# IMPACT OF KILNING PROCESS ON THE TOTAL ANTIOXIDANT ACTIVITY OF MALT

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## Introduction

Malt antioxidants impart to wort a natural defense against oxidation reactions which are responsible for off-flavours in beer. Appropriate selection of barley varieties and malting process could lead to the production of malt with high antioxidant potential, avoiding the use of chemical exogenous antioxidant compounds.

In that purpose, the present work attempts to determine the origin of malt total antioxidant activity (TAA) and assess the impact of kilning process parameters. Moreover, the contribution of malt antioxidants to the antioxidant potential of resulting wort and beer was also evaluated.

*Changes during kilning*

Numerous changes occur during kilning. Water is removed by passing a large amount of hot air through the green malt. The moisture level is reduced from about 44% in the green malt to about 3-5%, so that the finished malt product can be stored safely. As a result of the removal of water, germination and modification are stopped. The kilning process takes care to protect the enzymes, which are needed in the brewhouse to break down substrates. By heating at high temperature, numerous volatile flavour compounds are driven off. Above 80°C, low molecular weight breakdown products can also react to bring colour and new flavours. The Maillard reactions are especially of prime importance in the production of special malts where they could also bring interesting antioxidant properties.

*Classification of end products*

Based on the starting material used and the kilning or roasting profile, the end products can be classified according to their colour (Table 1). Special malts are usually grouped into three types based on the raw material used. *Type 1.* Roasted barley is obtained by roasting the dressed barley to give a colour of 1200 – 1400 °EBC. *Type 2.* Chocolate and black malts are prepared by roasting white malts to give colours of around 800 and 1200°EBC. White malt, is a poorly modified barley obtained after one day germination and then kilned. *Type 3.* Crystal malt is obtained by kilning a green malt, that is to say, a well modified barley obtained after 4 to 5 days germination. There are low colour and high colour crystal malts.

Except for roasted barleys, the special malts are usually made from high nitrogen barleys. Special malts have usually a low hot water extract value and contribute poorly to the enzymatic activity in the grist. Special malts and roasted barley are mixed to standard malt to target optimal colour and flavour.

**Table 1**. Classification of end products

| | Starting material | Definition | Products | Colour (°EBC) |
|---|---|---|---|---|
| *Type 1* | BARLEY non modified | barley, dressed 12-15% moisture | **roasted barley** | 1200 – 1400 |
| *Type 2* | WHITE MALT poorly modified | kilned chit malt 4-6% moisture | **chocolate malt** **black malt** | 500 – 1100 1100 – 1300 |
| *Type 3* | GREEN MALT well modified | barley germinated 40-45% moisture | **low colour-** **high colour-** **crystal malt** | 20 – 35 60 – 300 |
| | GREEN MALT well modified | barley germinated 40-45% moisture | **pale malt** | 2.5 – 3.5 |

For the production of pilsner or pale malt, green malts with low protein content (max. 11%) are predried before applying higher temperatures (max. 85°C). The temperature can only be raised above 50°C when water content is below 10 - 12%. By this way, proteolytic enzymes will be kept for mashing and few colour compounds are synthesized.

*Contribution of malt to the TAA of beer*

The total antioxidant activity (TAA) of malt, wort and beer has been measured as the inhibition time observed during the AAPH-induced linoleic acid oxidation (Liégeois *et al.*, 2000). Beer was produced by using either 100% pale malt or 10% caramel and 90% pale malt (Figure 1). The TAA, measured on a methanolic extract of malt (133.3 mg/L), indicate the highest value for the caramel malt (Tinh = 24.8 min.) compared to the pale malt (Tinh = 16.3 min.). Due to their higher intrinsic antioxidant activity (52% more), the use of 10% caramel malt contributes to increase (5%) the antioxidant activity of the resulting wort and beer compared to a 100% pale malt-based beer. Wort filtration reveals to be the most important step in term of extraction of malt antioxidants. Around 70% of malt antioxidants are extracted in the wort and survive until the final beer.

