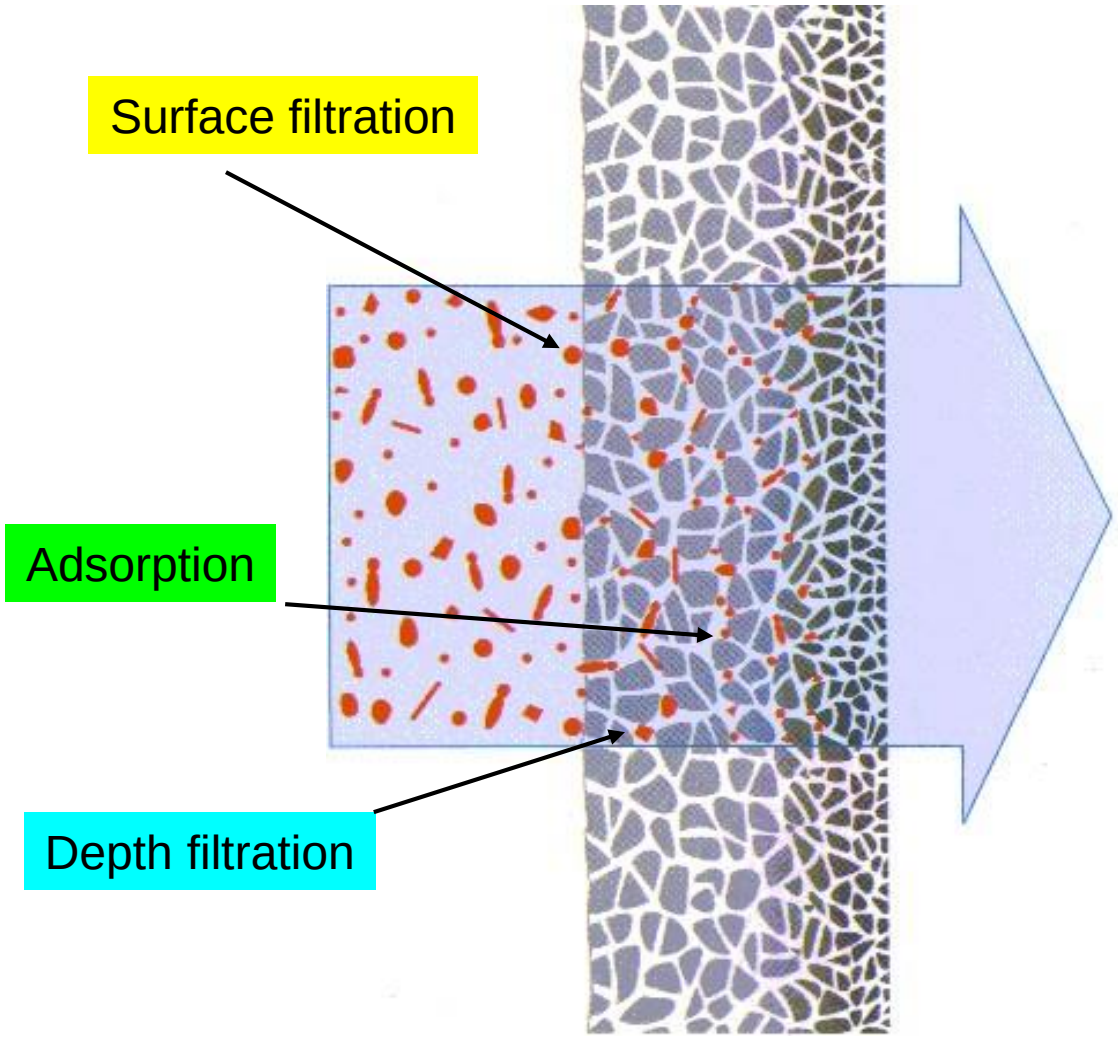
Significance of Filtration during the production of spirits

- Stability of the spirit
- Safe reduction of substances causing hazing and haze particles
- Gentle filtration = preservation of value-adding ingredients
- Selective filtration of undesirable components

Requirements for Filter Systems

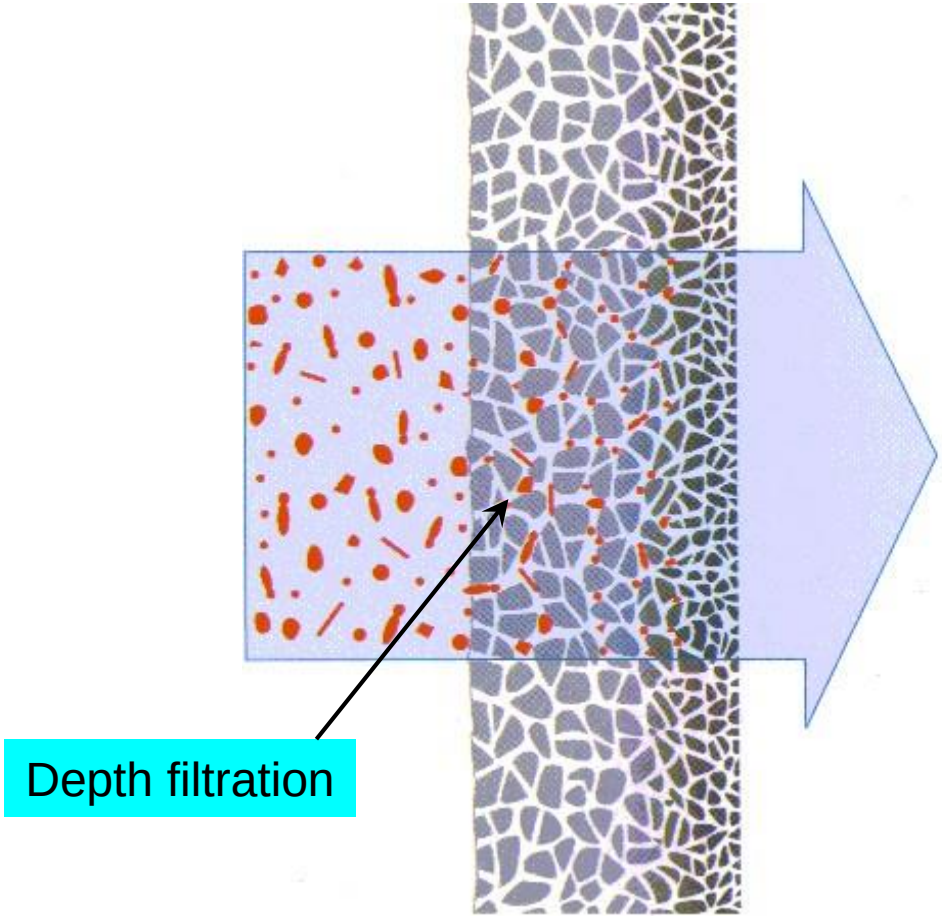
- Safe separation of fine and colloidal to coarse and disperse haze substances
- Maximum efficiency during the separation of ethereal, oil-like compounds
- High dirt holding capacity for the separation of crystalline precipitation, metal haze and carbon particles
- High overall performance
- High mechanical resilience
- Simple handling

