Extract Yield in Relation to Choice of Raw Materials, Brewing Regimes and Enzyme Addition

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ABSTRACT

Extract yield of raw materials for brewing has been in focus for decades. Plant breeders have selected for large kernels, thin husk and low protein content in order to improve extract yield. Use of various adjuncts including rice, wheat, corn grits and corn starch have increased the overall extract yield as have the use of different brewing regimes and the addition of external enzymes.

In the present poster, the relation hip between extract yield and composition of raw materials, brewing regimes and addition of brewing enzymes will be examined. It will include trials, which shows that by the right choice of brewing regime and brewing enzymes the extract yield can be significantly increased, e.g:

- the extract yield of well-modified malt by 1%
- the extract yield of malt + barley adjunct by 2%
- the extract yield of undermodified malt by 3%
- the extract yield of malt + wheat adjunct by 6%

For each example the cost of extract is calculated based on recent world market prices for raw materials and enzymes.

Keywords: Extract Yield, Raw Material Extract, Yield Improvement, Cost of Extract

INTRODUCTION

One percent more extract yield, equivalent to an increase of 1 hectolitre of beer per 1000 kg extract, is significant to a brewer. To meet the demands for more extract, barley breeders have made significant efforts to increase the extract yield of malt by selecting barley primarily for low protein, large kernels and thin husk. For European 2 row spring barley this has resulted in an increase in extract yield from less than 79% dry matter to about 84% dry matter during the latter half of this century.

Alternatively, extract for brewing beer can be increased by adding starch-rich sources other than malt, or by more effective extraction.
• More substrate
  - Bigger malt kernels
  - Thinner husk of malt kernels
  - Less protein of malt kernels
  - Addition of starch-rich adjuncts

• Better extraction
  - Finer grinding
  - Optimal malting regimes
  - Optimal extraction systems
  - Addition of external brewing enzymes

**INCREASING EXTRACT**

More substrate is accomplished by using:

1. High quality malting barley, taking into account both variety, growing conditions and the actual protein content, giving extract yields up to 84.5%
2. Starch-rich adjuncts (examples)
   - corn grits giving an extract yield up to 94.0%
   - rice giving an extract yield up to 95.0%
   - corn starch giving an extract yield up to 95.5%

Better extraction is obtained by:

1. More effective extraction systems, including finer grinding and new mash filters giving up to 2% more extract
2. Addition of external brewing enzymes giving from 1% to 6% more extract depending on the properties of the raw materials (Table I)

**COST OF EXTRACT**

**Extract prices**

Prices of raw materials for extract have varied substantially over the years, and from one part of the world to the other depending on the nature of local crops, taxes, restitutions, special agreements, etc., consequently specific calculations must be made for each brewery.

An example, however, illustrating various extract prices based on accessible international prices and average extract values is given in Table 2.

**Cost savings**

As seen from Table 1 and 2 significant cost savings can be achieved by choosing alternative substrates to malting barley malt for extraction.

Additional cost savings can be realized by increasing the extract yield with the aid of external enzymes.

**Calculation of cost savings**

The savings related to higher extract yield are composed of several elements involving both savings in raw materials (Table 1), and production cost savings.

To get a fair estimate of the savings, which can be used in all breweries, the value of one hectolitre of beer can be calculated.

1000 kg extract will give rise to about 82 hectolitres standard lager beer. That is, 1% higher extract yield (say from 81% to 82%) results in approximately one hectolitre more beer per 1000 kg extract or the value of 1% higher extract yield equals the value of 1 hectolitre beer per 1000 kg extract.

In a “1 million hectolitre brewery” 1% more extract represents 12,000 hectolitres of beer per year. With a brew size of 400 hectolitres, this equates to 30 additional brews per year.

**Cost saving versus enzyme expenses**

The cost of enzyme treatment depends on the supplier, the quantity, the location of the brewery, etc. Most important, however, is the choice of the right blend of enzymes and the optimal quantity: not too much, not too little. The data given in Table 1 represent maximum quantities, which in all cases can do the job. Consequently in most cases, less enzymes will be sufficient.

