ACTA SCIENTIARUM POLONORUM *Acta Sci. Pol., Technol. Aliment. 3(1) 2004, 45-53*

COMPARISON OF BACTERIAL AND YEAST ETHANOL FERMENTATION YIELD FROM JERUSALEM ARTICHOKE (*HELIANTHUS TUBEROSUS* L.) TUBERS PULP AND JUICES

Katarzyna Szambelan, Jacek Nowak, Krystyna J. Chrapkowska
Agricultural University of Poznań

Abstract. The fermentation of Jerusalem artichoke (*Helianthus tuberosus* L.) tubers and juices using various microorganisms: the bacterium *Zymomonas mobilis*, a distillery yeast *Saccharomyces cerevisiae* and a yeast with inulinase activity was investigated. Jerusalem artichoke carbohydrates in mashed tubers and juices were acid and enzymatic hydrolysed before fermentation by the bacterium and a distillery yeast. Although enzymatic hydrolysis with an inulinase gave less reducing sugars it was significantly more efficient in fermentation process. The ethanol yield after enzymatic hydrolysis (expressed as % theoretical yield) was 78.3-90.0% and 72.4-84.2% for the bacterium and yeasts respectively in tubers as well as 78.3-88.1% and 74.4-82.2% for the bacterium and yeasts in juices. The yield was 2.0-9.2% higher than after acid hydrolysis. The yeast with an active inulinase yielded better when juices were used for fermentation than on mashed tubers.

Key words: Jerusalem artichoke, inulin hydrolysis, bacterium, yeast, ethanol yield

INTRODUCTION

Jerusalem artichoke contains 11-20% carbohydrates and that is why it constitutes a good material for distillery industry. 70-90% of these carbohydrates is inulin and inulids. Inulin consists of linear chains of D-fructose units in the $\beta(2\rightarrow1)$ position. Each chain is terminated by a D-glucose residue linked to fructose by an $\alpha(1\rightarrow2)$ bond [Azis et al. 1999, Niness 1999]. Jerusalem artichoke is very resistant to frost and plant diseases and can grow in poor land. This plant may yield tubers up to 90 $t \cdot ha^{-1}$ with a carbohydrates yield of 5-14 $t \cdot ha^{-1}$ [Swanton et al. 1992, Kosaric et al. 1984]. Jerusalem artichoke has good potential for alcohol production when fermented by suitable microorganisms. The bacterium *Z. mobilis* and a classical distillery yeast do not readily fer-

Corresponding author – Adres do korespondencji: dr hab. Jacek Nowak, prof. nadzw., Institute of Food Technology Agricultural University of Poznań, Wojska Polskiego 31, 60-624 Poznań, e-mail: jacnow@ au.poznan.pl

ment high molecular weight β-fructosides, such as inulin. A hydrolysis is thus needed prior to fermentation. The use of a yeast with inulinase activity should allow fermentation of Jerusalem artichoke without prior hydrolysis of inulin and inulids [Pekić et al. 1985, Margaritis et al. 1981]. The effect of hydrolysis and strain of microorganism on fermentation yield from Jerusalem artichoke tubers and juices was tested in this research.

MATERIAL AND METHODS

Two cultivars of Jerusalem artichoke tubers: 'Albik' and 'Rubik', were obtained from Plant Breeding and Acclimatization Institute, National Center for Plant Research in Radzików, Poland. Mashed tubers directly and juices obtained by crushing and pressing the tubers were used in classical batch fermentation processes.

The bacterium *Zymomonas mobilis*, strains 3881 and 3883 obtained from Czech Culture Collection in Brno, a distillery yeast *Saccharomyces cerevisiae*, strains Bc16a and D2, and yeasts with an active inulinase *Kluyveromyces fragilis* ŁOCK 0027 and *Kluyveromyces marxianus* ŁOCK 0024 obtained from Collection of the Institute of Fermentation and Microbiology in Technical University in Łódź, Poland, were used.

