Bio-ethanol Production from Waste Potatoes

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1 Introduction

Ethanol can be used as an alternative fuel to gasoline. Bio-ethanol can be produced by fermentation from several renewable sources, such as from potatoes and corn. Globally, there is a growing interest for the production of ecologically sustainable bio-fuels. The target in the European Union is to compensate 5.75% of the fossil fuels which is used by traffic with biomass-based fuel by the year 2010 and 20% by the year 2020 (Euroopan parlamentin ja neuvoston direktiivi 2003/30/EY). The goal of United Nations climate conference in Bali is that industrial countries have to decrease total carbon dioxide effluents 30% by the year 2020 (European Parliament Website).

2 Objectives of the research

Potato-based bio-ethanol production utilizes waste potatoes as a raw material. Waste potatoes are produced as by-products in potato cultivation. The quality of waste potatoes is high enough for food production but the size is incorrect. In food potato industry a lot of solid potato mash is also formed which can be considered as raw material in bio-ethanol production. (Kilpimaa 2008, Liimatainen 2004)

3 Bio-ethanol production

Process of potato-based bio-ethanol production is presented in Figure 1. When potato mash is used as a raw material, mashing is not needed. Instead waste potatoes have to be mashed. A portion of water and enzyme (α-amylase) is added before cooking. Optimized cooking time is 30 minutes. Cooking step is called a gelatinisation. Starch hydrolysis is carried out using enzymes in two steps. After boiling the mash is cooled down to 80–90 ^{o}C and the rest of α-amylase is added. The aim of α-amylase is to crack carbohydrates of starch to shorter chains. This step is called liquefaction. Optimized reaction time for α-amylase is 30 minutes and after that the mash is cooled down to 60 ^{o}C. Termamyl enzyme, which modifies starch to glucose, is added and allowed to react 30 minutes. This step is known as a saccharification. After that mash is cooled down to 30 ^{o}C and yeast is added. Optimized fermentation time is 3 days. During fermentation the mash is mixed daily. (Kilpimaa 2008, Liimatainen et al. 2004, Liimatainen et al. 2005)

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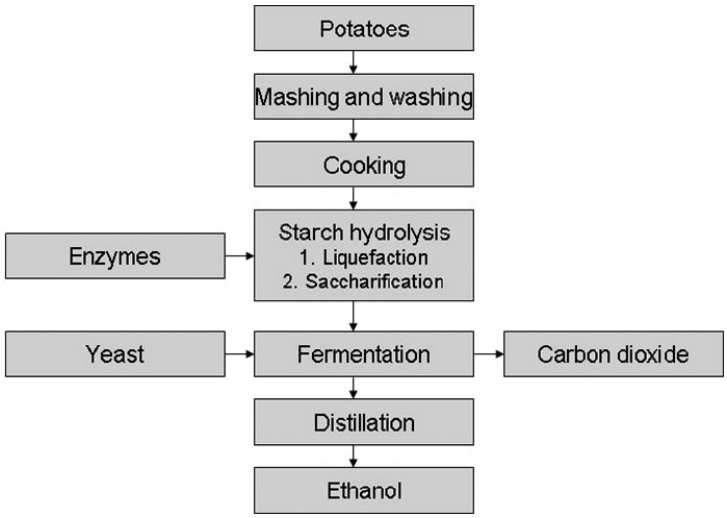

Figure 1 Potato based bio-ethanol production process (modified from Vahtola et al. 1999)

3.1 Dehydration

Bio-ethanol, if it is used as a fuel, must be anhydrous. Most of the water can be removed by distillation, but the alcohol content of the distillation product is limited to 95 vol-% due to the formation of a water-ethanol azeotrope. There are many dehydration processes to remove the water from an azeotropic mixture. The first process is called azeotropic distillation, in which auxiliary substance, benzene or cyclohexane, is added to the mixture. The formed azeotropic mixture is stronger than the original one, and anhydrous ethanol can be formed from the mixture on the top of the column. The second method is called extractive distillation, in which a ternary component is added to the mixture. Ternary component will increase the relative volatility of ethanol.

Distillation-based methods are very energy-intensive. There exist also some modified, less energy-intensive methods, e.g. membranes. Through membranes water can be separated from water-ethanol mixture without distillation. Water molecules penetrate the membrane and ethanol molecules concentrate to the other side of the membrane. Pervaporation is combination of membrane permeation and evaporation, and it can be used for dehydration. Adsorption is also a usable method especially in case of the azeotropic mixtures. (Tanskanen 2008)

4 Relevance of the research

Currently, a lot of attention has been paid for the production of bio-fuels in order to contribute the demands within EU region. Finland has to increase also the production of biomass-based energy. Among the forest biomass also other biomass sources such as secondary flows from food production should be considered. Use of waste potatoes in bio-fuel production seems to be potential, since the production of bio-ethanol from waste potatoes is a well-known process. Bio-ethanol production is also carbon dioxide neutral because raw material is from waste sources. Bio-ethanol production must be decentralized because of logistical reasons.

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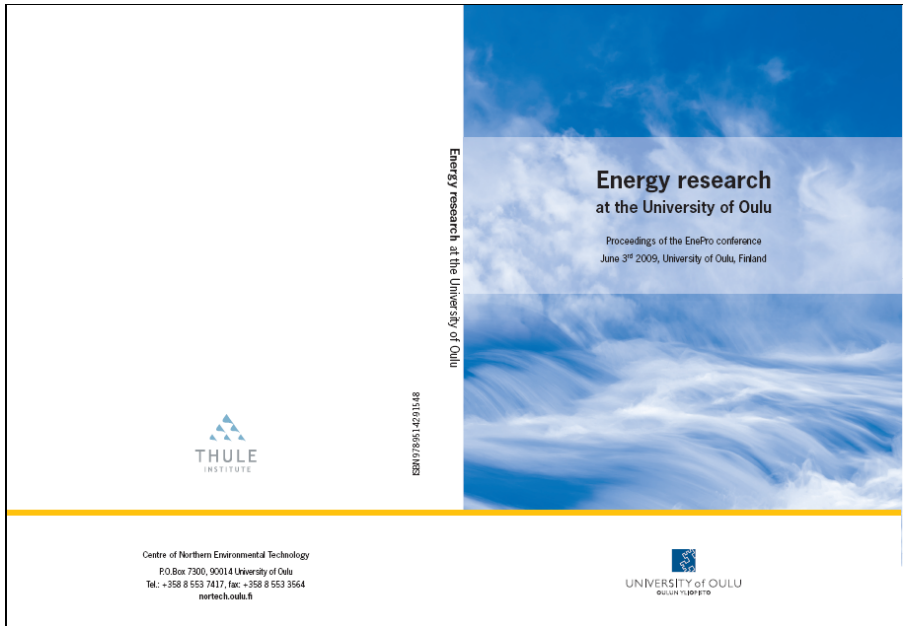

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