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Production of bioethanol from varieties of dates of poor quality

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Algeria is one of the important date-producing countries with a yearly production of about 850,000 tons. The number of date palms is more than 18 million palm trees with more than one thousand varieties, however only 30% of this product is of good quality, and the rest is consumed locally or directly fed to the cattle. This study aims at transforming low quality types of dates using technical biotechnology (fermentation) into bioethanol. Our research shows that the average rate of ethanol production is 350 ml per kilogram of dates, thereby achieving a profit margin up to 2.9 € per kilogram, not to mention the byproducts of fermentation: The nuclei of dates, fibers etc. The application of this study allows the exploitation and marketing of poor quality date and a thus taking large profit that helps promote date palm trees cultivation and the production of all its types.

Key words: Fermentation, bioethanol, anaerobic, biomass, palm tree, dates, El-ouel.

INTRODUCTION

In Algeria, the number of date palms is over 18 million with a number of varieties that exceeds one thousand varieties (Document, 2012; Website of the FAO, 2012). The State of El Oued is considered among the most important States of Algeria producers of dates with a rate of 29.54% of the national production; the phoenicicole potential of this State has a significant increase with a number nearing 3.4 million date palms for an area of over 32562 ha, producing about 212 thousand tons, including 31,330 thousand tons of Deglet Nour, considered as the best variety of commercial dates (Document, 2013a). The dates of low market values represent approximately 50% of the total production of dates; these dates can be used as raw material for the production of various products such as flours dates, syrups, creams and jams date, alcohol, vinegar, citric acid, yeast, cattle feed and other products (Amallal and Chibane, 2008; Messaid, 2008; Siboukeur et al., 2001; Ould et al., 2006; Acourène and Tama, 2001; Acourene et al., 2008). For example, in Iraq, wort dates is the main feedstock for ethanol production (Mohammed and Al-Abid 2006).

The work done in this study, aims at valorizing four varieties of dates (Ghars, Tinissine, Taquermeste and Boucheire) in a bid to obtaining a widely used product. It is precisely the bioethanol prepared at the laboratory by the fermentation of the most of the varieties of dates and the optimization of parameters of the alcoholic fermentation of the most of dates.

Choice of varieties

Targeting a comparative study of the different varieties of must yield of bioethanol, the following four varieties were

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Figure 1. Photo of dates variety Ghars.

Figure 2. Photo of dates variety Tinissine.

Figure 3. Photo of dates variety Taquermest.

chosen: Ghars, Tinissine, Taquermeste and Boucheire (Figures 1 to 4). We opted for this choice for two basis: Their abundance and availability in considerable quantities in the region of El Oued.

Figure 4. Photo of dates variety Boucheire.

The region of El Oued

The State of El Oued is located in the south-east of Algeria, with an area of 44586.80 Km^2 (Document, 2013b). Its borders are: From the North- east with the State of Tebessa and Khenchela, from the North-West with the State of Biskra, from the West with the State of Djelfa, from the South and West with the State of Ouargla and from the East with Tunisia. The State has four main population centers: Souf region, Erg, Oued, Righ and depression regions (Figure 5).

MATERIALS AND METHODS

Physico-chemical characterization of the raw material

We determined the physical characteristics that are: Color, consistency, weight of the date, weight of the pulp, the pulp / report date, weight of the core, length and width of the date. The chemical characteristics are determined: The rates of sugars (total sugars, reducing sugars and sucrose)

Physical analysis

1. The color was visually appreciated;
2. Consistency: by touch;
3. The size is determined by means of a vernier caliber;
4. The weights are determined directly using an analytical balance.

Chemical analysis

Determination of reducing sugars: Determining the reducing sugars is performed by the method of phenol / sulfuric acid: The carbohydrates in sulfuric acid medium and at hot are dehydrated into furfural derivatives which readily combine with phenol and give a salmon-pink color (glucose provides the hydroxyfurfural). The absorbance is read at a wavelength of 490 nm. The color is permanent (Dobois et al., 1956; Audigie et al., 1983).

The determination of total sugars: An acidic medium allows the hydrolysis of sucrose into reducing sugars, the analysis is easier

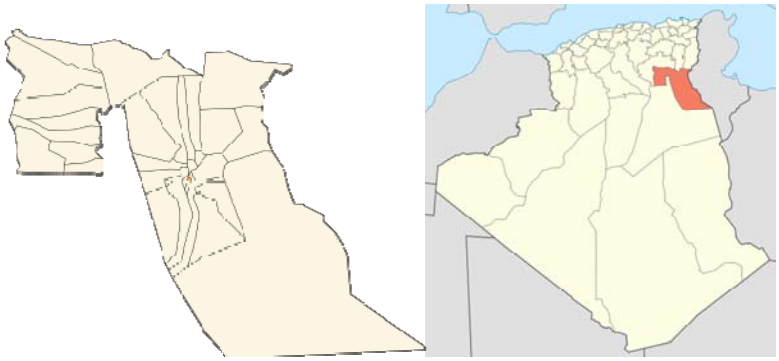

Figure 5. Geographic situation and the card of the state of El Oued.

(the determination of reducing sugars). The result obtained represents the amount of reducing sugars already present as well as sugars obtained by hydrolysis of sucrose, so we can know the amount of total sugars (Audigie et al., 1983).

The sucrose content: The sucrose content is obtained by the difference between the total sugar content and the content of reducing sugars present in the sample.