Zymomonas mobilis and *Saccharomyces cerevisiae* were grown on a medium containing: glucose, 80 g; yeast extract, 10 g; KH_2PO_4, 1 g; $(NH_4)_2SO_4$, 1 g and $MgSO_4 \cdot 7H_2O$, 0,5 g per l for 20 h at 30°C. *Kluyveromyces fragilis* and *Kluyveromyces marxianus* were grown on a medium containing: malt extract, 3 g; yeast extract, 3 g; peptone, 5 g; glucose, 10 g per l for 20 hours at 32°C with shaking at 140 rpm.

Acid hydrolysis of inulin and inulids into fermentable sugars was conducted at the 2.0 pH adjusted with sulphuric acid (H_2SO_4) and held at 100°C for 1 hour. The pH was adjusted to 5.0-5.5 before fermentation.

Enzymatic degradation of inulin and inulides was performed using the inulinase (Sigma-Aldrich, 17 $U \cdot g^{-1}$) from *Aspergillus niger* (0.02 $g \cdot kg^{-1}$ tubers) at pH 5.0, for 1 hour at 55°C. The inulinase was not inactivated after the hydrolysis.

Sterilized at 121°C for 15 minutes Jerusalem artichoke tubers and juices were used as the media for ethanol fermentation by yeasts with an active inulinase.

Batch fermentations of Jerusalem artichoke tubers and juices were conducted in 500 cm^3 Erlenmeyer flasks. Each flask contained 200 g of mash from tubers or 200 cm^3 of juice and 20 cm^3 of the inoculum. The samples were then incubated at 30°C for 72 hours.

Dry matter was determined by drying at 60°C to a constant weight. Reducing sugars were estimated with 3,5-dinitrosalicylic acid (DNS), using fructose as the standard [Miller 1959]. Total reducing sugars were assayed by the same method after acid hydrolysis (pH adjusted with sulphuric acid, 100°C, 1 h). Ethanol was measured after distillation by density method and expressed as the percentage of theoretical yield and as grams of alcohol produced per 1 gram of carbohydrate, referred to the carbohydrates consumed during the fermentation.

RESULTS AND DISCUSSION

Jerusalem artichoke tubers and juices, as a rich source of carbohydrates, were used for alcohol production. Acid hydrolysis of mashed tubers let obtain 178.8 $g \cdot kg^{-1}$ reducing substances for 'Albik' and 167.6 $g \cdot kg^{-1}$ for 'Rubik'. Enzymatic hydrolysis with an inulinase produced only 68.6 $g \cdot kg^{-1}$ for 'Albik' and 59.7 $g \cdot kg^{-1}$ for 'Rubik' (Table 1). The content of fermentable sugars in juices from tubers after acid hydrolysis was 182.1 $g \cdot dm^{-3}$ for 'Albik' and 162.4 $g \cdot dm^{-3}$ for 'Rubik'. Juices after enzymatic hydrolysis were characterised with less fermentable sugars (85.6 $g \cdot dm^{-3}$ for 'Albik' and 73.5 $g \cdot dm^{-3}$ for 'Rubik') than after acid hydrolysis (Table 2).

Table 1. The content of reducing sugars in Jerusalem artichoke (*H. tuberosus* L.) tubers
Tabela 1. Zawartość cukrów redukujących w bulwach topinamburu (*H. tuberosus* L.)

Cultivar Odmiana	Dry matter Sucha substancja %	Reducing sugars directly Cukry redukujące wprost		Reducing sugars after acid hydrolysis, 1 h Cukry redukujące po hydrolizie kwasowej, 1 h		Reducing sugars after enzymatic hydrolysis, 1 h Cukry redukujące po hydrolizie enzymatycznej, 1 h	
		$g \cdot kg^{-1}$ $g \cdot kg^{-1}$	% d.m. % s.s.	$g \cdot kg^{-1}$ $g \cdot kg^{-1}$	% d.m. % s.s.	$g \cdot kg^{-1}$ $g \cdot kg^{-1}$	% d.m. % s.s.
Albik	22.9	11.3	4.9	178.8	78.2	68.8	30.0
Rubik	22.8	10.5	4.6	167.6	73.6	59.7	26.2

Table 2. The content of reducing sugars in Jerusalem artichoke (*H. tuberosus* L.) juices
Tabela 2. Zawartość cukrów redukujących w sokach z bulw topinamburu (*H. tuberosus* L.)

