



# MALTING BARLEY CHARACTERISTICS FOR CRAFT BREWERS

## EXECUTIVE SUMMARY

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The brewing industry is evolving rapidly, and the barley malt supply chain should likewise evolve rapidly to meet the very different needs of all-malt beer brewers. Brewers Association member craft brewers have identified malt supply mismatch as a potential impediment to growing their brands. To produce all-malt beer brands, craft brewers seek barley malts with

- > distinctive flavors and aromas
- > lower free amino nitrogen (“FAN”)
- > lower Total Protein
- > lower Diastatic Power (“DP”)
- > lower Kolbach Index (ratio of Soluble Protein to Total Protein, or “S/T”)

Such malts differ significantly from the current suite of available barley malts produced in North America. The demand for such malts will grow significantly as craft production increases.

## INTRODUCTION

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The U.S. brewing industry is currently undergoing profound and lasting structural change. Craft brewers are changing the face of the industry at all levels: retail, wholesale, production and supply. As of March 2014 there are over 2,800 breweries operating in the U.S., likely producing over 10,000 beer brands. This diversity presents challenges as well as opportunities for wholesalers and retailers, and unprecedented choice for beer consumers. The U.S. beer market is arguably the most diverse on Earth.

In July 2012, Brewers Association staff attended a North Dakota-based barley field course offered by the Institute of Barley and Malt Sciences (IBMS) and North Dakota State University (NDSU). Brewers Association staff learned at that U.S. craft brewers were already using over 20% of all malt consumed by U.S. brewers, belying their relatively small production share (at that time, around 6% of U.S. beer production). In response, barley grower and North Dakota Barley Council Chair Doyle Lentz replied “then craft brewers better figure out how to communicate with growers.”

The Brewers Association couldn’t agree more. This paper is offered in the spirit of communication with and by growers, academics, breeders, maltsters, dealers and brewers, and all other barley and malting industry stakeholders. These collected ideas and perspectives represent a single snapshot in time of an incredibly complex industry that continues to evolve rapidly.

## RECENT HISTORY AND CURRENT STATUS OF BREWING AND MALTING INDUSTRIES

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During the middle half of the 20th century (1930s to 1980s) the U.S. beer market was generally characterized by -

- Increased product homogeneity and dominance of adjunct lager styles
- Decreasing number of brewing companies via attrition and consolidation
- Increasing dominance of a relatively small number of brands of adjunct lagers
- Slowly decreasing original gravities
- Relatively homogenous barley malt needs

During this time breeders made important advances in yield, disease/stress tolerance, extract and digestibility – attributes that yielded high quality malt for a growing brewing Industry. Nonetheless, prior to the advent of craft brewery companies in the late 1970s and early 1980s, barley growers and the malting industry responded to relatively uniform brewer needs by developing a relatively small number of high diastatic power, high FAN malt varieties suitable for adjunct brewing.

By definition, the malt used to produce beer was nearly all consumed by large producers of adjunct lagers.

