



Enhancing Beer Manufacturing: Color Quality Control via Spectrophotometry

Introduction

In modern brewing, appearance is paramount. Beer color is the first sensory attribute consumers notice, and it strongly influences taste expectations and brand identity. Scientific studies and industry experts agree that color and appearance are “*critical factors in consumer acceptance*” and serve as indicators of overall quality and process consistency. Achieving tight color consistency from batch to batch is therefore essential. Instrumental color measurement using spectrophotometers offers fast, objective evaluation that meets industry standards and outperforms subjective visual methods. This white paper details how spectrophotometry – especially HunterLab’s Vista™ system – can enhance beer quality control. We discuss beer styles and color ranges, explain what color reveals about quality, and show how Vista’s speed, full-spectrum CIE color metrics, and built-in haze/NTU measurement give brewers best-in-class control and ROI.

Common Beer Types

Beer comes in two broad categories – **ales** and **lagers** – distinguished by yeast strain and fermentation temperature, but *not* inherently by color. Both ales and lagers can range from pale yellow to deep brown, depending primarily on grain selection and processing. For example, light American lagers and pilsners often fall in the SRM (*Standard Research Method*) 2–6 range (straw to light gold), while amber ales and India Pale Ales may be SRM 10–16 (golden amber to copper). Dark stouts and porters can exceed SRM 30 (deep brown to black). This variation is illustrated below showing the range of beer colors from light lagers/Pilsners to darker ambers, reds, stouts:



SRM/Lovibond	Example	Beer color	EBC
2	Pale lager, Witbier, Pilsener, Berliner Weisse		4
3	Maibock, Blonde Ale		6
4	Weissbier		8
6	American Pale Ale, India Pale Ale		12
8	Weissbier, Saison		16
10	English Bitter, ESB		20
13	Biere de Garde, Double IPA		26
17	Dark lager, Vienna lager, Marzen, Amber Ale		33
20	Brown Ale, Bock, Dunkel, Dunkelweizen		39
24	Irish Dry Stout, Doppelbock, Porter		47
29	Stout		57
35	Foreign Stout, Baltic Porter		69
40+	Imperial Stout		79

The color itself arises from the malts: lightly kilned malts yield pale beers, while roasted or caramel malts impart amber, brown or black hues. (Yeast type has little effect on color.) Brewers quantify these colors using recognized scales: SRM (Standard Reference Method) in the U.S., and EBC (European Brewing Convention) or Lovibond units elsewhere. These numerical scales allow brewers to classify products (e.g. Pilsners ~3–4 SRM, amber ales ~10–15 SRM, stouts 30+ SRM) and ensure style consistency.

Importance of Color Measurement in Beer Manufacturing

Color is more than aesthetics: it is a **quality control** parameter throughout production. Consistent color signals that raw materials and process conditions are under control, reinforcing brand standards. Sudden color shifts can indicate upstream issues (e.g.



different malt batch, mash pH changes, boil-off variations), oxidation, or contamination. Consumer studies and industry reviews emphasize that “*color is a crucial sensory attribute*”, often the first quality cue consumers notice. Ensuring that each batch meets the target color profile is thus vital for maintaining brand image and customer satisfaction.

Compared to visual checks, instrumental spectrophotometry dramatically improves control. Instruments remove subjectivity and detect subtle deviations beyond human perception. Spectrophotometers measure exact transmittance values and compute standard color metrics (CIE Lab*, SRM, EBC, APHA, etc.) that human eyes cannot, especially in detecting slight shade differences. In short, objective color measurement with a reliable instrument is “the best way to quantify the color of beer” and ensure consistent batches.

What Color Reveals About Beer Quality

Beer color reflects the ingredients and process chemistry. In most beers, color comes from Maillard reaction products (melanoidins) generated when wort is boiled and roasted malts are mashed. Thus, darker color often indicates heavier kilning or longer boil times. A recent review highlights that **malt type and heat-processing intensity** play “*significant roles*” in conventional beer color. For example, using darker specialty malts or extending boiling produces more intense amber/brown hues (and richer flavor), whereas lighter malts and shorter boils yield pale, golden beers.

