Analysis of Liquid Fuel Calorific Value

Jeevanantham. S[a*]
[a*] Assistant Professor,
Department of Mechanical Engineering,
Gnanamani College of Technology, Namakkal,
Tamilnadu, India.

Venkatesh. S[b], Sudharson. M[c], Indresh. J[d], Sasikumar. R [e]
[b,c,d,e]UG Scholar,
Department of Mechanical Engineering,
Gnanamani College of Technology, Namakkal, Tamilnadu, India.

Abstract:- **Biodiesel has recently received increasing attention because of many advantages such as higher cetane number and flash point compared to diesel fuel. However, corrosion of engine parts exposed to biodiesel or biodiesel-diesel fuel blends is still a critical challenge in the biodiesel industry. In the existing literature, there is still a lack of systematic studies including corrosion process in light alloy and changes in mechanical and fuel properties of engine parts (such as brass) after exposure to biodiesel. Therefore, in this study, (1) waste sunflower oil biodiesel (WSOB, B100) was supplied and blended with diesel fuel (B0) at the volume ratios of 10%, 20%, and 40%, which are called as B10, B20, and B40, as usual.**

Key words: Coal, Calorific Value, XRF, DTA, DSC, Bomb Calorimeter, Indian Standards (IS), ISO, ASTM

INTRODUCTION:-

The olive pomace is the solid byproduct that results from the olive oil industry. Until very recently, the accumulation of olive pomace in the premises of the olive mills in Jordan constituted a very heavy burden on the environment due to the lack of large-scale useful uses for such material. However, since the turn of the twenty-first century, the olive pomace in Jordan has become a precious asset for olive mills owners due to the heavy demand on its use as a solid fuel useful for heat generation during winter time especially in residential space heating.Unlike exhausted olive pomace, which is practically oil-free pomace, the olive pomace in Jordan is a crude po-mace that retains its residual oil.

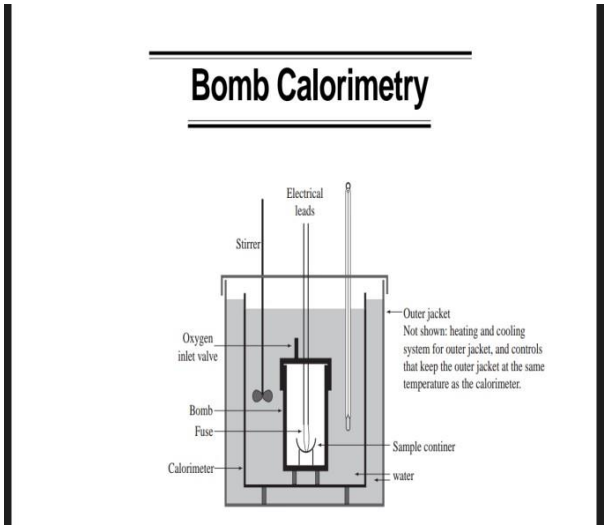
LITERATURE OF SURVEY:-

- *1)Hai -Jun Su (University of Maryland Baltimore County), Denis V.Dorozkhin (Iowa State University), Judy M. Vance (Iown State University IA-50011 , 2009):*
"A screw theory based approach for the design of flexure based joints for compliant mechanisms is introduced in this paper."
- *2) Chris Rorresl , Hydraulic Research Vol. 126 No. 1, January 2000:*
" This papers focus on the geometry of an Archimedes screw is governed by certain external parameters (its outer radius, length, and slope) and certain internal parameters (its inner radius, number of blades, and the pitch of the blades)."
- *3) L Janssen, A phenomenal logical study of twin screw extruder 1976 :*
"This study was designed to screen theophylline (125mg) tablets manufactured via twin screw granulation."
- *4) Jer-Rong Jang Shen-Tarng Chiou*, Chong-Gaung Chen* 12th IFTOMM World*

MATERIAL AND EXPERIMENTAL PROCEDURE:

A brief description of the samples used in the present study is given in Table 1. All the reported measurements concerning the wood and pomace samples were carried out on powder samples. A hand-held drill was used to get samples from the wood chunks; further grinding was achieved by using a laboratory grinder. The bark of wood samples was excluded. The grinder was also used for preparing the powder of the olive pomace samples. Care was taken to avoid formation of oil droplets due to heat generated during the grinding step of the pomace samples. The liquid samples of olive oil, kerosene, and diesel were used as received. The sulfur and nitrogen content of these liquid samples was determined by X-ray fluorescence. The nitrogen content of the wood and olive pomace samples was estimated from the acid wash at the end of the oxygen bomb calorimetric measure-ment. NaOH with molarity of 0.0866 M was used for titrating the acid wash with phenolphthalein as indicator. The moisture content of the solid samples was determined by drying at 110˚C for about 15 hours in a conven-tional drying oven. The ash content of the solid samples was determined by burning the test sample in a muffle furnace at 600˚C for three hours. The reported results of moisture and ash content are averages of two runs. Per-centages of carbon and hydrogen of wood and olive pomace were determined by using an elemental analyzer. The thermogravimetric analysis of the wood and olive pomace samples was carried out by using a TGA-50

Shimadzu Thermogravimetric Analyzer stationed at the Research Laboratories Division, Jordan University of Science and Technology (JUST).



The pyrolysis thermograms were recorded under the following conditions: An inert atmosphere of nitrogen at a flow rate of 50 ml per min, a heating rate of 25˚C per min from room tempera-ture up to about 600˚C, and the use of aluminum crucibles with pierced lids. The heat of combustion (gross ca-lorific value, GCV) measurements were carried out by using an adiabatic oxygen bomb calorimeter (IKA C 2000 Calorimeter System) stationed at the Royal Scientific Society (RSS). The reported data of the GCV are averages of two runs.

MOISTURE AND ASH CONTENT: MOISTURE CONTENT:

The results of moisture content are given in Table 2. All of the samples have moisture content less than 10%. The differences in the moisture content among the samples reflect variations in sample history. With the excep- tion of sample KT7 which received special treatment of not being exposed to direct sun light, the moisture con-tent of KT26 and its sieved fractions seems to be higher than that of the other olive pomace samples. Samples KT26-KT32 had not been stored for long and presumably contained appreciable volatile matter to be lost in the moisture determination experiments. Being the one with smallest particle size, sample KT32 is a fine powder which is expected to have the highest surface area. Fine powder samples usually retain much water and other volatiles which necessarily lead to higher moisture loss upon heating.

ASHE CONTENT:

Examination of the ash percentages given in Table 2 indicates that the percentages fall in the range 0.5% to 6%. It should be mentioned that samples KT23 and KT24 are hand- separated pulp and pits fractions of a batch of sample KT25 with mass proportions equal to 55% pulp and 45% crushed pits. Based on this information and the ash percentages of samples KT23 and KT24, the calculated ash percentage of sample KT25 is 3.081% which is less than the actual value by 7.6%. Within the limits of experimental error, this result is an indication of self-consistency in the results of these three samples. However, such self-consistency was not observed for sample

KT26 and its sieved fractions given in Section 3.2.3; presumably due to the fact that each sieved fraction is a mix of variable proportions of both pits and pulp fractions. The gradual increase in the ash content as the particle size diminishes is quite evident in Table 2 for the sieved fractions. Based on differences in physical hardness of pits and pulp, it is quite reasonable to assume that samples KT27, KT28, and KT29 are fractions rich in mill-crushed pits. The average ash% of these three samples is 1.064%, which is close to the ash% of the pure pits of sample KT24. On the other hand, samples KT30, KT31, and KT32 can be assumed to be rich in crushed pulp. Among these samples, sample KT32 with ash% equal to 88% of that of the pure pulp of sample KT23 seems to be the fraction with highest pulp content. The ash content of the pit sample reported in the present study falls in a literature range of 0.35% - 1.55% .

METHODOLOGY

Fig.1 describes the steps, processes and methods used to produce biodiesel product. This process started from free fatty acid to determine acid value and step of process. Second process is drying to remove water in FAME and last process is analysis to determine contents of FA ME. Waste cooking oil(WCO) was collected from the street sellers in Salem, Namakkal, Erode.

COLLECTING WASTE COOKING OIL

⇩

FINDING ACID NUMBER

⇩

TRANSESTERIFICATION

⇩

BIODIESEL PRODUCTION

⇩

SEPARATION

⇩

BLENDING

⇩

ANALYSIS & RESULT

Figure 1:Overall flow process

OPERATING THE 1108 OXYGEN BOMB :

Detailed instructions for preparing the sample and charging the 1108 oxygen bomb are given in Instruction Sheet, No. 205M. Follow these instructions carefully, giving particular attention to the precautions to be observed in charging and handling the bomb.