Filtration Mechanisms



Filtration Characteristics

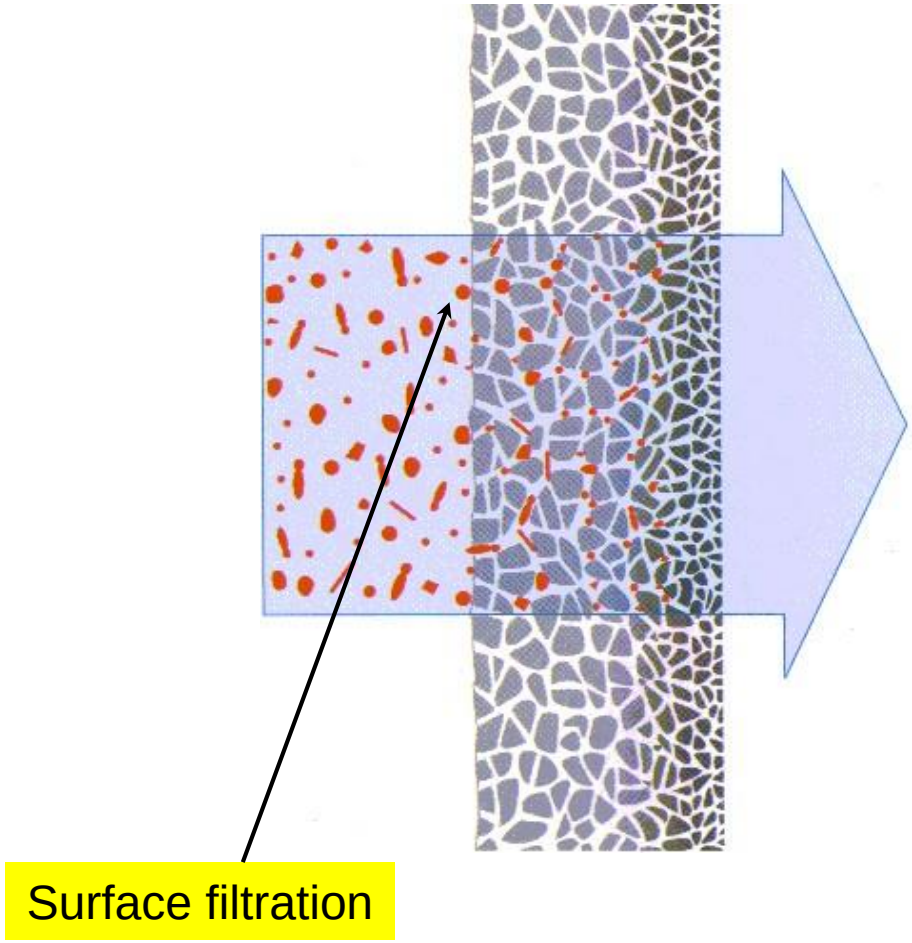
of depth filter sheets



- Three-dimensional, labyrinth-like structure through highly porous filter materials, i.e. cellulose, kieselguhr or perlite.
- Retention of haze particles at the internal sheet surface (depth filtration).
- At 1 sq. meter of filter area and 4 mm thickness, pore volumes of 75-80% result in 3 liters of unfiltrate volume.
- Effective mainly for activated carbon particles, crystalline precipitation, yeasts.

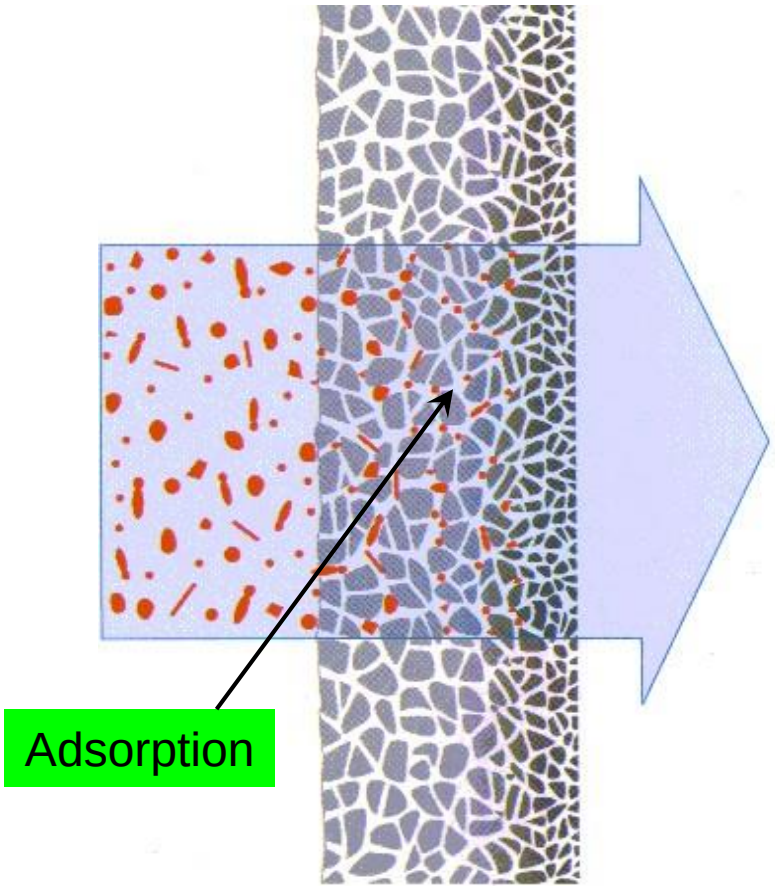
Filtration Characteristics

of depth filter sheets



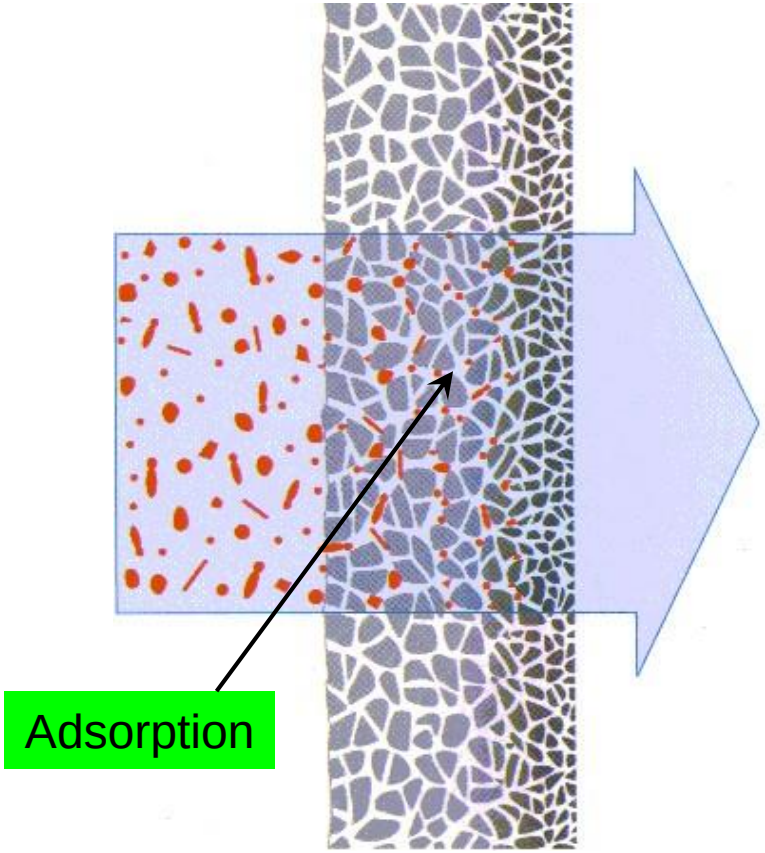
- Mechanical screening effect.
- Retention of particles that are greater than the pores of the filter sheet.
- Deformable particles, e.g. from alcoholic extracts of drug and herbs (macerates) tend to block the surface quickly => rapid reduction in performance.