Cultivar Odmiana	Dry matter Sucha sub-stancja %	Reducing sugars directly Cukry redukujące wprost		Reducing sugars after acid hydrolysis, 1 h Cukry redukujące po hydrolizie kwasowej, 1 h		Reducing sugars after enzymatic hydrolysis, 1 h Cukry redukujące po hydrolizie enzymatycznej, 1 h	
		$g \cdot kg^{-1}$ $g \cdot kg^{-1}$	% d.m. % s.s.	$g \cdot kg^{-1}$ $g \cdot kg^{-1}$	% d.m. % s.s.	$g \cdot kg^{-1}$ $g \cdot kg^{-1}$	% d.m. % s.s.
Albik	17.3	22.3	12.0	182.1	98.1	85.6	46.1
Rubik	15.9	19.8	11.7	162.4	95.4	73.5	43.2

It was stated that the bacterium *Z. mobilis* gave significantly ($p < 0.05$) higher ethanol yield from enzymatic-hydrolysed Jerusalem artichoke tubers and juices than after acid hydrolysis. It was observed that *Z. mobilis* 3881 stood of better ethanol productivity than 3883. *Z. mobilis* 3881 yielded 84.2% and 90.0% of theoretical value (for 'Albik' and 'Rubik' respectively) from tubers as well as 86.1% and 88.1% of theoretical ethanol yield from juices (Table 3, 4). Media prepared by acid hydrolysis were utilized with significantly lower efficiency (Table 3, 4) (Fig. 1, 2). *Z. mobilis* was more efficient in converting sugars to ethanol when fermented inulinase hydrolysed media (96.9--99.6%) than acid hydrolysed media (93.5-96.8%) (Table 3, 4). There are very few data for fermented mashed tubers as most researchers have worked with Jerusalem artichoke juices [Toran-Diaz et al. 1985]. Margaritis et al. [1981] reported similar ethanol yield for juices fermented with *Z. mobilis* but in shaken culture.

Table 3. Fermentation of Jerusalem artichoke (*H. tuberosus* L.) tubers by the bacterium *Zymomonas mobilis* (30°C, 72 h)
Tabela 3. Fermentacja bulw topinamburu (*H. tuberosus* L.) po zastosowaniu bakterii *Zymomonas mobilis* (30°C, 72 h)

Cultivar Odmiana	Type of hydrolysis before fermentation Rodzaj hydrolizy przed fermentacją	Strain of *Z. mobilis* Szczep *Z. mobilis*	pH after fermentation pH po fermentacji	Utilized sugars Cukry wykorzystane %	Ethanol Etanol % v/v	Ethanol yield $g \cdot g^{-1}$ utilized sugars Wydajność etanolu $g \cdot g^{-1}$ wykorzystanych cukrów
Albik	Acid hydrolysis	3881	5.0	96.0	9.1	0.42^{a}
	Hydroliza kwasowa	3883	5.2	96.8	8.2	0.37^{b}
	Enzymatic hydrolysis	3881	4.9	98.7	9.7	0.43^{c}
	Hydroliza enzymatyczna	3883	4,9	98.3	8.8	0.40^{d}
Rubik	Acid hydrolysis	3881	5.0	93.5	8.7	0.44^{G}
	Hydroliza kwasowa	3883	5.1	95.2	7.9	0.39^{H}
	Enzymatic hydrolysis	3881	5.3	99.6	9.7	0.46^{I}
	Hydroliza enzymatyczna	3883	5.5	96.9	9.1	0.44^{A}

Means in the columns with different superscript letters are significantly different at $p < 0.05$. Small letters (a, b, c, d) are for cultivar 'Albik' and capitals (A, G, H, I) for 'Rubik'.

Wartości oznaczone w kolumnach różnymi literami różnią się istotnie przy $p < 0,05$. Małe litery dotyczą odmiany 'Albik', a duże odmiany 'Rubik'.