The current beer market can be characterized very differently –

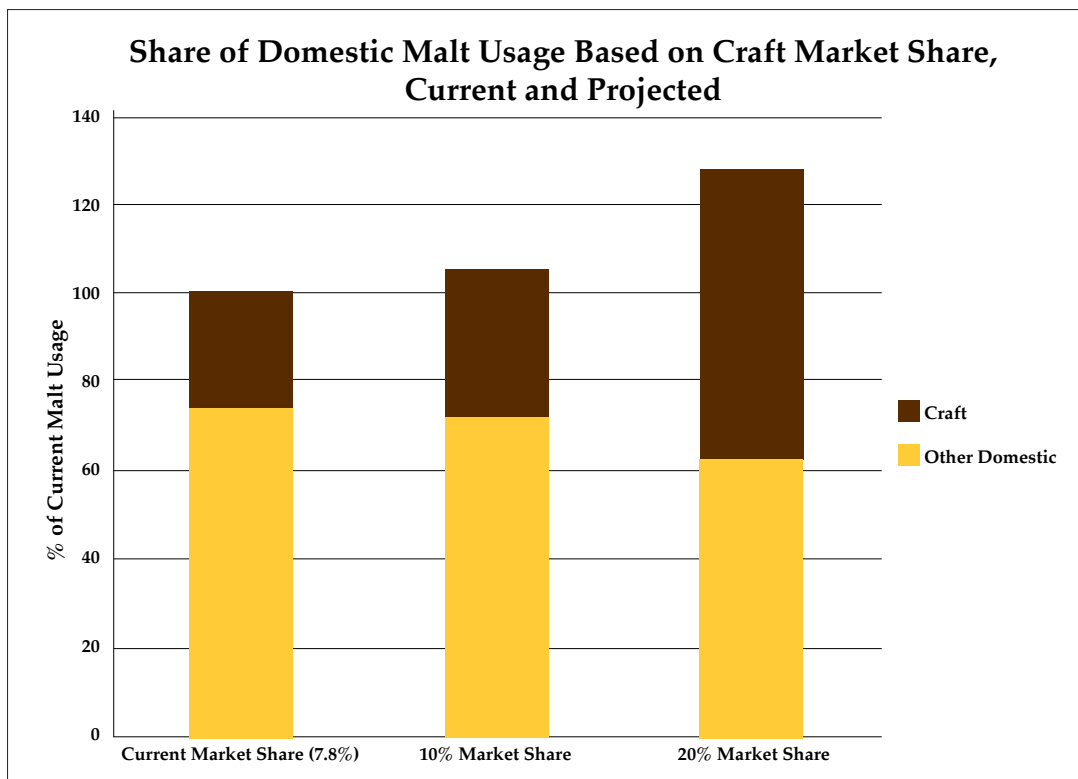
- Rapidly increasing product diversity and proliferation of all-malt beer styles
- Rapidly increasing number of brewing companies
- Rapid brand proliferation and all-malt brand growth
- Increasing original gravities of all-malt brands
- Large adjunct brewer barley needs which are diverging rapidly from each other
- All-malt brewer barley needs that have diverged significantly from the needs of adjunct brewers

Today's beer market is far more diverse, with many thousands of brands being produced. New brewing companies are opening every day, slowly and surely adding to U.S. brewing capacity, as well as U.S. beer market brand diversity. The earliest successful craft brewers now own maturing and rapidly growing brands, some of which are 20 or 30 years old or older, and are expanding their geographic reach as they grow.

The proliferation and growth of all-malt craft beer brands has significant meaning to the malt industry. Craft beer brands are defined by unique, diverse flavors demanded by increasingly sophisticated beer consumers. **The high number of brewing companies and number of craft brands means that continued innovation in all-malt brands will be fueled by an increasingly diverse barley malt supply.** U.S. craft brewers have access to, and increasingly use, diverse malts from around the world in order to flavor differentiate their brands from all others.

The higher original gravities of typical craft beer brands, along with typical all-malt grist composition and often lower brewhouse extraction efficiencies means that craft beer malt consumption is disproportionately high compared to craft beer volume share. **In early 2014 craft beer volume accounted for roughly 7.8% of total beer volume in the U.S.; but craft brewers consumed over 25% of the malt used by all U.S. brewers,** a factor of roughly 3.4x. Sources for this striking figure include the 2012 Brewers Association Benchmarking Survey, the 2013 and 2014 Brewers Association Beer Industry Production Surveys, TTB malt usage data, and personal communication with Scott Heisel at AMBA. In 2000, craft brewers likely used less than 9% of the malt consumed by U.S. brewers; what a difference 13 short years make.

While it's impossible to predict the future, craft beer volume growth will most likely continue. The chart below clearly shows the barley and malt market potential represented by craft brewers at certain potential craft beer volume market shares. The chart assumes the following: that craft market share growth is independent of import share change; that the ratio of craft volume share/malt usage will remain roughly constant; and that total U.S. beer market size remains constant.



Based on current production ratios, if and when craft volume share reaches 10%, craft brewers will consume 31.1% of all malt used by U.S. brewers, and the total malting capacity needed to fulfill that consumption will have to increase 5.1% over current levels. These staggering figures continue if craft reaches 20% volume share. At that share, if attained, craft brewers would consume an estimated 51.0% of all malt used by U.S. brewers, and the malting capacity needed to fulfill that consumption will have to increase by an estimated 28.3% over current levels.