OPERATING THE CALORIMETER:

All operations required to test a sample or to standardize the 1341 plain calorimeter should proceed step-wise in the following manner:

1. Prepare the sample and charge the oxygen bombas described in Instruction Sheet No. 205M.

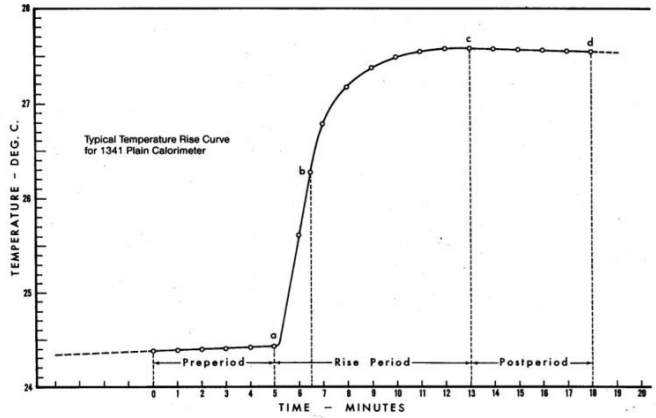
2. Fill the calorimeter bucket by first taring the dry bucketon a solution or trip balance; then add 2000(+/-0.5) grams of water. Distilled water is preferred, but demineralized or tap water containing less than 250 ppm of dissolved solid is satisfactory. The water temperature should be approximately 1.5°C below room temperature, but this can be varied to suit the operator's preference. It is not necessary to use exactly 2000 grams, but the amount selected must be duplicated within +/-0.5 gram for each run. Instead of weighing the bucket it can be filled from an automatic pipet or from any other volumetric device if the repeatability ofthe filling system is within +/-0.5 ml. and the water temperature is held within a 1ºC range.

3. Set the bucket in the calorimeter.Attach the lifting handle to the two holes in the side of the screw cap and partially lower the bomb in the water. Handle the bomb carefully during this operation so that the sample will not be disturbed. Push the two ignition lead wires into the terminal sockets on the bomb head. Orient the wires away from the stirrer shaft so they do not become tangled in the stirring mechanism. Lower the bomb completely into the water with its feet spanning the circular boss in the bottom of the bucket. Remove the lifting handle and shake any drops of water into the bucket and check for gas bubbles.

4. Set the cover on the jacket. Turn the stirrer by hand to be sure that it runs freely; then slip the drive belt onto the pulleys and start the motor. Turn on the 6775 Digital Thermometer.

5. Let the stirrer run for 5 minutesto reach equilibrium before starting a measured run. At the end of this period record the time on the timer of the 6775 Digital Thermometer and read the temperature.

6. Read and record temperature sat one- minute intervals for 5 minutes. Then, at the start of the 6thminute… 7. Stand back from the calorimeter and fire the bomb by



pressing the ignition button and holding it down until the indicator light goes out. Normally the light will glow for only about ½ second but release the button within 5 seconds regardless of the light. Caution: Do not have the head, hands or any parts of the body over the calorimeter when firing the bomb; and continue to stand clear for 30 seconds after firing.

8. The bucket temperature will start to risewithin 20 seconds after firing. This rise will be rapid during the first few minutes; then it will become slower as the temperature approaches a stable maximum as shown by the typical temperature rise curve below. It is not necessary to plot a similar curve for each test, but accurate time and temperature observations must be recorded to identify certain points needed to calculate the calorific value of the sample.

CALCULATING THE HEAT OF COMBUSTION :

Assembly of Data.The following data should be available atthe completion of a test in a 1341 calorimeter:

a = time of firing

b = time (to nearest 0.1 min.) when the temperature reaches 60 per cent of the total rise

c = time at beginning of period (after the temperature rise) in which the rate of temperature change has become constant

ta = temperature at time of firing tc= temperature at time c
r1= rate (temperature units per minute) at which the temperature was rising during the 5-min. period before firing

r2= rate (temperature units per minute) at which the temperature was rising during the 5-min. period after time c. If the temperature was falling instead of rising after time c, r is negative and the quantity -r (c-b) becomes positive and must be added when computing the corrected temperature rise

c1 = milliliters of standard alkali solution used in the acid titration

c2= percentage of sulfur in the sample

c3 = centimeters of fuse wire consumed in firing

W = energy equivalent of the calorimeter, determined under standardization

M = mass of sample in grams

Temperature Rise:

Compute the net corrected temperature rise, t, by substituting in the following equation:

t = tc- ta - r1(b-a) - r2(c-b) **Thermochemical Corrections:**
Compute the following for each test:
e1= correction in calories for heat of formation of nitric acid (HNO3)

= c1 if 0.0709N alkali was used for the titration

e2 = correction in calories for heat of formation of sulfuric acid (H2SO4)

= (13.7) (c2) (m)

e3 = correction in calories for heat of combustion of fuse wire

= (2.3) (c3) when using Parr 45C10 nickel chromium fuse wire, or

= (2.7) (c3) when using No. 34 B. & S. gage iron fuse wire.

Gross Heat of Combustion:

Compute the gross heat of combustion, Hg, in calories per gram by substituting in the following equation:

Hg=(t W - e1 –e2 - e3)/m Example.
a = 1:44:00 = 1:44.0

b = 1:45:24 = 1:45.2

c = 1:52:00 = 1:52.0

ta = 24.428 + .004 = 24.432 °C

tc = 27.654 + .008 = 27.662 °C

r1 = + .010 °C /5 min. = + .002 °C /min. r2 = - .004 °C /5 min. = .001 °C /min.
c1 = 23.9 ml.

c2 = 1.02% Sulfur

c3 = 7.6 cm. Parr 45C10 wire W = 2426 calories/ °C
m = .9936 grams

t = 27.662-24.432-(.002) (1.4)-(-.001) (6.6)

= 3.234 °C

e1 = 23.9 calories

e2 = (13.7) (1.02) (.9936) = 13.9 calories

e3 = (2.3) (7.6) = 17.5 calories

Hg = [(3.234) (2426) – 23.9 – 13.9 – 17.5]/0.9936

= 7841 calories/ gram
= (1.8) (7841) = 14,114 Btu/lb

Standardization Procedure:

The procedure for a standardization test is exactly the same as for testing a fuel sample. Use a pellet of calorific grade benzoic acid weighing not less than 0.9 nor more than 1.25 grams. Determine the corrected temperature rise, t, from the observed test data, also titrate the bomb washings to determine the nitric acid correction and measure the unburned fuse wire. Compute the energy equivalent by substituting in the following equation:

W=(Hm+e1+e3)/t

W = energy equivalent of the calorimeter in calories per °C (Centigrade)

H = heat of combustion of the standard benzoic acid sample in calories per gram

m = mass of the standard benzoic acid sample in grams

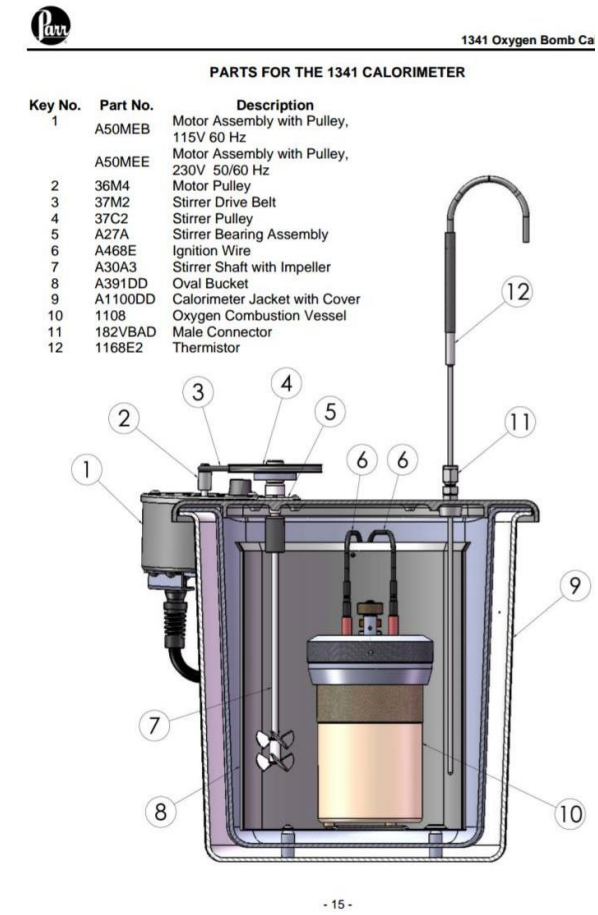
t = net corrected temperature rise in ° C

e1= correction for heat of formation of nitric acid in calories.

e3= correction for heat of combustion of the firing wire in calories.

