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# Investigation of bio-ethanol Production from Waste Potatoes

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**ABSTRACT**

*Considered to be the cleanest liquid fuel, bioethanol can be a reliable alternative to fossil fuels. It is produced by fermentation of sugar components of plant materials. 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. Bio-ethanol production from potatoes is based on the utilization of waste potatoes. Waste potatoes are produced from 5-20 % of crops as by-products in potato cultivation. Therefore, the aim of this study was to study investigation of bio-ethanol production from waste potatoes.*

**Keyword:** bio-fuels, bio-ethanol, potato

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## INTRODUCTION

Due to the potential exhausting of traditional fossil fuels and the increasing price of petroleum together with environmental concerns, the search for alternative renewable fuels has attracted great attention in recent years [1]. Attention has been devoted to the conversion of biomass into fuel ethanol, which is the cleanest liquid fuel alternative to fossil fuels [2]. Biologically produced alcohols, most commonly ethanol, were used as a fuel source for cars well into the 1930s. After World War II, however, little interest remained in using agricultural crops for liquid fuel production because of the abundant and cheap supply of fuel from petroleum and natural gas [3]. With the current limited oil supplies, there is a renewed focus on the need for alternative energy sources; Fuel ethanol remains an attractive option. It benefits farmers by creating a substantial new market for crop supplies and by creating new jobs in economically depressed rural areas and small communities. Ethanol is produced by the action of microorganisms and enzymes through the fermentation of sugars, starches or cellulose[2]. Yeast is one of the most important microorganisms in the production of ethanol but now many microorganisms can replace yeast for ethanol production. In addition to ethanol, butanol has been introduced as a fuel [3]. Biobutanol (also called biogasoline) is often claimed to provide a direct replacement for gasoline, because it can be used directly in a gasoline engine in a similar way to biodiesel in diesel engines. Biodiesel can be made from vegetable oils [4].

### 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 gelatinization. Starch hydrolysis is carried out using enzymes in two steps. After boiling the mash is cooled down to 80–90$^0$ 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 $60^0$ 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 $30^0$ C and yeast is added. Optimized fermentation time is 3 days. During fermentation the mash is mixed daily [5].

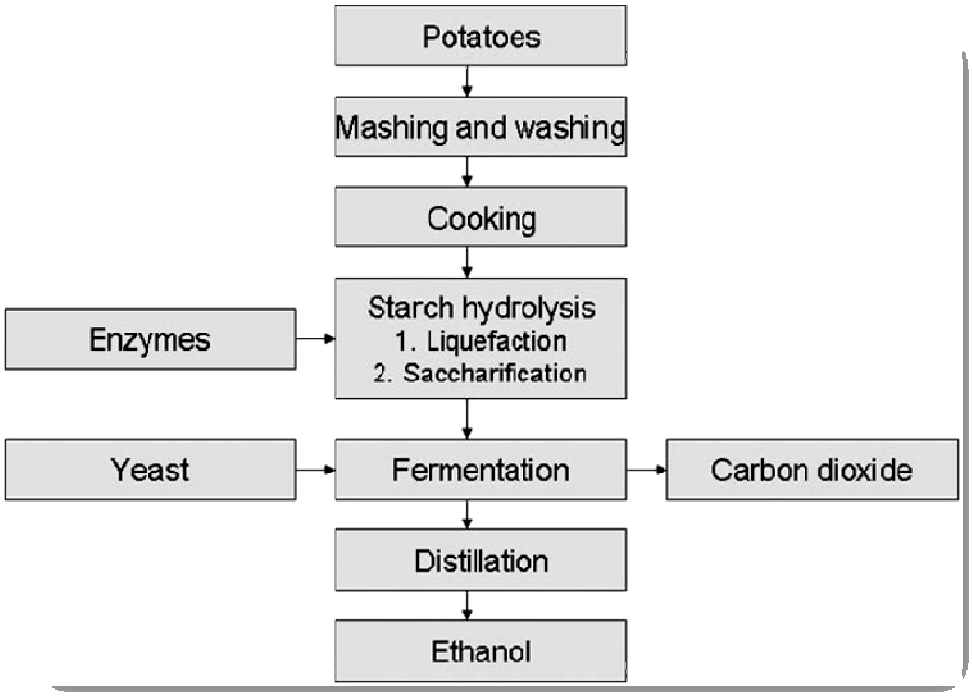


**Figure 1 Potato based bio-ethanol production process (modified from Vahtola et al. 1999)**

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 [6]. 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 [7].

Distillation-based methods are very energy-intensive [8]. 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 [9]. 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 [10].

**Current uses of ethanol and other bio-alcohol fuels**

Ethanol and other alcohols can be used to power motor vehicles instead of gasoline. In almost all cases the ethanol is mixed with gasoline [11]. Gasoline-powered vehicles have no difficulty using gasoline that contains small amounts of ethanol [12]. Generally this mix must contain at least 10 percent ethanol to qualify as gasohol. Gasohol is widely available in Denmark, Brazil, and the American Midwest .The state of Minnesota requires all gasoline sold there to contain at least 10 percent ethanol [13].

Many car manufacturers are now producing flexible-fuel vehicles (FFV's), which can safely run on any combination of bioethanol and gasoline, up to 100% bioethanol. They dynamically sense exhaust oxygen content, and adjust the engine's computer systems, spark, and fuel injection accordingly. FFV internal combustion engines are becoming increasingly complex, as are multiple-propulsion-system FFV hybrid vehicles, which impacts cost, maintenance, reliability, and useful lifetime longevity [14].

Increasing numbers of light trucks are sold as flexible fuel vehicles, capable of burning a variety of fuels, including mixes of gasoline and ethanol and other alternative fuels such as P-Series fuels. Vehicles that can run on pure ethanol are rare and require special engineering to function, which is why fuels for FFVs usually contain at least some gasoline. One common ethanol blend is called E85, which contains 15 percent gasoline and 85 percent ethanol. Producers add this small amount of gasoline to the ethanol to make the vehicle start better in cold weather. E85 is generally priced at about the same level as gasoline [15].

Ethanol and methanol can both be used as fuels in fuel cells, though ethanol is a less efficient source than methanol. Fuel cells would use the energy stored and released by hydrogen. Ethanol also has many other uses. It has a low melting point, so it can be added to liquids as an antifreeze [16]. In addition, it can be added to gasoline as an anti-knocking agent. It can also be a safe replacement for MBTE, a fuel additive that has been found to present environmental problems [17].

**The Future of Biofuels**

Biofuels are a reliable alternative energy resource but more development and research is necessary to overcome the advantages and disadvantages of biofuels and make them suitable for widespread consumer use. When the technology is available, many of the disadvantages will be minimized and consumers can begin to enjoy all the benefits of this sustainable, renewable energy source.

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