Chapter 2

Proximal composition of base malts

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ABSTRACT
In this work, the proximal composition of seven base malts were evaluated. Wheat malt had the highest moisture content, and protein and the lowest lipid, ash, and carbohydrate content, the lowest color, and Brix. The lowest moisture, highest color, and ash content were from Munich malt. Rye had a high ash content, low protein, and lipid content, and the lowest crude fiber (FB) content. The highest % of FB was obtained with the Pale Ale malt. The highest °Brix and the lowest protein content were obtained with Maris Otter.

Keywords: humidity, ashes, carbohydrates, proteins, lipids, fibers.

1 INTRODUCTION

Briefly, beer is a drink obtained primarily from the use of water, malt, hops, and yeast (IN 65, 2019). Malt is the result of the malting process, which is the controlled germination of barley to obtain a grain with characteristics conducive to the production of beer (or whiskey) such as high starch and enzyme content (Rosa; Afonso, 2015). Any cereal can be malted, but the main thing is barley. The other cereals, when malted, receive the name malt plus the name of the cereal, for example, Wheat malt, Rye malt (IN 65, 2019).

The malting process consists of three phases: maceration, where the grain is soaked in water, reaching 45% humidity, so that it germinates. Germination is the initial development of the grain for the production of enzymes that will later be used in brewing. This phase is carried out with temperature, oxygen, and humidity control. The final phase is drying, where the green malt loses most of its water, obtaining a final product with approximately 4 to 5% moisture. According to the drying temperature, the base malts are differentiated by color, and consequently, aroma and flavor, varying their drying temperatures from 75°C for lighter malts to 110°C for darker malts (greater generation of melanoidins). The malt color unit is the EBC (European Brewing Convention), you can also use the SMR (Standard Reference Method) and Lovibond. The higher the EBC, the darker the malt. This increase in temperature causes, in addition to color gain, a loss of the malt's diastatic power, which is its ability to convert starch into fermentable and non-fermentable sugars, that is, its starchy enzyme content. Malts that manage to self-convert starch are called base malts and the higher the content of these enzymes, the more modified the malt is (Mallet, 2021).

The drying phase needs to be intense enough to eliminate compounds such as S-methyl methionine, which is a precursor of dimethylsulfide (DMS), a compound that brings an undesirable aroma to beer. Thus, darker malts contain less DMS than paler malts. On the other hand, very intense drying can degrade a lot of β-glucanase, an enzyme that is very important to keep the wort viscosity low (Bamforth, 2003; Mallet, 2021).

Even though any cereal can undergo the malting process, none are as simple and efficient as barley. Rye is a difficult grain to maintain as it releases gum and starch during the process, making the grain bed viscous and compact, thus making the process difficult (Mallet, 2021).

The main base malts used in the brewing process are Pilsen, Pale Ale, Vienna, Munich, and Maris Otter (Mallet, 2021). Wheat and rye malts are less used but are also highly requested for the production of beers such as weissbier and rye beer (BJCP, 2021; Briggs, et al.; 2004).

Pilsen malt has a color that varies from 2.4 to 3.9 EBC, is traditionally made with two-row barley, which has a lower protein content, is widely used in 100% malt light beers, has a moderate enzymatic potential, has a flavor of a little green and a higher amount of DMS due to the low drying temperature. The Pale Ale malt (EBC: 5.3 to 7.5) has a moderate to a high level of modification and a low concentration of DMS due to the higher drying temperature used in the production process, it has an evident maltiness with notes of biscuit and toast. Vienna malt brings a slight toast to the drink, reminiscent of chestnut, has 4.9 to 7.9 EBC, and has enough enzymatic power to convert up to 100% of the malt load. With an EBC of 5.9 to 39.4, Munich malt can also self-convert starch and bring a malty flavor to beer. Wheat malt (EBC: 3 to 6.9) is widely used to improve the quality of beer foam, it also brings turbidity and a slight breading flavor. Rye malt (EBC: 5.5 to 7.3) brings a spicy, spicy flavor to the beverage (BJCP, 2021, Mallet, 2021).

The association of barley malts with wheat and rye malts is easy because they all gelatinize at temperatures below 70 °C (Bart, 2013; Briggs, 2004), unlike other grains such as rice and corn that have a higher gelatinization temperature (Bamforth, 2003; Briggs et al., 2004). As wheat and rye are grains without husks, when used in high proportions in the malt mixture (> 50% m/m) it is recommended to use rice husks to facilitate the filtration of the wort (Mallet, 2021).