PARTS FOR THE 1341 CALORIMETER:

The 1341 calorimeter parts and working operation was briefly explained by given following figure.



1341 Oxygen Bomb Ca

PARTS FOR THE 1341 CALORIMETER

Key No.	Part No.	Description
1	A50MEB	Motor Assembly with Pulley, 115V 60 Hz
	A50MEE	Motor Assembly with Pulley, 230V 50/60 Hz
2	36M4	Motor Pulley
3	37M2	Stirrer Drive Belt
4	37C2	Stirrer Pulley
5	A27A	Stirrer Bearing Assembly
6	A468E	Ignition Wire
7	A30A3	Stirrer Shaft with Impeller
8	A391DD	Oval Bucket
9	A1100DD	Calorimeter Jacket with Cover
10	1108	Oxygen Combustion Vessel
11	182VBAD	Male Connector
12	1168E2	Thermistor

- 15 -

GENERAL PROPERTIES FOR SOME COMMON FUELS:

This data is aggregated from 26 sources in order to give a representative view of each fuel's properties, with global scope and no specific application. The tables on the following pages give the data presented in each source, which can be used to represent more specific situations (e.g. automobile fuels in Europe).

		Density at STP (kg/m³)	Ratio of HHV to LHV energy content	Net Calorific Value / LHV (MJ/L)	(MJ/kg)	Gross Calorific Value / HHV (MJ/L)	(MJ/kg)	Carbon Intensity (g CO_2-eq / MJ LHV)
Crude Oil		856 ± 24	1.052 ± 0.001	36.84 ± 1.05	43.05 ± 1.40	38.76 ± 1.10	45.30 ± 1.47	73.5 ± 2.6
Petrol / Gasoline		741 ± 4	1.063 ± 0.015	32.70 ± 0.44	44.15 ± 0.74	34.77 ± 0.47	46.94 ± 0.70	70.8 ± 4.4
Diesel		837 ± 8	1.063 ± 0.011	35.94 ± 0.45	42.91 ± 0.46	38.19 ± 0.47	45.60 ± 0.49	74.3 ± 2.3
Fuel Oil		959 ± 17	1.058 ± 0.008	39.21 ± 1.09	40.87 ± 0.94	41.50 ± 1.15	43.26 ± 1.00	77.8 ± 2.1
LPG		533 ± 18	1.077 ± 0.008	24.67 ± 0.80	46.28 ± 0.74	26.57 ± 0.86	49.84 ± 0.80	63.9 ± 2.1
Kerosene		807 ± 6	1.053 ± 0.001	35.24 ± 0.41	43.69 ± 0.51	37.10 ± 0.43	45.99 ± 0.54	72.0 ± 1.8
Hydrogen	(35 MPa)	23.65 ± 0.09	1.183 ± 0.001	2.837 ± 0.003	119.95 ± 0.13	3.355 ± 0.004	141.88 ± 0.16	0
	(70 MPa)	39.69 ± 0.16		4.761 ± 0.005		5.631 ± 0.006		
	(liquid)	72.41 ± 0.72		8.685 ± 0.010		10.273 ± 0.011		

	(kg/m³)	(HHV / LHV)		(MJ/kg)		(MJ/kg)	(g/MJ LHV)
Coal		1.050 ± 0.004	-	25.75 ± 2.64	-	27.05 ± 2.77	95.7 ± 7.0

		(kg/m³)	(HHV / LHV)	(MJ/m³)	(MJ/kg)	(MJ/m³)	(MJ/kg)	(g/MJ LHV)
Natural Gas		0.768 ± 0.039	1.109 ± 0.003	35.22 ± 2.22	45.86 ± 3.95	39.05 ± 2.47	50.84 ± 4.38	56.9 ± 3.4
Hydrogen	(1 atm.)	0.0838 ± 0.0008	1.183 ± 0.001	10.05 ± 0.01	119.95 ± 0.13	11.88 ± 0.01	141.88 ± 0.16	0

ACKNOWLEDGEMENTS:-

The author is grateful to Yarmouk University for the financial support, to Mr. Eyad Hamzeh (JUST) for his assistance in the TG measurements, and to Miss Ayshyh Subeh (Yarmouk University) for her assistance in the extraction experiments and ash determination. Thanks are due to Professors
M. Al-Khateeb, A. Al-Ajlouni, and E.

