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ANALYSIS OF BIOCHEMICAL METHODS OF ETHANOL PRODUCTION

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Abstract. World consumption was analyzed ethanol and problems associated with its production. Analysis of biochemical method used to produce ethanol. Consider additional material in the production of ethanol. The article deals with the use of ethanol in various industries and optimization of ethanol production.Review of the species composition of raw materials.

Keywords: biochemical method; chemical method; ethyl alcohol; raw materials; grain.

Intoduction

One of the most widely produced aliphatic alcohol is ethyl alcohol (ethanol, CH_3CH_2OH).

Ethyl alcohol – a clear, colorless liquid with pungent taste and characteristic odor. Boiling point at atmospheric pressure of its 78.35 °C, the density of 789.27 kg/m^3. Soluble with water in all proportions and is a good solvent. Ethyl alcohol is hygroscopic and absorbs moisture from the air, from plant and animal tissues, causing their destruction. Chemically pure ethyl alcohol has a neutral reaction (pH = 7). Alcohol vapor harmful to humans, the maximum allowable concentration in the air 1 mg/l. Alcohol explosive (Becker *et al.* 1990).

Today, ethanol is widely used in chemical, electrical engineering, perfumery, food industry and medicine. Ethanol is also used as fuel and in laboratory studies as antifreeze and other industries. Ethanol is widely used in various industries. In technical fields used technical ethyl alcohol derived from ethylene-containing gas, wood and waste wood pulp production. In branches of food industry (canning and vitamins, winemaking, alcoholic beverages), as well as in the medical industry uses food alcohol obtained from food raw material (Irisov 1933).

Alcohols are used in many areas and approximately in 50 branches of production. Among them is produce many kinds of products, including ethanol, which used as an additive to gasoline because it is environmentally friendly, ensures the completeness of combustion and does not form toxic combustion products (Higgins *et al.* 1988).

World production of ethyl alcohol is about 4 million tons. Alcohol industry in Ukraine has been and remains the industry, forming the export potential of the state. It consists of 80 distilleries and mills with an annual capacity of 65.9 mln dal ethanol. Own country's demand is estimated at 20 mln dal (Kuznetsov *et al.* 2001).

Today the world bioengineering optimizes processes to produce ethanol, and on the other hand – is looking for its production alternative resources. Therefore, continuous and comprehensive study of alcohols and methods of their obtaining is an important theme today.

Problem formulation

Aim – analysis and a analytical overview about produce of ethanol by biochemical method.

Object of study – technological process of ethanol production biochemically.

Subject – raw material used to ethanol production biochemically

Hypothesis – study more effective ways of producing ethanol, an environmentally and economically justified.

Analysis of studies and publications

According to modern nomenclature technology of alcohol production relates to biotechnology. The basic processes of alcohol production – conversion of starch into sugar and from sugar into ethanol under the action of biological catalysts (enzymes). Since enzymes for hydrolysis of starch to sugars produced by molds and bacteria, and for converting sugars into alcohol by yeasts, alcohol technology are inseparably linked with the technical microbiology.

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The fundamental works about the theory of the structure and physico-chemical properties of water-alcohol solutions and distillation of alcohol were made before the revolution in Russia by scientists D. I. Mendeleev, A. G. Doroshevskiy, D. P. Konovalov, M. S. Vrevskiy. E. Sorel and E. Barbeau in France laid the foundations of the theory and method of cleaning alcohol from impurities (Vorobyova 1989).

Obtaining of alcohols is carried out by biochemical and chemical methods. Many of them are mass products of petrochemical synthesis. Chemical synthesis from hydrocarbons is relatively inexpensive production method. Also one of the most important methods is to obtain alcohol through hydration of olefins. Thus, receiving isopropyl, tert – and sec- butyl and ethyl alcohols. Obtaining of methyl alcohol (methanol) is based on the dry distillation of wood (Zherebova, Shapiro 1934).

In the food industry ethanol is produced from cereals, potatoes, beet and molasses (fig. 2) (Varfolomeev, Kalyuzhniy 1990).

In other industries alcohol is produced from wastes of sulfite-cellulosic production and hydrolysis products of wood and also synthesized from associated gases containing ethylene, which obtained during recycling of crude oil.

Today, there are two methods of producing alcohol:

– biochemical (microbiological) – fermentation of sugars under the action of yeast enzymes, acetone-butanol-ethanol fermentation;

– chemical or synthetic – through accession to ethylene water in the presence of catalysts (Karpov *et al.* 2006).

For the production of ethanol 3 types of raw material are used:

– sugar containing (wastes from sugar production, beet, fruits, berries, grape);

– starch containing (potato, rye, oat, barley, corn, wheat);

– cellulose containing (wood, straw, husk from cereals and another wastes from plants) (Blinov 1989).