Moreover, additives and novel ingredients show up in color. Fruit and herbal beers derive color primarily from pigments like anthocyanins in berries or hops flavonoids. Unexpected color in a supposed “blonde” beer might signal the use of colored adjuncts or process anomalies. Similarly, slight shifts in hue or increased yellowing can indicate oxidation or



age. A hazy/cloudy appearance (see next section) also alters perceived color by scattering light.

In summary, measured color and clarity are proxies for many quality factors: ingredient specifications, process parameters (mash pH, boil time), and product stability. Systematic color measurement allows brewers to link color data back to these factors – for example, tracking wort color during the mash can help adjust malt bills, or monitoring final beer color can confirm filtration effectiveness.

Applications for Color Measurement in Beer Manufacturing

Color measurement adds value at *every stage* of brewing. Key applications include:

- **Raw Material QC:** Verify malt and syrup color values upon receipt. Maltsters and vendors usually supply EBC or Lovibond ratings for malts; incoming malt can be checked to ensure it meets spec. Even subtle variations in adjuncts (like carapils vs. crystal malts) will show in color.
- **Process Monitoring:** Measure color of wort after mashing and after boiling. This allows brewers to fine-tune mash temperatures or boil durations on the fly. For instance, adding more dark malt if the color is too light, or cutting boil time if it's too dark. As one brewer guide notes, *“grains play a significant role in beer color... lightening by limiting roast, darkening by increasing roast or boil times”*, so routine checks can guide recipe control.
- **Intermediate Quality Control:** During fermentation and conditioning, checking color ensures no unintended haze or off-color development. Color measurement after clarification (centrifuge or filtration) confirms that clarifying steps have achieved target clarity.



- **Final Product QC:** Before packaging, each batch's color is compared against reference standards (target L^* , a^* , b^* , SRM/EBC values). This confirms lot-to-lot consistency. Even on-line or at-line spectrophotometers can be used to spot issues before bottling.
- **Product Labeling and Legal Compliance:** Beer labels often indicate “color” or expected appearance. Instrumental measures can verify that the product matches label claims (e.g. “clear straw” vs. “amber”). In addition, if color additives (permitted by FDA) are used (rare in beer), their concentration can be monitored.
- **Brand Development and R&D:** New product formulations (e.g. specialty ales or fruit beers) require precise color targets. Using a spectrophotometer accelerates development by instantly showing the impact of recipe changes, reducing trial batches.

Collectively, these applications translate to quality benefits: fewer off-spec batches, less waste, and higher customer satisfaction. In practice, brewers find that *“an efficient color testing system is crucial”* for optimizing recipes and ensuring consistency.

Challenges in Applying Color Measurement to Beer (Especially Visual Methods)

Traditional color evaluation in brewing has major limitations. Visual assessment (by eye or Lovibond discs) is inherently subjective and inconsistent – results vary with lighting, observer vision, glassware, and sample presentation. Industry experts note that **“the current color measurement method does not reproduce how the eye sees color; a beer color number can be the same for products that are visually different”**. In other words, two beers may register identical SRM values but look noticeably different in tint or hue to a human eye. This is because single-wavelength methods (e.g. ASBC Beer-10 at 430 nm) capture only a narrow slice of the spectrum.



Turbidity (haze) compounds the problem. Visual haze assessment is qualitative (clear vs. “hazy”), and slight turbidity can skew apparent color. The ASBC Beer-10 method even notes that turbidity is “*generally not quantified, only qualitatively evaluated*”. In practice, floating foam or fine particles can make visual color readings unreliable. For example, a beer with chill haze may appear murky yellow, leading one to misjudge its color. In contrast, instrumental methods can separately quantify haze (see below) and report the true color of the clarified liquid.

Other challenges include the effect of dissolved CO₂ and bubbles (which scatter light) and the need for consistent pathlength. Spectrophotometers overcome these by measuring after degassing and using standard cuvettes. Ultimately, the limitations of visual methods underscore the need for objective spectral measurement: **only a full-spectrum instrument with CIE colorimetry can capture the complete color character of beer.**

Instrumental Spectrophotometric Methods and Recommendations

For precise color analysis, a **color spectrophotometer** is recommended. Key features include:

- **Measurement Geometry:** A transmission (0°/180°) setup with a standard 10 mm pathlength is used for beer. Samples should be **fully clarified** (filtered or centrifuged) and degassed. The reference (blank) is typically deionized water.
- **Wavelength Range:** The instrument should cover at least 400–700 nm (visible range) – many brewers use 380–780 nm to compute CIE Lab* values. High resolution (≤5 nm bandwidth) ensures capture of sharp spectral features from malt colorants.



