Tailoring Malt for Brewing and Distilling: Characteristics and Uses of Brewer's Malt, High-Diastatic Power Distiller's Malt, and Pot Still Malt

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ABSTRACT

This mini-review explores the unique characteristics and applications of brewer's malt, high-diastatic power distiller's malt, and pot still malt in brewing and distilling. Brewer's malt is optimized for high extract yield, ease of processing, and flavor stability, while high-diastatic power distiller's malt and pot still malt are designed to maximize alcohol yield and comply with distilled spirit safety standards, such as controlling glycosidic nitrile levels. Understanding the specific properties of each malt type allows brewers and distillers to optimize their processes, ensuring high-quality production in both beer and whisky industries.

Introduction

Malting, brewing, and distilling have a rich and intertwined history that spans thousands of years. Malt is the backbone of both brewing and distilling, providing fermentable sugars necessary for alcohol production and contributing essential flavors, colors, and textures to the final products (1). In brewing, barley malt is the primary grain used due to its enzyme package, which is crucial for converting starches into fermentable sugars during the mashing process (2). The type and quality of malt significantly influence the characteristics of beer color, body, flavor, and stability. In distilling, the enzymes present in high-diastatic power (DP) distiller's malt, although only accounting for 8–12% of the grain bill in American bourbon, are essential for breaking down starches from various resources into sugars and providing sufficient yeast nutrition for fermentation (3). For making all-malt whisky, pot still malt is a specialized malt used predominantly in the production of spirits through pot still distillation. This malt is typically made from non-glycosidic nitrile (GN) barley and is carefully processed to retain high levels of essential enzymes and specific qualities that support the unique requirements of pot still distillation.

Brewer's malt, high-DP distiller's malt, and pot still malt each have unique characteristics and specifications tailored to meet the specific needs of beer and whisky production. The aim of this review is to provide a brief introduction to the characteristics, specifications, and intended uses of brewer's malt, high-DP distiller's malt, and pot still malt. By understanding the distinct properties of each type of malt, brewers and distillers can make informed decisions to optimize their production processes, achieve desired product qualities, and design a new beer or spirit (1).

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https://doi.org/10.1094/TQ-62-0102-01

Brewer's Malt

Brewer's malt is utilized in both all-malt and low-adjunct mashes (<30–40% adjunct), primarily for beer production. It is defined by key specifications tailored to meet the precise requirements of brewers (1). Central to its importance is extract yield. The amount of extract a malt can produce in the brewhouse will always be of crucial economic importance, because it determines the amount of beer that can be produced. Brewer's malt should provide an extract yield of over 80% by weight (fine grind, dry basis) (4), as a result of ongoing efforts by breeders (5). Another significant characteristic of brewer's malt is its ease of milling. The malt must possess sufficient friability, allowing it to be milled easily without causing excessive wear on milling equipment (2). This characteristic ensures that the malt can be processed smoothly, which is vital for maintaining production efficiency. Brewers also seek malt that is plump and uniform, as this consistency helps achieve high extract efficiency without the need for frequent adjustments to the mill. However, with climate change and increasing instances of drought, achieving plump kernels can be challenging in some years (6). Brewer's malt should facilitate the production of a clear wort with minimal particulate matter. Efficient wort separation and filtration contribute directly to the overall quality and clarity of the final beer, making it an essential attribute for brewers who aim for high-quality products.

Fermentation performance is another critical aspect of brewer's malt. The malt should support yeast nutrition to achieve a vigorous fermentation process and develop a clean and desirable flavor profile (1). In addition to these factors, the ability of brewer's malt to contribute to foam stability is highly valued. Good foam stability enhances the sensory experience of beer, making it a desirable trait for brewers (2). Clarity is another important characteristic, as clear wort is often preferred, especially in beer styles where visual appeal is important. Brewer's malt should help achieve a bright, clear beer with low levels of haze-forming compounds, unless the production of a style like a hazy IPA is intended. To achieve a clear wort, it is recommended that brewer's malt maintain wort turbidity below 10 NTU (nephelometric turbidity units) (7). Flavor stability is crucial for ensuring that the beer maintains its intended taste over time. Brewer's malt should contribute positively to this stability, providing consistent flavor profiles that meet consumer expectations from batch to batch (2,6).