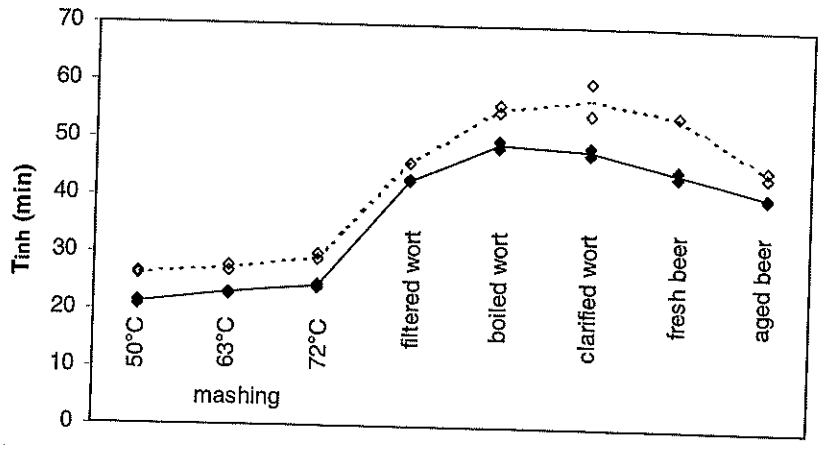


**Figure 1.** TAA profile during the brewing process, measured as inhibition time (Tinh) of the AAPH-induced linoleic acid oxidation. Results are expressed for a 12°Plato wort diluted 400 times in the assay. (—) mashing of 100% pale malt (2.8°EBC); (---) mashing of 90% pale malt (2.8°EBC) and 10% caramel malt (152°EBC).

*Origin of malt TAA*

Different end products were produced from the same barley and compared in terms of TAA (Figure 2) : a roasted barley (*type 1*), a black malt (*type 2*), two crystal malts (*type 3*) and a pale malt. The TAA has been measured by the ABTS radical cation assay (Araki *et al.,* 1999) on 1g/L extracts (extraction of the ground sample in acetate buffer pH 5.4, similar to the mashing conditions).