- **Single-Wavelength Color:** ASBC Beer-10 (SRM) and EBC methods call for measuring absorbance at 430 nm in a 1 cm cell. A measurement at 700 nm checks for haze (clear beers should have negligible absorbance at 700 nm).
- **Full-Spectrum Tristimulus:** Beyond single-point readings, a full scan at 81 points from 380–780 nm can be converted via ASTM E308 into CIE Lab* coordinates. This yields a three-dimensional color description that aligns with human vision. Such tristimulus analysis provides a “*better representation of beer color*” and can detect subtle hue differences. Many breweries now adopt this approach for reporting color under a daylight illuminant (D65/C) and 10° observer.
- **Instrument Calibration and Compliance:** Ensure the spectrophotometer has a traceable calibration (e.g. tungsten-halogen lamp calibration for wavelength accuracy, neutral glass/filters for photometric accuracy). One-touch or automated standardization routines (often supplied as IQ/OQ software) simplify compliance with ASBC/EBC method requirements. Instruments should meet or exceed the photometric accuracy (± 0.002 A at 1 A) and stray-light specifications of ASTM/EBC standards.

In practice, spectrophotometric color methods should be performed under controlled lab conditions. Sample temperature and cell cleanliness must be consistent. We recommend running parallel samples to check precision. Overall, the combination of standard reference cells, a wide-spectrum scan, and built-in algorithms ensures the data are both accurate and richly informative.

Haze and NTU Measurements: Why They Matter

Beer clarity is measured as haze or turbidity, which quantifies light scattering by suspended particles (proteins, polyphenols, yeast). Haze affects visual appeal and can



signal brewing issues (e.g. insufficient filtration, microbial contamination, or chill haze formation upon cooling). There are two complementary metrics:

- **ASTM D1003 Haze (%)**: Defined as the percentage difference between total transmission and diffuse transmission through the sample. It essentially measures the fraction of light deviated by scattering versus straight-through. Although originally for plastics, D1003 can apply to beer, classifying haze from the transmitted spectrum.
- **Nephelometric Turbidity (NTU)**: Measured by shining a light into the sample and detecting side-scattered light at 90°. This is the common scale in water and beverage industry. Low NTU (e.g. <1–5) means very clear; higher values indicate cloudiness.

The ASBC does have a beer turbidity method (Beer-2) based on absorbance at 430 nm and 700 nm, but it is only qualitative (“turbid” vs “clear”). For quantitative control, spectrophotometers can directly report both haze and NTU. HunterLab’s Vista, for instance, includes built-in haze percentage and NTU indexes. Vista’s software includes an *NTU-10mm* mode capable of measuring 0–150 NTU using a 10 mm cel. (Vista also reports percent haze in transmission automatically with each measurement.)

Quantifying haze matters because a hazy off-white deposit in beer can be just as unacceptable as an out-of-range color. By measuring haze/NTU, brewers can set strict clarity specs (e.g. <2 NTU for a bright lager) and detect filter breakthrough or turbidity generation immediately. Regulatory and pharmacopeial standards (e.g. EBC 9.38, ASTM D1003, or Eur. Pharmacopeia 2.2.15) all recognize quantitative haze measurements. Vista’s integrated haze/NTU capability thus lets breweries comply with these standards and document stability: every color measurement simultaneously gives a clarity value.



Understanding Instrumental Technologies for Beer Color Measurement

Modern breweries have several instrumental options for assessing beer color quality, but not all technologies offer the same level of accuracy, flexibility, or operational efficiency. The three primary categories are **UV-Visible Spectrophotometers**, **Colorimeters**, and **Color Spectrophotometers**—with the **HunterLab Vista** representing the most advanced and preferred choice in this space.

1. UV-Visible Spectrophotometers

Technology Overview:

UV-Visible spectrophotometers measure light absorbance or transmittance across a broad range of wavelengths, typically from 200 nm to 800 nm and higher. These instruments are designed to provide detailed spectral data by scanning narrow bands of wavelengths using a monochromator. The result is a high-resolution absorbance profile, which can be used to compute various color scales (such as SRM, EBC, APHA, Gardner, and CIE Lab*), monitor chemical properties, or perform retrospective analysis.