Filtration characteristics
of depth filter sheets
Adsorption/electrokinetic processes



- Separation of tiny unfiltrate particles and colloidal dissolved substances.
- Particles are significantly smaller than the pores of the filter sheet.
- Retention via electrokinetic forces (zeta potential).
- Adsorptive processes (not mechanical retention) through van der Waals forces, Coulomb forces.

Filtration Characteristics
of depth filter sheets
Adsorption/electrokinetic processes



Influence factors:

- Temperature increase (impairs adsorption)
- pH value: Influences the iso-electric point of media with dipole
- Specific flow rate
- Interfering substances

Influence of Depth Filter Sheets on fatty acid ethyl esters

Order of significance of the main "hazing culprits" K. Malinowsky, Nordhausen workshop 2000	
Calcium, magnesium, silicates	25%
Iron	23%
Polysaccharides, pectins, dextrins	21%
Microorganisms	18%
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Polyphenols	5%
Machine contamination	3%
Coal dust abrasion	1%
Terpenes	1%
Oil emulsions/varnish/urine	1% each
Corks	1%
Volatile S compounds	1%

Influence of Depth Filter Sheets on fatty acid ethyl esters

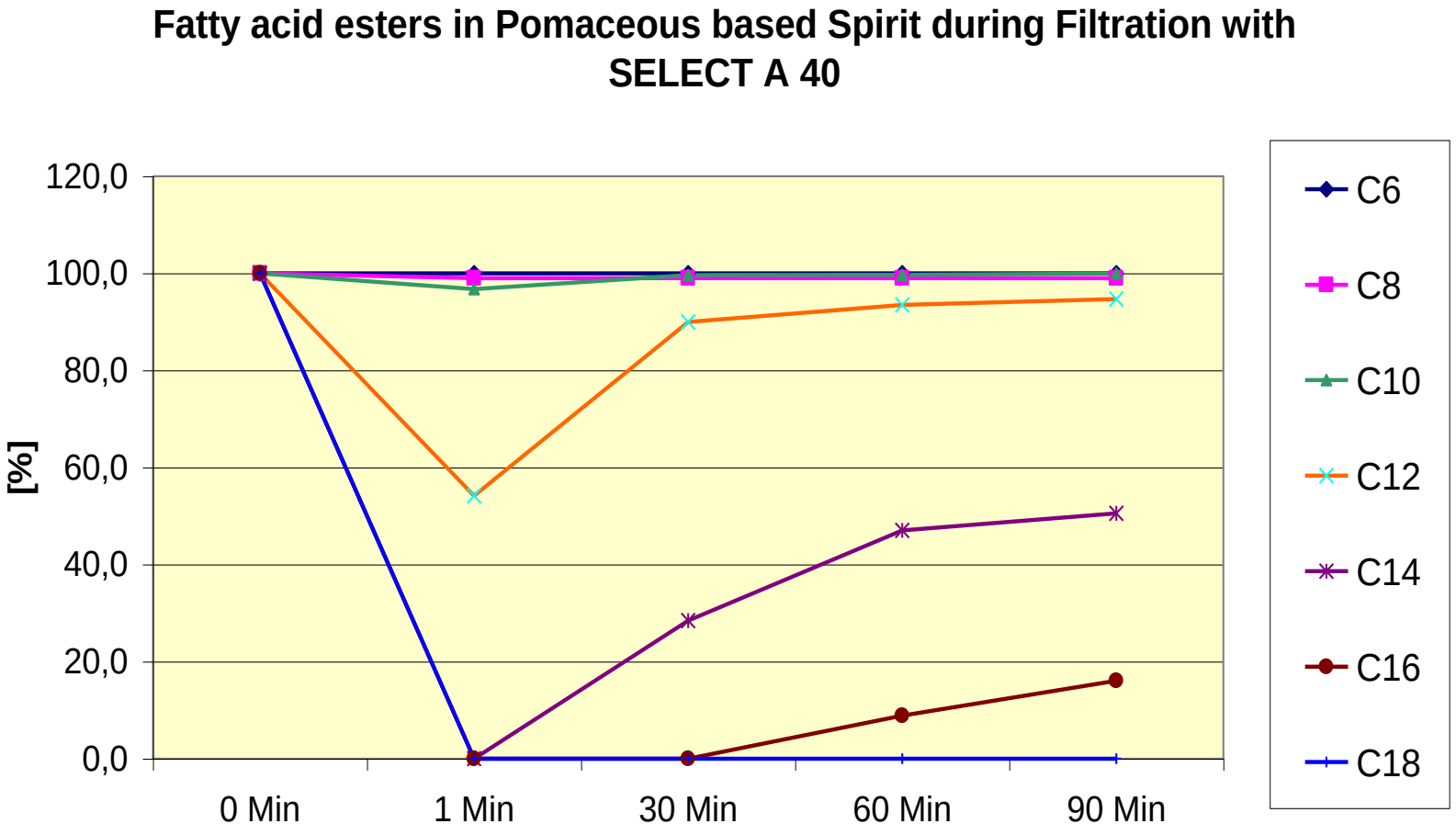
- Short-chain fatty acid esters have a strong influence on the flavor of spirits.
- Medium and long-chain fatty acid esters are the main cause of hazing.
- Recent studies indicate that long-chain fatty acid esters may be responsible for the last running characteristics of spirits.
- Goal: Filtration should be as selective as possible.

Influence of Depth Filter Sheets
on fatty acid ethyl esters

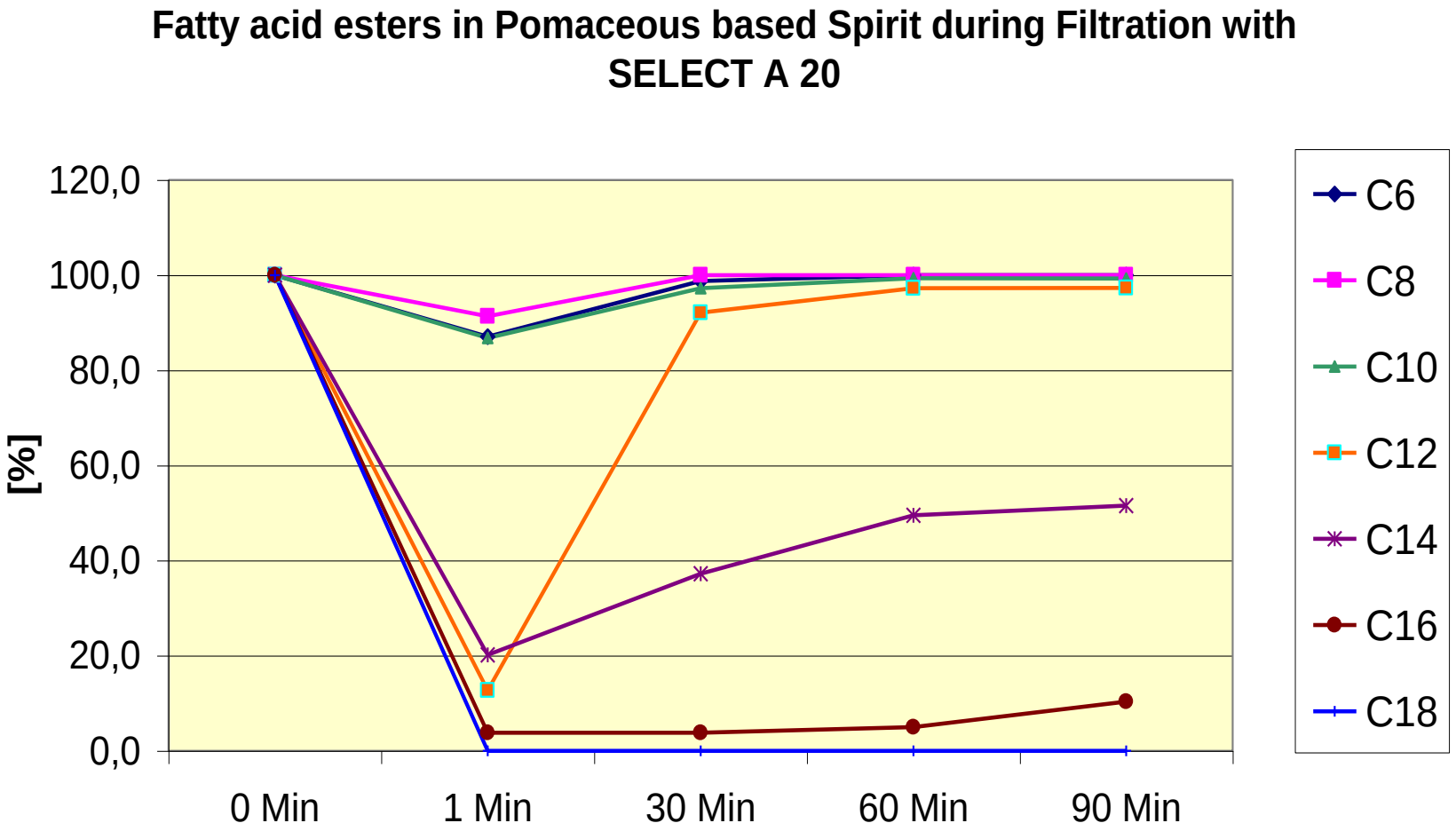
Filtration trial parameters:

- Filtration temperature 15°C
- Specific flow rate: 350 l/m²h
- Filter sheet BECO-SELECT A
- Fractionated sampling
- Different distillates

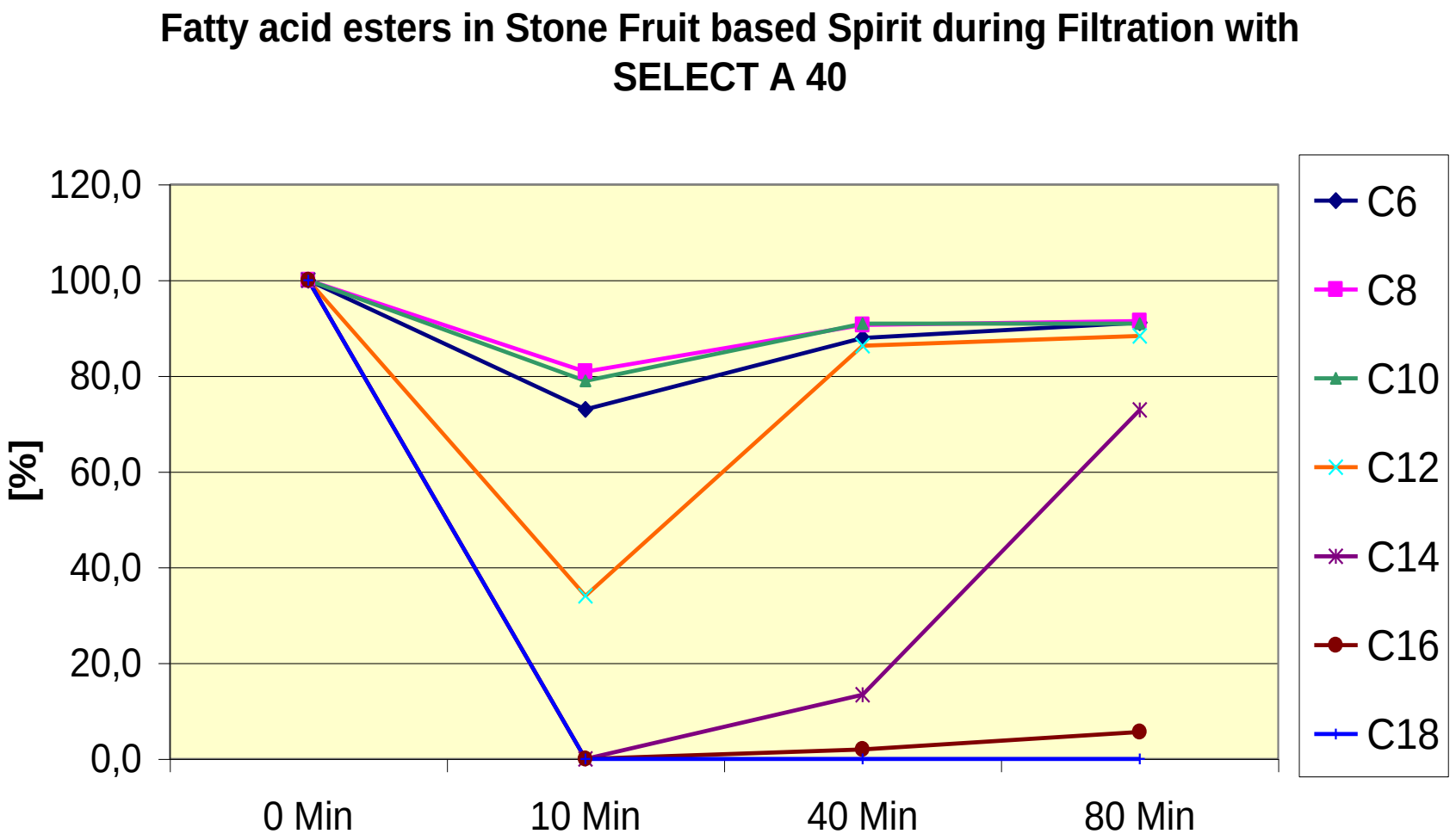
Influence of Depth Filter Sheets on fatty acid ethyl esters