Brewer's malt must also have a low potential for dimethyl sulfide (DMS) formation. DMS is typically described as having an aroma of cooked vegetables or creamed corn. The control of its presence is essential to maintaining the brewer's intended flavor profile (2). Therefore, the expectation is that brewer's malt will naturally minimize the risk of DMS contamination in the final product. Finally, compliance with food safety standards is an essential requirement for brewer's malt. It must effectively control levels of harmful substances such as *N*-nitrosodimethylamine (NDMA) and mycotoxins like deoxynivalenol (DON) (1). Ensuring the malt meets these safety standards is critical to producing beer that is not only enjoyable but also safe for consumption. Since the 1970s, with advancements in malting equipment and the requirement of indirect heating in kilns, NDMA levels have been effectively controlled below 2.5 ppb (3).

Intention to Use

Brewer's malt is intended to meet the high standards required by beer producers, including commercial and craft brewers. The focus is on achieving high extract yields, ease of processing, excellent wort filtration, and fermentation performance, while ensuring flavor stability and safety compliance. Brewing and whisky production have fundamentally different requirements. For brewing, the barley selection, malting techniques, and finished malt specifications are all driven by these needs.

In Figure 1, the relationship between various malt quality parameters (on the left side, under "Maltster") and their impacts on brewing performance metrics (on the right side, under "Brewer") is illustrated. Factors like extract, β-glucans, color, friability, free amino nitrogen (FAN), DP, and soluble to total protein (S/T) are crucial indicators of malt quality (1). For instance, high β-glucan levels correlate with increased wort viscosity, which can hinder filtration performance (8). Brewing performance metrics emphasize how these malt characteristics influence brewing outcomes, such as beer filterability, wort clarity, yeast health, and, ultimately, beer taste. The visual representation in Figure 1 underscores the importance of understanding the malt certificate of analysis (COA) to predict and optimize brewing performance, ensuring consistency and high-quality beer production. It's important to note that a malt COA is typically based on results from a Congress mash, which assesses malt performance in an 8.6°P wort. However, the mashing process in a brewery differs—the wort concentration is usually higher, often exceeding 12°P. This difference means that the malt's behavior under actual brewing conditions may vary, and brewers should consider this when interpreting COA data to optimize brewing performance (9).

High-DP Distiller's Malt

High-DP distiller's malt is specifically designed for high-adjunct mashing processes (>30% adjunct) and grain whisky production, with a primary focus on maximizing alcohol yield. This type of malt is distinguished by its exceptionally high DP (over 200°L) and α-amylase activity (over 90 DU), which is crucial for breaking down various adjunct starch resources into fermentable sugars. The malt's ease of milling and the extent of cell wall degradation also are important characteristics. High-DP distiller's malt should be easily millable, with a high degree of cell wall breakdown, which results in a brittle malt that dissolves uniformly during mashing. This uniform dissolution is essential for consistent and efficient mashing, enabling the complete extraction of fermentable sugars from the malt.

Protein degradation within the malt also is necessary to ensure that the maximum amounts of essential nutrients are available for yeast during fermentation. High-DP distiller's malt must provide sufficient levels of FAN, typically exceeding 250 mg/L, which is vital for yeast health and activity because of the dilution of these nutrients by low-protein starch adjuncts. Adequate protein breakdown supports a robust fermentation process, leading to higher alcohol yields.

Figure 1. The relationship between brewer's malt certificate of analysis and brewery performance.

Intention to Use

Since distillers aim to maximize alcohol yield by converting all fermentable sugars during fermentation, high-DP distiller's malt is specifically engineered to enhance this conversion efficiency, ensuring the highest possible alcohol production from the grains. Spirits like bourbon, Tennessee whiskey, and grain whisky utilize high-DP distiller's malt to provide the enzymatic power needed to convert starches from adjunct grains into sugars. By incorporating malt with high DP and α-amylase activity, distillers ensure the highest possible alcohol production from the grains, optimizing the economic efficiency of their operations (3,10).

In Figure 2, a series of malt quality parameters that need to be measured for typical whisky malt is shown on the left, while the distillers' expectations for different aspects of the malt are shown on the right. Compared to the beer malt specifications, the whisky malt specifications seem much simpler (11). Critical factors such as moisture, DP, and α-amylase significantly influence the fermentability and predicted spirit yield (PSY) in distillation. These parameters ensure that the maximum amount of starch is converted into fermentable sugars, thereby optimizing alcohol production. In terms of distillery performance metrics, the graph highlights how these malt characteristics impact key distillery outcomes, including fermentability, yeast health, and food safety. For instance, high levels of α-amylase and DP enhance fermentability, directly increasing the PSY. Sufficient FAN levels support yeast health, ensuring a robust fermentation process. Moreover, distiller's malt typically requires much higher protein in barley compared to that in a brewer's malt. This higher protein content indicates a higher yield of enzymes, such as DP and α-amylase. Maltsters often push the level of modification in this type of malt to an extreme, which results in a high level of FAN, exceeding 250 ppm, and a high S/T, >50% (1).