Production of ethanol by fermentation of dates

First of all we can mention that the whole study was prepared in the laboratory. The production of ethanol from dates is based on the following steps: The preparation of most of dates, the process of alcoholic fermentation, the distillation and rectification.

Preparation of must

The most is a sweet liquid taken from the prepared dates which must be washed to get rid of dust and to reduce their microbial loads, then they are pitted. The most of dates is obtained by maceration of pitted dates in warm water 70 to 80°C. The quantity is determined by1000 g of date pitted for each 3000 mml distilled water with continuous stirring of the mixture for 5 h to avoid sedimentation of date and maintaining the homogeneity of mixture at all points. Finally the solution is filtered through a fabric of fibers between the dates and the must (Boulal et al., 2010; Kaidi and Touzi, 2001).

Process of alcoholic fermentation

The must already prepared is directly used for the anaerobic fermentation with the baker's yeast Saccharomyces servisiae developed in a medium enriched with inorganic salts (ammonium sulfate, ammonium phosphate). The Must and the yeast are put in the fermentor. The fermentor (which is a recipient made of glass with holes above through which we can add the electrodes of pH meter ; also it has a valve used as an exit for gases). In order to keep the temperature constant at 32°C the fermentor is immersed in a water bath, with a pH adjusted between 4.2 and 5.4; the amount of yeast used is 3 g for 3 L of must, fermentation lasts 72 h.

Distillation and rectification

At the end of fermentation, the date wine is obtained; it must be filtered using a tissue to separate fibers from yeast. To extract ethanol, the filtered wine is distilled at a temperature of about 79°C. The rectification of the crude alcohol requires a second distillation of the order of 78°C (we mention that the distillation was done with a simple mounting).

RESULTS AND DISCUSSION

Physical analysis

Table 1 lists the physical characteristics of the four cultivars studied:

Chemical analysis

The sugar content of the four varieties is shown in Table 2. It may be noted that the date of Ghars variety is sweeter with a total sugar content of 88.52%, other varieties have close levels of reducing sugars, the varieties Boucheire and Ghars are rich in sucrose with a sucrose levels respectively 5.13 and 5.04%. However the other two varieties (Tinissine and Taquermeste) have low levels of sucrose 0.85 to 1.14%. High levels of sugars facilitate the fermentation of musts of dates and thus help obtaining bioethanol. Our results of physicochemical analysis are similar and close to those dates studied previously (Amallal and Chibane, 2008; Cheikh, 1994; Dowson and Aten, 1963; Hamdoud, 1994; Khali et al., 2007; Munier, 1973; Ould, 2001; Riviere, 1975).

Yield bioethanol

After distillation and rectification we obtained the results in Table 3. Our results are comparable to the results of Touzi who came to the production of ethyl alcohol in the laboratory with a yield of 87%.

Dates variety of Ghars is largely consumable. Its price in the Algerian market is between 50 and 100DA or between 0.47 and 0.95€. The prices of the other varieties in the Algerian market do not exceed 25DA (0.23€). The cost of ethanol production from dates is about 60DA

Table 1. Physical characteristics of dates studied.

Parameter	Variety			
	Ghars	Tinissine	Taquermeste	Boucheire
Color	Brown	Black	Black	Amber-Black
consistencies	Soft	Soft	Soft	Soft Half
Weight date (g)	12.68	8.18	12.48	8.27
Pulp weight (g)	11.6	6.75	11.25	6.44
Report pulp / date (%)	91.48	82.52	90.14	77.87
Core weight (g)	1.08	1.43	1.23	1.83
Length date (cm)	4.45	3.7	2.4	3.85
Width date (Cm)	2.0	1.55	2.5	1.2

Table 2. Levels of sugars studied dates.

Variety	Sugar content (%)		
	Total sugars	Reducing sugars	Sucrose
Ghars	88.52	83.1	5.13
Tinissine	77.6	76.7	0.85
Taquermeste	79.9	78.7	1.14
Boucheire	73.21	78.51	5.04

Table 3. Bioethanol yield for 1kg of pitted date.

Variety	Ghars	Tinissine	Taquermeste	Boucheire
Volume of ethanol (ml) in for 1 kg of date	624	242	333	475

(0.57€) per 1kg of date (electricity, reagents, raw material, labor etc). The average yield of the three varieties (Tinissine, Taquermeste and Boucheire) is 350 ml of ethanol per 1 kg of these varieties, the price of ethanol 95° in the world market is 10.6 € (1113DA) (website servilab, 2013), so the price of 1 kg of these dates when converted into bioethanol is about 3.71€ instead of 0.23€ without transformation. It means a profit of about 2.91€ per 1 kg of this variety of dates.

Conclusion

Wastes from dates varieties: Tinissine, Taquermeste and Boucheire grown in the region of Oued Souf can be converted into bioethanol by fermentation. We arrived at an average rate of ethanol production of about 350 ml per kilogram of dates, taking into consideration the price of these varieties in the market, the cost of processing and the price of ethanol (we can reach a margin up to 2.9 € per kg), regardless the byproducts of fermentation process: nuclei dates, fibers, etc. The application of this study allows the exploitation and marketing of dates of poor quality and thus taking large profits that helps promote date palm cultivation and production of all types. In addition to all that, the bio ethanol could be used as a bio-fuel because of its characteristics as a green energy.

Conflict of Interest

The authors have not declared any conflict of interest.

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