As a rule-of-thumb the value of 0.5 - 1% gain in extract yield compensates for the expense of the enzymes.

So with the gain of 1% extract, the enzyme expense will already be paid.

Extract gain in excess of 1% and the value of less production problems will thus be to the benefit of the brewer. Maximum cost savings, however, are achieved if brewing enzymes are used together with unprocessed cereal grains (Table 1 and 2).

In these cases more than 1% additional extract is gained by using the right blend of brewing enzymes, which in most cases is necessary, in order to avoid production problems such as incomplete saccharification and prolonged filtration time.

**FIGURE 1**

Barley breeders have increased extract yield by 5% over the last 50 years.
<table>
<thead>
<tr>
<th>Raw materials</th>
<th>Extract (% d.m.)</th>
<th>Extract (% d.m.)</th>
<th>Enzyme addition (per 1000 kg raw materials)</th>
<th>Raw material cost per 1000 kg of extract* (US$)</th>
<th>Raw material cost per 1000 kg of extract* (US$)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>After enzyme addition</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>100% Barley malt</td>
<td>81.4</td>
<td>82.5</td>
<td>0.5 kg Ultraflo L</td>
<td>215</td>
<td>212</td>
</tr>
<tr>
<td>67% Barley malt 33% Barley</td>
<td>77.6</td>
<td>79.7</td>
<td>0.25 kg Ceremix 6X MG</td>
<td>183</td>
<td>178</td>
</tr>
<tr>
<td>100% Undermodified feed barley malt</td>
<td>78.2</td>
<td>80.3</td>
<td>0.7 kg Ceremix</td>
<td>198</td>
<td>191</td>
</tr>
<tr>
<td>50% Barley malt 50% Wheat</td>
<td>79.0</td>
<td>84.9</td>
<td>0.4 kg Ultraflo L 1.5 kg Ceremix 2XL 0.25 kg Shearzyme 500L</td>
<td>168</td>
<td>156</td>
</tr>
<tr>
<td>50% Malt 50% Corn starch</td>
<td>90.7</td>
<td>91.4</td>
<td>0.1 kg Ceremix 6X MG 0.5 kg Termamyl 120 L</td>
<td>207</td>
<td>205</td>
</tr>
</tbody>
</table>

**TABLE 1**

Examples of extract yield and costs of various raw material blends with and without addition of external enzymes.

* Data from Table 2 has been used for the cost estimation in the last 2 columns.
** Enzyme costs not included.

<table>
<thead>
<tr>
<th>Raw material</th>
<th>Price/1000 kg (US$)</th>
<th>Extract Yield* (% dry matter basis)</th>
<th>Price/1000 kg extract (US$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feed barley</td>
<td>75</td>
<td>76</td>
<td>99</td>
</tr>
<tr>
<td>Wheat (unmalted)</td>
<td>90</td>
<td>78</td>
<td>115</td>
</tr>
<tr>
<td>Malting barley</td>
<td>95</td>
<td>78</td>
<td>122</td>
</tr>
<tr>
<td>Corn grits</td>
<td>140</td>
<td>92</td>
<td>152</td>
</tr>
<tr>
<td>Feed barley malt</td>
<td>155</td>
<td>79</td>
<td>196</td>
</tr>
<tr>
<td>Corn starch</td>
<td>200</td>
<td>95</td>
<td>210</td>
</tr>
<tr>
<td>Malting barley malt</td>
<td>175</td>
<td>82</td>
<td>213</td>
</tr>
</tbody>
</table>

**TABLE 2.**

Average international prices in US$ on raw materials and extract derived from them.

*Average values when no external enzymes are added.
CONCLUSIONS

The data presented in this poster demonstrates that:

- Extract yield and cost of extract can vary dramatically
- Maximum cost savings are achieved when cereal grains are used directly for extraction
- High extract yield and additional extract can be achieved by using brewing enzymes
- The maximum gain in extract yield obtained so far by barley breeding and new processes is surpassed by choosing alternative raw materials in combination with the addition of brewing enzymes

FIGURE 2
The cost of extract for producing beer varies by more than 100%.