Maris Otter is a variety of barley that has gained prominence due to its malt (EBC: 5.5 to 7.5) containing a more pronounced flavor perception. Its price is generally higher than other base malts because its cultivation has a lower yield than other barleys (Mallet, 2021; Bamforth, 2003).

In this work, the proximal composition and analysis of soluble solids and color of the main base malts used in the market (Pilsen, Pale Ale, Vienna, Munich, Maris Otter, Wheat, and Rye) were evaluated.

2 MATERIAL AND METHODS

The experiments were carried out at the Integrated Laboratories of the IFTM - Campus Uberlândia, following a DIC (Completely Randomized Design), with seven treatments (types of malt) and three repetitions.

The malts (Pilsen, Pale Ale, Vienna, Munich, Maris Otter, Wheat, and Barley) were previously ground before analysis, using a PHILCO PERFECT COFFE electric grinder.

For the determination of moisture and ash, the methodology of Instituto Adolfo Lutz (IAL, 2008) 012/IV and 018/IV, respectively, were used. For proteins, lipids and crude fiber used Silva and Queiroz (2009). Carbohydrates were quantified by difference (IAL, 2008) according to Equation 1:

$$\%CH = 100 - (\%U + \%C + \%P + \%L + \%FB) \quad (1)$$

Onde: %CH = % carboidrato calculado por diferença
%U = % determined humidity
%C = % determined ash
%P = % determined protein
%L = % determined lipids
%FB = % determined crude fiber

For the color analysis, a standard must be formulated according to Bart (2013) and Mallet (2021). This must be also used to measure the Brix (Bart, 2013; IAL 2008), to verify the enzymatic conversion capacity (diastatic power) of the malts.

In the moisture analysis, porcelain crucibles and a Quimis Q-317B oven were used. For the ashes, Magnus 200FDM muffle was used. For protein determination, a Solab SL-25/40 digester block and a Tecnal TE-036.1 nitrogen distiller were used. For the quantification of lipids, a Tecmal TE-044 lipid extractor was used. The crude fiber content was obtained using a Marconi MA-444 fiber digester. In the color analysis, a Gehaka UV-340G spectrophotometer was used and in the total soluble solids content (° Brix) a REDI-P digital refractometer was used.

3 STATISTICAL ANALYSIS

For statistical analysis, the AgroEstat software was used, with the Tukey Test being performed with a 95% confidence level for the comparison of means. All analyzes were performed in triplicates.

4 RESULTS AND DISCUSSION

The proximal composition of the analyzed malts, as well as the color and soluble solids content (°Brix), are shown in Table 1.

Moisture

The moisture value for the analyzed malts, Table 1, ranged from 6.25±0.29 to 4.04±0.85%, with the highest value for Wheat malt and the lowest for Munich malt, which is inversely correlated to the color value of the unboiled wort, with Munich malt having the highest index for color (12.49±0.02 EBC) and Wheat having the lowest EBC value, 1.44±0.02.

Among the analyzed malts, Munich malt was subjected to the highest drying temperature 100-105 °C, which explains its lower moisture content and its worth having higher color index (12.49 ± 0.02 of EBC). The higher moisture content of Wheat malt can be explained by the absence of this cereal's husk since the part that carries more water in the grain is the starchy endosperm, added to this fact, we have its low drying temperature (approximately 70 °C) (Briggs et al., 2004), and in the color analysis, it was the most that showed the lowest EBC (1.44±0.02).

Table 1. Moisture content, EBC color, and soluble solids (SS) of the wort were obtained from the analyzed malts.

Malt	**Moisture (%)***	**Color (EBC)***	**SS (°Brix) ***
Pilsen	5,62 ± 1,36 b	2,76 ± 0,01 e	2,17 ± 0,06 a,b
Pale Ale	4,86 ± 0,47 cd	2,99 ± 0,02 d	2,03 ± 0,17 a,b,c
Munich	4,04 ± 0,85 e	12,49 ± 0,02 a	2,45 ± 0,26 a,b
Vienna	4,35 ± 0,47de	3,89 ± 0,03 b	1,23 ± 0,08 b,c
Maris Otter	5,06 ± 0,90 bc	3,57 ± 0,01 c	4,13 ± 0,06 a
Wheat	6,25 ± 0,29 a	1,44 ± 0,02 g	0,50 ± 0,15 d
Rye	5,37 ± 0,32 bc	2,70 ± 0,02 f	1,10 ± 0,11 c

* Significant analysis at the 5% probability level (0.01 =< p < 0.05).