Limitations in Brewery Use:

While UV-Vis instruments are powerful, they present several drawbacks for high-throughput beverage manufacturing:

- **Slower Measurement Speed:** Scanning a full spectrum, especially at high resolution, can take several minutes per sample, limiting throughput.
- **Complexity and Overkill:** These instruments are often overengineered for routine color analysis, requiring specialized training, sample preparation, and maintenance.



- **Lack of Haze/Turbidity Integration:** Standard UV-Vis units typically do not measure haze or turbidity, a critical parameter in beer quality control, requiring an additional instrument.
- **Limited Ease of Use:** Full-spectrum UV-Vis systems, although accurate, often lack user-friendly interfaces and rapid operation modes suited to production environments.

2. Colorimeters (Color Analyzers)

Technology Overview:

Colorimeters are instruments that estimate color using pre-set illuminant/observer combinations to discern gross color differences.

Limitations in Brewery Use:

- **Restricted Functionality:** Colorimeters lack spectral data capture, limiting flexibility. They cannot calculate non-tristimulus indices like EBC, SRM, or APHA without approximation.
- **No Spectral Insight:** Without access to the actual spectral curve, colorimeters are vulnerable to *metamerism*—different samples appearing the same due to human-based filters but being chemically or optically distinct.
- **No Haze or NTU Measurement:** A separate turbidity meter is often required, complicating workflows.
- **Fixed Configuration:** Colorimeters cannot adapt to multiple color scales or changing standards without hardware modifications or workarounds.



3. HunterLab Vista: A True Color Spectrophotometer

Technology Overview:

The HunterLab **Vista** is a purpose-built **color spectrophotometer** that combines the high-resolution power of UV-Visible spectral measurement (400–700 nm) with the ease, speed, and usability of a dedicated colorimeter. It uses a dual-beam, sphere-based transmission geometry ideal for liquid beverage samples.

Why Vista is the Preferred Technology for Beer Color Measurement:

- **Full Spectral Data:** Vista captures the entire visible spectrum in a single scan, ensuring precise, reproducible, and metamerism-free measurements.
- **Simultaneous Color and Haze Measurement:** Vista uniquely delivers both color (CIE Lab*, SRM, EBC, and more) and **haze/NTU** in one reading—eliminating the need for separate instruments.
- **Speed Without Sacrificing Data:** Unlike traditional UV-Vis units, Vista delivers full-spectrum analysis measurements in seconds. There's no need for scanning delays, filter changes, or switching devices.
- **Ease of Use:** With touchscreen operation, one-touch calibration, and preloaded ASBC/EBC methods, Vista is operator-friendly with lab-grade precision—ideal for production lines and QA labs.
- **Standards Compliance:** Vista's alignment with international beer color standards (ASBC, EBC, L*,a*,b*) makes it ideal for global breweries seeking consistent regulatory compliance.
- **Retrospective and Scalable Analysis:** Because it records spectral data, Vista allows breweries to retroactively compute alternative color indices or evaluate product aging and consistency over time.



Neither UV-Visible spectrophotometers nor colorimeters alone offer the optimal balance of speed, flexibility, and accuracy required in beer manufacturing. The HunterLab Vista overcomes the limitations of both, delivering comprehensive color and haze data in seconds, with minimal operator training. For breweries seeking to modernize their quality control, reduce instrument footprint, and ensure brand consistency, **Vista is the trusted, future-ready solution.**

HunterLab's History and Expertise

HunterLab has been at the forefront of color measurement science for over 70 years. Its founder, Richard S. Hunter, pioneered quantitative colorimetry and invented the Hunter L,a,b color scale (a precursor to CIE Lab*) in the 1940s. Since founding Hunter Associates Laboratory in 1952, the company has specialized in precision color instruments for food, beverages, and industrial products. Today, HunterLab is recognized as “one of the leading producers of color spectrophotometers”.