Table 4. Fermentation of Jerusalem artichoke (*H. tuberosus* L.) juices by the bacterium *Zymomonas mobilis* (30°C, 72 h)
Tabela 4. Fermentacja soków z bulw topinamburu (*H. tuberosus* L.) po zastosowaniu bakterii *Zymomonas mobilis* (30°C, 72 h)

Cultivar Odmiana	Type of hydrolysis before fermentation Rodzaj hydrolizy przed fermentacją	Strain of *Z. mobilis* Szczep Z. mobilis	pH after fermentation pH po fermentacji	Utilized sugars Cukry wykorzystane %	Ethanol Etanol % v/v	Ethanol yield $g \cdot g^{-1}$ utilized sugars Wydajność etanolu $g \cdot^{-1} g$ wykorzystanych cukrów
Albik	Acid hydrolysis	3881	4.8	95.5	8.9	0.40^{a}
	Hydroliza kwasowa	3883	5.0	95.7	8.7	0.39^{e}
	Enzymatic hydrolysis	3881	5.2	97.7	9.9	0.44^{f}
	Hydroliza enzymatyczna	3883	5.3	97.9	9.1	0.40^{a}
Rubik	Acid hydrolysis	3881	4.8	94.9	8.2	0.42^{G}
	Hydroliza kwasowa	3883	4.9	95.1	7.6	0.39^{E}
	Enzymatic hydrolysis	3881	5.4	98.1	9.1	0.45^{J}
	Hydroliza enzymatyczna	3883	4.9	98.4	8.7	0.43^{I}

Means in the columns with different superscript letters are significantly different at $p < 0.05$. Small letters (a, e, f) are for cultivar 'Albik' and capitals (E, G, I, J) for 'Rubik'.

Wartości oznaczone w kolumnach różnymi literami różnią się istotnie przy $p < 0,05$. Małe litery dotyczą odmiany 'Albik', a duże odmiany 'Rubik'.

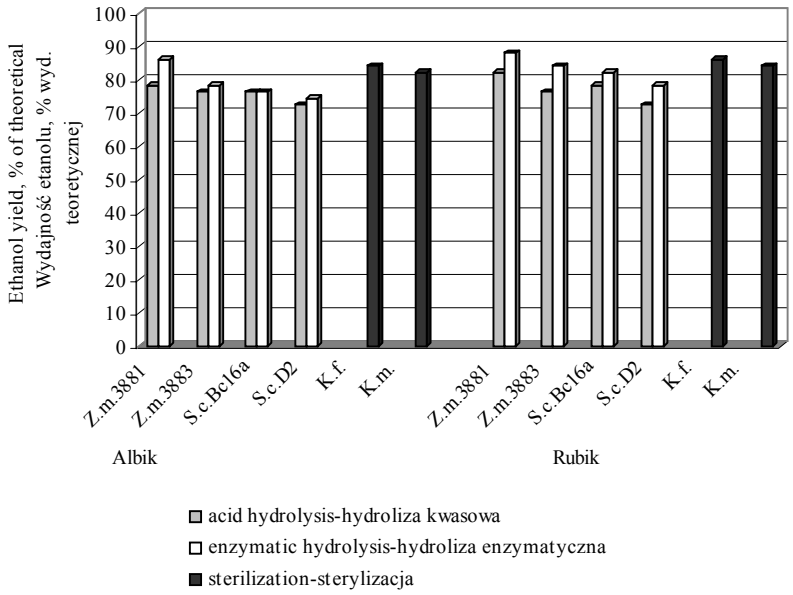

Fig. 1. Ethanol yield from Jerusalem artichoke (*H. tuberosus* L.) juices by the bacteria and yeasts
Rys. 1. Wydajność etanolu z soków z bulw topinamburu (*H. tuberosus* L.) z użyciem bakterii i drożdży