The process of alcohol production (regardless of raw material type), as any biotechnological process involves three main stages: preparation of raw materials to fermentation, fermentation, separation of alcohol from the received mash. Figure 1 shows that high production of ethanol by plants in Ukraine was achieved in 2006 (Malov, Erohov 1982).

Preparation of raw materials to fermentation. The most simple preparatory stage in the processing of sugar containing raw material into alcohol. For example, molasses is diluted with water to a concentration of solids 21–22 %, acidified with hydrochloric or sulfuric acid, add nutrients, containing nitrogen and phosphorus, which needed for yeast nutrition, and the substrate is ready for fermentation (Kononova, Safonov 2006).

Basic type of raw material in the production of nutritive alcohol is plant material, that rich on starch (cereals, potato), sugar (molasses, sugar beet) and cellulose (wood) (Mazur 2011).

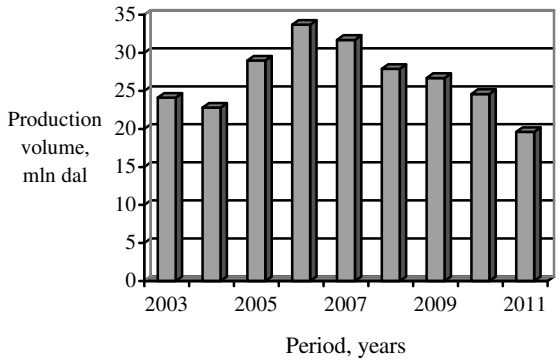

Fig. 1. Production of ethanol by plants of Ukraine in period 2003–2011

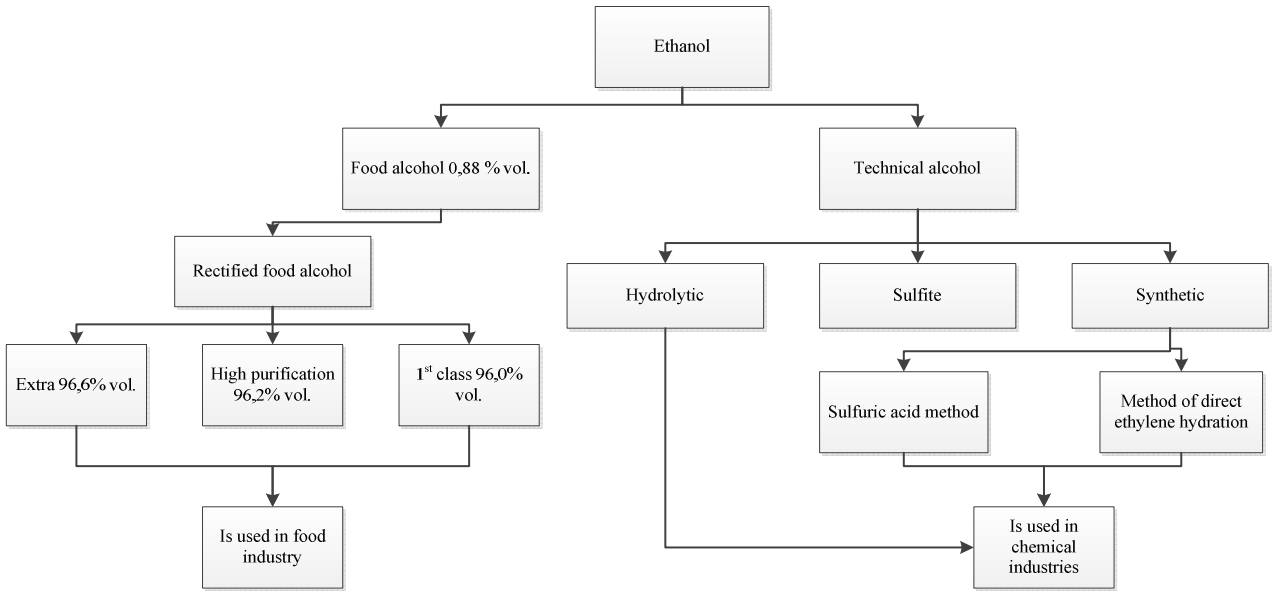

Fig. 2. Scheme of ethanol production

The scheme of ethanol production may be represented in such way:

– selection of raw materials and components that contribute the fermentation (yeast, protein food, water);

– preparation of raw material (washing, cleaning, grinding, overboiling);

– alcohol fermentation of solution that contain carbohydrates in conditions that exclude air entering;

– cleaning, often multiple rectification of obtaining ethanol;

– cleaning of water for dilution of ethanol;

– dilution of ethanol with adding of compounds, that creates some taste with the aim to give drink specific composition and organoleptic properties;

– maturation of received strong drinks;

– packaging, capping (Onopriyko *et al.* 2001).