Arafa (JUST) for their hospitability and for using their research equipment during my sabbatical leave.

REFERENCES:-

[1] Al-Shdeifat, S.M. and Al-Bdoor, H.A. (2009) Annual Report. National Center for Scientific Research and Agricultural Extension, Jordan.
[2] Abu-Qudais, M. and Okasha, G. (1996) Diesel Fuel and Olive-Cake Slurry: Atomization and Combustion Performance. Applied Energy, 54, 315-326. http://dx.doi.org/10.1016/0306-2619(95)00077-1
[3] Al-Widyan, M.I., Tashtoush, G. and Khadair, A.I. (2002) Briquettes of Olive Cake as a Potential Source of Thermal Energy. Journal of Solid Waste Technology and Management, 28, 51-59.
[4] Jumah, R., Al-Kteimat, E., Al-Hamad, A. and Telfah, E. (2007) Constant and Intermittent Drying Characteristics of Olive Cake. Drying Technology, 25, 1421-1426.http://dx.doi.org/10.1080/073739307015 36668
[5] Aljundi, I.H. and Jarrah, N.A. (2008) A Study of Characteristics of Activated Carbon Produced from Jordanian Olive Cake. Journal of Analytical and Applied Pyrolysis, 81, 33-36. http://dx.doi.org/10.1016/j.jaap.2007.07.006
[6] El-Sheikh, A.H., Sweileh, J.A. and Saleh, (2009) Partially Pyrolyzed Olive Pomace Sorbent of High Permeability for Pre- Concentration of Environmental Waters. Journal of Hazardous Materials, 169, 58-64. http://dx.doi.org/10.1016/j.jhazmat.2009.03.061
[7] Tawarah, K.M. and Rababah, R.A. (2013) Characteristics of Some Jordanian Crude and Exhausted Olive Pomace Samples. Green and Sustainable Chemistry, 3, 146-162. http://dx.doi.org/10.4236/gsc.2013.34018
[8] Mata-Sánchez, J., Pérez-Jiménez, J.A., Díaz- Villanueva, M.J., Serrano, A., Núñez-Sánchez, N. and López-Giménez, F.J. (2014) Development of Olive Stone Quality System Based on Biofuel Energetic Parameters Study. Renewable Energy, 66, 251-256. http://dx.doi.org/10.1016/j.renene.2013.12.009
[9] Garcia-Maraver, A., Terron, L.C., Zambrano, M. and Ramos-Ridao, A.F. (2013) Thermal Events during the Combus-tion of Agricultural and Forestry Lopping Residues. In: Mendez- Vilas, A., Ed., Materials and Processes for Energy:Communicating Current Research and Technological Developments, Formatex, 407-411.
[10] Misra, M.K., Ragland, K.W. and Baker, A.J. (1993) Wood Ash Composition as a Function of Furnace Temperature. Biomass and Bioenergy, 4, 103-116. http://dx.doi.org/10.1016/0961-9534(93)90032-Y

CONCLUSION:-

When properly dried at the premises of olive mills, sun-dried crude olive pomace can be marketed with moisture content of 10% or less; therefore much of its heat content is densified. Removal of extractives by solvent extrac-tion reduces the calorific value of crude olive pomace by a factor of about 10%. Marketing crude olive pomace in loose or compact form has no significant effect on its gross calorific value. The loose form of crude olive po-mace has

about 21% of its mass in the form of grains with diameter >2 mm and about 47% of fine particles of diameter <0.5 mm. The remaining 32% fall within the range of these size limits. These fractions have different calorific values. The crude olive pomace of Jordan is relatively rich in volatiles withmass percentage of 77.5%. Because of their low moisture content and low nitrogen and sulfur contents, the net calorific values of the studied crude olive pomace samples amount to about 92% of their gross calorific values.

The results of the TG and DTG measurements indicate the conformity of the pyrolysis of the lignocellulosic matter of the crude olive pomace samples to the pyrolysis behavior of other agrocellulosic biomass residues.

The data on proximate and ultimate analyses as well as the calorimetric data can be reliably considered for specification purposes of olive pomace in Jordan.