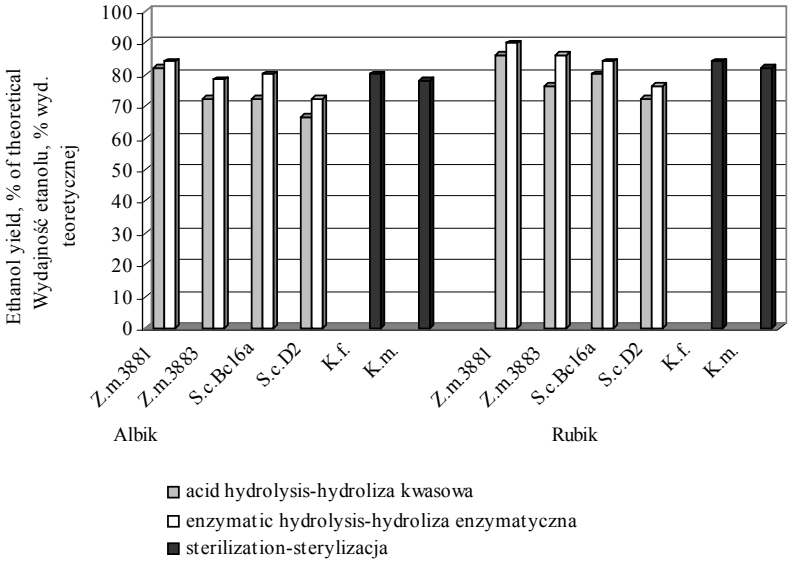

Fig. 2. Ethanol yield from Jerusalem artichoke (*H. tuberosus* L.) tubers by the bacteria and yeasts
Rys. 2. Wydajność etanolu z bulw topinamburu (*H. tuberosus* L.) z użyciem bakterii i drożdży

Concerning the tested *Z. mobilis* strains, both yielded better in the mashed tubers and juices compared to *S. cerevisiae* and *Kluyveromyces* strains. These results agrees with previous results that have compared the performances of the bacterium and a distillery yeast [Nowak 2001]. A distillery yeast *S. cerevisiae* was found to be significantly ($p < 0.05$) more effective in alcohol production when hydrolysis with an inulinase was applied before fermentation, than the acid hydrolysis. Among two applied strains, Bc16a fermented both Jerusalem artichoke media with higher ethanol yield than D2. *S. cerevisiae* Bc16a produced 80.2% and 84.2% theoretical ethanol yield from inulinase hydrolysed tubers (for 'Albik' and 'Rubik' respectively) and 76.3% and 82.2% ethanol yield from juices (Table 5, 6) (Fig. 1, 2). Lower ethanol yields were obtained from acid hydrolysed media: 72.4% and 80.2% theoretical ethanol yield from mashed tubers of 'Albik' and 'Rubik', respectively, as well as 76.3% and 78.3% ethanol yield from juices (Table 5, 6). It is also interesting to note, that distillery yeasts utilized as many as 98.7-99.8% fermentable sugars available in the enzymaticly hydrolysed tubers and juices and 93.4-98.9% from media hydrolysed by acid addition (Table 5, 6). The results with *S. cerevisiae* obtained in this research were higher than those reported by Sachs et al. [1981] and Duvnjak et al. [1982]. Nakamura et al. [1996] also showed lower ethanol yields for Jerusalem artichoke tubers fermented by *S. cerevisiae* after enzymatic hydrolysis with inulinase from *Aspergillus niger*.

Table 5. Fermentation of Jerusalem artichoke (*H. tuberosus* L.) tubers by yeasts *S. cerevisiae*, *K. fragilis* and *K. marxianus* (30°C, 72 h)
Tabela 5. Fermentacja bulw topinamburu (*H. tuberosus* L.) po zastosowaniu drożdży *S. cerevisiae*, *K. fragilis* and *K. marxianus* (30°C, 72 h)

