Bioethanol Production from Germinated Grains in Organic Farming

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Introduction

The most well-known and easiest way to produce bioethanol is by the enzymatic hydrolysis and fermentation of starch. In this process more that 34 mill. m3 of ethanol were produced in 2002 for transportation fuel, accounting for 60% of the total world ethanol production (Thomsen et al., 2003). In a new project **"BioConcens" (2007) (fig. 1) sponsored by DARCOF (DAnish Research Center for Organic Food and farming)** one aim is to develop a combined ethanol and biogas production for use in organic farming using starch containing biomass. Natural enzymes from cereals will be used for hydrolysis of starch to glucose in accordance with technology in brewing technology (Briggs, 1981). Commercial enzymes are often produced from gene-modified organisms and will therefore not be used in the suggested low-input organic context or process.

A preliminary study was performed in which grains of wheat, rye, and barley were germinated using traditional methods applied in malting for beer production. During malting the amylase enzymes present in the grain are activated (autoamylolytic effect, Rau et al. 1993).

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Three steps were applied in the malting process; 1) steeping (fig. 2), where grains were immersed in water for about 16 hours until it reached a moisture content of 42-48%, 2) germination, where the moist grains are allowed to grow under controlled cool conditions in a humid atmosphere, and 3) drying of the grains. After malting the grains were milled and mixed with water to 13% DM. The slurry was cooked at 57.5°C for 2 hours to efficiently initiate the enzymatic hydrolysis and then cooled to 30°C before adding Bakers Yeast. The SSF of germinated grains were compared to SSF of non-germinated grains using commercial liquefaction and saccharification enzymes (amylases).

Figure 2 Steeping of grain

↓ **Figure 3** Ethanol concentration after SSF with *Saccharomyces cerevisiae* in substrates of germinated wheat, rye, and barley (blue) compared to ethanol concentration in SSF with non-germinated grains (milled) and commercial enzymes (red).

Principal System Concept

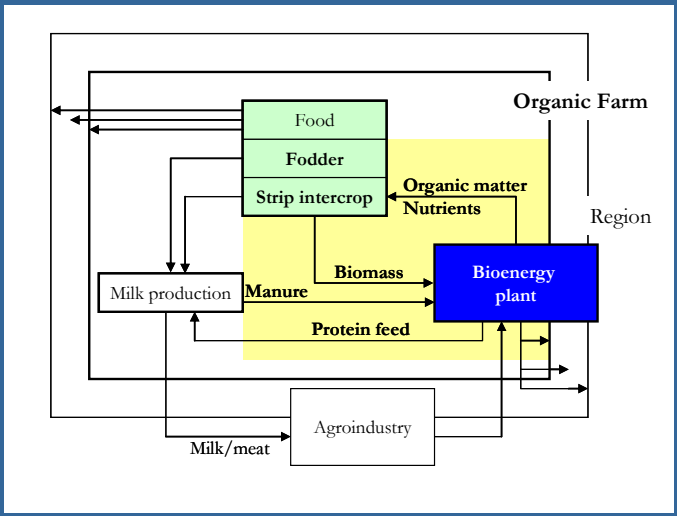
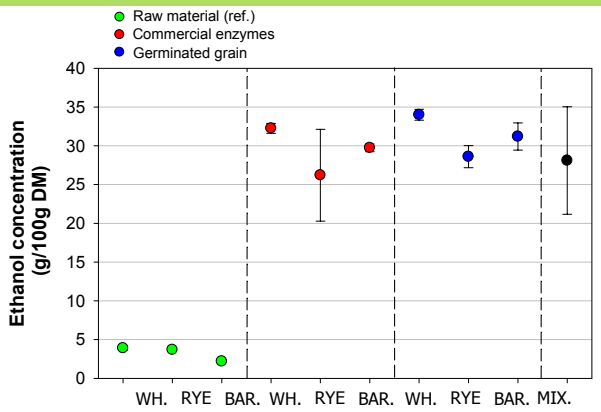


Figure 1 Outline of the relationship between experimental elements (shaded area) vs. socio-economic up scaling in BioConcens

Within BioConcens, a new 4-year Danish interdisciplinary project, the objectives are to:

- Develop new methods and processes for co-production of bioethanol, biogas and animal feed based on resources from organic agriculture and associated food processing.
- Suggest the outline of medium-sized plants for co-production of biogas, bioethanol, and animal feed.
- Design and test new strip cropping system for biomass production to be used for bio-energy, while at the same time safeguarding soil quality.
- Analyze the effects of residues from bio-energy production on soil fertility, GHG emissions, survival of parasites and weed seeds in the manure as affected by bio-energy production.
- Provide corporate and socio-economic analysis of the co-production of biogas and bioethanol at different scales.



Result and Future Perspectives

The results of this study indicate that efficient hydrolysis of starch can be achieved by activation of autoamylolytic enzymes in cereal grains after a malting process. The ethanol yields obtained in the autoamylolytic hydrolysis was comparable (or slightly higher) to that of reference experiments using the commercial enzymes. The highest ethanol yield was obtained with wheat followed by barley and rye (fig. 3).

Wheat:	34 g/100g DM grain
Barley:	31 g/100 g DM grain
Rye:	29 g/100 g DM grain

Activation of natural enzymes in grains is just one task that aims towards the concept of low-input bioenergy production respecting the values and principles behind organic agriculture. The BioConcens project are going to take a uniquely multidisciplinary approach to evaluate the potential and to be able to make recommendations for an integrated bioenergy production within the organic farm, with focus on reduction in reliance on fossil fuels and minimize greenhouse gas while maintaining soil fertility .

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