Scientific Bulletin. Series F. Biotechnologies, Vol. XXIII, 2019
ISSN 2285-1364, CD-ROM ISSN 2285-5521, ISSN Online 2285-1372, ISSN-L 2285-1364

HIGHER UTILIZATION OF WASTE FROM THE FOOD INDUSTRY THROUGH BIOTECHNOLOGICAL METHODS

Diana GROPOŞILĂ-CONSTANTINESCU, Luminiţa VIŞAN, Gabriela MĂRGĂRIT, Radu-Cristian TOMA, Dana BARBA, Marius HANGAN

University of Agronomic Sciences and Veterinary Medicine of Bucharest,
Faculty of Biotechnologies, 59 Mărăşti Blvd., District 1, Bucharest, Romania

Corresponding author email: bth.diana@yahoo.com

Abstract

Until now, the most important way to get rid of food waste was to use it in animal feed. Four methods are used to remove food waste: recovery in agriculture and animal husbandry, incineration, anaerobic fermentation, composting. This paper aims to evaluate new methods of recycling waste from the food industry through biotechnological methods. The wastes that were the subject of the research were the following: apple pomace, bakery waste, milk whey. All these have been processed using the strains of the Biotechnology Faculty Collection in order to determine the potential to obtain useful products of high economical value like bioethanol or probiotics. The experimental yield of 0.26-0.24 l of bioethanol/1000 g of food waste was at the minimum data mentioned in the literature (0.265 l) but justifies the capitalization of this food waste.

***Key words**: apple pomace, whey, bioethanol, probiotic, biomass.*

INTRODUCTION

The food industry is subject to increased pressures to improve environmental performance, both on the part of consumers and on the part of the legislation, which, in turn, responds to consumer pressure. A series of "friendly and clean" food processing technologies have been designed precisely to enable manufacturers to better understand the effects of their activities on the environment and to adopt practical measures to achieve sustainable production (Gavrila, 2007).

The two crucial issues related to food technologies are energy management and waste management. The production of food is done with high energy consumption, and relatively large quantities of waste result from the process. Waste from the food industry can be divided into three categories: waste from production processes, food waste from municipal waste and packaging.

Current methods of waste use have been developed along with traditional production lines, being closely linked to the agricultural origin of raw materials (Manimehalai et al., 2007). Traditional methods used in the past and beyond for the use of food waste, were: animal feed and fertilizer on farmland (Gavrila, 2007).

The following general methods (Russ et al., 2007) may be used to remove solid waste in general: recovery in agriculture or animal husbandry; incineration; anaerobic or aerobic fermentation; composting. In the case of liquid waste, the following methods can be used: ground application; various methods of physico-chemical treatment, fermentation.

In the case of waste with more than 50% humidity, anaerobic fermentation with the production of biofuels is much more appropriate (Gavrila, 2007). If cellulosic polysaccharides can be decomposed, the rate of decomposition is low, defining the limit of fermentation by producing biogas (Akpan et al., 2008).

Food industry waste should be viewed as a raw material source for the production of high added value products rather than as waste (Shalini et al., 2010).

For example, monosaccharides can be obtained by selective hydrolysis of whey, lactose and oligopeptides can be obtained from whey protein concentrate by peptide hydrolysis. Enzymatic conversion of cellulose-rich waste can produce ethanol. Pectin can be recovered from effluents from fruit juice production (Pap et al., 2000). There is practically no "waste" of the food industry that can not be used as a raw material to get value-for-money products.

This paper aims to evaluate new methods of recycling waste from the food industry through biotechnological methods. All food waste, apple pomace, bakery waste, milk whey, have been processed in order to determine the potential to obtain useful products of high economical value, bioethanol, probiotics, using strains from the Collection of the Faculty of Biotechnologies from UASMV Bucharest.

MATERIALS AND METHODS

Raw materials

The main raw materials were: apple pomace, bakery waste and milk whey.

The whey was provided by a private manufacturer and stored at 4^{o}C until processing.

The apple pomace was obtained in the laboratory, after the preparation of apple juice with a fruit-maker.

Bakery wastes were purchased from a local pastry and consisted of specific product scraps.