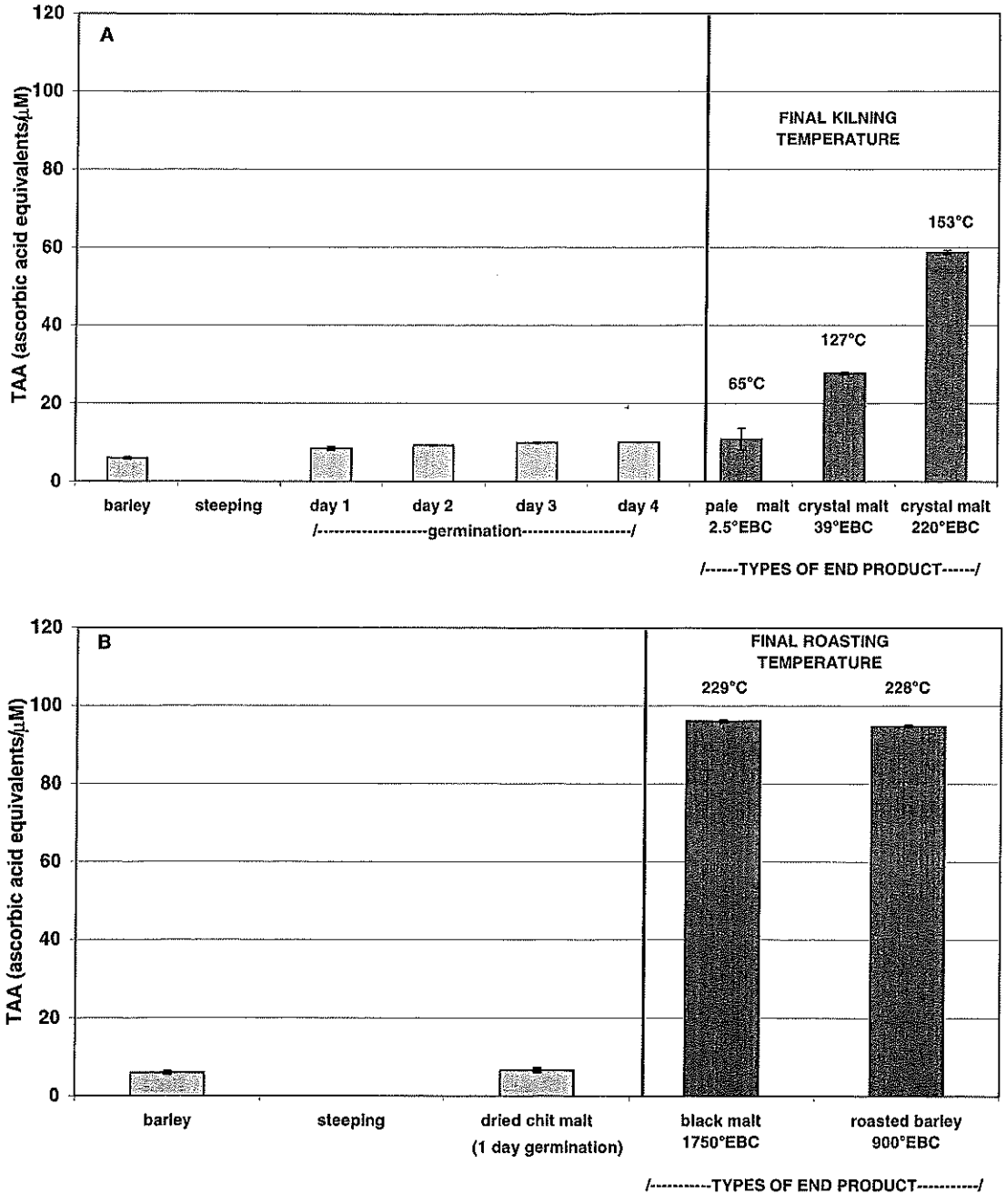


**Figure 2.** TAA of different end products produced from the same barley. The TAA of a 1 g/L extract, expressed in ascorbic acid equivalents, is measured by the ABTS radical cation assay.

Malt antioxidants originate either from the barley or from the malting process. Barley contains many phenolic compounds, which impart to grain a natural TAA. During the production of a pale malt, the TAA increases slightly through the malting process, indicating that barley antioxidants contribute to the most part of the pale malt TAA (55%) (Figure 2a). However, the TAA levels differ significantly between varieties (Figure 3).

Two crystal malts were produced from the same green malt, with different temperature profile at the end of the roasting process. After a stewing period of 40 minutes (from 20 to 102°C), drying was continued until 127°C or 153°C, leading to low (39°EBC) or high colour (220°EBC) crystal malt, respectively. As shown in Figure 2a, higher the final kilning temperature, higher the TAA and the colour. In that case, Maillard reaction products are most probably responsible of the very high antioxidant activity.

The two highly coloured products were obtained either from the non modified barley (roasted barley, 900°EBC) or the poorly modified barley (black malt, 1751°EBC). A depicted in Figure 2b, both achieved TAA values much higher than the crystal malts (8 times the TAA level of the pale malt whatever the colour).

