DOI: https://doi.org/10.54966/jreen.v1i1.1256

Journal of Renewable Energies

Revue des Energies Renouvelables

journal home page: https://revue.cder.dz/index.php/rer

Conference paper

Energy recovery from two low-value date varieties

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ARTICLE INFO

Article history:

Received July 31, 2024

Accepted September 4, 2024

Keywords:

Bioethanol,
Degla Beïda,
Timjouhart,
Saccharomyces cerevisiae.

ABSTRACT

Algeria produces 500,000 tons of dates a year, 53% are common varieties (Ould El Hadj 2012) (1).Production of bioethanol from two varieties of dates that are not widely marketed, Degla Beïda and Timjouhart. We analysed the physicochemical composition of the raw material: water content, acidity, °Brix degree, total sugars, reducing sugars, fat and proteins. The extracted date juice was then fermented for 72 hours and distilled to purify the ethanol. After fermentation and distillation, analyses were carried out by GCMS. The results showed that the juices extracted from the two varieties were rich in total sugars, 62.89% and 56% respectively for Degla Beïda and Timjouhart, but low in protein and fat. With regard to alcoholic fermentation, the yeast Saccharomyces cerevisiae proved effective in producing ethanol, with yields of 86.79 g/l for Degla Beïda dates and 68.64 g/l for Timjouhart dates. With the application of processing and bioprocessing technologies, these date varieties could be exploited for further opportunities in various industries.

1. INTRODUCTION

Today, the development of alternative biofuels for transport is receiving increased attention. Using by-product biomass to generate renewable energy remains a very prom- ising option compared to fossil fuels (Elbey 2023). Ethanol is a highly efficient, environmentally friendly renewable energy. Bioethanol can be produced from a variety of feedstocks using sugar, cellulosic and starch sources (Chniti 2017).

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ISSN: 1112-2242 / EISSN: 2716-8247

At present, in order to cover its various needs, Algeria imports between 30,000 and 50,000 hectolitres of ethyl alcohol per year (Acourene 2012).The conversion of by-products from the date industry into bioethanol is part of an economic and environmental approach.

However, the bio-conversion of palm waste, such as low value and waste dates, which is not readily marketable, could be involved in a future agricultural development program in Algeria (Kaidi 2001). Nowadays, with over 1,000 varieties, Algeria is the world's third largest dates producer. It appears that sorting deviations represent an average of 25% of date production annually (CHEHMA 2000). Currently, very little use is made of these by-products and they are discarded or, in limited cases, used for animal feed (Abbès 2011). Due to their high sugar content, dates can be used as a raw material in the production of various metabolites such as bioethanol (A. &. Boulal 2023). In this study, our aim is to valorize dates with low market value, namely Degla Beïda and Timjouhart, through ethanol production.

2. MATERIALS AND METHODS

Two different varieties of dates were studied Degla Beida and Timjouhart.These varieties are characterized by their low market value and their abundance.The Degla Beida and Timjouhart varieties were harvested at the Tamr maturity stage in Sidi OKBA (Biskra) in Algeria.

- **Dates compsition analysis** Dry matter was determined by oven-drying at 105 C to constant weight (AOAC 1990)(9), total nitrogen was determined by the Kjeldahl method, as described by Pearson (Pearson 1970)(10). Protein was calculated using the general factor (6.25), ash was determined by combustion of the sample in a muffle furnace at 550 ºC. Fatty acid (NF EN ISO 734-1, 2000) and total soluble solids (TSS) and titratable acidity were determined According to Anon (1990a) methods
- **Fermentation medium for ethanol production** Fruit samples were washed and rinsed with water to remove any pebbles, sand, insects or plant residues. Seeds were separated from pulp, which was grinded and diluted by adding distilled water, pH was maintained at 4 with 1 ml of sulphuric acid. The microorganism S. cerevisiae was used in the fermentation process of the date because of its cheapness, productivity, and tolerance
- **Biological material** The microorganism used for ethanol production is the yeast. Saccharomyces cerevisiae, because of its cheapness, productivity and ethanol tolerance. The yeast strain was isolated from dates at CDER, it is maintained on agar, and reactivated on Carlsberg fermentation medium to develop a high biomass.
- **Process of alcoholic fermentation** The prepared date must is transferred to a 1 litre fermenter and inoculated with sourdough. The fermentation temperature is 30°C, under anaerobic conditions for 72 hours in fed-batch mode. To monitor the fermentation, samples were taken every 24 h, for pH, ◦Brix, total sugars and ethanol content analysis.
- **Distillation** After fermenting for 72 hours, the wine obtained from the two varieties of dates is distilled using a distilling apparatus at a temperature of 78°C.
- **Ethanol identification** The instrument used to identify and quantify the compounds in both distillates obtained is the GCMS (HP Agilent Technologies 6800 chromatograph coupled to an HP Agilent Technologies MSD 5973 mass spectrometer).

3. RESULTS AND DISCUSSION

The results obtained from the physico-chemical characterization of the studied dates pulp are as follows (Table 1).