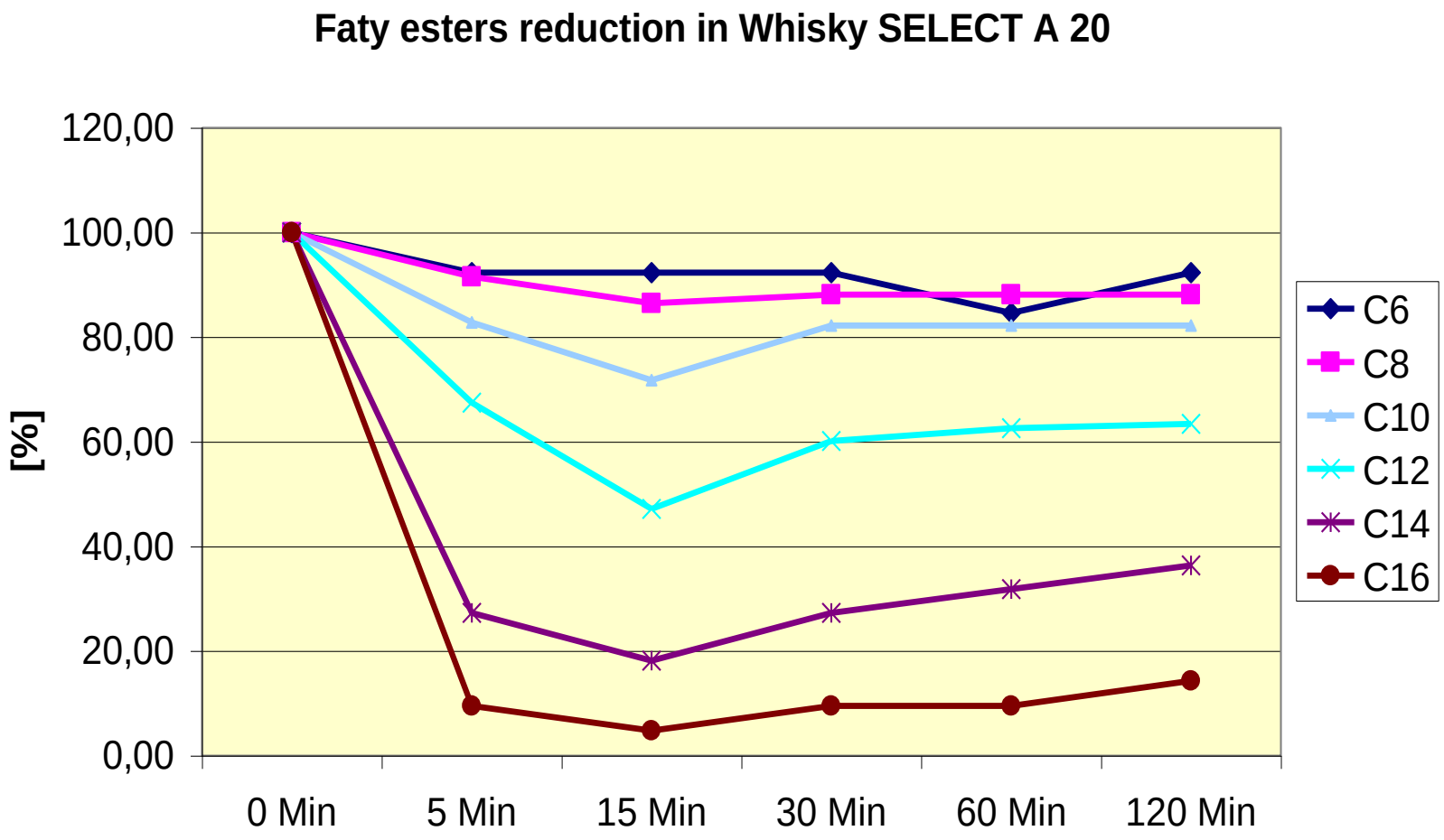
Influence of Depth Filter Sheets on fatty acid ethyl esters



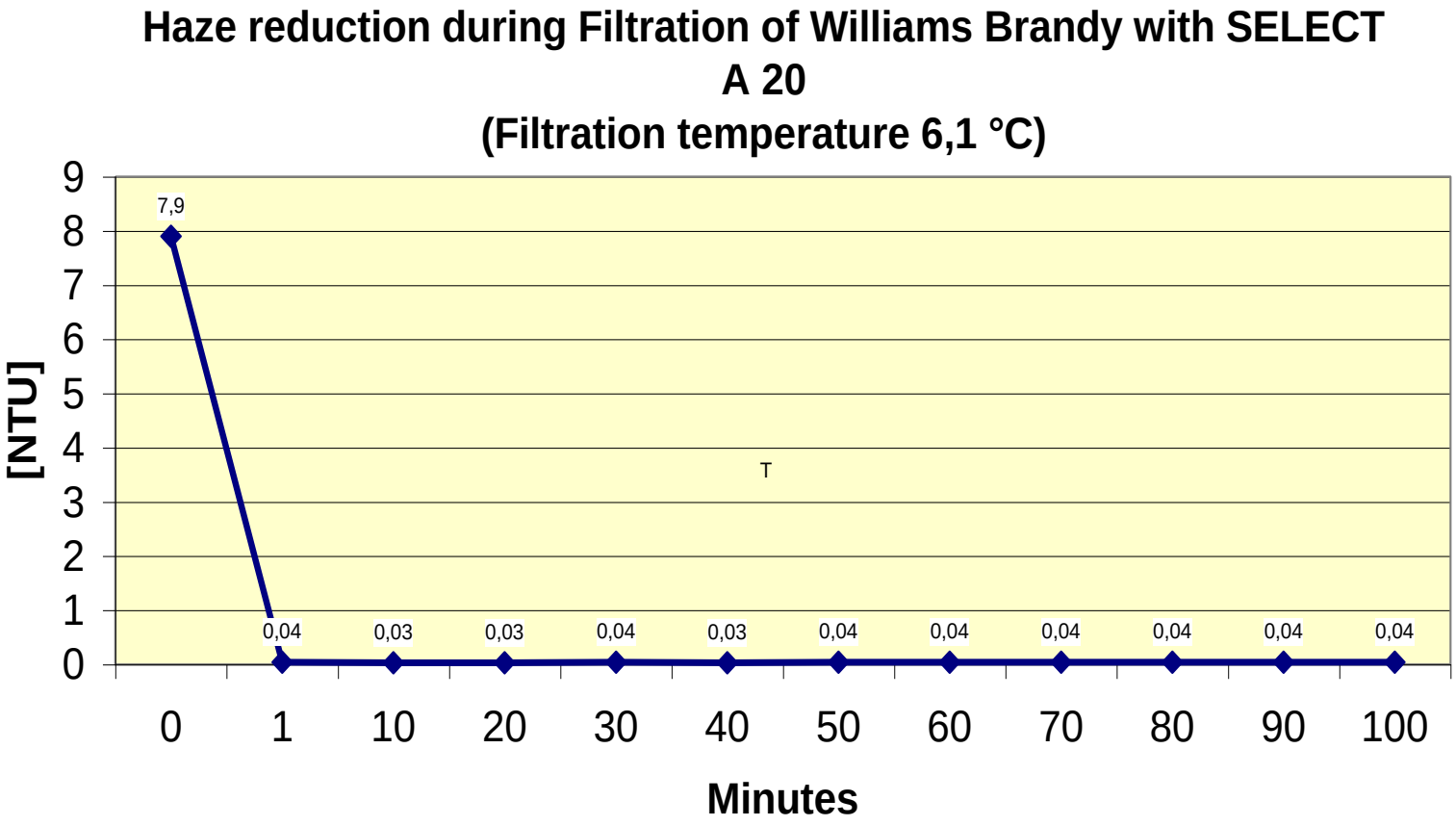
Influence of Depth Filter Sheets on fatty acid ethyl esters