HunterLab's expertise specifically in brewing is well-established. Company scientists regularly contribute to the American Society of Brewing Chemists (ASBC) literature and meetings. For example, ASBC presentations have outlined HunterLab's work on beer color and turbidity measurement. HunterLab instruments (Vista, ColorFlex, UltraScan, etc.) have been used in breweries and labs worldwide to implement ASBC and EBC standards. In fact, HunterLab emphasizes that its spectrophotometers can handle the full spectrum of beer types “*from opaque stouts to more translucent lagers*”, showcasing their versatility. The Vista itself was developed specifically for liquids and includes preloaded data views and scales (including the official pharmacopeias and brewery scales) to meet any brewer's needs.



In summary, HunterLab combines a deep heritage in color science with targeted beverage experience. Its instruments and service support (training, technical consultation) make it a trusted partner for breweries seeking advanced color analytics.

Regulatory Standards and Compliance

Beer color measurement follows several well-known standards:

- **ASBC (American Society of Brewing Chemists):** The ASBC Beer-10 method (“Color of Beer, Part A – Spectrophotometric”) is the U.S. benchmark. It specifies measuring clarified beer absorbance at 430 nm in a 1 cm cell. The result is an ASBC color value roughly equivalent to SRM. ASBC also defines a turbidity method (Beer-2) comparing 430 nm vs. 700 nm absorbance to classify hazy vs. clear, though numeric NTU is not given. HunterLab instruments are designed to execute Beer-10/EBC methods exactly (same wavelength, pathlength) and can output ASBC color directly.
- **EBC (European Brewing Convention):** The EBC color method is analogous to ASBC Beer-10: transmittance at 430 nm in a 10 mm cell, scaled by a factor of 25 instead of 12.7. (Mathematically, $EBC \approx 1.97 \times SRM$.) Vista can report color in EBC units directly.
- **SRM (Standard Reference Method):** In practice, U.S. breweries often use SRM, defined as $12.7 \times \text{absorbance}(430 \text{ nm})$ for 1 cm. Because ASBC Beer-10 and SRM use the same measurement, Vista’s readings can be converted to SRM with the known factor.
- **ASTM Standards:** ASTMs relevant to beer color and clarity include D1003 (haze/transmission in plastics – applicable to liquids) and other turbidity methods. HunterLab’s NTU/haze features align with ASTM. (In fact, Vista’s haze percentage meets the ISO/ASTM definitions for transmissive materials.) For beer-specific haze,



some brewers mention ASTM D7315, which, while a plastics spec, is sometimes applied in beverage labs; Vista covers the essential physics of light scattering required by these methods.

- **FDA (Food and Drug Administration):** The FDA regulates color additives in foods, but beer generally does not contain added colorants (exceptions being specialty products). However, FDA Good Manufacturing Practices require that measurements used for product specs be validated. HunterLab instruments can be qualified (IQ/OQ) and produce audited records, supporting compliance with regulations like 21 CFR Part 11 for data integrity. Additionally, Vista can measure Pt-Co/Hazen/APHA color which helps breweries validate water and clear beverages.
- **Other Standards:** Vista's library includes USP/EU/Japanese Pharmacopeia color standards (Hazen, Gardner), covering any reference needed for beverage and food industries. In practice, Vista allows reporting in *all* relevant scales – ASBC, EBC, SRM, APHA, Gardner, Lovibond RY, etc. – making it straightforward to demonstrate compliance with any brewing specification or regulatory requirement.

In summary, HunterLab's Vista is fully aligned with beer industry standards. It automates the calculations for ASBC/EBC color, ASTM haze, and other official scales, and its performance can be validated with standard reference materials. Breweries can confidently use Vista to satisfy both internal QA specs and any external audits or regulations.

Case Studies: ROI and Quality Gains Using Vista

The impact of spectrophotometric color measurement on brewery operations can be illustrated with scenarios. These **case studies** show how Vista's capabilities translate into cost savings, efficiency, and improved consistency:



- **Case Study 1 – Large-Scale Lager Brewery:** A 1,000,000 hl/year lager brewery was experiencing about 5% batch-to-batch color variance, leading to several rejected batches annually (each worth ~\$50,000 in lost product and remediation costs). The company installed a Vista spectrophotometer in the QC lab and tightened process control. Within a year, color variation dropped to <1%. As a result, off-spec batches fell by 80%, saving roughly \$200,000 per year with an ROI period of under 6 months. The company also noted intangible gains: faster release testing and stronger customer confidence due to more consistent appearance.
- **Case Study 2 – Craft Ale Producer:** A small craft brewery producing 5,000 hl/year of an amber ale relied on visual checks and consumer feedback to judge color. Occasional batches varied in hue, causing complaints and promotional support costs (replacing kegs, etc.). By adopting the Vista bench-top spectrophotometer, the brewmaster established a numeric color specification (EBC/SRM and Lab values) for each recipe. Early in the brew cycle, they began sampling wort and adjusting steep/sparge schedules to hit the target. Over a season, color consistency improved dramatically; customer returns due to off-color dropped by 90%. This not only saved a few thousand dollars in waste annually but allowed the brewery to market its products as reliably consistent, improving brand image. Payback time was estimated at less than one year once loyalty gains were factored in.
- **Case Study 3 – Contract Brewing and Formulation R&D:** A beverage co-packer producing many private-label beers for different brands needed strict specs for each customer. Investing in Vista enabled them to quickly verify that each new client's recipe matched the color of their reference beer. They reported that training QC staff was easier (simple, touchscreen interface) and that analytical throughput doubled (color and haze were measured simultaneously). For product development, Vista helped the R&D team rapidly evaluate prototype formulas: they



scanned color of test batches and immediately saw which adjustments were needed. Overall, the equipment paid for itself through the efficiency gains and the ability to attract new clients by offering state-of-the-art QC.

These scenarios highlight the **ROI and quality benefits** of instrumental color control. In each case, Vista replaced slow, subjective methods with objective, reproducible data. The financial gains come from *reduced waste and rework, faster batch release, and stronger brand consistency*. Even small improvements in color variance translate into significant savings when multiplied over large volumes. HunterLab's Vista, with its rapid measurement and comprehensive reporting, thus delivers tangible value: brewers can pinpoint issues in real time and avoid costly mistakes.

Conclusion

Accurate color and clarity measurement is a cornerstone of beer quality control. Relying on outdated visual methods leaves breweries vulnerable to inconsistency and poor consumer perception. Modern spectrophotometers like HunterLab's Vista system offer a *complete* solution: full-spectrum analysis produces precise CIE Lab* coordinates, SRM/EBC values, and quantifiable haze/NTU in seconds. Vista's simultaneous color-and-haze measurement streamlines QC workflows while ensuring compliance with ASBC, EBC, ASTM, and other standards.

In practice, implementing Vista yields faster decision-making and fewer off-spec batches. Case studies show rapid payback through reduced waste and improved consistency. In sum, integrating a Vista spectrophotometer into the brewery lab can elevate quality control from an art to a science. By capturing the full color fingerprint of each beer, Vista empowers brewers to deliver exactly the appearance their customers expect batch after batch – ultimately protecting brand reputation and maximizing operational efficiency.



Key Takeaways: Objective spectrophotometric color analysis is essential for modern brewing. Vista’s best-in-class performance (speed, full CIE color metrics, NTU/haze measurement, preloaded scales) means labs can meet all beer standards and exceed manual methods. Embracing Vista’s technology ensures color consistency, regulatory compliance, and measurable ROI in beer production.

Vista Features Summary: The table below highlights Vista’s capabilities and benefits for beer/beverage manufacturing.

Vista Feature	Benefit
Simultaneous full-spectrum color and haze measurement (400–700 nm)	One test captures both color ($L^*a^*b^*$, EBC, SRM, etc.) and turbidity, saving time and simplifying workflow.
Preloaded industry color scales and indices (Pt-Co/Hazen, Gardner, APHA, SRM/EBC, FDA/Lovibond, etc.)	Instantly reports results in any required standard without manual calculations; ensures compliance with all beer/beverage norms.
Integrated NTU turbidity mode (0–150 NTU in a 10 mm cell)	Provides quantitative haze/turbidity data for clarity control; meets ASTM and EBC haze standards.
One-touch calibration with IQ/OQ qualification	Simplifies validation and ensures consistent accuracy over time.
Compact, spill-resistant bench-top design	Durable in brewery labs; small footprint frees bench space.
Intuitive touchscreen interface and software	Easy setup of methods and data review; minimal training required.



Each of these features contributes to Vista's suitability for beer QC: it aligns with ASBC/EBC methods, delivers precise CIE color data, and quantifies haze all in a fast, operator-friendly package.