Table 1 Physico-chemical composition of different musts.

	Degla Beida	Timjouhart
Moisture	14.55%	22%
dry matter	85.45%	78%
ash	2.28%	2.8%
Titrable acidity	0.53%	0.48%
Total soluble solids	44%	40%
protein	4.37%	2.40%
fatty acid	0.27%	0.08%
Total sugars	56%	49%

The results obtained show that water content is between 14.55% and 22%. The titratable acidity is 0.53 and 0.23 for Degla Beida and Timjouhart respectively. It is therefore necessary to acid- ify the must by adding sulphuric acid to allow the Saccharomyces cerevisiae yeast to develop properly.Assuming that dates contain between 1.5 and 4% ash,it is comparable to results obtainedin this study,with ash content about 2.28% and 2.8% for Degle beida and Timjouhart, respectively . The protein content of the dates studied is low 2.40% for the Timjouhart variety, slightly lower than the 3.75% reported by (Akin 2008) (11) for the same variety and 4.37% for the Degla Beida variety. Both dates varieties are poor in fat content, sugars being the most important component. total sugar content for Degla Beïda variety is 56% and 49% for Timjouhart variety,while TSS value is about 44% and 40% for Degla Beida and Timjouhart, respectively.

Ethanol production: It is noted in Figure 1, that pH decreases during fermentation, This decline is followed by a slight increase for both varieties. The drop in pH is directly linked to the assimilation of the nitrogen source by the yeast. The increase, on the other hand, is due to a physico-chemical phenomenon. The production of alcohol from sugars leads to a change in the dissociation of the must components of the must, in particular the organic acids initially present in the must, resulting in a lower concentration of protons and therefore a higher pH. It has been shown that these two phenomena (nitrogen assimilation and the effect of ethanol on dissociation) are the main factors responsible for pH variations during must (Akin 2008) (12). However, some of the carbon dioxide produced during alcoholic fermentation dissolves in the must and also contributes to lowering the pH. The variation in °Brix during fermentation is shown in Figure 1. The °Brix of the two date varieties decreases during alcoholic fermentation and stabilises at 9 for Degla Beïda and 5.2 for Timjouhart. This decrease can be explained by sugar conversion to ethanol by the yeast Saccharomyces cereviciae.

Kinetics of fermentation: The observed changes in residual sugar content and ethanol production for both varieties are shown in Figs. 2 and 3. Regarding the variety Degla Beïda (Fig. 2), residual sugar amount decreases as ethanol production increases, reaching 2% after 72 hours of fermentation. In addition, ethanol production progresses gradually during fermentation, to reach an alcoholic degree of 5.5°, after 24 hours, then 10.6°, after 48 hours, to stabilise at 11°, corresponding to 86.79 g/l after.

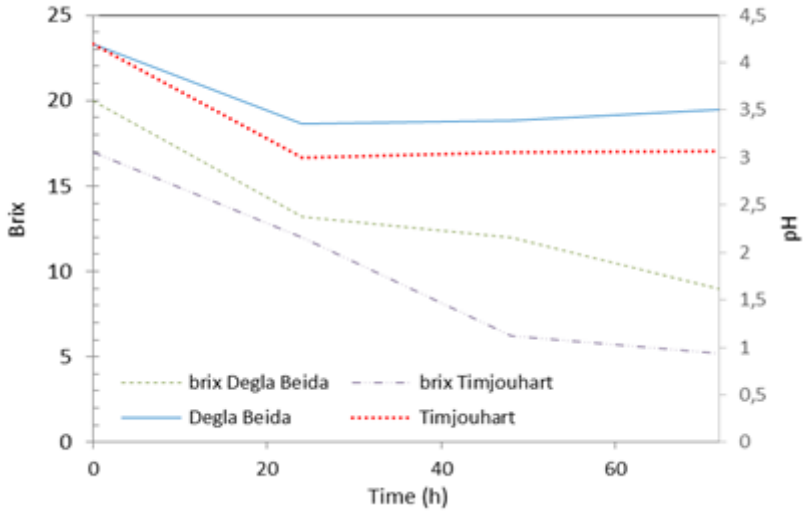


Fig. 1. Changes in pH and Brix during the alcoholic fermentation process

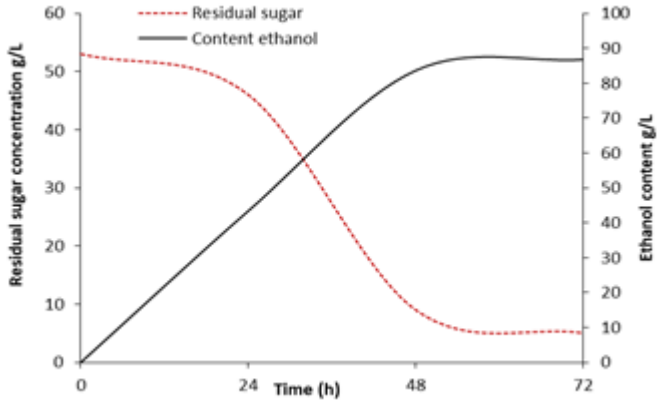


Fig.2. Changes in residual sugar and ethanol production

Regarding the variety Timjouhart (Fig. 3), during fermentation, sugar content decreases as ethanol production increases, reaching 2%, after 72 hours of fermentation. Ethanol production increases to reach an alcoholic degree of 4.9° after 24 h then 8.1°, after 48 h, to stabilise at 8.7°, corresponding to 68.64 g⁄L after 72 h.