## GAPS BETWEEN CRAFT BREWER NEEDS AND U.S. MALT SUPPLY, AND POSSIBLE BRIDGES/SOLUTIONS

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The Brewers Association has identified several mismatches and/or disconnects between craft brewer present and future needs, and the U.S. grown barley malt supply and markets. Some of these gaps have to do with barley itself while others have to do with market structure and practice. All of these gaps represent potential challenges to near- and long-term craft volume growth as well as opportunities for future medium- and long-term growth of both craft beer volume and all U.S. malt industry stakeholders.

### Flavor

Gap: Today's suite of U.S.-grown barley varieties and the resulting malts has been characterized by craft brewers as being flavor neutral and/or lacking distinctiveness. A number of Brewers Association member craft brewers have indicated that as a result of the recent varietal progression from Klages => Harrington => Metcalf, the sensory profiles of their flagship brands have evolved over time, drifting towards lower overall flavor impression and/or complexity.

As a group, craft brewers typically place a very high conceptual value on "flavor." Today's sophisticated beer consumers demand diverse flavors that can serve to differentiate craft brands from one another; delivering distinctive flavor defines the craft value proposition. Craft brewers often have diverse flavor preferences for their brands but are not able to articulate specific preferences with respect to their brands or at a varietal level for two key reasons. No common terminology or lexicon exists to describe the diverse range of flavors found in malts from different sources. There is poor understanding of the origins of flavor, whether genetic or arising during malting or kilning or from any combination of factors.

Bridges: As of today, the Brewers Association is aware of at least three separate research efforts in the U.S. to study and understand the origins of flavor in barley and malt (there are likely others). They are:

Colorado State University – Dr. Jessica Prenni

Oregon State University – Dr. Pat Hayes

USDA ARS National Small Grains Collection (Aberdeen, ID) – Dr. Gongshe Hu

These efforts parallel and complement other ongoing varietal development efforts within the industry. These modest first steps are being funded largely by craft brewers who for the first time have identified supply gaps, as well as reached a scale that allows for funding to bridge those gaps. They are also substantially supported by maltsters, growers and grower groups, public sector agricultural programs and the academic community.

The Brewers Association believes that one primary decider of many within the flavor puzzle lies within the malthouse. Over the past 24 months several malting industry experts have stated to Brewers Association staff and members that much or all flavor contained in malt arises in the malthouse. Perhaps those flavors are inherent to a variety by virtue of genetics. Or perhaps they arise due to some variety-dependent requirement that drives a malting parameter such as germination time, moisture content or temperature during germination, or kiln time or temperature. In any case, exploring how these levers affect malt flavor is crucial to continued innovation in the U.S. barley malt supply.

### FAN

Gap: Malt FAN levels are important to all brewers but for very different reasons. FAN deficiencies in wort can lead to poor yeast nutrition and health. Historically speaking, adjunct lager brewers have required malts which contribute relatively high wort FAN.

But excess FAN levels in finished beer can significantly reduce product flavor stability. These effects are amplified in all-malt beer production. High finished beer FAN levels can result in decreased flavor and biological stability in the package. As all-malt brands continue to grow geographically, the amount of time from brewery to consumer increases. High FAN levels in finished beer mean that over time product stability is threatened. In contrast lower FAN levels in finished beer actually contribute positively to product stability. *Larger Brewers Association member craft brewers have indicated that today's suite of relatively high FAN malts can make it more difficult for those brewers to manage the geographic growth of all-malt craft brands.*

The detrimental effects of individual amino acids on flavor stability was documented at the May 2013 European Brewing Convention 34th Congress in Luxembourg by Inaba et al and is the subject of an increasing body of academic as well as craft brewer research.

Bridge: The Brewers Association believes development and acceptance of malting barley varieties which include lower FAN levels are important for the continued growth of all-malt beer brands. Lower FAN malts will improve product stability and promote continued geographic growth of individual all-malt beer brands. While FAN levels will to some degree also decrease with lower total protein and lower enzyme levels, Brewers Association believes that FAN levels should be considered as an important characteristic during varietal breeding and development.

