AS CLEAR AS AMBER

Turbidity in whiskey – flaws or taste criterion

Whiskeys, i.e. distillates from grain mashes, are among the spirits that have long enjoyed enormous popularity and have been a continuous consumer favorite. Their country of origin distinguishes types of whiskey. The most important producers of “brown spirits” after Scotland and Ireland are primarily the United States and Canada. The undisputed market leader is scotch (Scotland), followed closely by malt whisky (Scotland), Irish whiskey (Ireland), and bourbon (USA, Canada). Three factors are responsible for their different aromas: the raw materials, the production process, and barrel aging. However, what these whiskey types have in common is the decision as to whether the last production step is filtration.[1]*

After mashing the grains, the flavorings are fermented with yeasts and then distilled. The final process steps prior to filling take place after the whiskey has been allowed to age for at least three years in wooden barrels. The steps include dilution to decrease drinking strength and, if appropriate, the creation of a blend. Afterward, multiple consecutive filtration steps are usually performed. In the first step, the distillate is clarified via removal of fine colloidal to coarse dispersed solids such as crystalline precipitates, metallic turbidity, and charcoal particles (barrel char). Depth filter sheets and stacked disc cartridges with a retention rating of 1 to 3 μm are suitable for this step. Alternatively, depth filter cartridges can be used. In a second filtration step, turbidity-causing compounds, such as those containing ethereal, oily and fatty compounds, are separated out at low temperature. This second “cosmetic” filtration step is not strictly required.

Whiskey filtration with depth filter sheets: Ion-reducing Beco® Select® A depth filter sheets, Beco Compact® Plate 400 filtration system, Beco Integra® LAB round filter (f.l.t.r.)

Due to its alcohol content and the temperature it is aged, visible turbidity may form in whiskey. This veil-like opalescence is often interpreted as a quality defect and has an unpleasing appearance in the bottle. To prevent this, the water used for dilution to drinking strength in the first process step should be drinking water quality and as free as possible from ions such as calcium, magnesium, silicates, and iron. In addition, cold filtration is usually performed to remove turbidity-forming agents in a targeted manner. For this selective filtration, special ion-reducing depth filter sheets have been developed for the spirits industry. Their great thickness gives them a very large inner surface and therefore maximum particle retention capacity. Their lower concentrations of calcium, magnesium, and iron ions ensure the stability of the filtrate against precipitation and secondary turbidity after filling. The use of conventional filter sheets always

Causes of Turbidity	Rank
Calcium, magnesium, silicates	25%
Iron	23%
Polysaccharides (pectins), dextrins	21%
Microorganisms	18%
Higher fatty acids and fatty acid esters	13%
Copper	7%
Polyphenols	5%
Proteins	3%
Mechanical impurities	3%
Charcoal dust	1%
Terpenes	1%
Cork	1%
Highly volatile sulfur compounds	1%

Table 1: Causes of turbidity in spirits[2]

Compound	Chain length	Turbidity tendency
Caproic acid ethyl ester	6 C atoms	+
Caprylic acid ethyl ester	8 C atoms	+
Capric acid ethyl ester	10 C atoms	++
Lauric acid ethyl ester	12 C atoms	++
Myristic acid ethyl ester	14 C atoms	+++
Palmitic acid ethyl ester	16 C atoms	+++
Linoleic acid ethyl ester	18 C atoms	+++

Table 2: Sensory characteristics of important fatty acid esters
Definition of turbidity tendencies: + = low, ++ = medium, +++ = high

Whiskey filtration with stacked disc cartridges: Ion-reducing Becodisc® BA stacked disc cartridge, Beco Integra Disc housing (f.l.t.r.)

poses the risk of ion introduction, which can again lead to turbidity problems. The following table lists additional causes of turbidity in the order of their frequency of occurrence.

Fatty acid esters in distillates

Fatty acid esters are an essential component of whiskey. Since they influence both aroma and turbidity, they must be examined in a differentiated manner (see table 2). The short- and medium-chain fatty acid esters (C6, C8, C10) give whiskey its typical aroma. The long-chain fatty acid esters (C12, C14, C16, C18) cause turbidity.