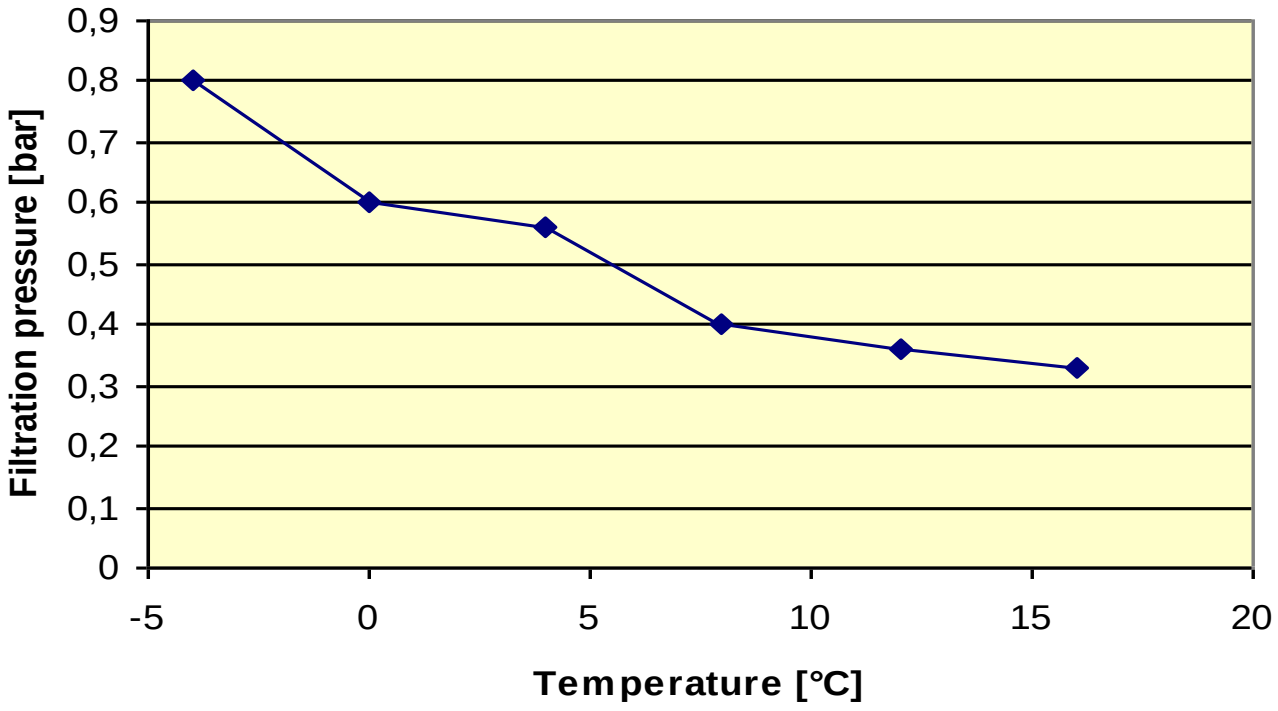
Influence of Depth Filter Sheets on fatty acid ethyl esters



Smooth Filtration conditions



Relationship between filtration pressure and filtration temperature Cherry Brandy, 40 percent by volume



Summary of Results

The application of BECO SELECT® A enables:

- Separation of mainly long-chain fatty acid esters, since they are adsorbed selectively.
- Safe removal of the main substances causing hazing at higher filtration temperature (up to 8°C).
- Filtration without affecting the flavor, since value-adding flavors (short-chain fatty acid esters) are preserved.

Recommendations for Application of BECO SELECT A depth filter sheets

- Reduction of the alcohol content prior to filtration to 1- 2% below drinking strength, while slowly adding and mixing blending water and distillate.
- Reduction of the throughput at the start of the filtration avoids surface blocking of the depth filter sheets.
- Reduction of filter performance with increasing hazing to avoid penetration of hazing.

Recommendations for Application of BECO-SELECT A depth filter sheets

Noble brandy	DFS	Filtration temperature	Throughput [l/m²/h]
Williams Christ pear	SELECT A 20 SELECT A 10	4-6°C	200 -250
Apple, pear	SELECT A 40 SELECT A 20	3-6°C	250-300
Quince	SELECT A 40	3-6°C	200-250
Stone fruit e.g. cherries	SELECT A 40 SELECT A 20	5-8°C	300-350
Rowan berries	SELECT A 40 SELECT A 20	3-6°C	200-250
Sloe	SELECT A 20	3-6°C	300-350
Elderberries	SELECT A 40 SELECT A 20	2-6°C	150 –200
Marc brandy Grappa	SELECT A 40 SELECT A 20	0-3°C	150-200

Application Options
for depth filter sheets

- Classic application of depth filter sheets in frame filters: Filtration of small quantities

Application Options for depth filter sheets

- Classic application of depth filter sheets in frame filters: Filtration of large quantities

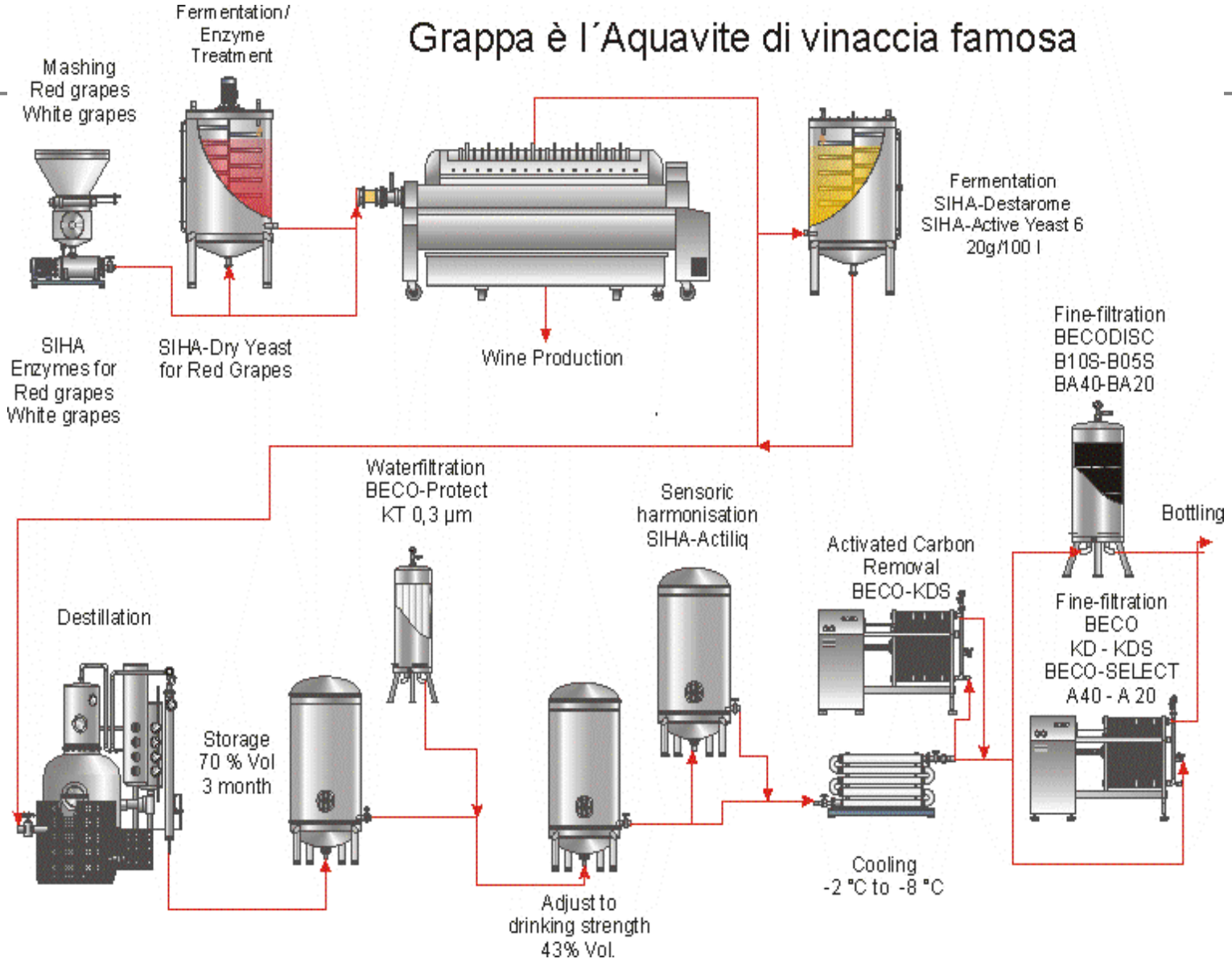
Application Options for depth filter sheets

- Application of depth filter sheets in BECODISC® stacked disc cartridges.

