

YIELD CALCULATION ON STARCH-BASED SPIRITS



Best Practices Series #3

Targets

In the distilleries, getting the optimum yield during the process of spirits production is a daily target. A lot of factors can impact the yield: the feedstock preparation, cooking, fermentation, and distillation.

Features of yield on starch-based feedstocks

- Yield calculation is the key to understanding how efficient a distillery is and to target areas for improvement.
- There are four different yield calculations you can use in your distillery which will give you different information.
- **Overall yield** gives you the cost of the grain to produce your spirit. This is a quantity of pure ethanol that you can sell per ton of grain.
- **Theoretical yield** is theoretical amount of ethanol that can be produced from certain amount of starch.

$$\text{Theoretical yield} = \frac{\text{amount of starch (kg)} \times 1.11 \times 0.511}{0.789}$$

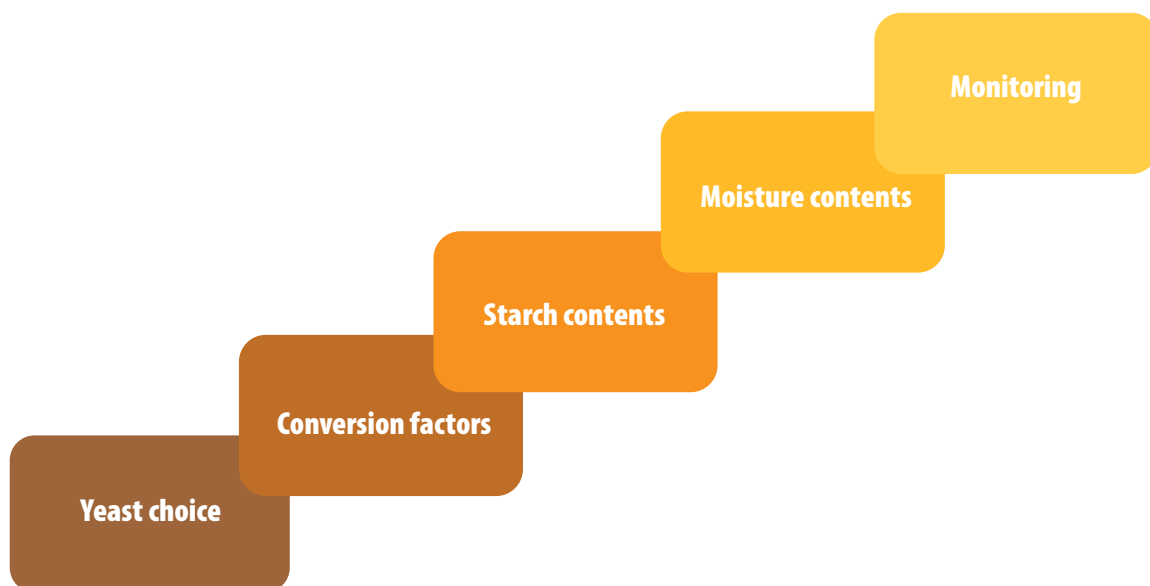
- **Fermentation yield** is the amount of ethanol produced in your fermentation from certain amount of starch.

$$\text{Fermentation yield \%} = \frac{V_{\text{Fermenter (L)}} \times \%abv_{\text{Fermenter}}}{\text{Theoretical yield}} * 100$$

The aim for the producers is to reach 82- 90 % of theoretical yield.

- **Distillation yield.** Final litres of your distillate produced divided by litres of ethanol into distillation.
- Why can we never get 100 % of the theoretical yield? Amid the diverse reasons are the production of daughter yeasts, some losses in factory production, the contamination by bacteria and wild yeast and the production of glycerol, organic acids, higher alcohols, esters, etc. There will also be losses in distillation.

Key points to consider for yield



■ Lallemand Distilling recommendations

Yeast choice

On grain such as corn, wheat, rye, etc. and also on roots such as potatoes, starch, through the action of enzymes, is converted to fermentable sugars: glucose, maltose, maltotriose. It is important to ferment with a yeast dedicated to this type of sugar to make sure that we get a complete fermentation with no residual sugars. Lallemand Distilling recommends looking at the characteristics of the **DistilaMax**[®] range to choose the yeast strain according to your process.

Conversion factors

Yeast cannot consume starch directly, so enzymes are necessary to convert starch into fermentable sugars. The conversion factor for starch to glucose is 1.11; that means that for 100 parts by weight of starch you get 110 parts of glucose. This conversion factor is variable according to the raw material e.g. for sucrose the conversion factor is 1.05. Lallemand Distilling recommends using the enzymes **DistilaZyme**[®] to optimize the mashing and the fermentation.

Starch contents

Starch is what the distiller pays for. The starch content of the grain determines the potential quantity of fermentable sugars and so the yield. If you have one ton of grains with 60 % (ww) starch, you will get 600 kg of starch; if it is 65 %, you will get 650 of starch. The difference of 50 kg of starch represents 55.5 kg of glucose (50x1.11) which is potentially 28,36 kg of ethanol (55.5 x 0,511). This is equivalent to 35,94 litres of ethanol (28.36/0,789 (density of ethanol) per ton of grain. If the efficiency is 85 %, you have a gain or a loss of 30,55 litres of ethanol per ton of grain. Getting grains with high starch content and making sure that the enzymes are used correctly is very important.

Moisture contents

The moisture content is a good indicator of the quality of the grain: high level moisture means bad quality of grain and so limited duration of storage and impact on the yield. If you have a ton of wheat at 65 % (dw) starch with 12 % moisture and a ton of wheat at 68 % (dw) with 15 % moisture, the loss or the gain will be 14 litres of ethanol per ton of grain (based on 85 % efficiency). Calculations are similar to the calculation for starch content.

Monitoring

Consistency is the key to success, so always working the same way and recording data are important. In fermentation, Lallemand Distilling recommends recording temperatures and specific gravity (SG) to make sure that the fermentation is completed. At the end of distillation, the final ethanol content is measured by distillation taking care of the accurate volumes of sample and distillate. The distillate temperature is adjusted at 20 °C before final measure.

■ Summary

To get the highest yield:

- Use a dedicated yeast strain to the sugar present in your feedstock.
- Target a complete fermentation with a level of RS less than 2 g/ litre.
- Use dedicated enzymes to optimize the conversion of starch into fermentable sugars.
- Tailor your process according to the quality of the grain taking in account the starch and moisture contents.
- Monitor your fermentation and distillation to get consistency.



Regarding the usage and dosage of products, Lallemand Distilling recommends consulting local regulations to ensure you comply with your product category approved processing aids. Lallemand Biofuels & Distilled Spirits (LBDS) is proud to supply distillers with a "one stop shop" format. Visit our website www.lallemanddistilling.com to find out more about our products or contact your local LBDS representative.