*J.Soil Sci. and Agric. Eng., Mansoura Univ., Vol. 9 (11):597– 600, 2018*

# Influence of Thermal Manipulation of Banana Husks on Ethanol Production

**El Ashmawy, N. M.**
**Senior Researcher, Agric. Eng. Res. Inst., Agric. Research Center, Giza, Egypt**

## ABSTRACT

This study attempts to produce ethanol from thermally manipulation banana husks using the microwave prior to fermentation operation using *Saccharomyces Cerevisiae* yeast. The short wave was provided using microwave at three different levels of 140, 160 and 180 Watt, and three different exposure times inside the microwave 3, 5 and 7 minutes. Sugar contained (sucrose and glucose) were measured in pre-treated samples under bio-concentration conditions. The fermentation operation of banana peel was carried out through seven successive days and the ethanol production was continuously measured once a day (every 24 hours). The optimal temperature of pre-treated banana husks fermentation was taken as 35°C from the previous study. The high level of ethanol production was achieved at 180 Watt and 5 minute of exposure time. Experimental results also clarified that, the thermally manipulated by microwave thereby significantly increased the glucose contained and lowered the sucrose contained, which being developed strategies for expanding the suitable use of different applications of banana husks in the foodstuffs industry.

## INTRODUCTION

The major tropical fruits available in Saudi Arabia are Banana fruit (*Musa paradisiaca L. var sapientum (l. O. Kuntze*). It is namely available as fresh or dried fruits year round. Banana is also one of the major form of the principal food resources in the world and constitute the fourth world rank of the most significant foodstuffs after milk, corn and rice (INIBAP, 2002). Most of the banana residues are converted into solid substance using natural or industrial dehydration. Thereafter, crushed into grains or pellets or powder and sold at a low price value to the manufacturers of animal foodstuffs. Therefore, this mode of banana residues utilization is not considered as a highly viable proposition. As mentioned by the FAO (2008), India is the first world producer countries of banana fruit with 30% share of production worldwide. Nevertheless, the residue of banana peels representing about 30 - 40% of the total weight of fruit. This residue is basically contained a full of meaning values of fiber, proteins, and carbohydrates (Emaga *et al*., 2008). Therefore, the banana peels is under-utilized as a potential growth medium for yeast strain by regarding their higher level of carbohydrate contained and other basic nutrients that can provide good medium for yeast growth (Hueth and Melkonyan, 2004; Essien *et al*., 2005; Brooks, 2008;). Because of the banana peels contain lower quantities of lignin; it can serve as a good substrate for producing of value-added products such as ethanol (Hammond *et al*., 1996). It is one of the most extensively consumed fruit in the world that represent about 40% of the world trade in the fruits (Singanusong *et al*., 2013). After citrus fruit, banana is the second largest product fruit, in which it contributes about 16% of the world's total fruit production. It is cultivated over 130 countries as the most widely grown tropical fruits. It existing from India and Eastern Asia (Malaysia and Japan) and some varieties are genetically linked with some other species from Africa (Mohapatra *et al*., 2010). After the inner fleshy portion of banana is eaten, the outer shell is discarded as waste. Besides to that, banana using as fresh fruit or processed into different products such as juice, jams, chips, puree pulps powder, and biscuits (Zhang *et al*., 2005). Global production of banana is estimated to be about 48.9 million tons. According to the FAO (2008) Egypt ranking number 18 with a production of 1.144.717 tons of banana in year 2013. However, approximate 40% of the total weight of fresh banana is produced as a waste product in industries producing banana based products (Tcehobanoglous *et al*., 1993). Nowadays, these wastes are not being utilized for any beneficial purposes and are mostly dumped as solid wastes at large expense. It is essential to find optimal utilization for these wastes as they can contribute to prevent the environmental problems (Zhang *et al*., 2005). Therefore, a great demand of ethanol as an alternative source of energy for various industrial applications accelerated the development of renewable energy sources in the form of alternative power sources. Ethanol production is substantially dependent upon the chemical synthesis of petrochemical substrates and microbial conversion of carbohydrates which presenting in most of the agricultural products. The possibility of using microwave energy for different applications was widely achieved since 1980s. Microwave has some advantages: it is operated faster than any other unit, lowering energy consumption, and provided higher level of product quality, as used in an inactivation of enzymatic, sterilization and pasteurization processes, tempering, and dehydration (Janani, *et al*., 2013). Moreover, the occurrence use of microwave ovens for domestic purposes and restaurants had already realized consumers with this novel type of technology and its advantages, and removing some reverences and bans that occurred at the beginning. It is imperative to take into account the changes in sociological of this particular period of microwave history and the consistent changes in domestic behaviors that placated the upsurge social acceptance of domestic ovens. This location made more vigorous researches aimed to better knowledge of the dielectric properties of food. Information that was not able to be dispensed with stimulating the development of industrial facilities based on scientific bases (Joshi *et al*,. 2001). As a result of this, the microwave operating was utilized as the pre-treatment mode for banana husks. The effect of pre-treatment using microwave radiation on final products of banana husks through the biotransformation mode was studied by several researchers. Reducing sugar and glucose contains are intermediate products for ethanol through biotransformation. Recent study for increasing practical applications of banana peel in the food processing was carried out by Sharma and Mishra (2015). They pretreated the banana peel via the microwave operating prior to operating the fermentation using aspergillus Niger and saccharomyces cerevisiae yeast. They were applied three different levels of microwave power 80,160, and 240 Watt at microwave pre-treatment time of 5 min. The reduction in sugar and glucose contained in pretreated samples under their pre-treatment conditions were measured using biotransformation mode. Fermentation process was performed through seven consecutive days and the ethanol production was measured at the end of every day. They revealed that, the optimal level of fermentation temperature and pH for the banana peels was 30°C and 6, respectively. They also clarified that, the pre-treatment by microwave provided a potential increasing in sugar contained at microwave power of 160 Watt, comprising reduction in glucose, which provided significant strategies. This research work aims to study the effect of microwave energy and exposure time on the production of ethanol from banana husks.

