ENERGY-QUALİTY ASSESSMENT OF THE PHOENİCİCOLE BİOMASSBİOFUEL.TİMJAUHART AND TAFİZİOUİN CULTİVAR CASE

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Abstract— The recovery and the preservation of oasis biomass is significantly contributing inthe expansionof oasis spaces. Its volume, availability and geographic dispersalmake difficult to be valorized through this weakly ecosystem. Inthis view, the objective of the current study focus on theaccurateevaluation of the energy quality ofthis biomass potential which is considered as the main step for such optimal and integrated assessment. Within the scope of the mentioned study, the proposedapproach is based on:the chemical and thermal characterization of the biomass (immediate, mineral and ultimate), considering the varietal aspect; as well as a preliminary statistical treatment of the data (ANOVA….).The last consists ofhundred elements and completed by other analyzes (ACP…) n order to obtain a classification of the biomass that has been studied by considering the most significant parameters. The studiedbiomass corresponds to the cultivars by-products of the Guerrara oasis namely Timjauhart and Tafiziouin. Theobtainedresults revealedinone hand the compatibility of phonenicicole biomass with conventional biofuelsandinthe other hand its heterogeneity translated by obtaining four distinct groups.

Keywords: Chemical and energetic characterization, Phoenicicole biomasse, Classification, Statistical analyzes.

1. Introduction

Nowadays, the development of biomass energy knows a global evolutionfor partial or total substitution of fossil fuels use (oil, coal, gas ..).In the oasis context,the date palm (phoenix dactylifera L.) appears to be a promising biomass for such valorization.Thus, the energy quality evaluation of this resource is a significantstep for optimizing suchpotential thermoconversionsselection[1-5].

The choice of this biomass is provedby its ecological prominencein the local ecosystem (oasis).Consequently its abundance and availability: indeed, a recent estimate of this resource has shown that the algerian phoenicultural field contains 18 201 640 palms [6]. This generates near 807,992 tons of lignocellulosic waste . At the local scale, this same study has revealed appreciable quantities of phoenicultural biomass [3, 7].

Otherwise , the energy and chemical quality analysis of the two main date palm cultivars (Deglet Nour and Ghars) showed the compatibility of this biomass with conventional solid biofuels. Indeed, the immediate composition showed a low moisture content (~ 5%), a high content of volatile matter and a variable ash content. On a calorimetric basis, the caloric value of this biomass is estimated at an average of 18 MJ / kg. Finally, an advantageous elemental composition was also revealed for the studied phoenicole biomass [3-5].

Considering the phytogenetic aspect of the date palm, Algeria has an important biodiversity which is reflected by the presence of nearly a thousand cultivars [8]. This leads us to take an interest in these different varieties and to study their abilities and energy limitations. The adopted subject is scheduled in the research thema of (Applied Resaerch Unit for Renewable Energy) URAER (Ghardaïa - Algeria) whichaims to the assessment of biomass deposit in the arid and semi-arid area. This paper targeted the determination of chemical characteristics related to the thermochemical transformations i.e the proximate analyzes (moisture, ash, volatile matter and fixed carbon), calorimetry (calorific value)and

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ultimate analysis (CHObased on empiric model)..

The study focused on two cultivars of Guerrara oasis - Algeria (Latitude: 32 ° 47 'North Longitude: 4 ° 30 East) namely Timjauhart and Tafiziouine

. The studied biomass correponds to the main mobilized phoenicicoles by-products (date palm lif (LIF), palms (DJ), date palm petiole (KER), fruit bunch (ARJ), spathe (KH), date palm rachis (AD) and fruit stalk pruning (SA).

Thus this study will enable us to answer and address the following research questions:

- What is the precise chemical composition of the different phoenicicole biomass components?
- What are the most chemically interesting phoenicicoles by-products for an eventual energy recovery?
- Has the diversity factor (variety/ cultivar) influence on phoenicicole biomass energy characteristics?
- What are the main correlations between the different parameters?
- What are the main phoenicultural categories identified based on the chemical and calorific parameters?