Pot Still Malt

Pot still malt is exclusively utilized in all-malt mashes, characteristic of traditional Scotch whisky production, which impart unique characteristics to the final spirit. The malt is designed with several key features to ensure it meets the stringent demands of distillers focused on maximizing both alcohol yield and flavor quality (5). A critical attribute of pot still malt is its high hot water extract (HWE), typically exceeding 81% on a dry basis and a high PSY. These metrics are essential for ensuring that the malt contributes to the maximum possible alcohol output during distillation. Cell wall degradation is another important characteristic of pot still malt. Similar to high-DP malt, pot still malt must undergo significant cell wall breakdown during the malting process. The uniform breakdown of cell walls is vital for achieving an even and efficient mashing process. Protein content and the provision of FAN are also important considerations. Pot still malt must have adequate protein levels to support yeast nutrition during fermentation. The presence of sufficient FAN ensures that the yeast has the necessary nutrients to perform effectively throughout the fermentation process. The S/T ratio for pot still malt aligns more closely with brewer's malt used for all-malt brewing, typically falling within the range of 38 to 45%.

The key parameters that Scotch whisky distillers consider crucial in determining the distilling quality of barley and malt encompass general requirements from the Scotch Whisky Association's (SWA) barley wish list; compliance with product protection and regulatory standards, including the preference for barley with low or no GN; and structural and biochemical factors that impact alcohol production and process efficiency, such as starch composition and structure, enzymes, cell wall composition, proteins, and protein derivatives (12).

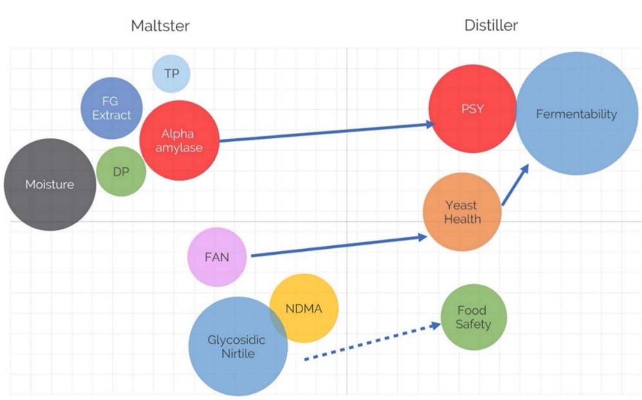

Figure 2. The relationship between distiller's malt certificate of analysis and distillery performance.

GN Food Safety Concern and Levels in Barley

The presence of GN is a significant concern in the distillation of alcoholic beverages due to it potential conversion into ethyl carbamate (EC), a compound classified as a probable human carcinogen by the International Agency for Research on Cancer (IARC) (13). The formation pathway for EC begins with the cyanogenic glycoside epiheterodendrin (EPH) in barley, a compound produced naturally as part of the plant's defense mechanism (14) (Fig. 3). EPH deters herbivores and pests, as it can release toxic hydrogen cyanide (HCN) upon break down, making the plant less palatable and more resistant to predation. During fermentation, EPH is broken down by the enzyme β-glucosidase, resulting in the formation of isobutyraldehyde cyanohydrin (IBAC). Under the high temperatures of distillation, IBAC decomposes, releasing HCN, which reacts with ethanol in the presence of copper to form EC (15,16).

A series of foundational studies published in the *Journal of the Institute of Brewing and Distilling* during the late 1980s and early 1990s by researchers such as Riffkin, Cook, and Aylott provided essential insights into these chemical processes. They described how copper's catalytic properties, while beneficial for distillation efficiency and flavor development, also facilitate the conversion of HCN to EC when present. These early works laid the groundwork for current EC management strategies in the distillation industry (17–21).

Building on these insights, Dr. Brad Berron and colleagues recently expanded the understanding of EC management through their research at the University of Kentucky's Beam Institute (20). Their work, funded by the American Distilling Institute, highlighted that effective copper contact during distillation—especially when positioned above the feed line—can promote early EC formation, ensuring that it exits with the stillage rather than persisting into the final product. This strategic use of copper is essential for preventing EC formation during barrel aging (10,22,23).