## MATERIALS AND METHODS

The experimental work was carried out at the Food Engineering Laboratory, Agricultural Engineering Department, King Saud University, Saudi Arabia. Bananas were purchased from the local market in Riyadh (imported from Egypt). Fresh bananas were cleaned and the banana peels were scrapped. The crust ratio was calculated for total weight (37.4%) and thereafter, chopped to 2-4 cm long as shown in Fig. (1). The natural sun drying (direct drying) was carried out for 5 successive days with daily measure of weight until reached the weight stability on the fourth and fifth days. Dried crusts were grinded using a home coffee grinder to a fine powder. Prior to the experiment, 10 grams of banana powder were placed in 200 ml flask and 100 ml of distilled water was added to the banana powder with good stirring. All determinations were conducted in triplicate.

**Fig. 1. The cutting of banana husks during the drying**
**Microwave pretreatment at Banana peel**

The flasks were situated inside the microwave oven (Samsung, model ME733K–FEBRUARY, 2017) at the Food Engineering Laboratory, Department of Agricultural Engineering, King Saud University as shown in Fig. (2). It is capable to operate with a maximum microwave power of 800 Watt with a frequency of 2450 MHz. Three different microwave powers of 140, 160,180 Watt were functioned at 3, 5, and 7 min of exposure times. After the pretreatment, the liquid was filtered to remove impurities. The mixed liqueur was collected to undergo enzymatic hydrolysis.

**Total soluble solid (TSS)**

Total soluble solids contained during the fermentation process was determined using Atago digital refractometer device (Tokyo, Japan) having a scale range of 0 to 30% brix unit (1 Brix = 10g/l). Total soluble solid contained was tested before and after fermentation processes. Brix refers to the measurement of sucrose in pure water solution by weight in percentage. This meaning of Brix degrees is only usable for pure sucrose solutions (BRIX-Sugar Determination by Density and Refractometer, 2004).

**Fig. 2. The Microwave for pretreatment at Banana peel**

**Glucose determination**

A high performance liquid chromatography system (HPLC, Shimadzu LC-10 AD, Shimadzu, Kyoto, Japan) equipped by a 94.6-mm column packed with 5-l Supelcosil LC-NH2 (Supelco, Bellefonte, PA, USA) and joined to a refractory index detector (RID-6A, Shimadzu Kyoto, Japan). It was functioned to measure the contained of glucose produced from the composition of enzymatic hydrolysis of pretreated biomass. Carbohydrate analysis columns were operated as the mobile phase at a flow rate of 1 ml/min, temperature of 18°C with 20% water and 80% acetonitrile, HPLC grade.