2. Methods

2.1. Sample preparation and analysis

Sampling, sample preparation and analysis were conducted according to the standards described in the reference [1, 2] . The samples invetigated represent the main date palm by-products (*phoenix dactylifera L.*) corresponding to TIMJAUHERT and TAFAZOUINE from Guerrara oasis (see Table 1 et 2).

Table 1.*Designation of the Main Palm Tree by-Products Subject of This Study*

Local designation	Lif (LIF)	Djerid (DJ)	Kernaf (KER)	Arjoun (ARJ)	Khallab (KH)	Addaf (AD)	Saqqas (SA)
Scientific designation	Fibrilium, lif	Palm	Petiole, kernaf	Fruit buch	Spathe	Rachis	fruit stalk pruning

Table 2.*Sampling, sample preparation and analysis standard*

Protocols and Analyzed Parameters	HigherHeating Value (HHV)	Moisture (M)	Volatile matter (VM)	Ash (A)	FixedCarbone (FC)	Mass fractions of the elementary composition (CHO)
Methods and utilized Norm	UNE-EN 14918	UNE-EN 14774-2	UNE-EN 15148:2010	UNE-EN 14775	FC= 100-VM- A	Mathematical model designed by Jigisha Parikh [9]

2.2. Statistical treatment

Principal Component Analysis (PCA) and Kmeans are the statistical methods used for the classification of the studied phoenicole biomass based on the measured / calculated chemical parameters: immediate composition and calorific value.
The analysis of variance ANOVA is the method used for the study of chemical parameter variability intra and between the cultivars and the phoenicicole by-products considered.

3. Results

3.1. Proximate composition

Figure1 represents the immediate composition of the phoenicicole biomass corresponding to the Timjuhart and Tafiziwin cultivars from Guerrerra oasis.

Moisture

Generally, moisture varies between (5,04 ±0,04) MJ/kg (AD_TIM) and (9,14 ±0,05) MJ/kg (KER_TAF) ; it is estimated on average at (6,19±0,05) MJ/kg (KH_TAF).
A comparison of the date palm by-products gives the following classification:

- AB(5,90%) < PB(6,40) < HAB,HAR,CB(12) < HAG (13) < WWB(19),considering solid biofuelscited in the literature [10, 11, 12].
- SAQ (5,72%) < DJ (5,79%) < ARJ (5,81%) < KH (6,10%) < LIF (6,37%) < AD (6,83%) < KER (8,05%) considering the studied waste.
- **TIM (5,93 %)<TAF (6,45 %)**, considering the studied cultivars.

The studied phoenicicole waste contains low moisture content (6,4% on average), which favors thermo-conversion without preliminary treatment [10].

