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# The study of process of alternative fuel production from renewable raw materials

Ludmila Kuznetsova[a]*, Ludmila Zabodalova[a], Natalia Yakovchenko[a], Maria Domoroshchenkova[b]

[a]*Institute of Refrigeration and Biotechnologies, ITMO University, Lomonosova street 9, 191002, Saint-Petersburg, Russia*
[b]*All-Russia Scientific Research Institute of Fats, Chernyakhovsky street 10, 191119, Saint-Petersburg, Russia*

**Abstract**

The objective of the research was to study the process of biofuels production from raw materials of plant origin such as wastes of food and agricultural industry. The process includes a stage of enzymatic degradation of plant polysaccharides. The proposed method allows to produce ecologically friendly renewable biofuels and to provide partial utilization of carbohydrate-containing industrial wastes or by-products. The economic efficacy of alcohol production is increased due to the yield growth as a result of the optimization of the microbiological synthesis process.

The disadvantages of existing methods of biofuel production are usage of food crops as raw materials, high labour and financial costs incurred during planting, harvesting, handling and storage of such crops and a small yield of the final product. The proposed method of biofuel production is based on the usage of non-edible raw materials of plant origin such as wastes and by-products of isolation of protein preparations from lupin seeds. The bioconversion of polysaccharide complex of feedstock to soluble carbohydrates is carried out using a composition of hydrolytic enzymes with cellulase activity of at least 3500 units gram 1 and xylanase activity of at least 2500 units gram-1. The liquid biobutanol is produced by fermentation of carbohydrate substrate obtained as a waste or a by-product after processing of raw materials with bacteria *Clostridium beijerinckii*.



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*Keywords:* renewable energy; plant polysaccharides; multienzyme composition; solid biofuels; liquid biobutanol; *Clostridium beijerinckii*

* Corresponding author. Tel.: +79214015280
*E-mail address*: mamaeva.ludmila@mail.ru


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## 1. Introduction

Alternative energetics is a promising field for applications of biotechnology. The development of industrial methods of production of biofuels has been gaining attention in recent years. In particular, one of the perspective methods of producing acetone butanol ethanol (ABE) is a cultivation of *Clostridium beijerinckii* using different growth mediums [1, 2]. A number of organisms is available for this bioconversion such as *Clostridium beijerinckii* P260, *Clostridium beijerinckii* BA101, *Clostridium acetobutylicum* and *Clostridium saccharobutylicum* P262. These cultures can utilize both hexose and pentose sugars derived from lignocellulosic hydrolysates such as corn fiber, wheat straw, barley straw, maize stover and switchgrass. Substrates such as Jerusalem artichoke, maize, rye, millet, molasses, potato can be used by the cultures listed too [3]. At the same time with the prospects of the use of raw materials of plant origin for biofuel production it is also important to increase their yield [4].

The processing of raw materials of plant origin requires the use of environmentally friendly methods related to cost-effective usage of resources, namely, utilization of such wastes of industrial food processing as molasses, milk whey and others. The alternative raw materials may be mash, potato starch and products produced from non-traditional crops [5]. In particular, in Russia at the University of Chemical Technology named after D. Mendeleyev, the quality of by-products of production of concentrated protein products was evaluated, as well as an experimental validation of the possibility of usage of wastes of soy protein production in feed supplements was made [6]. Other promising resources of plant origin that can be used to produce biofuels are birch wood and algae [7, 8].

Different species of lupin seeds have been gaining popularity in food technology as a raw material for extraction of protein and lipid fractions. Lupin protein preparations have been used in meat and bakery industries [9–11], and in the production of dairy analogues [12]. Lupin seeds of certain species have been used for solvent extraction of oil by means of different solvents [11]. Lupin protein isolates preparations were obtained from narrow leaf lupin seeds [13, 14].

This work is focused on the development of a perspective method of using food industry wastes with a high content of structural polysaccharides for motor fuel production. The method deals with utilization of a by-product of lupin protein isolate (LPI) production such as deproteinized lupin meal residue (DLMR). The bioaccessibility of DLMR can be increased through a chain of sequential processes, involving acid treatment and biodegradation with a specially selected multi-enzyme composition.

Enzyme compositions with different substrate specificity are often applied in industrial biotechnology. For instance, to increase the bio-accessibility of feeds, different compositions based on cellulase, xylanase, mannase and other enzymes have been developed [15, 16]. In the beer manufacturing process, a variety of compositions of amylase and cellulose are widely used at the mash preparation stage [17].

The objective of this study was to develop a waste-free technology of production of lupin protein isolate, involving mechanical and enzymatic degradation of solid waste materials with formation of the growth medium and its subsequent fermentation by *Clostridium beijerinckii*.

**Nomenclature**

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| ABE | acetone butanol ethanol |
| DLMR | deproteinized lupin meal residue |
| LPI | lupin protein isolate |
| UHT | ultra heat treatment |
| HPLC | high-performance liquid chromatography |
| m.f.b. | moisture free basis |