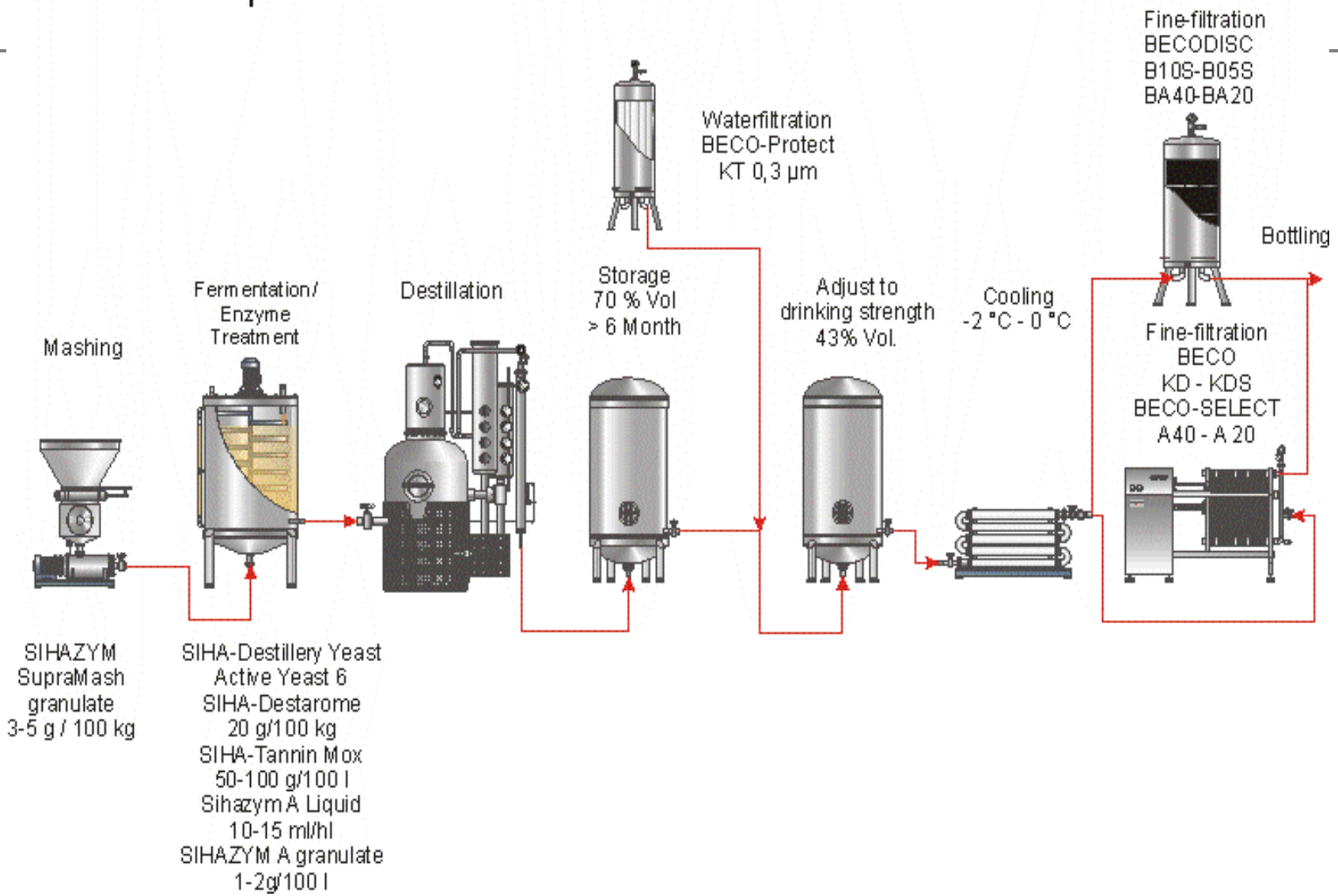
Advantages of BECODISC® stacked disc cartridges

- Enclosed filter system.
- Modular design enables simple and quick charging of the housing.
- Simply type separation through module change
- Small equipment dimensions.
- Low cost of investment for housing.

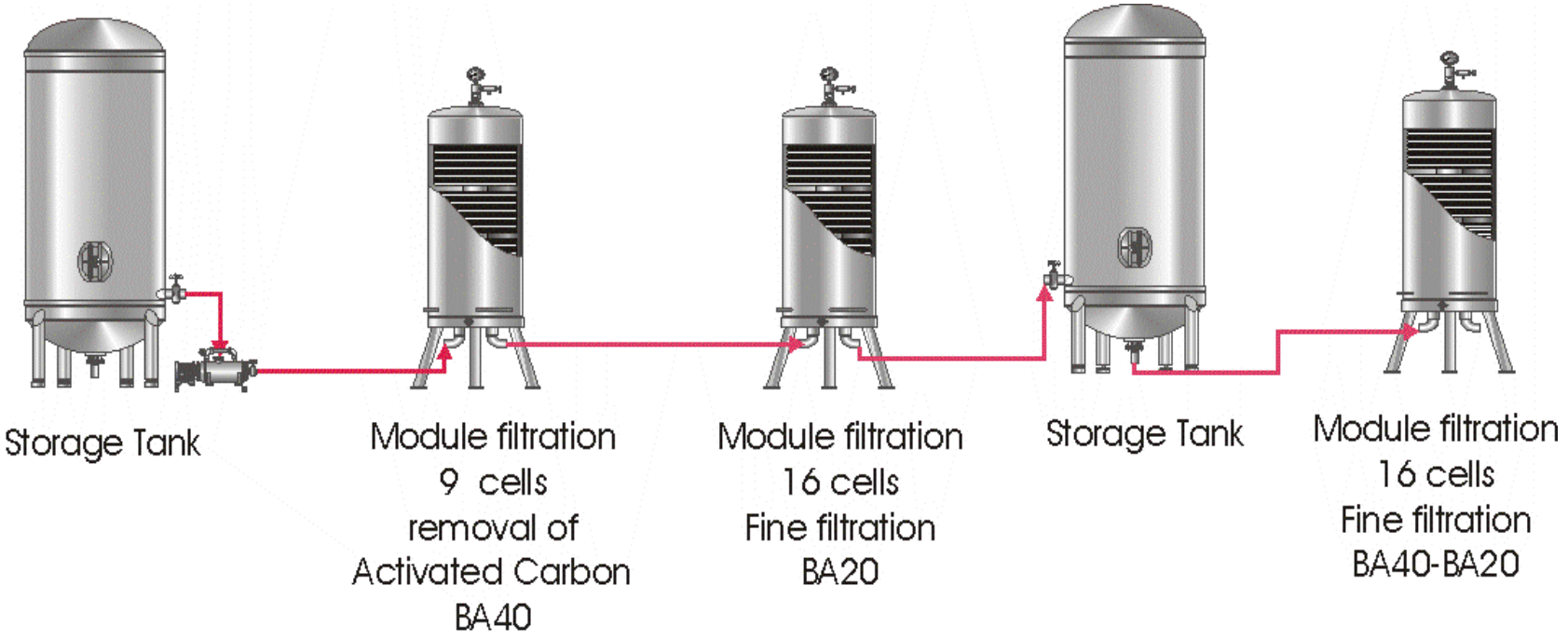
Grappa è l´Aquavite di vinaccia famosa



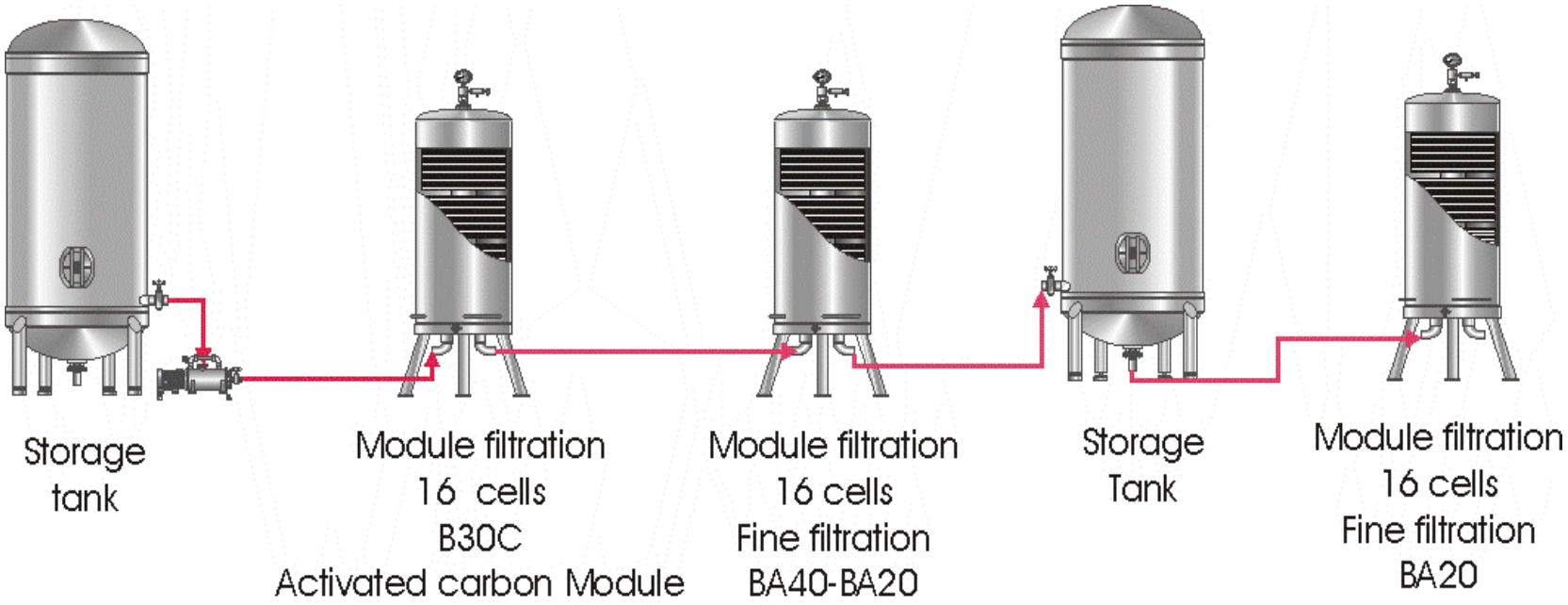
L´Acquavite d´uva o Destillato d´uva



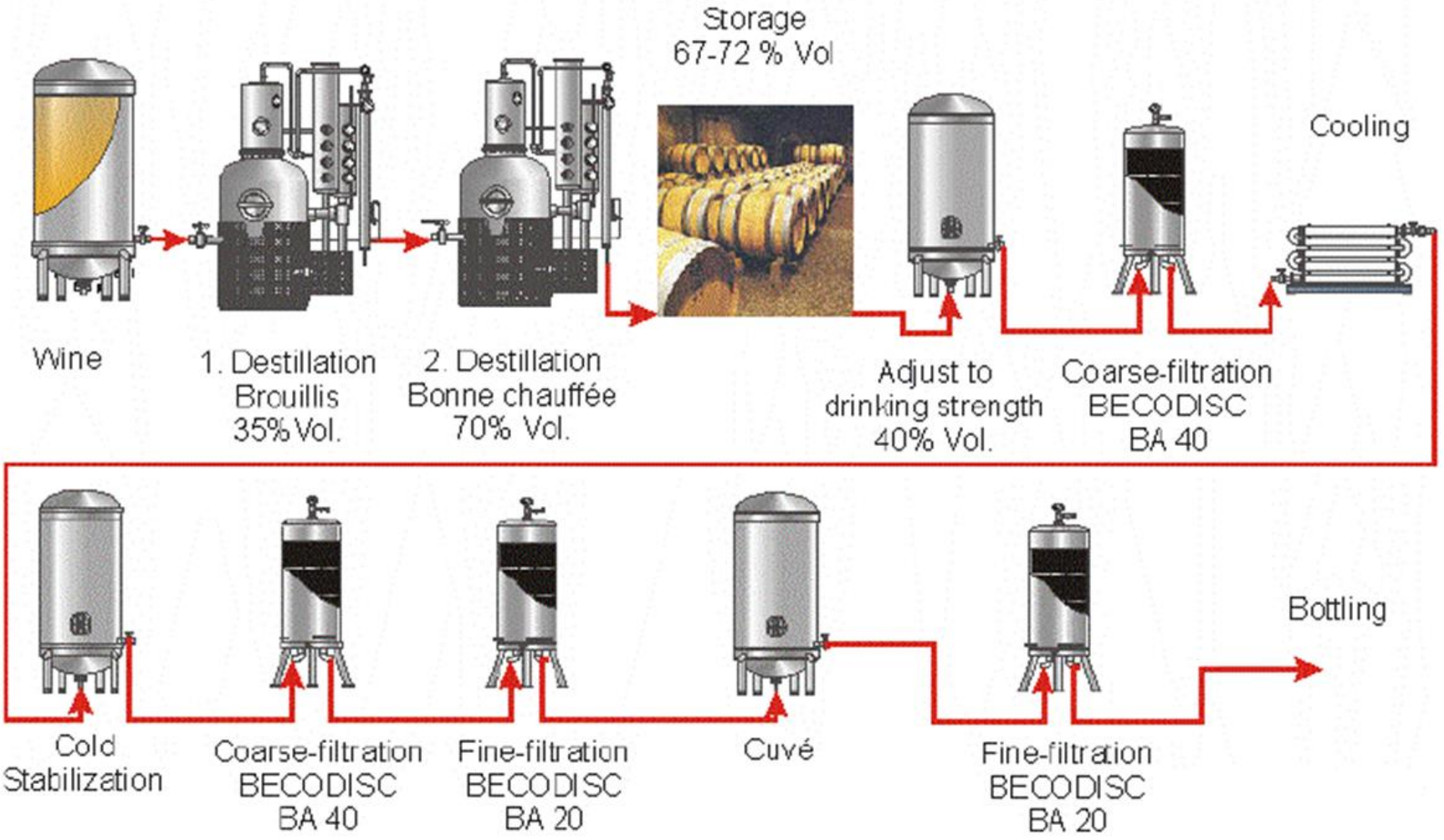
Wodka filtration: removal of activated carbon with 9 cell BECODISC modules



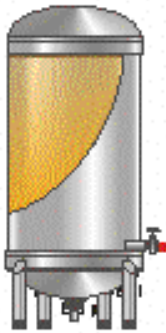
Wodka filtration with BECODISC activated Carbon Modules



Cognac Production



Whisky Production



Wash
6-7%Vol

1. Destillation
wash still
22%Vol.

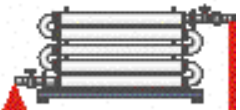
2. Destillation
spirit still
70% Vol.

Storage
63-72 % Vol

Adjust to
drinking strength
40%-43 Vol.

Coarse-filtration
BECODISC
BA 40

Chilling



Cold
Stabilization

Activated
carbon
filtration

Coarse-filtration
BECODISC
BA 40

Fine-filtration
BECODISC
BA 20

Ready for
Bottling

Fine-filtration
BECODISC
BA 20

Bottling

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