Volatile matter

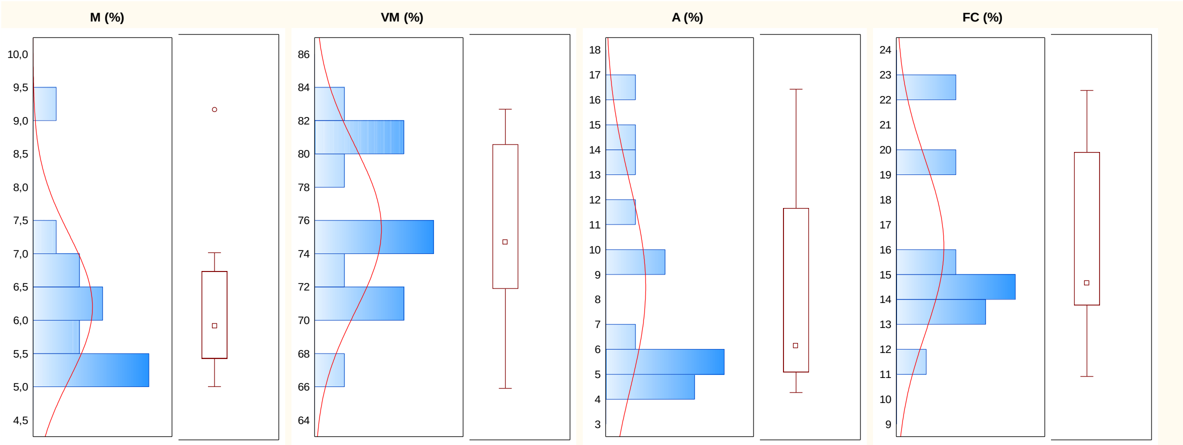
A classification of the studied biomass with the biofuels quoted in literature, place phoenicicole by-products in the following order : PB (74,64%) > HAG (69,00%) > HAS (66,70%) > HAB (66,00%) > HAR (64,60%) > CB (63,70%) > WWB (62,90%) > AB (52,50%). Overall, the volatile matter content of the palm by-products studied is high (~75%) in comparison with conventional solid biofuels which reflects an interesting thermal reactivity [11]. and gives it a low ignition temperature. However, this volatile fraction, which may be organic or inorganic, and which includes hydrocarbons, CO, CO2, H and tar; maintained quickly by burning [12]. Despite the small difference in this parameter between cultivars, the Timjuhart variety appears to be the most attractive because of the high value in volatile matter.

Ash

An intermediate ranking of the date palm byproducts with the solid biofuels reported in the bibliography was highlighted: AB (30,90%)> CB (18,60%)> PB (9,04%)>HAS (8,60%)> HAB (5,70%)> HAR (5,00%)> HAG (4,80%)> WWB (3,50%) [11]. The mineral composition of the studied phoenicicole biomass approximates that of the straw (HAS) whose ash content is estimated at 8,60%. This high ash content constitutes a limiting criterion for a possible energy recovery. This is precisely the case of fibrilium byproducts and palmswhose ash composition is close to that of fossil fuels, wastewater, greenhouse waste, droppings (4 - 52%). In contrast to this waste, the inflorescence contains the lowest ash content.

Fixed carbon

As we can see in figure 1, fixed carbone (FC) variesbetween11,010 ± 0,063% (ARJ_TIM) and 22,300 ±0.617% (LIF_TIM), It is estimated on average at 16,0930 % (LIF_TAF). Let's remember that (FC)is calculated as the difference between 100% and the sum of VMs and ashes (% dry weight). This values range (7 - 27%) related to the studied phoenicicole biomass is included in that of conventional biofuels (1 to 38%)[3, 5].
A significant variability of the fixed carbon is revealed by the analysis of the variance ANOVA (threshold of significance p-value = 2% <5%) (see table 3).



	M (%)	VM (%)	A (%)	FC (%)
N:	14	14	14	14
Mean:	6,191	75,43	8,479	16,09
Median:	5,941	74,70	6,203	14,68
Min:	5,041	66,05	4,371	11,01
Max:	9,139	82,58	16,34	22,30
L-Qrt:	5,456	71,95	5,172	13,82
U-Qrt:	6,745	80,51	11,65	19,86
Variance:	1,185	24,63	17,02	12,12
SD:	1,089	4,962	4,126	3,481
Std.Err:	0,291	1,326	1,103	0,930
Skw:	1,555	-0,115	0,808	0,787
Kurt:	3,198	-0,802	-0,782	-0,536
95% Conf SD				
Lower:	0,789	3,598	2,991	2,523
Upper:	1,754	7,995	6,647	5,608
95% Conf Mean				
Lower:	5,562	72,57	6,096	14,08
Upper:	6,820	78,30	10,86	18,10