Microorganisms

To obtain bioethanol and probiotics, strains of *Saccharomyces cerevisiae* SC2 and *Lactobacillus bulgaricus* L16 from the Microorganism Collection of the Faculty of Biotechnologies were used.

Microbial strains were grown on their specific media, respectively YPG medium for yeast and MRS for lactobacilli.

Processing of waste

The whey was first centrifuged for semipurification by removing solid residues and grease (8000 rpm, 15 min, 3^{o}C). Next, filtration was performed for removing residual impurities left after centrifugation.

Apple pomace, bakery waste were suspended in water in a ratio of 1: 2 g/v and boiled for 5 minutes.

The products obtained were used as the single nutritional source for microorganisms.

Obtaining of bioethanol and probiotics

For the biosynthesis of bioethanol and probiotics each processed waste was inoculated with 10% *Saccharomyces cerevisiae* inoculum.

In addition, milk whey was inoculated with 10% *Lactobacillus bulgaricus* inoculum to obtain the probiotic preparation.

Fermentations with *Saccharomyces cerevisiae* were carried out under the following conditions: 5 days, 25^{o}C, pH = 4.8.

Fermentations with *Lactobacillus bulgaricus* were carried out under the following conditions: 3 days, 35^{o}C, 20 rpm, pH = 5.5.

Analytical control of the fermentation process

Determination of dry cell weight (DCW).

10 ml of whey medium was centrifuged in a centrifuge tube at 4000 rpm for 20 minutes. After the supernatant was removed, the biomass was weighed. Wet biomass was then dried at 105-110^{o}C, to constant weight using a thermobalance.

Post-biosynthesis processing

After the completion of the fermentation process of whey, the first post-biosynthesis operation was to separate the biomass by centrifugation at 4000 rpm for 20 minutes. After centrifugation, wet biomass was collected and weighed, placed in trays and dried in the oven at 105^{o}C. Finally, the total amount of dry lactobacilli biomass was weighed.

In the case of alcoholic fermentation, the media were vacuum filtered on filter paper. The filtrate was distilled using a rotary evaporator to obtain bioethanol.

RESULTS AND DISCUSSIONS

Probiotic yield from milk whey

For probiotic biosynthesis milk whey was inoculated with *Lactobacillus bulgaricus* strain. Following the post-biosynthesis of the lactobacilli media, 2.8-3.2 g/l of dry biomass was obtained, 36% lower than those mentioned in the literature, which stated amounts of 5-5.1 g/l (Rezvani et al., 2016) (Figure 1).

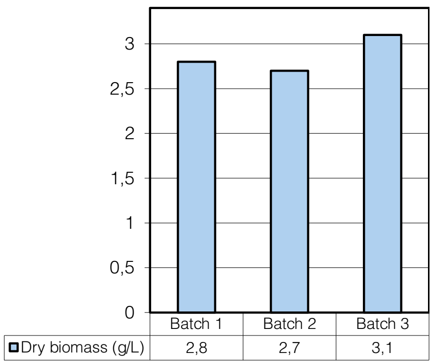

Figure 1. Dry biomass obtained from lactic fermentation

Bioethanol yield from apple pomace and bakery waste

The alcoholic fermentation process was characterized by two important parameters: the amount of dry biomass obtained and the resulting bioethanol volume.

From the data presented in the Figure 2, it can be concluded that apple pomace is a valuable nutrition source for the growth of yeasts in order to obtain bioethanol, achieving productivity of 2.56-2.62 ml/g of solid substrate.

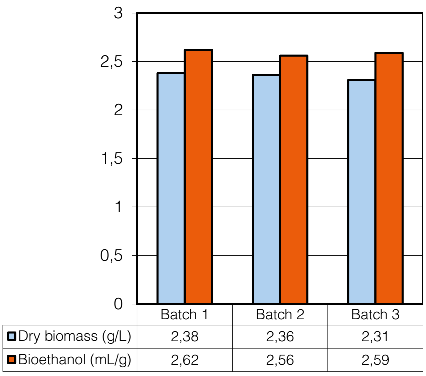

Figure 2. Dry biomass and bioethanol obtained from alcoholic fermentation of apple pomace

In the case of alcoholic fermentation of bakery waste, the results were slightly weaker than apples (Figure 3). The productivity in bioethanol ranged between 22.8-23.4 ml/100 g of material (Figure 4).

