Effect of Sonication on Malting Behaviour of Barley

Emmanuel Dutheila, Brijesh Tiwarib, Mahesh Guptac, PJ Cullenb, Charles Brennanb, Colm O'Donnella

"Biosystems Engineering, University College Dublin, Dublin, Ireland
bDepartment of Food, Manchester Metropolitan University, Hollings Faculty, Manchester, UK
cFood and Environmental Health, Dublin Institute of Technology, Dublin, Ireland

ABSTRACT

Barley is the main ingredient for malting and brewing in the manufacture of beer. Germination capacity and the level of β-glucans in barley grains play a significant role in the brewing process of barley. Poor germination capacity of barley reduces malt yield. The presence of β-glucans in the malt leads to filtration problems and haze formation in beer. The objective of this study was to investigate the effect of sonication on the malting behaviour of barley grains. Cleaned malting barley cultivar grains were sonicated using an ultrasonic bath. One kg barley grain samples were sonicated for treatment times of 20, 40 and 60 min at a constant frequency of 47 kHz ± 6%. Treated and control samples were analysed for germination capacity using the tetrazolium chloride test, pasting properties using a rapid visco analyser and β-glucan content using a megazyme enzymatic kit. Sonication treatment was found to have a significant effect on the germination capacity of barley grains. All sonicated samples had longer acrospires compared to control samples. Increases in length were higher for samples processed for 60 min. The peak viscosity, which is the maximum viscosity developed during or soon after the heating period, ranged from 201 to 498 mPa.s. All sonicated samples had significantly higher peak viscosity (p>0.05) compared to control. β-glucan content was found to decrease during malting. However sonication did not have any significant effect on the β-glucan content of malted barley. This study shows that sonication improves the germination capacity of barley grains. This effect may be due to enzymatic activity and micro fissures induced onto the grain structure.

Keywords: Sonication, Barley, Germination, Malting

INTRODUCTION

Barley is one of the major cereal grains used in the malting industry. The malt grain is used for the production of several alcoholic and non alcoholic products such as beers, lagers, barley wines, malt extract (powders and syrups) etc. Barley malt is an important trade commodity throughout the world as it is used in the brewing making process [1]. Generally barley malt is obtained from both hull-less barley and hulled barley. Hull-less barley is used to obtained "food malt" to distinguish it from brewers and distillers malts used for malting [2] and subsequent production of alcoholic beverages such as beer. Barley malt is obtained by germinating the barley grains under regulated conditions of moisture and temperature. Germination is generally achieved by steeping barley grains for 36 – 52 h to increase the moisture content of barley grains to about 45% at 12-20 °C. Germination capacity of barley grains plays a significant role in the brewing process of barley. Germination capacity of barley grain is influenced by both pre-harvest and post harvest stages [3,4]. Steeping time and temperature is one of the critical process influencing the modification of endosperm materials of barley malt [5]. Several researchers examined various techniques to reduce water usage during steeping for improving process efficiency and cost. Some studies reported that the use of ultrasound can enhance the germination of chickpea, wheat, pepper and watermelon [6]. Yaldagard et al.[7] investigated the application of ultrasound waves to accelerate and enhance the germination of barley seeds. They observed that the on field germination rate increased together with a reduced germination period in treated seeds. Power ultrasound as a novel processing method finds wide application in various food processing operations including fruit juice preservation [8,9], enhancing drying rate [10] and extraction of bioactive compounds [11]. The physical and mechanical effects such as strong shear forces, particle fragmentation, increased mass and heat transfer, nucleation of seeding induced by ultrasound [12] make it very versatile technology for food processing applications. The objective of this study was to investigate the effect of sonication on the malting behaviour of barley grains.
MATERIALS & METHODS

Sonication treatment
Malting barley cultivar grains were obtained from a brewery (Guiness, Dublin, Ireland), sieved and cleaned. One kg of cleaned barley grains were sonicated in 3 L of distilled water using an ultrasonic bath (Branson® 5210E DTH). Sonication treatment was performed for 20, 40 and 60 min at a constant frequency of 47 kHz ± 6% at a set temperature of 25 °C. Sonicated and control barley grains were steeped for 24 h by immersion in water at 16 °C and subsequently germinated for 96 h. Samples were kilned at 50 °C for 16 h before manually derooted to obtain malt.

RVA Analysis
Pasting properties of sonicated barley grain and control samples obtained after milling samples to flour (Cemotec® 1090 Sample Mill) were determined using a RVA model 3D (Newport Scientific, Australia). A flour suspension was prepared by placing 3.5 g (14% moisture basis) flour in an aluminium canister, which contained 25 g of distilled water. A programmed heating and cooling cycle was used at constant shear rate, where the sample was equilibrated at 35 °C for 2 min, heated to 95 °C at a rate of 11.8 °C/min, held at 95 °C for 2.5 min and cooled to 35 °C at the same rate. These tests were done in duplicate. A plot of paste viscosity (mPa.s) versus time was used to determine the cold (initial) viscosity, peak viscosity (PV), temperature at PV (Ptemp), final viscosity (FV), breakdown viscosity (BV) and total setback viscosity (TSB). Each sample was analyzed in triplicate.