Figure 1.*Proximate composition ofphoenicicole biomass*

3.2. Elementary and calorimetric composition

Figure 2 represents the elementary and the calorimetric composition of the phoenicicole biomass corresponding to the Timjuhart and Tafiziwin cultivars from Guerrerra oasis.
The calorific value of all phoenicicole by-products studied appears to be very advantageous (average of 19 MJ / kg) in comparison with solid biofuels quoted in the literature [11],this is precisely the case of the inflorescence while the fibrilium part is the least interesting thermally.
The elementary composition is also interesting for all the by-products studied at except fibrilium CHO which are far below the values found.On the other hand, the maximum carbon values, estimated between 45 and 48%, are attributed to the inflorescence part (spath and peduncle of the diet) of the studied cultivars.
The analysis of variance ANOVA (Table3), reveals that the ultimate composition of the studied biomass does not know any important variability. An exception is found for the Lif part, whose CHO content is much lower compared to the other phoenicicole by-products and the solid biofuels quoted in the biography [10, 11]. This means that Fibrilium has a low energy density which is confirmed by the heating value (HHV) [3, 5]
Taking into consideration the different byproducts of each cultivar, we can say that the hydrogen and oxygen content have the same tendency; they are low for the fibrilium parts and relatively high for the inflorescence parts (bunches and spathes).Ashes have a major effect on the energy quality of biomass in general, and phoenicicole byproducts in particular. Indeed, two major (inverse) correlations have been established: the one with the calorific value and the other with volatile matters.