The role of the malting process in GN levels is equally critical. Research by Turner et al. (24) has shown that factors such as prolonged germination periods, increased moisture, and higher temperatures during malting elevate GN levels by boosting enzymatic activity, particularly that of β-glucosidase. This enzyme catalyzes the breakdown of EPH, creating a higher potential for EC formation. The genotype–process interaction effect underscores the importance of selecting both the right barley variety and optimizing malting conditions to manage GN content effectively. The genotype–process interaction effect refers to the dynamic relationship between the genetic traits of the barley (genotype) and the specific environmental and malting conditions. These interactions influence GN levels, as different barley varieties respond uniquely to factors such as moisture, temperature, and germination time during malting. For instance, some genotypes exhibit lower GN levels under certain malting conditions due to reduced enzymatic activity, particularly that of β-glucosidase, which catalyzes the breakdown of EPH into precursors for EC formation. This underscores the importance of selecting the right barley variety and optimizing malting conditions to manage GN content effectively. While managing GN is critical for pot still malt used in single malt whiskey production, where GN levels impact EC risks, it is less of a concern for brewer's malt. Unlike distilling, beer production does not involve the high temperatures that convert GN-derived compounds into EC, making GN levels less significant in a brewing process. Recent advancements in barley breeding have focused on GN0 varieties, which do not produce EPH and, thus, mitigate the risk of EC formation. Morrissy et al. (10,21) have noted that these GN0 varieties are specifically designed to align with the needs of grain whisky distillers. Traditionally, grain whisky production relies on barley with high enzyme activity to ensure efficient starch conversion during mashing. GN0 varieties like LCS Odyssey and Oregon State University's Vivar and Top Shelf not only meet these enzymatic requirements but also reduce EC risk due to their inherent genetic makeup. This makes them highly suitable for grain distillers who are seeking both high fermentability and minimal GN levels in their malt (10,25).

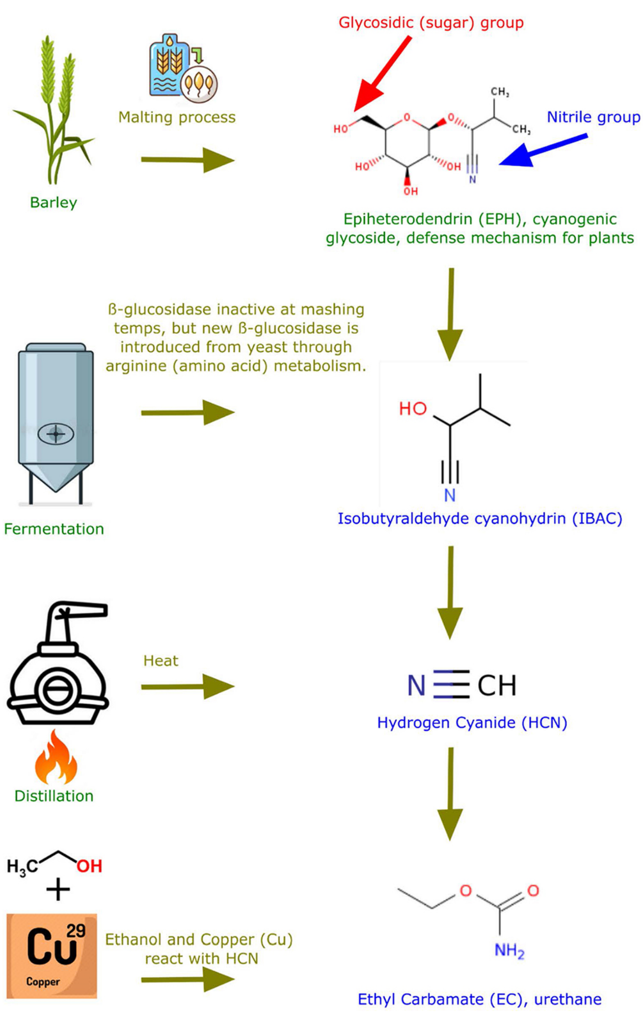

Figure 3. Ethyl carbamate formation in distilled spirits from epiheterodendrin in barley (21).

European breeding programs also have contributed to this advancement, producing several GN0 and low-GN varieties tailored to different climatic conditions. Varieties like Syngenta's Laureate and LC Diablo, known for moderate enzyme activity, gained attention for their adaptability and low GN levels. These GN0 varieties are characterized by enhanced DP and α-amylase activity, which is essential for converting starches into fermentable sugars. This ensures that distillers can achieve high spirit yields without compromising safety (26).