Cultivar Odmiana	Type of hydrolysis before fermentation Rodzaj hydrolizy przed fermentacją	Strain of yeasts Szczep drożdży	pH after fermentation pH po fermentacji	Utilized sugars Cukry wykorzystane %	Ethanol Etanol % v/v	Ethanol yield $g \cdot g^{-1}$ utilized sugars Wydajność etanolu $g \cdot g^{-1}$ wykorzystanych cukrów
Albik	Acid hydrolysis Hydroliza kwasowa	*S.cerevisiae* Bc16a *S.cerevisiae* D2	4.7 4.9	96.9 96.9	8.2 7.4	0.37^{a} 0.34^{b}
	Enzymatic hydrolysis Hydroliza enzymatyczna	*S.cerevisiae* Bc16a *S.cerevisiae* D2	4.5 4.6	99.1 98.7	9.1 8.2	0.41^{c} 0.37^{a}
	Sterylization Sterylizacja	*K.fragilis* *K.marxianus*	4.4 4.9	99.1 99.3	9.1 9.1	0.41^{d} 0.40^{e}
Rubik	Acid hydrolysis Hydroliza kwasowa	*S.cerevisiae* Bc16a *S.cerevisiae* D2	4.8 4.9	93.4 94.3	8.2 7.4	0.41^{F} 0.37^{A}
	Enzymatic hydrolysis Hydroliza enzymatyczna	*S.cerevisiae* Bc16a *S.cerevisiae* D2	4.3 4.8	99.1 99.4	9.1 8.2	0.43^{E} 0.39^{C}
	Sterylization Sterylizacja	*K.fragilis* *K.marxianus*	4.6 4.5	98.5 98.5	8.7 8.7	0.43^{G} 0.42^{H}

Means in the columns with different superscript letters are significantly different at $p < 0.05$. Small letters (a, b, c, d, e) are for cultivar 'Albik' and capitals (A, C, E, F, G, H) for 'Rubik'.

Wartości oznaczone w kolumnach różnymi literami różnią się istotnie przy $p < 0,05$. Małe litery dotyczą odmiany 'Albik', a duże odmiany 'Rubik'.

Table 6. Fermentation of Jerusalem artichoke (*H. tuberosus* L.) juices by yeasts *S. cerevisiae*, *K. fragilis* and *K. marxianus* (30°C, 72 h)
Tabela 6. Fermentacja soków z bulw topinamburu (*H. tuberosus* L.) po zastosowaniu drożdży *S. cerevisiae*, *K. fragilis* i *K. marxianus* (30°C, 72 h)

Cultivar Odmiana	Type of hydrolysis before fermentation Rodzaj hydrolizy przed fermentacją	Strain of yeasts Szczep drożdży	pH after fermentation pH po fermentacji	Utilized sugars Cukry wykorzystane %	Ethanol Etanol % v/v	Ethanol yield $g \cdot g^{-1}$ utilized sugars Wydajność etanolu $g \cdot g^{-1}$ wykorzystanych cukrów
Albik	Acid hydrolysis Hydroliza kwasowa	*S.cerevisiae* Bc16a *S.cerevisiae* D2	4.7 4.8	98.8 98.9	8.9 8.5	0.39^{c} 0.37^{a}
	Enzymatic hydrolysis Hydroliza enzymatyczna	*S.cerevisiae* Bc16a *S.cerevisiae* D2	4.5 4.6	99.7 99.8	9.1 8.7	0.39^{c} 0.38^{f}
	Sterylization Sterylizacja	*K.fragilis* *K.marxianus*	4.2 4.2	99.5 99.1	9.9 9.7	0.43^{g} 0.42^{h}
Rubik	Acid hydrolysis Hydroliza kwasowa	*S.cerevisiae* Bc16a *S.cerevisiae* D2	4.8 4.8	98.7 98.7	8.2 7.6	0.40^{E} 0.37^{A}
	Enzymatic hydrolysis Hydroliza enzymatyczna	*S.cerevisiae* Bc16a *S.cerevisiae* D2	4.4 4.6	99.6 99.6	8.7 8.2	0.42^{H} 0.40^{E}
	Sterylization Sterylizacja	*K.fragilis* *K.marxianus*	4.3 4.3	99.7 99.70	9.1 8.8	0.44^{I} 0.43^{G}

Means in the columns with different superscript letters are significantly different at $p < 0.05$. Small letters (a, c, f, g, h) are for cultivar 'Albik' and capitals (A, E, G, H, I) for 'Rubik'.