### Diastatic Power

Gap: As a group, and by design over several decades, the current suite of malting barley varieties grown in the U.S. is predominantly suited for production of adjunct lager beers. The resulting malts have very high diastatic power (DP) better suited for beers produced with high proportions of adjunct grains in the mash (e.g., rice, corn) which do not contain their own endogenous diastatic power.

Craft beers in general are brewed with all-malt grists, meaning they do not require such high levels of diastatic power in order to convert during mashing. Rather, high DP levels can actually be problematic to all-malt beer production; such grists are often referred to as "too hot." High DP grists can be very difficult to control during the mash, perhaps converting too quickly, or converting at variable times with small variations in mash temperature, pH or consistency, resulting in worts that overattenuate or attenuate to different

degrees. Overattenuation results in lower body and mouthfeel of the final product. Brand repeatability can therefore suffer when brewing all malt beers with high DP malt.

On the other hand, too low DP can result in under attenuation.

Bridge: The Brewers Association believes current barley varieties have sufficient enzyme potential and higher levels are not helpful for craft brewing. In fact, some craft brewers advocate for the development of malting barley varieties with lower DP levels.

### Scale

Gap: The U.S. malting industry is currently highly consolidated, with a relatively small number of very large malting operations (with a few notable exceptions). The scale of such physical plants is such that handling relatively smaller volumes of a larger number of varieties of barley and the resulting malts is exceedingly difficult, though not impossible. Further, much of the malting capacity developed during the 20th century is currently committed to malt production destined for large brewers either through contracted long term agreements or outright ownership.

Examples of large-size malting features which are scaled for an industry serving a small number of large brewery customers include: storage silos, conveyance equipment, malthouse tanks and packaging and shipping facilities. Many malting facilities lack bagging equipment, and therefore cannot directly serve smaller breweries that don't use bulk malt. Only 4% of brewing companies under 1,000 barrels of annual production use a bulk silo; whereas, nearly all (94%) brewing companies above 8,000 barrels of annual production use a bulk silo. Analysis of 2012 Brewers Association Benchmarking Survey data and 2013 Beer Industry Production Survey data shows that roughly 22%-25% of U.S. brewing companies use a bulk silo. This means that roughly 75% of U.S. breweries (includes most brewpubs and smaller packaging breweries) use bag malt. By definition these smallest producers as a group comprise the lion's share of total brewing companies; confoundingly and paradoxically they produce a very small percent (<5%) of total U.S. beer production volume.

Neither the business opportunity represented by small brewers nor the scale of U.S. malting capacity is likely to remain at current levels. Currently, both are changing dramatically and rapidly.

Bridge(s): The Brewers Association anticipates that existing malting companies will over time respond to rapidly evolving market requirements by adding binning, handling and packaging capacity scaled to process and produce smaller volumes of a larger number of malting barley varieties. The Brewers Association also anticipates continued growth in the number and geographic spread of relatively small scale malting companies (<500 tons annual capacity) producing malt for relatively small brewery customers. As of early 2014 at least 16 are operational; of these, 8 opened between 1998 and 2010, while the other 8 opened in 2011 or later. At least another 7 such companies are also under construction as of early 2014.

### Custom Contracting

Gap: The U.S. hop industry operates primarily by a custom contract business model. That is, brewers contract with dealers and growers to produce the hops they consume for beer production. This arrangement is one of necessity; because the brewing industry uses greater than 98% of hops grown, hops are by definition a very small industrialized crop. Growers typically will not produce hops without a brewer executed purchase contract because there is virtually no other market to sell into. Granted there is a small spot market for hops, but the vast majority of the U.S. hop crop is produced and sold under custom contract. Brewers, dealers and growers are all accustomed to custom contracting for hops. Contracting has served the hop market well in terms of grower surety of demand, as well as brewer surety of supply as well as variety. Craft brewers in particular continue to benefit from a diverse supply of aroma hop varieties in particular which they use to produce unique craft beer brand flavor and aroma profiles. *Custom contracting has allowed for tremendous innovation in especially unique aroma hop varieties precious to craft brewers and consumers. In a very real sense innovation and diversity in the hop market has fueled craft beer brand and volume growth.*

