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Bioethanol production from distinct starch sources by fermentation process through barley and yeast

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Abstract

Due to the intense need of bio-fuel in this energy crisis time a lab experiment was designed to have a cost effective ethanol production from potato and corn by using barely a source of diastase enzyme. The effects of temperature, yeast and barely quantity on ethanol production were also investigated. The results showed that potato yielded high amount of ethanol (242mL) as compared to corn which produced 64mL of ethanol. The cost estimate was also low in case of potato. It was also noted that with the increase of barely and yeast amount, ethanol production from different starch sources was increased. It was concluded from the present experiment that Pakistan has cheap sources of starch which could be used for biofuel production to withstand in this energy crisis time.

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Introduction

Ethanol, an organic compound in the form of alcoholic beverages has been produced by fermentation from the ancient times (Sanchez and Cardona, 2005). Biological production of ethanol also known as bioethanol is an economical process and has advantages over traditional extraction (Rubio-Arroyo *et al.*, 2011). Distinct raw materials can be used in the production of bioethanol. The most common among them are cereals (maize, barely, wheat etc), fruits (grapes, water melons, etc) and vegetables like pumpkins and potatoes (Wadhwa and Bakshi, 2013). Some industrial by-products like molasses are also used in the production process of ethanol (Pimentel and Patzek, 2005). It may also obtained from sugar or starch fermentation, however, these processes consume more energy (Sanchez and Cardona, 2005). Similarly, the use of agricultural harvest as the source of bioethanol production could eventually increase and drive the prices of these sources (Ferreira-Leitao *et al.*, 2010).

Presently, bioethanol is produced through corn and sugar cane fermentation because their production technologies are cheaper than other fermentation processes (Sanchez and Cardona, 2005). Forage sorghum has attracted interest as potential energy crop as it grows in conditions which are unfavorable and offers high biomass yield (Dien *et al.*, 2009).

On the other hand, Cassava is mainly used in animal feed but it is also an alternative source of starch which can be used for ethanol production (Sanchez and Cardona, 2008). Commonly barely is utilized for the purpose containing an appreciable amount of diastase equivalent to amylase. Barely is germinated, dried and ground and used as such as a source of amylase enzyme. During amylase digestion process of ethanol, the raw material containing starch is boiled in water to lose the starchy material and the process is named as mashing (Delcour *et al.*, 2010).

Similarly, zymase enzyme from yeast is also responsible for the conversion of carbohydrate part of carbon sources to ethanol (Rajvanshi *et al.*, 2007). The detail biological process consists of digesting the carbohydrate material, mainly of plant origin, with amylase enzyme. The converted material are then subjected to the action of yeast which later change them to ethanol.

Now a day's energy crisis is prevailing all over the world. Researchers are looking for renewable sources of energy. In this regard ethanol production is considered on its priority (Balat and Balat, 2009). In various advance countries ethanol mixed with gasoline have been used for driving vehicles and other small engine driving machinery (Reel, 2006). Several other countries including Pakistan have started using bioethanol as an alternative fuel (Mirza *et al.*, 2008). In Pakistan various starchy material are going into waste with little or no use. So this technology will not only help in environmental pollution but will promote the supply of renewable energy (Mirza *et al.*, 2008).

Therefore, present study was designed to have an insight in starchy sources (corn and potatoes) for ethanol production in terms of their readily availability, economic feasibility and production capabilities.

Materials and methods

Ethanol was produced from corn and potatoes used as source of starchy materials. Barley was used as enzyme (diastase) source during the process. These sources were compared for their final production, economical availability and also for yeast, barely and temperature management. Potatoes, corn and barely were purchased from local markets and their prices were noted for cost estimation during whole of the process.

Germination of barley for diastase activation

Weighted amount of barley were taken in a wooden crate and moistened with water such that extra water was percolated down. They were kept in dark for three days and the moisture content was monitored every day. The process was stopped when the length of seedling was a millimeter long from the size of seed. The barely were dried on using pan. The dried material was ground and was used as diastase source during ethanol production.

Preparation of corn and potato for diastase digestion

Half kg of both the materials were boiled in water, mashed and then diluted to a concentration of approximately 4% starch content. This solution was ready for diastase digestion. In each of the corn and potato solutions, one cup of ground barley was added. The solution was kept incubated at 60°C for 12 hours. After completion of the incubation, the solutions were brought to room temperature for yeast fermentation.

Yeast preparation

Yeast was obtained from the local market in a packet of 100g. One tea spoon was dissolved in glass of water and kept for a day at room temperature in dark. This solution was ready for corn and potato fermentation.

Fermentation

The corn and potato solution after filtration was mixed with 10mL of the yeast solution and kept for incubation upto seven days. The fermentation was then stopped by boiling the solution and ethanol was extracted by distillation.

Distillation

Distillation was carried out in rotavapour at 77°C under vacuum. The distillate was then dried passing over $CaCl_2$. The amount obtained was measured in graduated cylinder and was explained in terms of cost of yeast and barely quantity.