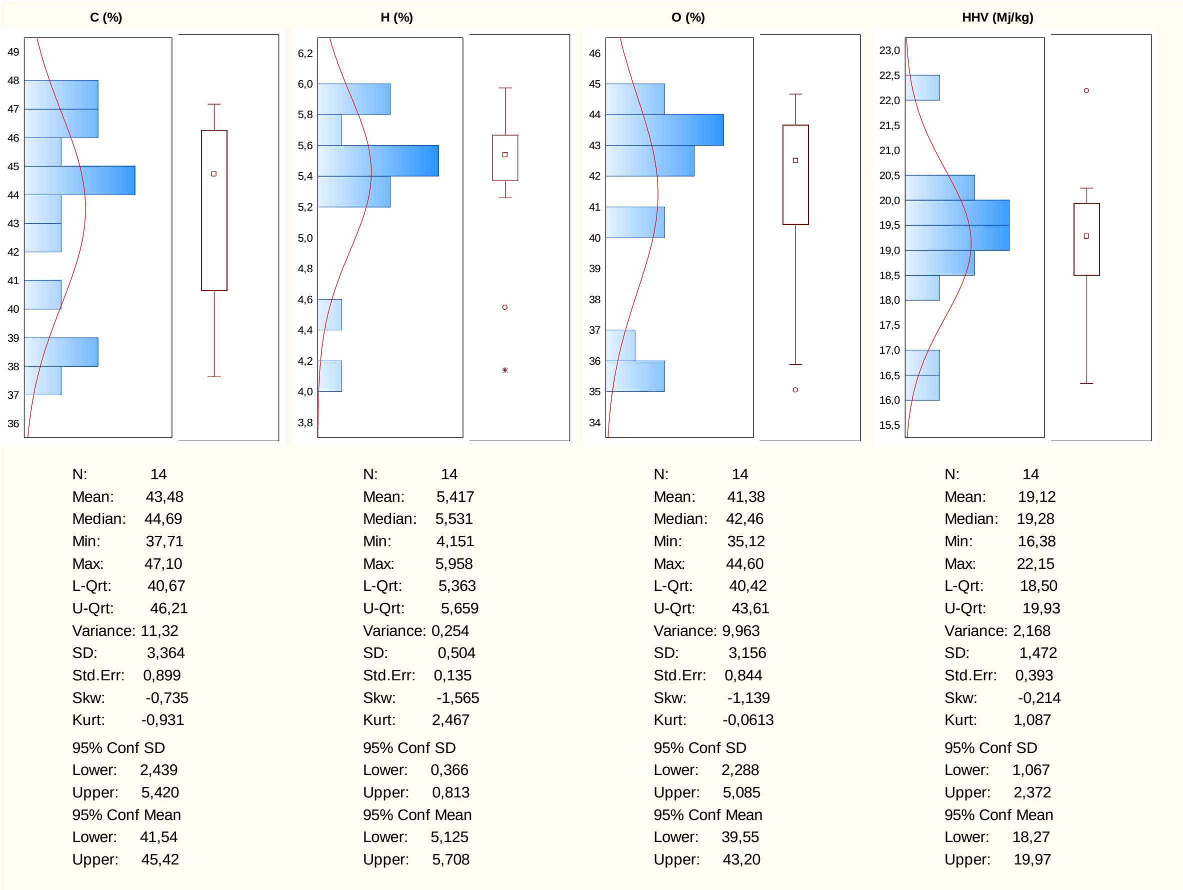


Figure 2.*Ultimate and calorific composition of phoenicicole biomass*

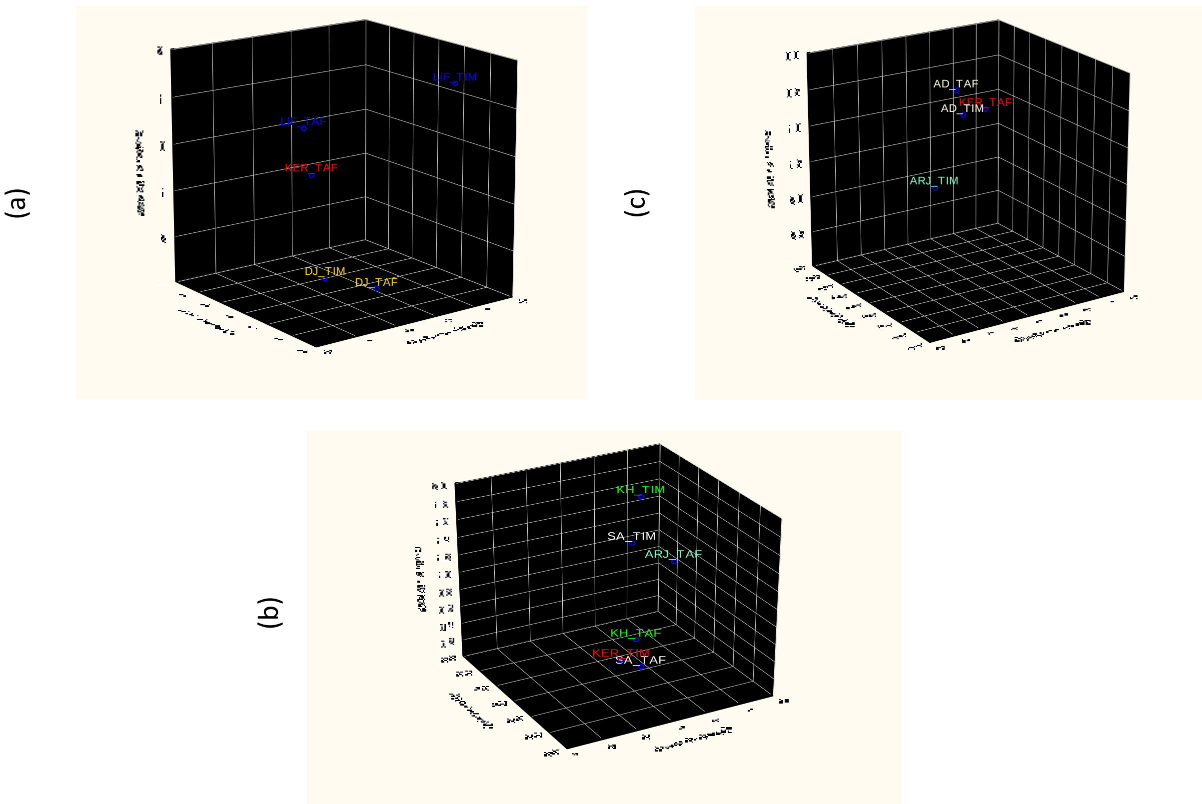


Figure 3. *Classification of phoenicicole biomass ((a)Group1 (b) Group2 (c) Group3)*

Table 3.Analysis of Variance (ANOVA) of elementary composition calculated from TIM and TAF cultivar