The barley market differs from the hop market in many fundamental ways, including for example the number of producers (thousands of U.S. barley growers vs. several dozens of U.S. hop growers) and the number of varieties (a few tens of U.S. malting barley varieties vs. nearly 200 hop varieties grown used by brewers worldwide). In the past when barley was used in several industries such as food, feed, export and brewing, the barley market could be characterized as a commodity market, and in this way differed considerably from the hop trade. Today however barley production continues a steady decline which began in the 1940s; the brewing industry has become the predominant consumer of U.S.-grown barley. The barley market is becoming increasingly concentrated in the brewing industry, and increasingly resembles the hop market in this important respect.

The largest few hundred U.S. brewers are able to contract for their barley malt either with dealers, maltsters or direct with growers. Barley grown under contract is malted and transported to brewers typically by rail or truck and blown into silos. The other 2,000 or so brewing companies purchase barley in bags or supersacks, typically on the spot market (with a few notable exceptions). Purchasing on the spot market leads to far less supply surety, less assurance of critical malt performance parameters which are typically enumerated in contract terms and importantly far less control over price fluctuations. In this sense many breweries remain relatively vulnerable to the vagaries of Mother Nature and global demand for barley malt with less access to many of the tools their larger brethren employ to manage risk.

As a rule of thumb, malt dealers have preferred to custom contract with brewers over 20,000-25,000 barrels of annual production, although BA understands that currently breweries having at least 8,000 barrels of annual production typically use bulk silos. Managing conversations between thousands of growers and thousands of brewers is a complex business model which malt dealers have not experienced historically; one important and unfortunate outcome is that smaller brewers have heretofore not been able to communicate their needs to maltster and grower. The supply diversity benefit arising from direct brewer - grower communication realized in the hop



market is therefore largely missing from the barley market. Among several other factors this missing communication link has generally slowed the pace of malting barley variety acceptance industry-wide, since only a small proportion of brewers are able to engage in custom contracting.

Bridge: The Brewers Association believes that all U.S. malting barley stakeholders will benefit from increased custom contracting by breweries of all sizes. Contracting will provide surety to growers and maltsters as they undertake the important process of increasing the number of malting barley varieties available to U.S. brewers. Because barley has rapidly become de-commoditized in a few short decades, custom contracting with an increased number of breweries for an increased number of varieties will be an essential solution to continued U.S. barley malt market innovation and competitiveness.

### Geography

Gap: Craft brewers as a group have preferred to use predominantly 2-row varieties of barley malt. In contrast and until very recently, large adjunct lager production, which has driven the warp and weft of the barley production and malting industries, has focused on 6-row varieties, which historically speaking delivered a relatively more active (sometimes referred to as “hotter”) overall enzyme package. A very large proportion of current U.S. malting capacity is located in northern tier locations such as Minnesota, North Dakota and Eastern Montana which customarily have grown 6-row varieties to satisfy customer need.

But brewer decisions are changing. In recent years larger brewers have begun to pivot towards 2-row varieties for economic reasons. The value provided by the extra few percent of extract contained in 2-row malting varieties has overcome the geographic advantages 6-row enjoyed historically. Locations producing 2-row malting varieties are generally located farther west along the northern tier regions, such as Central Montana, Idaho, Washington and Colorado.

Thinking strategically, energy and shipping costs are most likely to increase over the long term rather than to remain level or decrease. In addition at least one maltster representative has estimated that current U.S. malting capacity could become constrained sometime during 2016-2020.

Bridge: The Brewers Association believes development of 2-row malting barley varieties as well as less active “less hot” 6-row varieties suited for production in traditional 6-row growing regions is an important component to utilizing current malting capacity. The Brewers Association also believes construction of additional malting capacity that is not committed to supplying larger brewing companies and therefore available to craft brewers in traditional 2-row growing regions is important with respect to craft brewers being able to access 2-row malt in the future.