Germination test
The tetrazolium chloride (TZ) test was employed to determine seed potential viability and vigour. Grain viability was determined based on the number of barley grains stained red in 2-3-5 triphenyltetrazole chloride solution. The germination test was performed at 35 °C. The evolution of the germination was determined by the measurement of the lengths of the acrospires and sprout. Seeds were dissected longitudinally using a scalpel (or a knife) so that the embryo was exposed to the tetrazolium chloride solution (Figure 1). Only one half of the seed was used for the test. Care was required to prevent breaking of radicles and other damage to the seed. The seeds were placed in a 1% solution for 5 minutes at room temperature (20 °C ± 2 °C).

Figure 1. Barley Grain TZ test positive
\(\beta\)-glucan analysis

Determination of the \(\beta\)-glucan content of the two isolates was carried as described by McCleary and Glennie-Holmes [13] using a Megazyme® mixed linkage \(\beta\)-glucan assay.

RESULTS & DISCUSSION

The effect of sonication on acrospire length (mm) during germination is shown in Figure 2. A significant increase in the length was observed with an increase in sonication time. Figure 2 shows that the length of acrospire was higher compared to control at any given sonication treatment during a germination period of 96 h, clearly demonstrating that sonication enhances the germination rate. The TZ test also indicated a 100% grain germination rate for samples sonicated for 60 min compared to a rate of 95% for samples sonicated for 20 and 40 min and an 80% rate for control samples. Germination tests showed that sonication enhances both seed viability and vigour (Figure 3). The sonication effect on germination is mainly due to sonochemical reactions involving physical i.e. acoustic cavitations and chemical reactions [6,8,11]. The cavitations during sonication may also induce microfissures on the grain surface and improve imbibition of moisture for enhanced germination rate.

![Figure 2. Changes in length of acrospire during germination](image)

![Figure 3. Effect of sonication on germination after 96 h of germination period](image)
RVA analysis

The RVA profile of sonicated barley grains is shown in Table 1. While an increase in peak viscosity over control was observed at 20 and 40 mins, PV was found to decrease at 60 min treatment time. The variation in the peak viscosity may be due to changes in the amylose contents of the starches during sonication. Oguntunde [14] reported that the associative bonding of the amylose fraction is responsible for the structure and pasting behaviour of starch granules. A change in peak viscosity is also reported to be associated with the degree of starch damage and high starch damage results in high peak viscosity [15]. A decrease in breakdown viscosity was also observed for sonicated samples compared to control with exception to 40 min sonicated samples (Table 1). Breakdown viscosity indicates the ability of the sample to withstand heating and shear stress during cooking [16]. A significant increase in final viscosity was observed in sonicated samples. Final viscosity indicates the ability of a starch to form paste or gel after cooling [17]. The variation in the final viscosity might be due to the simple kinetic effect of cooling on viscosity and the re-association of starch molecules in the samples. The pasting temperature is a pasting property which provide an indication of the minimum temperature required for sample cooking, energy cost involved and other components stability. No significant changes were observed in pasting temperature (°C). The inconsistent changes in pasting profile of sonicated grains might also be influenced by thermal effect induced by sonication. An increase in the temperature during the sonication from 25 °C to 33 °C for 20 min, 35.8 °C for 40 min and 43.9 °C for 60 min was observed.

<table>
<thead>
<tr>
<th></th>
<th>Peak (mPa.s)</th>
<th>Trough (mPa.s)</th>
<th>Breakdown (mPa.s)</th>
<th>Final viscosity (mPa.s)</th>
<th>Peak time (min)</th>
<th>Pasting temp. (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>201</td>
<td>128</td>
<td>73</td>
<td>403.0</td>
<td>4.73</td>
<td>89.6</td>
</tr>
<tr>
<td>Sonicated 20 min</td>
<td>400</td>
<td>349</td>
<td>51</td>
<td>1195.0</td>
<td>7.00</td>
<td>87.05</td>
</tr>
<tr>
<td>Sonicated 40 min</td>
<td>498</td>
<td>413</td>
<td>85</td>
<td>1496.5</td>
<td>7.00</td>
<td>87.95</td>
</tr>
<tr>
<td>Sonicated 60 min</td>
<td>225</td>
<td>173</td>
<td>52</td>
<td>603.0</td>
<td>4.87</td>
<td>89.6</td>
</tr>
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β-Glucan analysis

No significant difference was observed for the β-Glucan content of both sonicated (0.55 – 0.86 mg/100gm) and control (0.97mg/100g) samples. However a significant decrease was observed during malting. A significant decrease of about 42.9 – 46.7% for sonicated and about 39.9 % for control samples was observed during malting. A decrease in β-glucan content during sonication process and subsequent germination might be due to several reasons including solublisation of soluble β-glucan during sonication process and enzymatic degradation of β-glucan due to β-glucanase. It has been reported that low power sonication enhances enzymatic activity.

CONCLUSION

This study shows that sonication improves the germination capacity of barley grains. This effect which may be due to enzymatic activity and micro fissures induced onto the grain structure which may enhance moisture imbibition. RVA analysis showed that sonication also had the possibility to alter viscosity. Ultrasound as a pre-treatment during barley steeping process can help in improving germination by reducing germination time and improving process efficiency.
REFERENCES