		Source of variations	*Sum of squares*	*Degrees of freedom*	*Mean square*	*F*$^{(a)}$	***P-VALUE (%)***
Proximate composition	**VM**	Between Groups	508,69	7	72,67	1,89	9%
		Within Groups	1844,85	48	38,43		
		Total	2353,54	55			
	A	Between Groups	107,77	7	15,40	0,51	82%
		Within Groups	1439,23	48	29,98		
		Total	1547,00	55			
	FC	Between Groups	328,23	7	46,89	2,67	2%
		Within Groups	843,08	48	17,56		
		Total	1171,32	55			
Ultimate composition	**C**	Between Groups	27,16	7	3,88	0,51	82%
		Within Groups	362,11	48	7,54		
		Total	389,27	55			
	H	Between Groups	0,49	7	0,07	0,63	73%
		Within Groups	5,35	48	0,11		
		Total	5,84	55			
	O	Between Groups	40,08	7	5,73	0,87	54%
		Within Groups	315,22	48	6,57		
		Total	355,30	55			
	HHV	Between Groups	16,00	7	2,29	1,14	35%
		Within Groups	96,27	48	2,01		
		Total	112,26	55			

(a) Test of Fischer

3.3. *Group identification* **:**

The classification of 14 phoenicicole biomass samples corresponding to the main byproducts of the two cultivars studied, was carried out by the principal component analysis (PCA) and illustrated in Figure 3.This classification identified the following three groups: The first consistsof the fibrilium part and the palm (DJ), is characterized by low thermal reactivity due to high ash and lignin content.The second corresponds to the inflorescence part, petiole and rachis. This group has a very interesting thermal reactivity which favors a possible thermo-conversion. Finally, the last group consisting of palm parts (petiole and rachis), has intermediate thermochemical characteristics.

4. Conclusion

This study allowed the evaluation the energy quality of the date palm main by-products of the correponding to the two cultivars Timjauhart and Tafiziouine from the Guerrara oasis. This contribution is based on the the realization of the proximate analyzes (moisture, ash, volatile matter and fixed carbon), calorific value measurement and determination of the elemental composition.This work revealed a compatibility of chemical composition and calorific properties related to the phoenicicole biomass in comparison with conventional biofuels. The moisture constitutesan advantageous energetic criterion for the studied biomass which doesn't needpreliminary heat treatment. Whereas the ash could be a limiting parameter for possible energy recovery(especially for the fibrilium) and has an inverse correlation on volatile matter and the calorific value.The classification of the studied phoenicicole biomass showed its heterogeneity and revealed the most recommended by-product and the least interesting in terms of energy. This classification based on the calorific value and the immediate composition led to the identification of three groups. The first one constituted of the fibrilium (LIF) and the palm (DJ), is characterized by a low thermal reactivity due to a high content of ash and lignin. The second corresponds to the inflorescence part, petiole and rachis. This group has a very interesting thermal reactivity which favors a possible thermoconversion. Finally the last group constituted by palm parts (petiole and rachis), has intermediate thermochemical characteristics.

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6. Nomenclature

%	: Percent	HHV	: Higher heating value (Mega joule/kg)
A	: Ash concentration (%)	KWh/Kg	: Kilowatt Hours per kg
AB	: Animal biomass	M	: Moisture concentration (%)
C	: Carbon Mass Fraction (%)	MJ/Kg	: Mega joule per kilogram
CB	: Contaminated biomass	O	: Oxygen Mass Fraction (%)
CF	: Fixed Carbon (%)	PB	: Palm date biomass
H	: Hydrogen Mass Fraction (%)	TAF	: TAFIZIWIN cultivar
HAB	: Herbaceous and agricultural biomass	TIM	: TIMJUHART cultivar
HAG	: Grasses	URAER	: Unit of Applied Research in renewable energies Ghardaïa
HAR	: Other residues	VM	: Volatile matter (%)
HAS	: Straws	WWB	: Wood and woody biomass

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