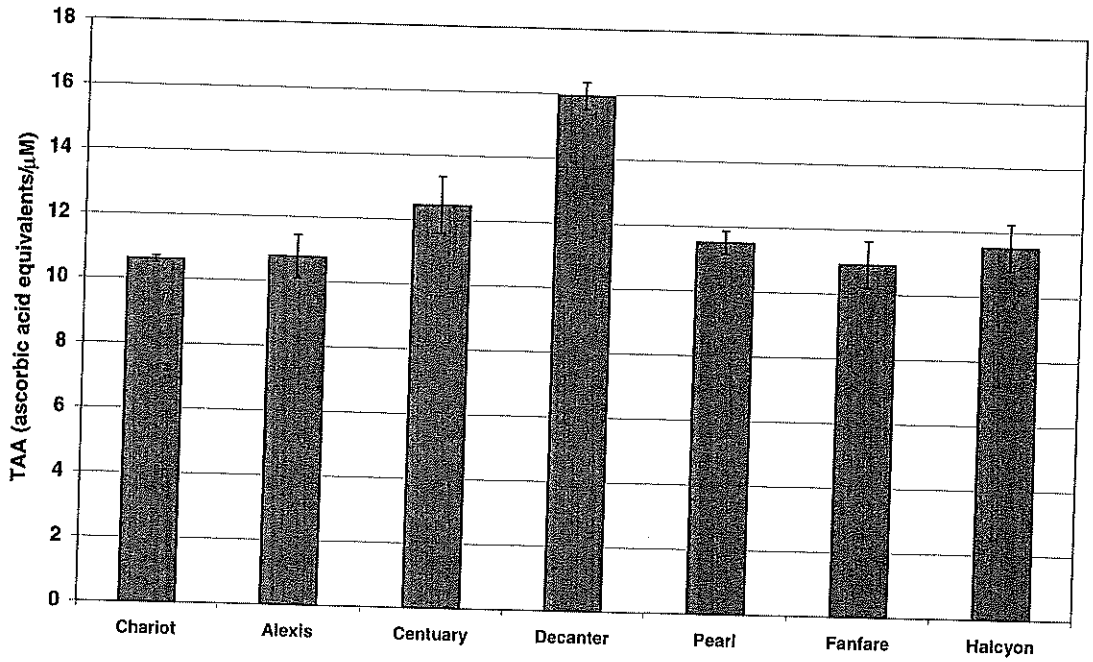


**Figure 3.** TAA of pale malts made from different barley varieties. The TAA of a 1 g/L extract, expressed in ascorbic acid equivalents, is measured by the ABTS radical cation assay.

*Relationship between TAA and kilning process parameters*

Temperature and moisture profiles together must be taken into account to optimize the final TAA value. In both crystal malt productions (Figure 4), TAA development revealed to start only when the moisture level reached 5%. After this period, the higher the temperature, the higher the TAA level.

