A Review on Techniques of Ethanol Production from Damaged Sorghum and Corn Grains

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Abstract: Ethanol production from starchy raw materials specifically damaged corn and sorghum grains by direct bioconversion are potential source for non-edible option. Ethanol production from damaged corn and sorghum starch requires the use of amylase and amyloglucosidase for the pre-treatment starch before fermentation. Preparation of damaged corn and sorghum grains for ethanol production is concentrated by study of separation for damaged grains to removing waste part and constituents reducing bio-ethanol conversion. This paper reveals the fermentation process for ethanol production from damaged corn and sorghum grains, for early detection of poor fermentation performance. Owing to rapid depletion of fossil fuel reserves, alternative energy sources that are renewable, sustainable, efficient, cheaper and eco-friendly options this work would be helpful in improvement of ethanol production. It is observed that Process of Ethanol production from damaged Sorghum and Corn grains is having vast potential and it would be very useful source of renewable energy.

Keywords: Kinetic parameter, mathematical model, Ethanol, Fermentation, pre-treatment

1. Introduction

Owing to global environmental problems associated with fossil energy, concern of fuel sustainability is growing which results in rapid increase ethanol production. Use of Maize as biofuels is not socially feasible because it is major source of caloric intake. Agricultural wastes and Insect, fungi and sprout-damaged kernels which are not fit for human consumption or industrial processing are still other options to produce biofuels. Some qualitative and quantitative losses are occurring in the postharvest system of cereals. Overall postharvest losses in maize are mainly during drying in the field and storage, and can predominantly be attributed to biotic factors such as insects, molds, rodents and sprouting. According to FAO (1993), the range of worldwide postharvest losses is between 10 and 37%.

Insects are the most important biotic factor related to postharvest losses. In addition to insect damage, fungal infections are also a major postharvest problem causing unwanted effects such as discoloration, off-odors, loss of germination capacity and contamination with harmful mycotoxins. In tropical areas, field and storage sprouting also causes direct and indirect losses due to the activation of degrading intrinsic enzymes that break down proteins, carbohydrates and lipids into simpler forms. The use of insect, fungi and sprout-damaged grain for human consumption is not always possible and its utilization in other industrial processes could reduce, at least to some extent, the producer losses.

Types of grain damages:-

A) Broken/Cracked Kernels

A broken or cracked kernel is a one of the most common form of grain damage. This type of damage occurs during handling process and moving grain anytime from one place to another. During further handling, deterioration of the grain more quickly through accelerated insect and fungal infestation and a faster propensity to breaking because of cracks in kernel. The increase in mechanical damage decreases the allowable of storage time.
Stress cracks can form within the kernel, in addition to exterior cracks. Combination of thermal and mechanical handling processes like drying usually causes the stress cracks in the grain. Kernels can break more rapidly during further handling because of internal stress cracks which have greater breakage vulnerability. Percentage losses also turn into large quantities of useless grains by contaminating them with their droppings, webs and odors apart from damage due to insect pests. Quantitative as well as qualitative losses in grains take place significantly during storage [3].

B) Fungal and Insect Infestation

Dry matter losses may be because of Fungal and insect infestations make the grain less valuable. Grain damage as well as loss the actual weight of the grain result due to grain Insect infestations. An insect infestation is able to reduce the chemical or nutritional value of the grain which is very important for the end use. Moisture, mechanical damage, storage temperature, and other factors can be trigger mold growth. Weight or quality losses because of insect during storage are not accurately measured though it is estimated around 35% of total production [2].

C) Heat Damage

Heat damage mostly arises from drying of grain. USDA recognized heat damage as new type of damage though it is a sub type of damage including broken or cracked kernels. Heat damaged kernels may have seed coats which are peeling off or have a discolored, wrinkled, and blistered, be puffed and/or swollen. It is undesirable effects due to elevated temperatures used to eliminate moisture by drying process. Breakage/cracks, discoloration, and shrinkage are the most common signs of heat damage. Interior and exterior stress cracks on the kernels are caused because of temperature and moisture gradients in the grain during the drying process. Grain qualities problems arise due to cracks are listed in the two earlier grain damage types. Brown et al. explained that for multiple types of drying, the percentage of stress-cracked kernels increases as moisture content increases [2].

Ethanol Production from Damaged Sorghum and Corn Grains:-

Ethanol production from damaged corn and sorghum grain is obtained by separation method for removal of damaged portion. Mechanical damaged corn and sorghum grains can be directly separated by using filters. Mechanically damaged food grains are prone for other damages because of breakage of protective grain shield. Sprouted damaged food grains can be processed to produce ethanol during early stage. Damaged portion can be removed by washing using water and then drying for further processing.

The ethanol production from damaged sorghum and corn grains mainly includes the following steps

1) Sample Preparation:-
In this process the damaged part from the grain is removed from it and it is used for further process.

Collect samples

↓

Washing & Cleaning

↓

Place it in hot air oven at 50°C for 5 hr. (Depend upon moisture content)

↓

Prepare powder of two particle size (250 & 180μ) through sieves

↓

Store in air tight containers

↓

Further use for fermentation

Figure No: - 2 Sample Preparation [3]
2) Simultaneous Saccharification and Fermentation (SSF)

The prepared sample from damaged grain is further used for Simultaneous Saccharification and Fermentation (SSF) to extract alcohol from it.