Potatoes – the best kind of raw material for the production of alcohol. From unit of cultivated area of potato it is possible to get in average of 3 times more starch than with crops and, consequently, more alcohol. In addition, potato starch gives a high yield of alcohol (Fig. 3). At distilleries processing technical sorts that satisfy the following requirements: high starch containig, high yield, resistance to disease, resistance during storage. The main varieties are processed to produce alcohol, are Lokhvitskii, Nemeshaevsky jubilee, Ostbote, V-man and other.

Grain crops are used in the production of alcohol firstly, to obtain malt needed for saccharification of starch, and secondly, cereals directly processed into alcohol. For the use malt barley, oats, millet, rye, which correspond to a number of requirements (moisture content of grain impurities and energy of pullulation) (Vostrikov 2001).

The quality of grain that is supplied directly to obtain alcohol is not regulated, but it is desirable to have high starch content. For alcohol production is used rye, wheat, barley, corn, oats and millet.

Chemical composition of cereal grains depends on the variety, soil and climate growing conditions and other factors. The average grain cereals contain 14–15 % of water and 85–86 % dry matter. The content of starch in wheat ranges 49–73 %, in rye – 55–73%, barley – 45–68 %, oats – 24–64 % corn – 61–83 %, millet – 51–70 %, rice – 48–68 %. The total sugar content in mature grains is 2–5 % (Grachev 1988).

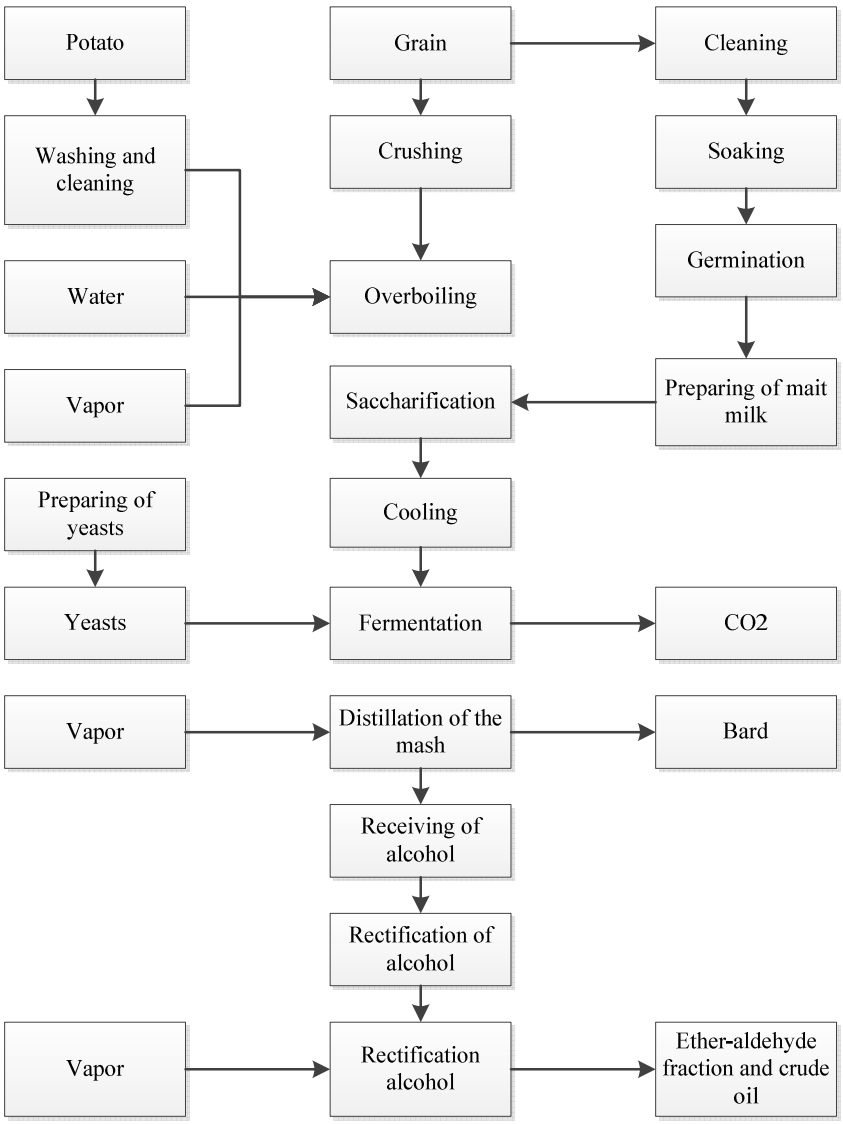

Fig. 3. Scheme of ethanol production

As raw material for the production of alcohol, baker yeasts and other products of fermentation industries is used molasses that is a by-product of sugar beet production. It is a dark brown viscous liquid. The chemical composition of molasses depends on the quality of beet and conditions of its recycling on sugar plants. The average chemical composition of molasses are follows (in %): water – 18–25, sucrose – 45–50, invert sugars – 0.5, raffinose – 2; not sugars – 35–40.