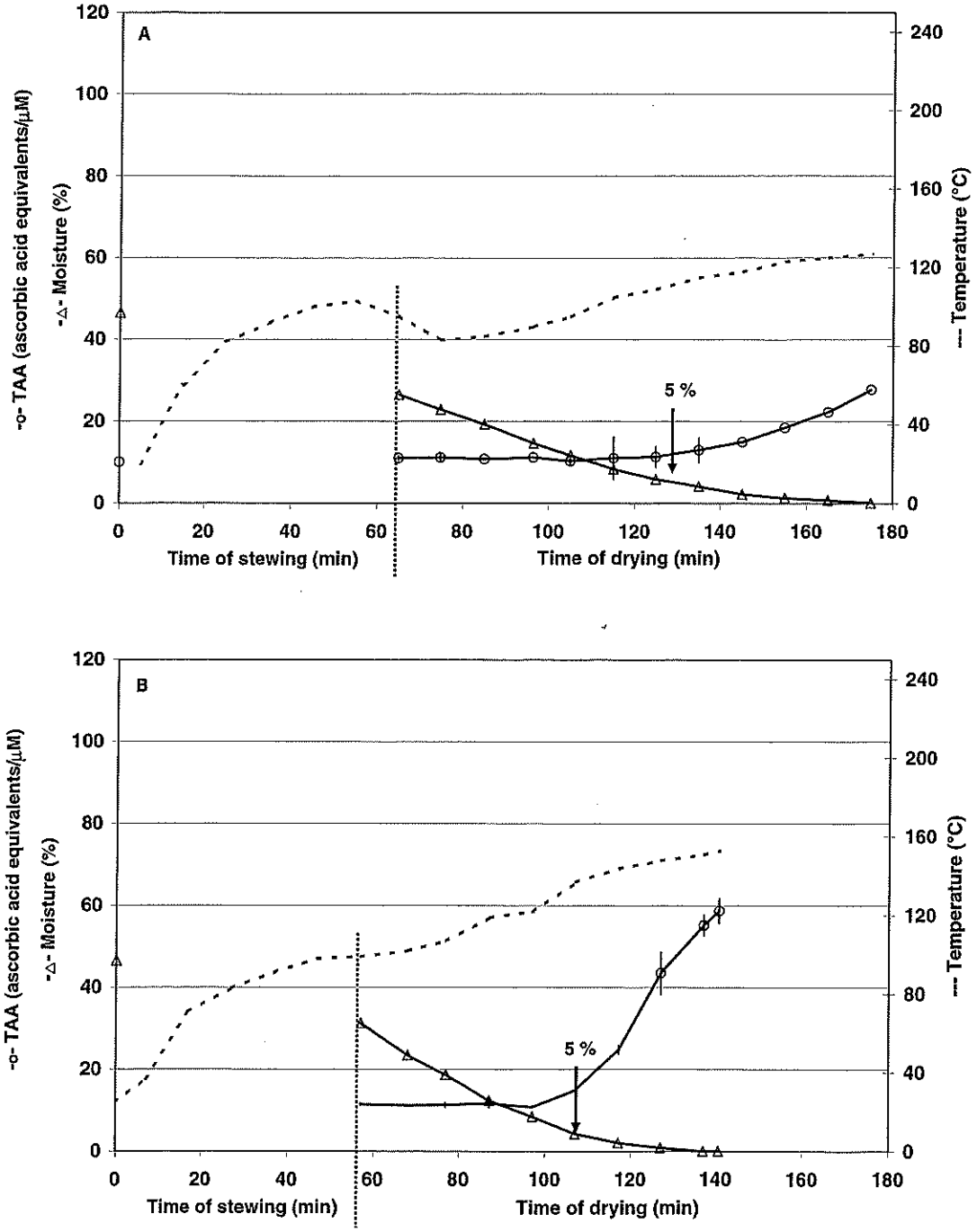


**Figure 4.** TAA development during kilning of crystal malts in relation with kilning process parameters. (a) the low colour crystal malt (39°EBC); (b) the high colour crystal malt (220°EBC). The TAA of a 1 g/L extract, expressed in ascorbic acid equivalents, is measured by the ABTS radical cation assay.

On the other hand, the moisture level is not a limiting factor for melanoidin synthesis when dried chit malt is used as starting material (Figure 5). Therefore, we can assume that only temperature and Maillard product precursors are limiting factors for the black malt TAA value.

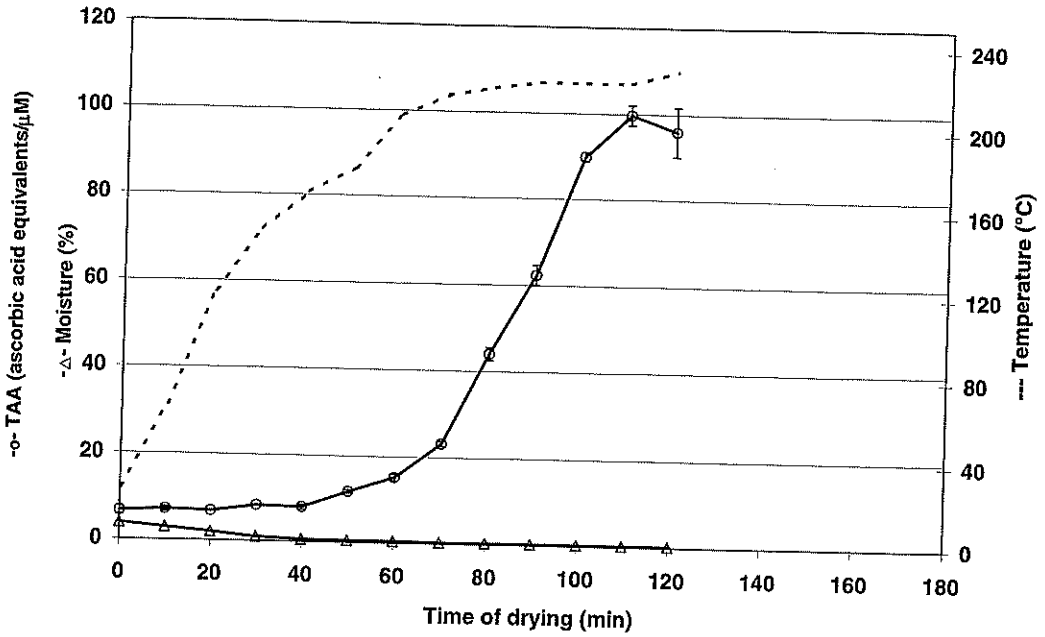


**Figure 5.** TAA development during roasting of the black malt (1750°EBC) in relation with kilning process parameters. The TAA of a 1 g/L extract, expressed in ascorbic acid equivalents, is measured by the ABTS radical cation assay.

## Conclusions

Endogenous antioxidants found in the barley contribute to the most part of the natural TAA of pale malts. Significant differences in antioxidant potential have been measured between varieties. Maillard reaction products revealed to affect the TAA value only when intensively kilned malts are produced.

The development of these heat-induced antioxidants depends on :
- the modification level of the starting material;
- the kilning temperature profile which will define when the 5% moisture threshold is reached;
- the final kilning temperature (min. 100°C).

The intrinsic antioxidant activity of malt greatly contributes to the antioxidant activity of wort and beer. The use of special malts, exhibiting higher TAA values, significantly increases the antioxidant potential of the resulting wort.

## References

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