Pale ale malts are dried at a temperature of 95 to 105 °C, whereas Vienna malt undergoes a drying temperature of 90 °C (Briggs et al., 2004). Even though the moisture of these malts was statistically equal by the Tukey test, it was to be expected that the Vienna would have a higher average moisture than the Pale Ale malt, since it is dried at a lower temperature. The color analysis of the unboiled must differ statistically between them and presented the parameter for greater color for the Vienna malt (EBC: 3.89±0.04) compared to 2.99±0.02 of EBC for the malt Pale Ale. Through this analysis, it can be inferred that the Vienna malt was dried at a temperature slightly higher than the Pale Ale malt. It is noteworthy that malts made from barley produced during the summer spend a proportionally longer time at higher temperatures than malts produced in the winter (Mallet, 2021). In this case, it could be that the Pale Ale malt was produced in reverse and the Vienna malt in the summer. The same happened with Wheat malt, EBC: 1.44±0.02, and with Pilsen malt, EBC:

2.76±0.01. A higher EBC value was expected for the unboiled Wheat malt wort, however, Pilsen malt showed a higher value for the color parameter. The color of malt and wort is given by the formation of melanoidins, which are a group of substances derived from Maillard reactions. For such reactions to occur, proteins and carbohydrates must be present, which, when heated, form the color substances (Bamforth, 2003; Briggs et al., 2004, Mallet, 2021). Regarding soluble solids (ºBrix), an estimate of the carbohydrate content in the must, Wheat malt had the lowest value among those analyzed (0.50±0.15). Despite the high protein content in this grain (Table 2), the formation of melanoidins in the must be impaired due to the low sugar content. The same behavior is observed about the Maris Otter malt when presenting an EBC value above the Pale Ale. Maris Otter was dried at temperatures similar to Pilsen, however, even being the lowest in protein content (Table 2), it presented the highest value of sugar in the must (4.13±0.06 °Brix), which possibly contributed to a greater formation of melanoidins.

The low sugar value (Brix) in the musts analyzed is because the enzymatic conversion took place in conditions that are not conducive to starchy enzymes (α and β), which work best in the pH range of 5.2 to 5.6 (Palmer and Kaminski, 2021) since distilled water with a pH close to 7.0 was used. Another point is the low malt water ratio in the standard wort, 0.125 kg malt per liter of water, compared to conventional worts ranging from 0.4 to 0.5 kg L-1 (Brigg, et al., 2004). α-amylase is calcium-dependent, that is, this ion is an essential cofactor for the activity of this enzyme. Barley malt has a higher concentration of calcium ions when compared to wheat malt, and rye has an intermediate value between the two (IBGE, 1999; TACO, 2004).

Protein

Table 2 presents the protein contents obtained in the analyzed malts. Wheat malt had the highest percentage of protein (12.78±0.96), which was expected. This malt is commonly used to improve foam formation and retention in beer (Mallet, 2021).

Table 2. Protein contents were found in the analyzed malts.

Malt	% Protein*
Pilsen	9,31±0,47 b,c
Pale Ale	10,93±0,52 a,b
Munich	10,35±0,18 b
Vienna	9,92±0,78 b
Maris Otter	8,10±0,57 c
Wheat	12,78±0,96 a
Rye	8,11±0,73 c

* Significant analysis at the 5% probability level (0.01 =< p < 0.05).

The lowest protein value (8.10±0.57) was obtained in Maris Otter malt. Stewart, et al., 2022, show that, due to its low protein content, the Maris Otter variety is associated with the production of beers with a more refined flavor. It is worth noting that Rye malt also had a low protein content, similar to Maris Otter malt.

Even the barley malts showed a significant difference in the percentage of proteins, all had adequate levels of protein (Briggs et al., 2004, Mallet, 2021), around 10% (Table 2). Barley planted in the dry season tends to have higher protein content than those grown in the rainy season. 2-row barley also has lower protein content when compared to 6-row barley. Most brewers avoid using malts with high protein contents because they can cause excessive turbidity in the beer, it is a source of nutrients for organisms that can cause deterioration of the product, it provides less fermentable extract (lower yield), and can cause inconsistency in the batches produced (Mallet, 2021).

Lipids

Table 3 shows the levels of lipids found in the analyzed malts. The malt with the highest lipid content was Maris Otter (1.12±0.20) and the lowest lipid content was presented in Wheat malt (0.91±0.22).

The low content of lipids in the malt is important because, during beer aging, lipid oxidation compounds (eg, trans-2-nominal) generate unpleasant aromas and flavors, especially when the beverage is more intensely exposed to oxygen, heat, and light.

Table 3. Lipid contents found in the analyzed malts.

Malt	% Lipids*
Pilsen	1,07±0,21 b,c
Pale Ale	0,94±0,22 a,b
Munich	1,08±0,20 b
Vienna	1,06±0,10 b
Maris Otter	1,12±0,20 c
Wheat	0,91±0,22 a
Rye	0,92±0,08 c

*Analyses significant at the 5% probability level (0.01 =< p < 0.05).

On the other hand, a low concentration of lipid material, along with good aeration in pre-fermentation, is essential for good yeast development during the fermentation phase (Mallet, 2021; Bamforth, 2003; Briggs et al.; 2004).

Gross Fiber

The crude fiber content of the analyzed malts is shown in Table 4.

Table 4. Fiber contents were found in the analyzed malts.

Malt	% Gross Fiber *
Pilsen	3,86±0,14 a
Pale Ale	4,31±0,21 a
Munich	4,14±0,18 a
Vienna	3,83±0,35 a
Maris Otter	3,47±0,50 a
Wheat	1,93±0,34 b
Rye	0,81±0,01 c

*Analyses significant at the 5% probability level (0.01 =< p < 0.05).

Rye and wheat malts had the lowest fiber contents, 0.81±0.01 and 1.93±0.34, respectively. Barley malts (Pilsen, Pale Ale, Munich, Vienna, and Maris Otter) had statistically equal fiber content. This result was expected since the highest fiber content of the grains is concentrated in the husk and the Rye and Wheat malts do not have husks like the analyzed barley malts.

The bark is important in the beer production process because it acts as a filter in the hot clarification process of the beverage (Venturini, 2005). On the other hand, polyphenols are concentrated in the husk of the grain and if the grains are not properly washed after mashing, an excess of polyphenols can be dragged into the must, which results in unpleasant flavors (Venturini, 2005), in addition to cause turbidity (association of polyphenols and proteins) in the finished beverage. However, this turbidity can be mitigated by filtration processes using polyvinylpyrrolidone (PVPP), silica gel, and diatomaceous earth (Briggs et al., 2004).

Ashes

Table 5 shows the ash content found in the evaluated malts. Rye and Munich malt were the ones with the highest values, 1.68%. The malt with the lowest mineral content was Wheat (1.24±0.09).

Table 5. Ash content was found in the analyzed malts.

Malte	% Ashes*
Pilsen	1,48±0,02 c
Pale Ale	1,63±0,13 a,b
Munich	1,68±0,07 a
Vienna	1,60±0,01 a,b,c
Maris Otter	1,53±0,16 b,c
Wheat	1,24±0,09 d
Rye	1,68±0,06 a

*Analyses significant at the 5% probability level (0.01 =< p < 0.05).

Some minerals are important cofactors for enzymatic activity during mashing (Palmer, 2021) and yeast metabolism (White; Zainasfeff, 2020). Typically, the malt wort supplies all of the mineral nutritional needs of the yeast, with the possible exception of zinc ions which may be chelated by wort amino acids (proteins and phytates), and a proportion of these may be removed as insoluble precipitates during the brewing process of boiling (Briggs et al., 2004).

Carbohydrates

In this work, carbohydrates were determined by difference, according to equation 1, and the results are presented in Table 6. Carbohydrates are the main source of starch that will be converted into fermentable and non-fermentable sugars during mashing and later the fermentable ones will be consumed by the yeast during the fermentation process to generate ethanol, carbon dioxide, and other by-products (White; Zainasfeff, 2020; Bart, 2013; Venturini, 2005).

Table 6. Carbohydrate contents were determined for the analyzed malts.

Malte	% Carbohydrates*
Pilsen	78,67±0,68 b,c,d
Pale Ale	77,34±0,49 c,d
Munich	78,70±0,53 b,c,d
Vienna	79,23±1,05 b,c
Maris Otter	80,71±0,32 b
Wheat	76,87±1,42 d
Rye	83,11±0,71 a

* Significant analysis at the 5% probability level (0.01 =< p < 0.05).

Wheat malt had the lowest carbohydrate content, reflecting its higher moisture content (Table 1) and protein (Table 2). The malt that had the highest carbohydrate content by difference was rye because it had low values of protein (Table 2), lipids (Table 2), and fiber (Table 4). Barley malts had similar carbohydrate values, with Pale Ale malt having the lowest value and Maris Otter malt having the highest value.

5 CONCLUSION

The analyzed malts showed significant differences in most of the analyzed parameters, and such differences may be related to the malting process, the variety of barley, and the type of cereal used for malting production.

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