Results and discussion

Effect of sources on ethanol production

In this study, ethanol was produced from corn and potato. The effect of variability in amount of barley (used as amylase) and yeast was also observed. From the data it was cleared that potato produced higher yield i.e. 242mL of ethanol (Fig. 1) under similar conditions, keeping all other factors constant. Corn produced less ethanol (64mL) as compared to potato. The comparing cost per Kg of potato and corn were compared and it was not surprising that corn was much expensive than Potato. Production of ethanol from potato and potato co-products has been reported (Cardona *et al.*, 2009). Another study reported on a net production of 6-7% of ethanol from potato which contained about 11-14% of starch content. Low energy consumption during production of ethanol from corn has also been reported (Pimentel and Patzek, 2005).

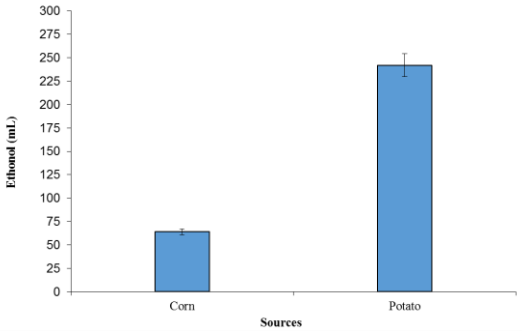

Fig. 1. Effect of sources on ethanol production. The error bars indicate the standard error of means of triplicates.

Effect of temperature on ethanol production

Temperature had critical effect on the ethanol production where yeast, barely and substrate amount was kept similar. In present study, corn and potato were kept at 22°C (1) and 35°C (2) (Fig. 2). The production difference in case of potato was obvious from the increase (5.3 to 6.9mL) while in case of corn the increase was from 4.9 to 5.6mL.

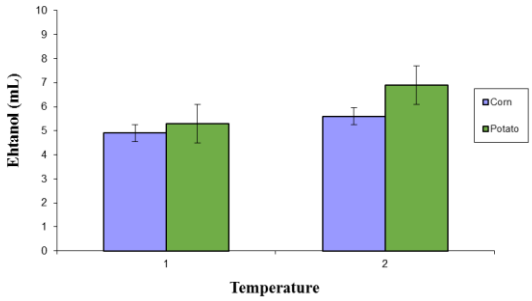

Fig. 2. Effect of temperature on ethanol production from corn and potato. Temperature 22°C (1) 35°C (2). The error bars indicate the standard error of means of triplicates.

Effect of barley concentration

Similarly, during experiment with various concentration of barley showed that increase in barley quantity in suitable amount increased ethanol production as cleared from Fig. 3. By increasing barely from 12 to 15g in a 50g of each potato and corn showed an increase in ethanol quantity i.e. from 12.9 to 13.2 mL and 12.4 to 14.5 mL respectively.

The yeast amount there was same. The increase in barely amount caused boost in soluble starch as well as provided highest amount of enzyme which increased ethanol production (García-Aparicio *et al.*, 2011).

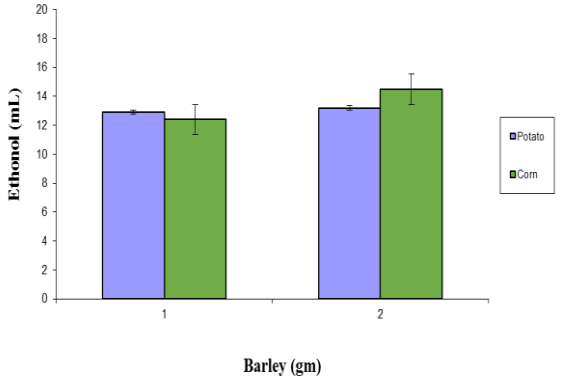

Fig. 3. Effect of barely on ethanol production from corn and potato. Whereas 1 represents 12gm and 2 is 15gm. The error bars indicate the standard error of means of triplicates.

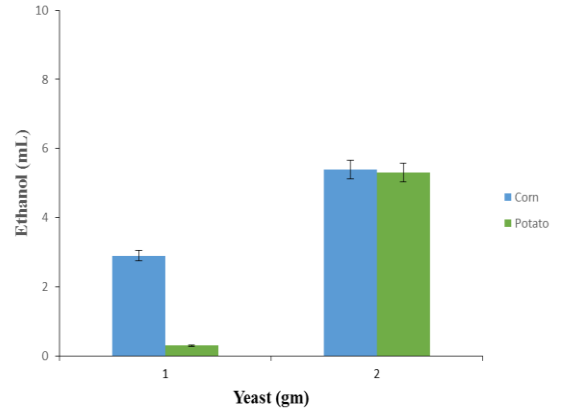

Fig. 4. Effect of yeast amount on ethanol production from corn and potato. 1 represents 1gm whereas 2 represents 2gm of yeast. The error bars indicate the standard error of means of triplicates.

Effect of yeast on ethanol production

Yeast also had its quantitative effect on ethanol production from both the sources. The data showed that increase in yeast quantity increased ethanol production.

Studies showed that specific ethanol production rate of raw starch by arming yeast cells displaying α-amylase and glucoamylase increased significantly when the cells and starch granules settled together in high proportion (Khaw *et al.*, 2007).

By increase in the amount of suitable yeast like saccharomyces had been considered good at producing ethanol (Arapoglou *et al.*, 2010).

Conclusions

From the present study it was concluded that cheap vegetables like potato could be used for ethanol production. Also adjustment of various factors could increase the production of ethanol. It is recommended that various cheap starch sources from vegetables and cereals which were not of direct use of man i.e going into waste could be utilized in ethanol production

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