The findings of Turner et al. (24) emphasize that while GN0 barley is a significant step forward, even these varieties must be processed carefully during malting to maintain low GN levels. High enzyme activity in GN0 malts also aids grain distillers by optimizing conversion and fermentation efficiency, which is critical for large-scale operations seeking consistent output and compliance with international EC regulations.

The comprehensive strategy for managing EC involves selecting GN0 barley varieties, optimizing malting processes, and using strategic copper contact during distillation. This approach not only minimizes EC risks but also supports distillers in meeting stringent safety standards, enhancing product quality, and ensuring consumer safety in the growing international spirits market (10,11,21,24).

Ideal Commercial Malt Criteria in American Malting Barley Association Malting Barley Breeding Guidelines

Ideal commercial malt criteria in American Malting Barley Association (AMBA) Malting Barley Breeding Guidelines are listed in Table 1 (11). In comparing all-malt brewing and distilling two-row malt with grain distillers two-row malt, several distinctions are evident. All-malt requires more than 90% plump kernels, while grain distiller's malt needs only 70%. All-malt maintains protein below 12.0%, promoting a balanced extract level and enzyme package, whereas grain distiller's malt allows higher protein content (11.5–14.0%) to boost robust enzyme activity. In terms of FAN, all-malt targets 140–190 mg of FAN per liter; whereas grain distiller's malt exceeds 250 mg/L to support yeast in bourbon whiskey fermentations. All-malt has a DP of 110–150 °ASBC and α-amylase activity of 40–70 DU, while grain distiller's malt focuses on higher levels, with DP over 200 °ASBC and α-amylase above 75 DU. These differences highlight that all-malt is optimized for balanced brewing and distilling, emphasizing flavor and enzyme balance, while grain distiller's prioritizes high enzyme activity and alcohol yield. Interestingly, GN breeding guideline levels for both all-malt distilling two-row and grain distiller's two-row are <0.5 g/t, indicating the potential food safety concern about GN in the bourbon whiskey industry as well.

Conclusions

Brewer's malt, high-DP distiller's malt, and pot still malt each play crucial roles in their respective industries and are tailored to meet the unique demands of beer and whisky production. Understanding the specific characteristics and specifications of each

Table 1. Ideal commercial malt criteria in American Malting Barley Association Malting Barley Breeding Guidelines

Category[a]	All-Malt Brewing and Distilling Two-Row Malt	Grain Distiller's Two-Row Malt
Barley factors		
Plump kernels (on 6/64)	>90%	>70%
Thin kernels (thru 5/64)	<3%	<5%
Germination (4 mL, 72-h GE)	>98%	>98%
Protein	≤12.0%	11.5–14.0%
Skinned and broken kernels	<5%	<5%
Malt factors		
Total protein	≤11.8%	11.0–13.5%
On 7/64 screen	>75%	>50%
Glycosidic nitrile (g/t)	<0.5	<0.5
Predicted spirit yield (LPA/t)	≥400	
Measures of malt modification		
β-Glucan (ppm)	<100	
Soluble/total protein	38–45%	>48%
Turbidity (NTU)	<10	
Viscosity (absolute cP)	<1.50	
Congress wort		
Soluble protein	<5.3%	>6.0%
Extract (final gravity, db)	>81.0%	>79.0%
Color (°ASBC)	1.6–2.8	<4.0
FAN (mg/L)	140–190	>250
Malt enzymes		
Diastatic power (°ASBC)	110–150	>200
α-Amylase (dextrinizing units)	40–70	>75

[a] GE = germination energy; LPA = liters of pure alcohol; NTU = nephelometric turbidity units.

type of malt enables brewers and distillers to optimize their processes and achieve desired outcomes. The careful selection and processing of malt are fundamental to the quality and efficiency of both brewing and distilling, highlighting the importance of tailored malt specifications to meet industry needs.

In summary, while brewer's malt focuses on high extract yield, ease of processing, foam stability, clarity, and flavor stability, high-DP distiller's malt and pot still malt prioritize high DP, high α-enzyme activity, maximum alcohol yield, and compliance with stringent safety standards—particularly controlling GN levels to prevent EC formation. By addressing these specific requirements, malt producers can provide high-quality products that meet the diverse needs of brewers and distillers, ensuring excellence in both beer and whisky production.

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