Distillation: The two distillates collected during the distillation process are analysed by GCMS.

Analysis by GCMS of the of the distillate from the two musts shows the presence of volatile compounds, mainly in three chemical classes: 2-methyl-1-propanol, 2-me- thyl-4-butanol, 3-methyl-1-butanol, propanol, 2-methyl-1-butanol, 1-propanol and eth- anol. With a predominance of the latter, 79.287% for Degla Beïda and 79.695% for Timjouhart. However, the presence of a low concentration of acetic acid, 1.851% for Degla Beïda and 4.752% for Timjouhart, is probably due to the ingress of oxygen at some point during fermentation. In the presence of oxygen, some of the acetaldehyde is converted to acetic acid instead of ethanol, or some of the ethanol is converted to acetic acid.

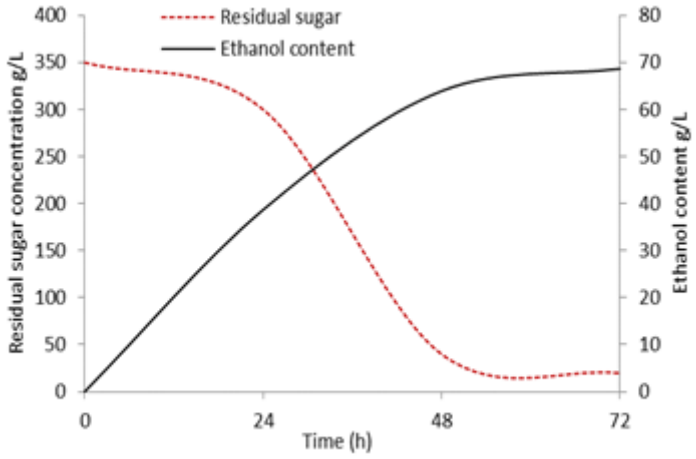
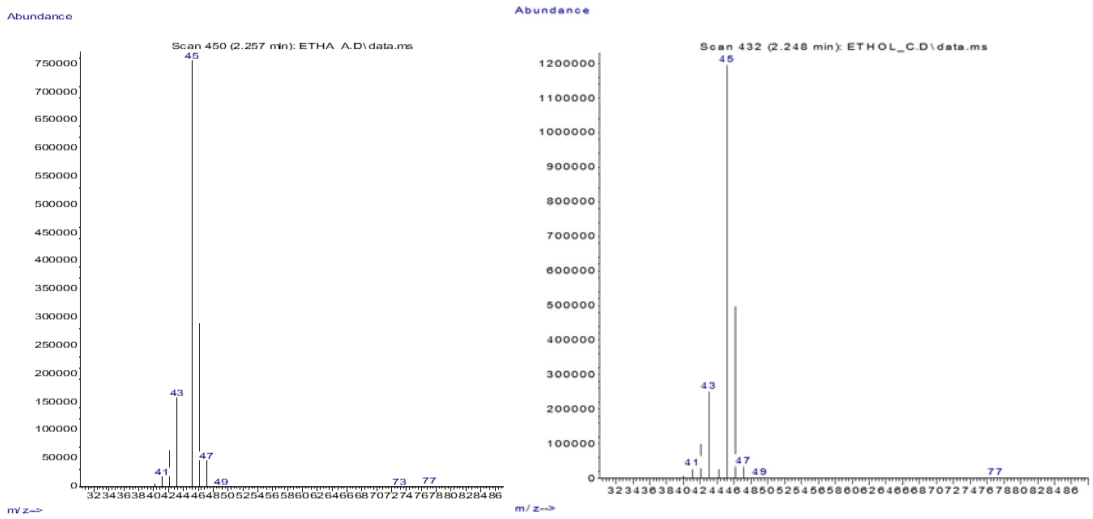


Fig. 3. Changes in residual sugar content and ethanol production during fermentation of Timjouhart must



A B

Fig.4. GCMS spectra of the must distillate of Degla Beïda (A) and Timjouhart (B) varieties

CONCLUSION

In view of the results obtained, date must appears to be a sugar-rich medium that can be easily assimilated by native Saccharomyces cerevisiae yeast strain, isolated at CDER , which is capable of carrying out a successful fermentation process with good alcohol productivity. In conclusion, the two varieties of dates studied in this study are a high-energy food, rich in easily

assimilated sugars. Considered as a raw material, these dates offer enormous possibilities if their development by means of processing and bioprocessing technology is envisaged.

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