## MALTING BARLEY CHARACTERISTICS FOR CRAFT BREWERS

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In late 2011 thru the first half of 2012, members of the Brewers Association Pipeline Committee participated in a survey to ascertain their preferred malt characteristics. Members were asked to describe the base malt characteristics best suited for their brands.

In general and not surprisingly survey respondents preferred base malts with highly divergent characteristics. Even so, some areas of consensus emerged which are shown below. Certain results differed considerably from the characteristics of typical malts available in today’s suite of malting barley varieties. The Brewers Association believes these results present important opportunities for informed barley variety development.

One important and surprising outcome of this exercise was that even as specific consensus targets emerged survey respondents favored small, incremental changes to the characteristics of the current suite of varieties rather than wholesale radical changes. Respondents favored not “reinventing the wheel”, but rather slowly moving away from current variety models. **U.S. craft brewers’ barley malt preferences represent an in-between spot, neither completely satisfied with the current suite of U.S. varieties, nor true European types which members indicate can be problematic for agronomic reasons as well as reasons pertaining to performance in some U.S. craft brewhouses.**

Other factors not highlighted in the chart below include yield, extract, Nitrogen Usage Efficiency (NUE) and Water Usage Efficiency (WUE).

Craft brewers understand that agronomic realities force growers to make planting decisions, and that barley is often planted as a rotation crop. Therefore they favor increasing yield and disease resistance through Marker Assisted Selection (MAS) and continued use of genotype and phenotype characteristics provided by Triticeae Coordinated Agricultural Project (TCAP) to allow barley to remain competitive with other crops.

Craft brewers, like all brewers, put a premium on high levels of extract. Historically speaking, craft brewers have preferred 2-row varieties for this reason. Looking ahead, craft brewers favor development of malting barley varieties with extract content at current or increased levels.

Craft brewers also believe that lower protein levels go hand in hand with increased extract, and to some degree with lower FAN, lower S/T and lower diastatic power. Having said that, they also realize that it may not be possible to decouple carbohydrate modification from protein modification. So the highlighted attributes below represent a starting point for future discussion and efforts.

Brewers also likewise favor development of malting barley varieties with increased agronomics, WUE and NUE. Increased WUE and NUE are important to allow for decreased input costs and therefore crop competitiveness. They are also important with respect to sustainable production of malting barley over time in the future, given the current shift in growing areas steadily northward resulting from climate change and competition from other crops.

Trait/Topic	Consensus Target	Collected Comments
Flavor	The most commonly cited attribute	Survey Respondents placed the most emphasis on flavor, calling it priority one. Respondents agreed that recent 10- to 25-year trend towards ever increasing flavor neutrality must be reversed. At the same time brewers recognize that this is the most difficult trait to communicate with specific granularity for reasons having to do with basic knowledge gaps of how and when flavor arises and minus a lexicon for describing malt flavors.
FAN	<150 ppm	Generally lower than suite of current varieties to promote biological and flavor stability of finished beer. One brewer favored 125-150 range FAN as ideal, but indicated 140 or 150 would work. Another indicated that 140 < FAN < 200 was critical, favoring especially <200 as a maximum.
Diastatic Power	<150 Lintner	In all-malt beer production, the primary concern noted was too much enzyme, or an enzyme package that is "too hot." One surveyed brewer favored very modest change here, citing under-attenuation as a potential concern with too low DP.
Protein Modification (S/T)	35% to 45%	Achieved via varietal change, <i>not by pushing germination moistures lower on existing varieties.</i> Most group members favored 42% maximum; a few favored 45% maximum. Keep moisture levels elevated (43%-44%) towards end of germination. Related, a caution against moderating S/T at the expense of higher Beta Glucan/Viscosity.
Protein Content	10.5% Maximum	Many craft brewers acknowledge that protein, DP and FAN are coupled to some extent, and to lower FAN especially, lower protein levels are far more favorable. Some brewers also noted the difficulty in developing malt color if proteins were too low. Because all-malt grists contain ample enzyme, respondents generally encouraged pushing heat at Break Through during malting to develop color and flavor even if this results in the loss of some enzyme.
Beta Glucan	<140 ppm	Respondents favored lower Beta Glucan levels in general. Respondents also called for development of a more sensitive assay for Beta Glucan.

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