Wartości oznaczone w kolumnach różnymi literami różnią się istotnie przy $p < 0,05$. Małe litery dotyczą odmiany 'Albik', a duże odmiany 'Rubik'.

Yeasts with an active inulinase had much more potentials in fermenting Jerusalem artichoke juices than mashed tubers (Table 5, 6). *K. fragilis* let obtain better results than *K. marxianus*. Using *K. fragilis* for Jerusalem artichoke tubers fermentation, 80.2% and 84.2% theoretical ethanol yield was obtained (for 'Albik' and 'Rubik' respectively) (Table 5). The results were similar to those obtained from inulinase hydrolysed tubers fermented by a distillery yeast (Fig. 1, 2). Fermentation of Jerusalem artichoke juices by *K. fragilis* yielded 84.2% and 86.1% ethanol of theoretical for 'Albik' and 'Rubik', respectively (Table 6). Our results are better than reported by Duvnjak et al. [1982] or Rosa et al. [1986]. Some researchers [Chabbert et al. 1985, Margaritis and Bajpai 1982] showed even higher yields from juices fermented by yeasts with an active inulinase, when shaken flasks process was employed.

The comparison of Jerusalem artichoke tubers and juices fermentation proved the significant influence of the strain of microorganism, as well as the method of preparing the media for fermentation, on ethanol yield and sugar utilization. The cultivar of Jerusalem artichoke also significantly influenced the ethanol yield. Ethanol fermentation of

'Rubik' was more efficient than those of 'Albik'. Most studies on alcohol production from Jerusalem artichoke published so far, have been conducted on juices rather than on tubers directly. The fermentation of juices is easier to handle than of mashed tubers but the step of juice production might increase the cost of the process significantly. It is also important to note that both mashed tubers and juices can serve for ethanol producing microorganism growth and alcohol production without additives since they contain enough essential nutrients.

CONCLUSIONS

1. Enzymatic hydrolysis with an inulinase yielded less fermentable substances than acid hydrolysis in 1 hour process but it affected higher ethanol production, both for the bacterium and a distillery yeast.

2. The bacterium *Zymomonas mobilis* was found to be more desirable for industrial production of ethanol than a distillery yeast and a yeast with inulinase activity. Strain 3881 stood of better productivity than 3883.

3. Using a yeast with inulinase activity seemed to be a good solution but for juices fermentation. Ethanol yield from tubers fermented as mash was lower.

4. Cultivar 'Rubik' let obtain better ethanol fermentation results than 'Albik'.

5. The highest ethanol yield was achieved when enzymatic hydrolysis and the bacterium *Z. mobilis* 3881 was applied for Jerusalem artichoke tubers fermentation. The yield reached 90% of theoretical.

6. The kind and the strain of microorganism, as well as the method of Jerusalem artichoke inulin and inulids hydrolysis influenced significantly ethanol production efficiency.

REFERENCES

Azis B.H., Chin B., Daecon M.P., 1999. Size and shape of inulin in dimethyl sulphoxide solution. Carbohyd. Polym. 38, 231-234.

Chabbert N., Guiraud J.P., Arnoux M., Galzy P., 1985. Productivity and fermentability of different Jerusalem artichoke (*Helianthus tuberosus*) cultivars. Biomass 6, 271-284.

Duvnjak Z., Kosaric N., Kliza S., 1982. Production of alcohol from Jerusalem artichoke by yeast. Biotechnol. Bioeng. 24, 2297-2308.

Kosaric N., Cosetino G.P., Wieczorek A., Duvnjak Z., 1984. The Jerusalem artichoke as an agricultural crop. Biomass 5, 1-36.

Margaritis A., Bajpai P., 1982. Ethanol production from Jerusalem artichoke tubers (*Helianthus tuberosus*) using *Kluyveromyces marxianus* and *Saccharomyces rosei*. Biotechnol. Bioeng. 24, 941-953.

Margaritis A., Bajpai P., Cannell E., 1981. Optimization studies for bioconversion of Jerusalem artichoke tubers to ethanol and microbial biomass. Biotechnol. Lett. 3 (10), 395-399.