Of particular note is the change of using molasses bards – should sharply reduce its emissions in the field of filtration, to make the production of alcohol from molasses wasteless, environmentally and economically justified.

The task of recycling molasses bards is difficult but must be proved to a successful resolution. Unfortunately, the foreign theory and practice haven't appropriate solution to recycling molasses bards as in the production of alcohol and baker yeasts and food acids. It would be correct the association of financial and material resources in this area, a number of advanced countries.

Further substitution of malt with complex enzyme preparations, all continuous processes, including continuous cultivation of microorganisms (yeasts, bacteria and fungi), membrane ultrafiltration, reverse osmosis and adsorption in water treatment, alcohol and various intermediates and other products staying reasonable landmarks in the production of qualitative alcohol from all kinds of raw material, which is recycling.

The innovative technology to produce ethanol is the modification of Escherichia coli to ferment carbohydrates to form Brown Algae ethanol.

Researchers from the bioengineering laboratory at Berkeley (USA) report in the journal Science that they have found a way to efficiently produce ethanol from brown algae. This species was chosen because it is more unpretentious, environmentally sustainable and growing much faster than the green and red. Macrocystis perifera may one day grow up to a meter. Common bacteria can not ferment carbohydrates algae, but are capable of marine bacteria such as Vibrio splendidus. In E. coli Escherichia coli corresponding genes inserted its ocean "colleagues", then E. coli acquired the ability to break algal alginate and produce ethanol based on it. The researchers emphasize that the enzymes that break down polysaccharides produced by bacteria in the environment, so the intermediate product obtained in this cleavage, easy to use for the synthesis of other organic substances (plastic or nylon) or other alcohols (butanol) or for the production of biodiesel (Kichakova 1998).

Conclusions

Alcohols are used in many areas and approximately in 50 branches of production. World production of ethyl alcohol is about 4 million tons. High production of ethanol by plants in Ukraine was achieved in 2006 – 33,7 mln dal.

Today the world bioengineering optimizes processes to produce ethanol, and on the other hand – is looking for its production alternative resources. Therefore, continuous and comprehensive study of alcohols and methods of their obtaining is an important theme today.

In the food industry ethanol is produced from cereals, potatoes, beet and molasses.

Basic type of raw material in the production of nutritive alcohol is plant material, that rich on starch (cereals, potato), sugar (molasses, sugar beet) and cellulose (wood). Potatoes – the best kind of raw material for the production of alcohol.

Production of alcohols may be by using biochemical and chemical methods. Chemical synthesis of hydrocarbons is relatively inexpensive production method.

Biochemical (microbiological) method is the fermentation of sugars under the action of yeast enzymes. In the food industry ethanol is produced from cereals, potatoes, beets and molasses. In other industries alcohol is produced from wastes of sulfite-cellulosic production and hydrolysis products of wood and also synthesized from associated gases containing ethylene, which obtained during recycling of crude oil.

In the production of alcohol for food purposes are widely used molasses (sugar beet), potatoes and cereals.

As auxiliary materials used saccharifying agents – malt and enzyme preparations. In the alcohol industry used barley, wheat, millet and oat malt. Millet and oats have a high ability dekstriniruyuschey and provide a high yield per unit of the starch contained in the raw material.

The subsidiary materials include antiseptics – hydrochloric and sulfuric acids, sulfanol, formalin, bleach. Applied rich mineral salts or their sources containing nitrogen and phosphorus.

Yeast is used as a biological object, providing fermentation. Alcohol production uses a lot of water on the technological and technical needs.

Acetone–butanol–ethanol (ABE) fermentation is a process that uses bacterial fermentation to produce acetone, n-Butanol, and ethanol from starch. It was developed by the chemist Chaim Weizmann and was the primary process used to make acetone during World War I, such as to produce cordite. The process is anaerobic, similar to how yeast ferments sugars to produce ethanol for wine, beer, or fuel. The process produces these solvents in a ratio of 3-6-1, or 3 parts acetone, 6 parts butanol and 1 part ethanol. It usually uses a strain of bacteria from the Clostridia Class (Clostridium Family). Clostridium acetobutylicum is the most well-known strain, although Clostridium beijerinckii has also been used for this process with good results.

In order to make ABE fermentation profitable, many in-situ product recovery systems have been developed. These include gas stripping, pervaporation, membrane extraction, adsorption, and reverse osmosis. However, at this time none of them have been implemented at an industrial scale.

ABE fermentation is attracting renewed interest with an eye on butanol as a renewable biofuel.

The innovative technology to produce ethanol is the modification of Escherichia coli to ferment carbohydrates to form Brown Algae ethanol.

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