Innovative production technology ethanol from sweet sorghum

N F Kashapov¹ M M Nafikov¹ M X Gazetdinov² M M Nafikova² and A R Nigmatzyanov³
¹Kazan (Volga region) federal university, Kazan, Russia
²Kazan state agrarian university, Kazan, Russia
³Tatar institute of retraining specialists agribusiness, Kazan, Russia

Arnig76@yandex.ru

Abstract. The paper considers the technological aspects of production of ethanol from non-traditional for Russian Federation crops – sweet sorghum. Presents the technological scheme of alcohol production and fuel pellets from sweet sorghum. Special attention is paid to assessing the efficiency of alcohol production from sweet sorghum. The described advantage of sugar content in stem juice of sweet sorghum compared with other raw materials. Allegedly, the use of the technology for producing alcohol from sweet sorghum allows to save resources.

The main criterion in the production of alcohol is its cost: the lower cost of production, so it is more competitive. The cost of alcohol is greatly influenced by raw materials and production technology. In our country food alcohol produced from grain and potatoes, and technical - from sawdust [1, 2, 3, 4, 5].

The cheapest alcohol currently produced in Brazil from sugar cane. This is the most simple and cheap technology of production of both sugar and alcohol. It consists of the following cycles: clean the stems from the leaves, pressing the stems with the release of the juice, adding the juice of yeast and the fermentation of sugars to alcohol, separating the alcohol by distillation.

For alcohol, you can use any materials containing significant amounts of sugar or materials that can be converted into sugar, for example, starch or cellulose.

In Russia the climate in most part of the territory dictates the cultivation of a limited number of plants, which may receive sugar. In addition to traditional crops, there is a possibility of cultivation of sweet sorghum to obtain ethyl alcohol (table. 1).

| Raw          | Production from 1 ha, m³ | Cost, USD / m³ |
|--------------|-------------------------|----------------|
| Sugar beet   | 2,5-3,0                 | 300-400        |
| Sugar cane   | 3,5-5                   | 160            |
| Corn         | 2,5                     | 250-400        |
| Wheat        | 0,5-2                   | 380-400        |
| Potatoes     | 1,2-2,7                 | 800-900        |
| Sugar sorghum| 3,0-5,0                 | 200-300        |
Calculations show that the lowest cost is alcohol from sugar - and starch-containing products such as sugar cane, sweet sorghum and corn.

With regard to involvement in agricultural turnover of raw land in Russia may be expanded in crops of sorghum and maize to 18-20 million hectares, which will produce by 2020 about 1.5 million tons of alcohol without breaking the rotation (Fig. 1).

Figure 1 - The yield of alcohol from various raw materials (at 90% conversion of starch into alcohol)

Sweet sorghum in the world agriculture occupies more than 30 million hectares. In Russia, sorghum is cultivated on an area of over 700 hectares. Culture is common in the southern regions of the European part (Rostov region, Stavropol and Krasnodar Krai), Lower and Middle Volga region, the Urals and the far East. Exceptional drought tolerance and high yields make this crop very promising for cultivation in the arid regions of the Russian Federation, including the Republic of Tatarstan [6, 7, 8, 9, 10, 11].

The content of sugars in the stem juice of sweet sorghum is not inferior to the sugar cane, but the juice differs in composition. If sugar cane in its juice contains only sucrose (crystallizing sugar), the juice of sweet sorghum contains sucrose in addition to the largely glucose and soluble starch, which interferes with crystallization. In addition, an important characteristic is the fact that sweet sorghum belongs to the plants with C4 photosynthesis and therefore photosynthetic potential is 2-3 times higher than that of spring wheat, soybeans and sugar beets. The maximum number of accumulation of sugars coincides with the phase of wax and full ripeness of grain. From one hectare of sweet sorghum sowing you can get 5-7 tonnes of sugar and 15 tons of pulp (dry bagasse), and 3-5 m3 of alcohol. We have proposed the technology of cultivation of sugar sorghum and the scheme of obtaining from plant raw material alcohol and fuel pellets.

Process flow diagram of alcohol production and fuel pellets are presented in figure 2.

Received from the field, the crop material is crushed to facilitate the further deflection of his juice. Then it enters the mill. The mixture should be pressed twice, moistening between the first and second time with water to dilute the pulp contained in sweet liquid (maceration). The maximum possible squeeze 90-93% of the total contained in the stems of sugar with a small diluted juice. Extracted juice
passes through the filter, where impurities are separated, small pieces of stems, etc. pressed Solid fraction is used for production of solid biofuels (pellets). Part of the pressed juice is taken and fed into projektering for the cultivation of yeast, the remainder is mixed with yeast in a fermentation apparatus.

For fermentation in a vegetable juice add to the culture of Saccharomyces cerevisiae with enzymes (invertase and simaz) process the sucrose into ethanol.

\[
\text{C}_{12}\text{H}_{22}\text{O}_{11} + \text{H}_2\text{O} = \text{C}_6\text{H}_{12}\text{O}_6 + \text{C}_6\text{H}_{12}\text{O}_6
\]

sucrose  glucose  fructose  zimasa

\[
\text{C}_6\text{H}_{12}\text{O}_6 = 2\text{C}_2\text{H}_5\text{OH} + 2\text{CO}_2
\]

Glucose (fructose)/ ethanol

Figure 2 - Scheme of the technological process of production of alcohol and fuel pellets from sweet sorghum
Well, the product the ethanol content shall not be less than 10%, but not more than 13%. The concentration of residual sugars - not more than 0.45%, the acidity does not exceed 0.2%. On the ethanol yield, the rate of its formation and the physiological state of the culture Saccharomyces cerevisiae is greatly influenced by their concentration in the fermentation product. The optimum concentration is 15-20 g per 1 l of the fermentation product. This amount of yeast spaevaet sugar quickly, usually within 6-7 hours, and the ethanol yield reaches 57-59 l of 100 kg fermentable sugars. Next, the rabble, the product is distilled, the method is based on the fact that ethanol and water have different boiling points. If the water under normal conditions boils at a temperature of 100°C, then ethyl ethanol need to 78°C. In addition to water and ethanol rabble product contains a lot of impurities. The lungs begin to boil at a temperature of 68°C, and heavy – 85°C. Therefore, the distillation of the fermentation product, it is important to achieve such a temperature at which the ethanol is boiling, fusel oils yet. At the outlet of a distillation column ethanol is obtained by a fortress no more than 96.2.

Work on the production of alcohol is carried out in 3 shift of 8 hours. To work on presents a technological line of manufacture of alcohol requires 3 main employee - operator, to operate equipment required 2 auxiliary worker (mechanic, electrician).

Conclusion

1. World and domestic experience show the great economic value of sweet sorghum as culture comprehensive use of. It is a highly valuable feed and industrial crop. In the vegetable juice of sweet sorghum contains sucrose in addition to the largely glucose and soluble starch, which interferes with crystallization.

2. In the Republic of Tatarstan the possibility of cultivation and use of crop sweet sorghum for sugar to 3 to 5 tons and eco-friendly food alcohol to 3-5 m3 per 1 ha of sowing.

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