**Prepare yeast environment,**

A bakery yeast (Wild strain Saccharomyces cerevisiae yeast) for fast fermentation was added with wheat flour, molasses at a concentration of 70%, grape juice at 20% sugar. The rate of mix was 1.5 g yeast, 1.5 g wheat flour, 4 g molasses, and 8 g grape juice for each 500 ml of distilled water. The sterilization of the fermentation environment was done in autoclave at a temperature of 121°C for 15 minutes. One gram of fast-fermentation yeast (Saccharomyces Cerevisiae) was added to 250 g of fermentation environment, at capacity of 1 liter (anaerobic fermentation with flipping of 120 rpm at 15 min /2 hours for 24 h at 35°C.

**Fermentation process**

The experiments were executed by adding 10 ml of the activated yeast environment per 100 ml of juice and placed in a glass fermenter with 200 ml fermentation capacity. The glass fermenters were situated in a water basin to control the fermentation temperatures at 35°C. Fermentation process was performed through seven successive days and the ethanol production was measured at the end of every day.

## RESULTS AND DISCUSSION

The obtained data from the experimental work were taken and analyzed. During the fermentation process the color of the solution was changed after 7 minutes for microwave power of 160 and 180 Watt, and the results were as follows:

**Effect of microwave pre-treatment on total soluble solid (TSS)**

The effect of microwave pretreatment on total dissolved solid (sugar) is listed in Table (1). It is evidently revealed that, as the microwave power and the exposure time of the microwave pretreatment technique increased the ratio of dissolved solids increased. The increase in ratio of dissolved solids ranged from 20.83 % to 37.50%, 33.33% to 75.00%, and 41.67% to 70.83% as compared with the control unit, at 3, 5, and 7 minutes of exposure time, respectively. The ratio of dissolved solids was also increased and ranged from 20.83% to 41.67%, 29.17% to70.83%, and 37.50% to 70.73% as compared with the control unit, at 140, 160 and 180 Watt, respectively.

**Table 1. Total dissolved solid (sugar) contained with three different microwave powers and three different exposure time.**

| Sample | Total solid mg/g | | |
|---|---|---|---|
| Exposure time | 3 min. | 5 min. | 7 min. |
| Control | | 240 | |
| 140 W | 290 | 320 | 340 |
| 160 W | 310 | 400 | 410 |
| 180 W | 330 | 420 | 410 |

**Effect of microwave pretreatment on Glucose determination**

The average ratio of glucose concentration under different energy levels is summarized and listed in Table (2). It is clearly revealed that, increasing the microwave energy and the exposure time led to increase the ratio of glucose concentration. The increase ranged between 43.75% and 75.00% , 62.50% and 137.50%, and 68.75% and112.50% as compared with the control unit, at 3, 5, and 7 minutes of exposure time, respectively. The ratio of glucose concentration was also increased from 43.75% to 68.75%, 68.75% to 106.25%, and 75.00% to112.50% as compared with the control unit, at 140, 160 and 180 Watt, respectively. Table (2) also shows that, lower levels of glucose concentration occurred with microwave energy of 160 and 180 Watt at 7 min as compared with the same levels of microwave energy and exposure time of 5 min.. This explains the color change caused by polymerization of glucose under longer time of exposure (7 min.). Figure (3) reveals the relationship between glucose produced and microwave energy levels at three different exposure times.

**Influence of pretreatment on production of ethanol**

The production of ethanol from microwave pretreatment of banana husks is listed in Table (3) and plotted in Fig. (4). In reality the glucose concentration in the fermentation media plays an important role in ethanol production. Microwave energy induces in conversion of cellulose into carbohydrates that resulting in increasing the concentration of glucose. Therefore, the highest level of ethanol production was achieved at microwave energy level of 180 Watt at exposure time of 5 minutes. The results are in agreement with Sharma and Mishr (2015).

**Table 2. Percentage of glucose concentration under three different levels of microwave energy and exposure times**

| Sample | Glucose concentration mg/g | | |
|---|---|---|---|
| | 3 min. | 5 min. | 7 min. |
| Control | | 160 | |
| 140 W | 230 | 260 | 270 |
| 160 W | 270 | 370 | 330 |
| 180 W | 280 | 380 | 340 |