![Simultaneous Saccharification and Fermentation (SSF) diagram]

Grain damaged by sprouting may not affect ethanol production and final ethanol yield negatively but may lose value for food applications. Ethanol yield from field-sprouted corn and sorghum grain is slightly higher than that from the non-sprouted control grain. High ethanol yield indicates the positive effect of cell-wall-degrading intrinsic enzymes generated during sprouting. The fermentation process for sprouted grain could be much shorter than that required for normal grain.

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<th>Table No. 2 Ethanol yield from damaged corn and sorghum grain [4]</th>
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In all treatments, an increase of Fungal infected is observed because of the reduction of density due to endosperm damage or starch consumption or degradation. Insect damage and sprouting is more detrimental in corn compared to sorghum. After 72 h fermentation, all the glucose was metabolized by the fermenting yeast. This indicates a complete and high efficient fermentation and the effectiveness of the liquefaction step that rendered dextrins highly susceptible to amylglucosidase and pullulanase. Therefore, the presence of S. zeamais and intrinsic enzymes did not affect yeast and α-amylase or amylglucosidase/ pullulanase activities. For insect damaged kernels, a reduction in yield is indeed observed. These findings are crucial in geographic regions where S. zeamais is the principal infesting agent and indicates the robustness of sorghum against this particular insect. The negative impact of the use of insect or mold-damaged kernels is mainly due to dry matter losses incurred during storage and stresses the importance of first-rate storage practices. However, this study clearly demonstrates the use of already damaged kernels is possible. These kernels can be acquired at a discount price by biorefineries and subsequently converted into bioethanol with similar efficiencies.
Salient findings from review:

Findings from scholars work for the use of damaged food grains is summarized here in brief. Main causes of grain damages are mechanical damages during harvesting and handling grain size reduces due to breakage. Moisture content and due to insecticides deterioration of grain occurs heavily. Measurements of grain quality for determination of grain damage are also briefly discussed in this paper. After identification of sorghum and corn grain in damaged condition, that is these grains are not usable as food or feed. The next best option for its utilization is as fuel energy production [2].

Owing to rapid depletion of fossil fuel reserves, alternative energy sources need to be renewable, sustainable, efficient, cheaper and eco-friendly. A worldwide interest in the utilization of bio-ethanol as the future transportation fuel has stimulated studies on the cost and efficiency of industrial process for ethanol production. Keeping this in view, improvements in the ethanol fermentation have been focused. Generally, economic restrictions force industrial processes to work in a very small range of operating conditions. For some batch processes which have long operating times in each cycle and depend strongly on the operating variables. It is very important to define the optimum conditions to achieve sufficient profitability. From the review of literature it is observed that kinetic models describing the behavior of microbiological systems are very useful tool and it would reduce testing for elimination of possibilities. Mathematical models are effective tool for analyzing biological process and microbial growth phenomenon. The studied model shows more insight into the environmental conditions that is surrounding bio-process and can be used for further development and optimization of bio-processes. This paper reviews the various process options and kinetic models adopted towards resolving the technological challenges to develop a low-cost commercial process [16].

Bioethanol produced from renewable biomass, such as sugar, starch, or lignocellulosic materials. Bioethanol is one of the alternative energy resources; this is both renewable and environmentally friendly. Although, the priority in global future ethanol production is put on lignocellulosic processing, which is considered as one of the most promising second-generation bio-fuel technologies, cereal grains for fuel ethanol is still underutilized. Sugar-based that is molasses, sugar cane, sugar beet and starch-based that is corn, wheat, triticale, potato, rice, etc., feed stocks are still currently predominant at the industrial level. They are, so far, economically favourable compared to lignocelluloses. Currently, approximately 80 % of total world ethanol production is obtained from the fermentation of simple sugars by yeast. In this paper, a review of the state of the art in bio ethanol production and availability is discussed. Pointing out the progress possibilities on starch-based production are discussed, in the respect of feedstock choice, pre-treatment, optimization of fermentation and process integration. It is observed that utilization of cereal grains for bioethanol production is the best option after food application [3].

The result of this study shows that simultaneous saccharification and fermentation of damaged sorghum grain as a substrate is feasible. The starch content in damaged grains is inferior when compared with fresh sorghum grains. But as these damaged grains are cheaper than fresh grains further production of ethanol is possible by using damaged sorghum grains at low cost. It equally revealed the fact that optimization of culture condition could enhance ethanol production from damaged grains using co-culture technique, thereby increasing the economy. It also showed that increasing temperature, pH, and agitation rate increases ethanol yield up to a certain level. But further increase in these parameters beyond certain level neither increase ethanol yield nor cell dry weight [15].

Conclusion

Damaged corn and sorghum grains has immense potential source for non-edible option due to removal waste part as well as constituents reducing bio-ethanol conversion from it. Use of techniques available for separation of damaged portion would further enhanced ethanol production yield from corn and sorghum starch. Complete process optimization from damaged corn and sorghum grains is possible by the study of each step involve during conversion from damaged grains to ethanol. So, more stress is given on study of bifurcation useful and nonproductive material in this work which is not specifically focused earlier.

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8. References:


