Ethanol Production of Biomass Rich in Sugar: Energy and Environmental Opportunity

N. Nedjah, N. Laskri, D. Daas, and M. Baccouche

***Abstract*—Of our days, fossil fuels, which are at the base of the oil, are scarce. In addition, the whole world knows at this time a growing commitment to a sustainable environment. Result? Use biofuel (ethanol and diesel) of biomass. The main motivation of the development of biofuels (ethanol and biodiesel) is the environmental gain potential that biofuel provide compared to petrochemical fuels.**

According to the International Energy Agency (IEA), biofuel will account for 12% of global stocks of liquid fuel by 2030, and this percentage will increase to 26% by 2050. In 2008, biofuel represented a little more than 1 per cent of the whole of the liquid fuels for engines.

This paper interested in the realization of the alcoholic fermentation of biomass rich in sugar; the waste of dates of two varieties; at the laboratory scale in order to optimize the performance in bioethanol per kg of biomass; this reaction is governed by operating conditions very critical for this our first step of work has been to determine the parameters of the good functioning of the alcoholic fermentation.

The results of our study has shown that the optimal temperature of the alcoholic fermentation is 30 ℃, the pH range of 6-5.5, agitation is 150 rpm, the residence time of the reaction is 72h and for a concentration of 300g/L glucose of waste soft dates of we produces a concentration of 280g/L of ethanol and a productivity of 3,88g/L/h of ethanol for 165g of biomass. In the case of waste dried dates of mass 173g, it was found for a concentration of 100g/L glucose, we produces 320g/L of ethanol with a productivity of 4,44g /l/h.

***Index Terms*—Bioethanol, energy, fermentation, biomass, sugar.**

I. Introduction

Bioethanol is a renewable form of energy has high added value, it east regards as a positive solution with the problems economic and environmental caused by the vegetation wastes.

The ethanol or ethanol C_2H_5OH, is obtained in a traditional way by fermentation of the glucose extracted from sugar matters (beet, canes with sugar) or by starch-based matter hydrolysis (corn, barley, but) [1].

The reaction of conversion of ethanol sugar is as follows:

$$C_6H_{12}O_6 \longrightarrow 2C_2H_5OH + 2CO_2 + \text{heat}$$

The substrate chosen for this bioconversion is an agricultural waste, made up of date scrap of fable commercial value of the western south of Algeria, of two various varieties; these dates have the advantage of having a high sugar rate and a great tonnage [2].

This area of the great south of Algeria has an arid Saharan climate, characterized by high temperatures involving an acceleration of the maturation of dates, a dehydration and appearance of a brownish coloring of this fruit. One notes during all the year a very weak pluviometer, an intense luminosity; a strong evaporation in particular at the times of the maturation of dates and a very strong wind and very violent one [3].

Under these conditions there, one can only collect dates of less value commercial. This fruit badly developed by the farmers, and considered as an agricultural waste, can be used like substrate of alcoholic fermentation to produce a substance with strong added value (ethanol) [4].

On the level of the laboratory, one it was considered useful to start two alcoholic fermentations of musts of soft and dry date. The two fermentations was carried out by the selected yeast action (Saccharomyces cerevisiae) all that to form a wine having a color and a special savour indicator of alcohol presence. The fermentation efficiency is deduced by measurement from the physicochemical results of the analysis such: concentration in glucose, pH, and concentration out of dry matter and finally quantity of alcohol produced [5].

The two tests have given a bioalcool of alcoholic degree of; 28 °for the soft date, and 32 °for the dry date; these results are encouraging and we believe improve this performance by the development of the distillation [6].

Of this fact and through a alcoholic fermentation and while valuing a biomass rich in sugar and low market value, we produce a bioalcool of high market value and especially considered, in our days, a renewable energy that can replace the oil in the near future[7], [8].

II. Materials and Methods

A. Vegetable Material (Selection of the Fermentation Substrate): Soft Date and Dry Date

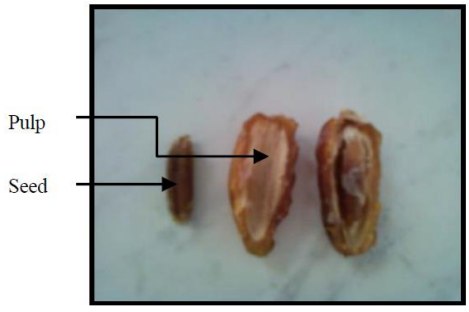

Fig. 1. Soft date section.

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The Fig. 1 and Fig. 2 present the vegetal material used in the fermentation alcoholic.

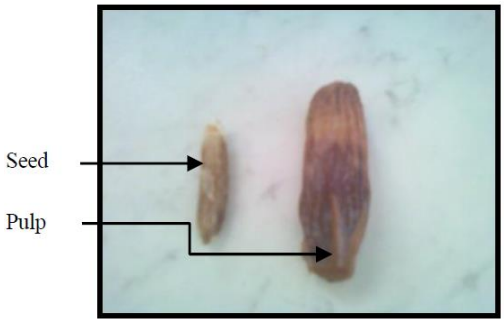

Fig. 2. Dry date section.

TABLE I: CONTENT OF SUGAR IN THE DATE PALM

Varieties Parameters	Dry dates	Soft dates
Water content %	13.70 - 15.5	25.40-37.3
Total sugar % MS	72.30 -82.46	79.80-87.42
Sucrose % MS	40.55-52.40	0.9-5

The Table I illustrate the analysis of the fermentation substrate: dry and soft date.

B. Production of Dates

In Algeria: The Date Palm is grown at the level of17 cities only, for an area of 120 830 hectares. However, four main cities represent 83.6% of the national heritage phoenicicole: Biskra 23%, Adrar 22%, El-Oued 21% and Ouargla 15% [2].

In the national territory, the variety Deglet-Nour(dates fine), occupies the first place and represents 52.87% of the total production of dates [3]. The TABLE II mentions the date palms in Algeria.

In the world: the main producer countries of dates are: Egypt, Iran, Saudi Arabia, the United Arab Emirates, Pakistan, Algeria and the Sudan. The world production of dates carried out in 2004 is 5.85 million tones; the TABLE III mentions the classification of the countries of the world by date production [4].

TABLE II: DATE PALMS IN ALGERIA

Varieties Cities	Fine date *(Deglet -Nour)*	Soft date *(Ghars)*	Dry date *(Degla-beida)*	Palm date	Number of palm date
Adrar	0	0	2150904	2904150	2860071
Biskra	1964460	436530	748200	3149190	5802012
Tamanraset	2940	0	0	417140	167760
Ourgla	1092330	783850	193130	2310069	1130667
Eloued	1884030	703330	296300	2660883	2580238
Tindouf	350	24250	0	24600	3200
Ghardaia	377100	154400	378900	910400	631600

TABLE III: DATE PRODUCTION (FAO, 2004))

Countries	Date production (quintal)
Egypt	1100 000
Iraq	910 000
Iran	880 000
Saoudi Arabia	830 000
United Arab Emirates	760 000
Pakistan	650 000
Algeria	450 000
Sudan	330 000
Oman	238 611
Libya	140 000
Tunisia	110 000
Morocco	54 000
Yemen	33 000
Mauritania	24 000
Chad	18 000
United States America	18 000
Bahrain	17 000
Qatar	16 500

From the quantitative point of view, the Algerian production represents 7 per cent of the global production, but from a qualitative point of view, it occupies the first rank thanks to the variety Deglet-Nour, the more appreciated globally [2].

The morphological characters of waste soft and dry dates are defined in Table IV and Table V.

The morphological characters of the fruit of this variety are according to the origin of seed and the studied area [9].

By studying these morphological characters of anonymous dates of the area of Adrar in the laboratory; and finds us the characters following Table V [2]:

TABLE IV: MORPHOLOGICAL CHARACTERS OF WASTE SOFT DATES

Pulp	Seed
Straight form	Straight form
Average height	Average height
Weight of 20 fruits 87 - 220g	seed/ fruit : 1/2 - 2/3
red or brown color ‘Bser’	Weight of 20 seeds : 13 - 24g
Brown color ‘tmar’	Brown color
Pleated epicarp	Smooth surface
No alteration	Groove shape: variable
Soft or elastic plasticity	Center germinal pore
Fibrous or floury texture	Long stem
Perfumed taste	Bonding tegument
Soft consistency	

TABLE V: CHARACTERS MORPHOLOGICAL OF DATES DRY

Pulp	Seed
Straight form	Straight form
Average height	Average height
Weight of 20 fruits 125.5 à135g	Weight of 20 seeds : 18 à25g
red or brown color ‘Bser’	-
Brown color ‘tmar’	-
Dry consistency	-
Fibrous texture	-
Perfumed taste	-

C. Biological Material

The yeast of bakery dries (Saccharomyces cerevisiae) [7] it is preserved in a cold and dry medium. Saccharomyces cerevisiae is a micro-organism, a particular yeast among all the leavens. Its size varies from 6 to 12 μm for the length and from 6 to 8 μm for the width Saccharomyces can produce energy necessary to its survival and its reproduction in two different ways, according to the ambient conditions. These two modes of energy production are [10]: The aerobic way and the anaerobic way: the first is used in kitchen, while fermentation is privileged for the production of alcohol [11]. The tests of fermentation are carried out in a bioreactor of 1L volume, placed in a Marie bath provided with a temperature regulator.

After several tests, one noticed that good fermentation is made at a temperature in the mesophoilic zone mésophile, of 32 ℃, optimal temperature for reproduction [12].

The date scrap (dry and soft) will undergo a thermal pretreatment, it is the first stage of the process: a dilution with hot water (90 ℃ with 95 ℃), during an optimized time; This water rich in sugar will be used thereafter as water of dilution of must.

The following figures (Fig. 3 and Fig. 4) illustrate the two varieties of dates used.

Fig. 3. Soft date.

Fig. 4. Dry date.

After of elimination the stone of the dates, we start the second physical treatment, it is the crushing of the substrate. We weigh pulp and stone of the two varieties of dates; we obtain the results presented on the following Table VI:

TABLE VI: WEIGHT OF PULP AND CORE

Variety	soft	dry
Weight of pulp (g)	162.3	173.1
Weight of stone (g)	37.6	26.9

Fig. 5. Must of soft date.

Dilution of the pulps crushed by the water, the prepared solution is called must of date (Fig. 5).

Fermentation is made in anaerobic during 72 hours. Each 24heures, one takes a quantity of must fermented to measure the following parameters and especially to detect the odor of alcohol in must.

During fermentation we followed the following parameters [13]:

- acidity of must using an indicating pH paper ,
- temperature of the bain-marie;
- temperature of the reactor;
- The rate of glucose and protein;
- Followed evolution of the color and odor of must;

After 72 H of fermentation we stop the reaction.

III. RESULTS AND DISCUSSION

The western southern area of Algeria annually produces an important tonnage of dates, approximately 675 miles quintals per year. These dates present a low commercial value, they are intended for subsistence farming, the animal feeds or the exchange in the form of barter towards Mali and Niger [3]. On the other hand, no processing industry of date, is established in the area.

For this reason these dates constitute a substrate of choice for the production of bioalcohol, The ethanol of vegetable origin is anything else only of ethanol, It can be mixed with the gasoline in proportions going from 5 to 85 %. Beyond 20 %, adaptations to the engines of cars are often necessary [7]. According to many experts and certain Western governments, the biofuels, and in particular bioalcohol, produce less emission of CO_2 which is one of principal gases for purpose of greenhouse, from where the environmental stake is preserved, in our case the ethanol produced at the laboratory presents an output of 87% [8], [9].

Results of the first test; for soft dates of mass 200g; are recorded in the Table VII.

TABLE VII: RESULTS OF THE FIRST TEST OF ALCOHOLIC FERMENTATION

Time (h)	pH	Glucose (g/l)	Protein (g/l)	T (℃)
00	5.5	300	0.3	32
24	5.5	250	0.3	34
48	5.5	10	0.05	31
72	5.5	1	0.025	30
96	5.5	0.5	-	30

After filtration of the wine we recover a volume of the formed wine of 430 ml.

In the same way for dry dates of mass 200g, the follow-up of the kinetics of fermentation is recorded in Table VIII.

TABLE VIII: RESULTS OF SECOND TEST OF ALCOHOLIC FERMENTATION

Temps (h)	*pH*	*Glucose (g/l)*	*Protein (g/l)*	*T (℃)*
00	6	10	0.05	30
24	6	5	0.025	31
48	6	2.5	0.0125	31
72	5.5	0.01	-	31
96	5.5	0.005	-	30

We filter the solution obtained, the residue recovered at the bottom of the engine is dried then weighed, and the volume of the formed wine is 430 ml.

We weigh the weight of the residue of each varieties of dates.

Concerning the dry variety, we found a weight of the residue equalizes with 39,3g (Fig 6), on the other hand for the soft variety, the weight of residue is of 12.67g (Fig 7);.

The formed wine will undergo a series of distillation to increase the alcohol level extracted dates, for the first experiment by using 165g soft dates of concentration of

300g/l of glucose, we produce a concentration of ethanol 280g/l i.e. a productivity of ethanol 3,88g/L/h. In the case of the date scrap dry of mass 173g, we found for a concentration of 100g/L of glucose, one produced 320g/L ethanol, with a productivity of 4,44g /L/h.

Fig. 6. Dry residue.

Fig. 7. Soft residue.

Fig. 8 exposes the ethanol produced by the two substrates, the date soft and the dry date [3].

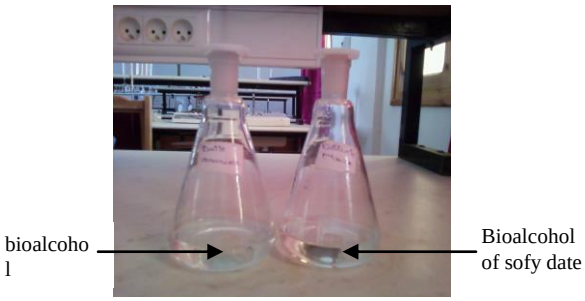

Fig. 8. Biaolcohol producted by the two varieties.

IV. Conclusion

The South West region of Algeria annually produces a substantial tonnage of dates, approximately 675 miles quintals per year. These dates have a low market value, they are intended for the own consumption, animal feed or to the exchange in the form of barter to Mali and the Niger.

On the contrary, no industry of date transformation, is established in the region, for this reason these dates constitute a choice substrate for the production of the bioethanol, according to trials performed at the level of laboratory, fermentation in the presence of the yeast Saccharomyces cerevisiae, produced the ethyl alcohol with a satisfactory output and by medium alcoholic degree, this output can augment by working on the quantity of the yeast and the quality of distillation, it is the following stage of our research work.

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