Since fatty acid ethyl esters are present in the raw materials used to make whiskey – grain and fermentation yeasts – these esters enter whiskey naturally. Most of them are introduced by the yeasts via enzymatic biosynthesis during fermentation. The fatty acids are formed by sugar and acetyl (CoA). The yeasts produce enzymes that esterify the fatty acids using the ethanol resulting from fermentation.[3]

Further process-related factors leading to high concentrations of fatty acid ethyl esters include high pH values (> 5) during mashing, high temperatures (> 77 °F/25 °C) during fermentation and aerobic fermentation conditions. Moreover, during the aging process, the concentration of ethyl esters can also increase in the distillate if free fatty acids react with ethanol.[4]

The foreshots and the heart of the run contain an excess of short-chain, aromatic esters, whereas the long-chain esters that cause turbidity dominate the feints. Therefore, it is also possible to selectively influence the overall concentration of fatty acid ethyl esters when defining the separation between foreshots and feints.

Chill filtration

Cold filtration is also called “chill filtration.“ Its objective is to prevent temperature-based secondary turbidity or precipitation in the bottle. It is performed at 32 to 39 °F (0 to 4 °C), and in exceptional cases at temperatures down to 21 °F (-6 °C). At such low temperatures, the viscosity of the whiskey is altered, and emulsion causes the turbidity-forming agents to become visible as milky-white veils, clouding, and floating fatty globules. The filter medium can separate out the turbidity in this state. At temperatures below 32 °F (0 °C), the short-chain fatty acid esters also gradually become visible, so it is important to control the temperature of the whiskey as it is cooled to retain the valuable constituents. Thus, to preserve the whiskey’s aromatic profile, one should not cool more than is necessary.

***The spelling gives a clue to the country of origin.**

Whiskey with an “e” comes from Ireland, the USA, and Canada. Whisky without an “e” is produced in Scotland.

Whiskey filtration with depth filter cartridges: Beco Protect® PG depth filter cartridges, Beco Integra Cart cartridge housing (f.l.t.r.)

Additional factors influencing the effectiveness of turbidity removal are filtration speed and maximum differential pressure. Eaton recommends a flow rate of 6.1-8.6 gal/ft^2/h (250-350 l/m^2/h) at a maximum differential pressure of 21.8 psi (1.5 bar) when filtering spirits. In general: The lower the flow-through rate, the greater the respect of the product's qualities and the higher the reduction of turbidity.

When selecting the pump, one should be sure to use a gentle frequency-controlled type. Particularly recommended in this case are special peristaltic or progressive cavity pumps. If such pumps are not used, the oily and fatty compounds can be broken down, pass through the filter medium, and enter the final product.

Summary

Despite the fact that more and more distillers are including an unfiltered version in their product line, turbidity in whiskey is seen as undesirable and appreciated only by true aficionados. Visible turbidity in the bottle or a glass can be due to various causes that do not negatively impact the aroma. The most frequent causes are a high concentration of calcium, magnesium, and iron ions and the presence of turbidity-causing long-chain fatty acid esters, but visible turbidity may also be caused simply by the ice cubes many drinkers put in their glasses.

If special attention is paid to the quality of the raw materials, the yeast strain, the fermentation conditions, the distillation technique, and the quality of the water used to dilute drinking strength, constituents that cause turbidity can be reduced even before filtration. Polishing filtration and chill filtration with ion-reducing depth filter sheets at constant low flow rates reliably remove turbidity in the last production step and preserve the aroma and color of the whiskey.

In Scotland, a two-step filtration system with ion-reducing depth filter sheets has proven to preserve aroma very effectively. In step 1, large particles such as charcoal residues and crystalline compounds that enter whiskey during the aging process, which in some cases lasts decades, are targeted for removal. In step 2, the long-chain fatty acid esters are selectively removed at low temperature.

In the USA, mineral-free cellulose depth sheets are used during filling filtration to polish the whiskey one last time.

For cost reasons, ion-reducing filter sheets are usually not used for whiskeys produced on an industrial scale, and instead filtration is done with conventional filter sheets.

These examples show that, during whiskey production, the exclusive focus is not on turbidity removal. The emphasis is rather on achieving the desired product quality by increasing the product's value. And, in the end, customer acceptance influences the producer's decision regarding whether and how to filter. ☐

References:

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