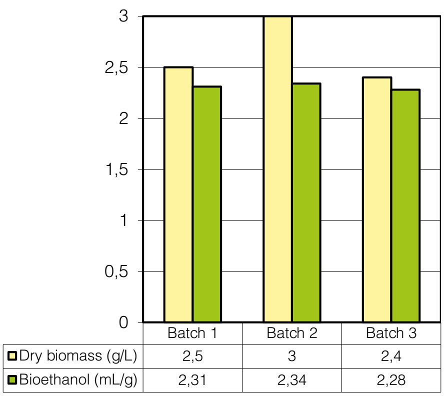

Figure 3. Dry biomass and bioethanol obtained from alcoholic fermentation of bakery waste

By comparing the amounts of bioethanol obtained from the two nutrient sources, apple pomace has a 9-13% higher productivity than bakery waste.

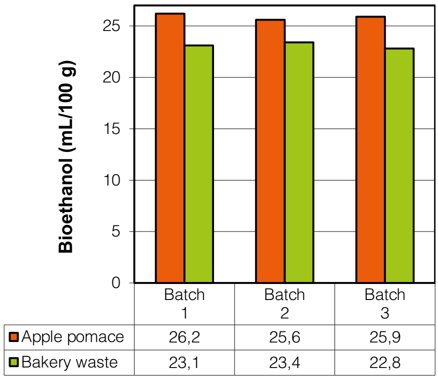

Figure 4. Comparison of the amounts of bioethanol obtained from the raw materials tested

The volume of bioethanol produced from 100 g of food waste was 26 ml. As reported in literature by Mathewson (1980), that a 1 ton of 40%-60% fermentable sugar substrate can produce 265-378 l of bioethanol, this means that substrate of 1000 g can produce a maximum bioethanol yield of about 0.265 l and a minimum yield of 0.378 l.

The experimental yield of 0.26-0.24 l of bioethanol from 1000 g of food waste is well within acceptable range.

The experimental results obtained in this work showed that fermentation processes was at the minimum data mentioned in the literature for production of bioethanol from food waste.

CONCLUSIONS

For lactobacilli, 2.8-3.2 g/l of dry biomass was obtained on whey, 36% lower than data mentioned in the literature,

For bioethanol, from the two nutrient sources, apple pomace has a 9-13% higher productivity than bakery waste.

The experimental yield of 0.26-0.24 l of bioethanol/1000 g of food waste was at the minimum data mentioned in the literature but justifies the capitalization of this food waste.

REFERENCES

Akpan, U. G., Alhakim, A. A., Ijah, U. J. J. (2008). Production of ethanol fuel from organic and food waste. *Leonardo Electronic Journal of Practices and Technologies*, *13*, 1–11.

Gavrila, L. (2007). Gestionarea valorificarea si minimizarea deseurilor industriei alimentare. *Faculty of Engineering, Online course*, 1-8.

Manimehalai, N., 2007. Fruit and waste utilization. *Bev Food World*, *34*(11), 53–54.

Pap, N., Pongrácz, E., Myllykoski, L., Riitta L. Keiski (2014). Waste minimization and utilization in the food industry. Jatindra Kumar Sahu (Ed.). *Introduction to advanced food processing engineering*. CRC Press, Taylor & Francis Group. Chapter 19, 595–630.

Rezvani, F., Ardestani, F., Najafpour, G. (2016). Growth kinetic models of five species of *Lactobacilli* and lactose consumption in batch submerged culture. *Braz J Microbiol.*, Apr-Jun, *48*(2), 251–258.

Russ, W., Schnappinger, M. (2007). Waste related to the food industry: a challenge in material loops. In: Oreopoulou V., Russ W. (eds.), *Utilization of By-Products and Treatment of Waste in the Food Industry*. Springer, 1–13.

Shalini, R., Gupta, D. K. (2010). Utilization of pomace from apple processing industries: a review. *J Food Sci Technol.*, *47*(4), 365–71.