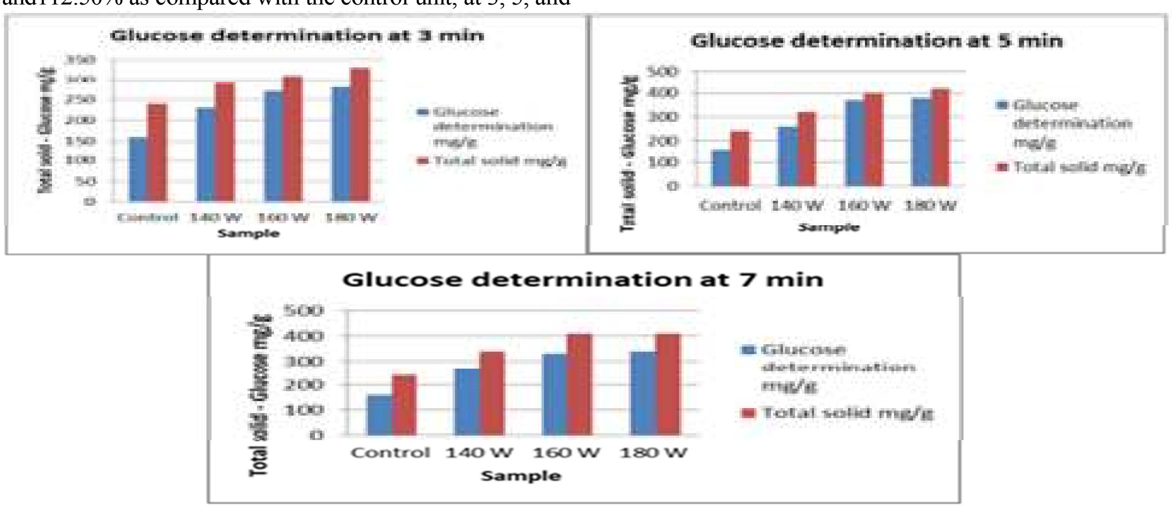


**Fig. 3. Percentage of glucose concentration versus microwave energy under three different times of exposure.**

**Table 3. Percentage of ethanol production for various microwave energy and exposure times within 7 days of fermentation**

| Sample/days | Production of ethanol (%) | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | | | 2 | | | 3 | | | 4 | | | 5 | | | 6 | | | 7 | | |
| Time of exposure to energy | 3 | 5 | 7 | 3 | 5 | 7 | 3 | 5 | 7 | 3 | 5 | 7 | 3 | 5 | 7 | 3 | 5 | 7 | 3 | 5 | 7 |
| Control | | 0.50 | | | 0.91 | | | 1.98 | | | 2.95 | | | 3.92 | | | 4.21 | | | 5.00 | |
| 140 W | 0.61 | 0.65 | 0.68 | 0.93 | 0.96 | 0.99 | 1.97 | 2.11 | 2.13 | 3.46 | 3.54 | 3.66 | 4.00 | 4.2 | 4.50 | 5.30 | 5.34 | 5.74 | 5.56 | 6.1 | 6.13 |
| 160 W | 0.65 | 0.70 | 0.75 | 0.94 | 0.98 | 1.06 | 2.65 | 2.97 | 2.99 | 3.85 | 3.98 | 4.01 | 4.92 | 4.97 | 5.00 | 5.67 | 5.90 | 6.01 | 6.02 | 6.23 | 6.09 |
| 180 W | 0.65 | 0.71 | 0.76 | 0.97 | 1.01 | 1.11 | 2.87 | 2.99 | 3.07 | 3.97 | 4.01 | 4.09 | 4.94 | 5.0 | 5.05 | 5.73 | 5.93 | 6.16 | 6.06 | 6.34 | 6.12 |

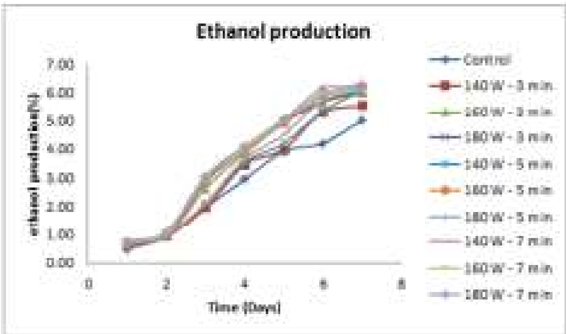


**Fig.4. Ethanol production for various microwave energy and exposure times within 7 days of fermentation**

## CONCLUSION

Based on the previous experimental results, pre-treatment using microwave energy at 180 Watt for 5 minutes of exposure time was significantly improved sugar and glucose reduction contained in the simultaneous looping process. Moreover, the microwave processing was improved sugar production to the maximum level. As compared with the untreated substances, sugar (sucrose) and glucose contained was increased by 180 and 220 mg/g, respectively.