Miller G.L., 1959. Use of dinitrosalicylic acid reagent for determination of reducing sugar. Anal. Chem. 31, 426-428.

Nakamura T., Ogata Y., Hamada S., Ohta K., 1996. Ethanol production from Jerusalem artichoke tubers by *Aspergillus niger* and *Saccharomyces cerevisiae*. J. Ferment. Bioeng. 81 (6), 564-566.

Niness K.R., 1999. Inulin and oligofructose: what are they? J. Nutr. 129 (07), 1402S-1406S.

Nowak J., 2001. Comparison of Polish industrial distillery yeast with ethanol producing bacteria *Zymomonas mobilis*. EJPAU Food Sci. Technol. 4, 1-10.
Pekić B., Slavica B., Lepojević Ź., Petrović S.M., 1985. Effect of pH on the hydrolysis of Jerusalem artichoke inulin. Food Chem. 17, 169-173.
Rosa M.F., Viera A.M., Bartolomen M.L., 1986. Production of high concentration of ethanol from mash, juice and pulp of Jerusalem artichoke tubers by *Kluyveromyces fragilis*. Enzyme Microb. Technol. 8, 673-676.
Sachs R.M., Viera A.M., Bartolomen M.L., 1981. Fuel alcohol from Jerusalem artichoke. Calif. Agric. 29, 4-6.
Swanton C.J., Cavers P.B., Clements D.R., Moore M.J., 1992. The biology of canadian weeds: 101 *Helianthus tuberosus* L. Can. J. Plant Sci. 72, 1367-1382.
Toran-Diaz I., Jain V.K., Allais J.J., Baratti J., 1985. Effect of acid or enzymatic hydrolysis on ethanol production by *Zymomonas mobilis* growing on Jerusalem artichoke juice. Biotechnol. Lett. 7, 527-530.

PORÓWNANIE WYDAJNOŚCI ETANOLU Z BULW I SOKÓW Z BULW TOPINAMBURU (*HELIANTHUS TUBEROSUS* L.) PO ZASTOSOWANIU BAKTERII I DROŻDŻY

Streszczenie. Bulwy oraz soki z bulw topinamburu (*H. tuberosus* L.) poddawane były klasycznej fermentacji okresowej z użyciem bakterii *Zymomonas mobilis*, drożdży gorzelniczych *Saccharomyces cerevisiae* oraz drożdży z aktywną inulinazą (*Kluyveromyces fragilis* i *Kluyveromyces marxianus*). Fermentacje z wykorzystaniem bakterii i drożdży gorzelniczych prowadzone były po wstępnej hydrolizie kwasowej lub enzymatycznej inuliny i inulidów bulw topinamburu. Pomimo że hydroliza enzymatyczna powodowała uzyskiwanie mniejszych ilości cukrów fermentujących w trakcie 1 godzinnego procesu, była bardziej efektywna z punktu widzenia wydajności procesu fermentacji alkoholowej. Wydajność etanolu, dla bakterii i drożdży gorzelniczych, po hydrolizie enzymatycznej (wyrażona jako % wydajności teoretycznej) wynosiła 78,3-90,0% i 72,4-84,15% dla bulw oraz 78,3-88,1% i 74,4-82,2% dla soków. Wydajność ta była o 2,0-9,2% wyższa w porównaniu z fermentacją hydrolizowanych kwasowo podłoży. Drożdże zawierające aktywną inulinazą produkowały etanol wydajniej z soków niż z rozdrobnionych bulw.

Słowa kluczowe: topinambur, hydroliza inuliny, bakterie, drożdże, wydajność etanolu

Accepted for print – Zaakceptowano do druku: 26.04.2004

***For citation – Do cytowania**: Szambelan K., Nowak J., Chrapkowska K.J., 2004. Comparison of bacterial and yeast ethanol fermentation yield from jerusalem artichoke (Helianthus tuberosus L.) tubers pulp and juices. Acta Sci. Pol., Technol. Aliment. 3(1), 45-53.*