## REFERENCES


BRIX-Sugar Determination by Density and Refractometry (2004) www.density.com

Brooks, A. A. (2008) "Ethanol production potential of local yeast strains isolated from ripe banana peels" African journal of Biotechnology, 7(20): 3749 – 3752.

Emaga, T.H.; Robert, C.; Ronkart, S.N.; Wathelet, B.; and Paquot, M. (2008) "Dietary fiber component and pectin chemical features of peels during ripening in banana and plant varieties" Bio-resource Technology, 99 : 4346 – 4354.

Essien, J.P., Akpan, E.J., Essien, E.P. (2005) "Studies on mould growth and biomass production using waste banana peels" Bio-resource Technology, 19: 361 – 363.

FAO, (2008) "Food and Agriculture Organization of the United Nations" FAOSTAT statistics database http:// faostat.fao org/ site/567/ Desktop Default.aspx? PageID =567 ( last updated 11 May 2008).

Hammond, J. B.; Egg, R.; Diggins, D.; and Coble, C. G. (1996) "Alcohol from bananas" Bio-resource Technology, 56 : 125 – 130.

Hueth, B; and Melkonyan, T. (2004) "Quality measurement and contract Design, Lessons from the North American sugar beet Industry" Ca9nadian Journal of Agricultural Economics, 9952: 165 – 181.

INIBAP (2002) "Net Working banana and plantain INIBAP Annual Report 2001" Montpellier, France

Janani, K.; Ketzi, M.; Megavathi, S.; Vinothkumar, D.; Ramesh Babu, N. G. (2013) "Comparative studies of ethanol production from different fruit wastes using saccharomyces cerevisiae" International Journal of Innovative Research in Science, Journal Engineering and Technology, 2(12): 7161 – 7167.

Joshi, S. S.; Dhopeshwarkar, R.; Jadav, U.; Jadav, R.; D souza, L. and Jayaprakash, D. (2001) "Continuous ethanol production by fermentation of waste banana peels using flocculating yeast" Indian Journal of Chemical Technology, 40: B25.

Mohapatra, D.; Sabyasachi, M; and Namrata, S. (2010) "Banana and it by– product utilization: an overview" Journal of Scientific and Industrial Research, 69: 323 – 329.

Sharma, P. and Mishra, A. A. (2015) "Biofuel production from banana peel by using microwave" International Journal of Science, Engineering and Technology, Volume 3 Issue 4: 1015 – 1018. www.ijset.in.

Singanusong, R.; Worasit, T.; Teeraporn, K.; and Chiraporn, S. (2013) "Extraction and properties of cellulose from banana peels" Journal of Science and Technology, 21(3): 201 – 213.

Tchobanoglous, G.; Theisen, H.; and Vigil, S. (1993) "Integrated solid waste management" Engineering principles and management issues, McGraw-Hill, NewYork, pp. 3 – 22.

Zhang, P.; Whistler, R. L.; Be Miller, J. N.; and Hamaker, B. R. (2005) "Banana Starch: production, physicochemical properties, and digestibility" Carbohydrate Polymer, 59: 443 – 458.


## تأثير المعالجة الحرارية لقشور الموز على إنتاج الايثانول

**ناصر مصطفى العشماوى**
**معهد بحوث الهندسة الزراعية – الدقى – جيزة**

تم معالجة قشور الموز من خلال المعاملة بموجات المايكرويف قبل تحللها وتخمرها باستخدام خميرة Saccharomyces cerevisiae. وتم المعالجة بالموجات القصيرة باستخدام الميكرويف عند ثلاث مستويات من الطاقة 140 و160 و180 واط ، وثلاث أزمنة للمكوث بالميكرويف 3 و5 و7 دقائق. تم قياس محتوى السكر ( السكروز ) والكلوكوز في العينات المعالجة مسبقًا في ظل ظروف التركيز الأحيائي. تم تنفيذ التخمر لمدة 7 أيام لقشور الموز وتم قياس نسبة الإيثانول الناتجة كل 24 ساعة. كانت درجة الحرارة المثلى لتخمر قشور الموز 35 درجة مئوية. وكانت أفضل النتائج عند 180 واط وزمن مكوث 5 دقائق وأشارت النتائج التجريبية إلى أن العلاج بالموجات الدقيقة يمكن أن يحسن بشكل كبير إنتاج السكر ، بما في ذلك خفض السكروز وزيادة الجلوكوز ، والتي توفر استراتيجيات محتملة لتوسيع التطبيق العملي لقشور الموز في الصناعات الغذائية.