Global Journal of Science Frontier Research: I
Interdisciplinary
Volume 17 Issue 2 Version 1.0 Year 2017
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals Inc. (USA)
Online ISSN: 2249-4626 & Print ISSN: 0975-5896

Optimization of the use of Betterave (*Beta Vulgaris*) for the Production of Green Energy

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GJSFR-I Classification: FOR Code: 850499

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I. Introduction

For centuries economic development and technological advances have always been based on energy. Jean-Marie Boudaire, in his 2011 book on energy, talks about energy as being at the center of the three major issues that will shape the first decades of the next century. It is therefore crucial for a region or country concerned about its development to give capital importance to energy. However, the abusive or clumsy use of the latter leads to harmful consequences that can destroy human life in the long term (climate change, air pollution, diseases ...) (Cned, 2009). It is therefore necessary to produce energy, but it is equally important to think about how to produce it and how to use it. It is in this context that the development of renewable energies takes place. Renewable energy can be defined as a source of energy that is renewed rapidly enough to be considered inexhaustible on a human scale; Renewable energies come from regular or constant natural phenomena caused by the stars, mainly the sun, but also the moon and the earth (Marwan, 2009, Claudine, C., 2014). They can be classified into six main types: biomass, solar, wind, hydro, geothermal, tidal energy (Universalis, 2014). In this range of forms of renewable energies, we will focus on energy from biomass and in particular on biofuels. However, even at this level it is necessary to pay attention to the source, it is not necessary that the raw materials used for the production of energy compete with the food of the populations. This is why biofuels are first, second and third generation (Bates, L. 2007, Nadia et al, 2010). The second and third generation do not pose many problems because they do not compete with foodstuffs. On the other hand, the first generation, it is very often in competition with the food. To solve this problem, dedicated crops are recommended.

Our interest will be focused on sugar beet as raw material for the manufacture of ethanol. This last one is in the first generation but its strong production gives it an interesting potential to make dedicated crops. Its use for the production of sugar is very widespread in the countries of Europe. This sugar is also used to produce ethanol. However, we note that this process is very energy-intensive, especially for distillation; Which makes the technology unprofitable. The main target was the optimization of the process of ethanol production from beet. Before going inside this topic, some questions could be asked: How can the yield of the ethanol production process from sugar beet be improved? Can another beet variant be used? What is its impact on the environment?

This problem is of capital interest because the resolution of this problem will be an added value not only for the industrial sector (fuel alcohol production) but also for the agricultural and environmental fields (fight against the greenhouse effect) . A lot of work has been done around this theme; (Mohamed Mehdi KACIMI, 2008; RIESS julien, 2012; BADERTSCHER Ernest, 2005).

The general objective of this work is to propose a low-energy and environmentally friendly method for the production of ethanol from beetroot. To achieve this objective, we will carry out tests on beets, set up a miniature system and make energy balances.

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II. MATERIAL AND METHODS

The choice of the raw material (red beet) was made randomly. Indeed, these different samples were taken from the farmers of the town of Annemasse-France. The red beets were washed by hand to remove any soil residue and then chopped into smaller pieces. A juicer was used to extract the juice from the chopped red beets.

a) *Fermentation*

i. *Microorganisms*

Dried yeasts Saccharomyces cerevisiae, strain DF 639, were used for fermentation to ethanol. The yeasts (produced by SIHA, Germany) are enriched with nutrients and their biggest advantage is they do not need be propagated before application

ii. *Pretreatment*

a. *Beet Slicing*

Sugar beets are bulb-shaped red root vegetables weighing approximately two kilograms each. In order to remove sucrose from them, the beets first must be sliced into much smaller pieces (cossettes), and are shaped approximately like shoe-string French fries. A slicer was used to model this step in SuperPro Designer (Asadi, 2007).

b. *Sucrose Extraction*

Once the beets are sliced the next step in transforming them into ethanol is extracting the sucrose. In this step, cossettes are washed with a water stream in a counter-current arrangement to extract the sugar. Unlike processes that transform corn into ethanol, sugar beets do not require an enzymatic treatment to produce simpler sugars from starches. This makes the process considerably simpler. The extraction process was conducted using the method of Bogliolo et *al*. 1996.

c. *Filtration*

Impurities in the sucrose are removed by treating the raw juice with lime. In the filtration process calcium hydroxide is added to the beats. Then carbon dioxide is bubbled through the mixture and calcium carbonate is formed. This carbonation and clarification process were repeated twice. To simulate the formation of calcium carbonate, a continuous stirred tank reactor was used in order to model the conversion of calcium hydroxide to calcium carbonate (Asadi, 2007).

d. *Fermentation Process*

We propose to ferment the beet directly without passing through the sugar extraction. To extend the analysis we will proceed in two ways: a fermentation with pulp and a fermentation without pulp.

b) *Fermentation with Pulp*

To perform the fermentation, four mixtures were fixed:

- *1st test:* 2.5 kg of red beet + 1 piece of sucrose of 5 g + 10 g of yeast + 30 ml of water.

This first test contains practically no water added. The fermentation will only be carried out with the water contained in the beet.

- *2nd test:* 5 kg of red beets + 3 pieces of sucrose of 5 g + 25 g of yeast + 2 L of water.

This test complies with the rule 250 g of sugar per 1 L of water.

- *3rd test:* 5 kg of red beets + 3 pieces of sucrose of 5 g + 25 g of yeast + 1 L of water.

Here, half the recommended water has been added.

- *4th test:* 5 kg of red beets + 3 pieces of sucrose of 5 g + 25 g of yeast + 0,5 L of water.

Finally, in this last test, one quarter of the reference water quantity. was set

c) *Fermentation without Pulp*

For fermentation without the beet pulp, three tests were carried out in which less water has been chosen to be added because there are fewer molecules to hydrolyse. These tests were carried out in the following manner:

- *1st test (5th test):* 2.5 kg of red beet + 2 pieces of sucrose of 5 g + 14 g of yeast + 0.5 L of water. This test was carried out with half reference water.
- *2nd test (6th test):* 2.5 Kg of red beets + 2 pieces of sucrose of 5 g + 14 g of yeast + 0,25 L of water.

Here one quarter of the recommended amount of water has been added.

- *3rd test (7th test):* 2.5 kg of red beets + 2 pieces of sucrose of 5 g + 14 g of yeast.

The latter test contains practically no water added. The fermentation will only be carried out with the water contained in the beet.

S. cerevisiae strain (ITD00196) was used to conduct batch fermentation process at 35°C with a pH of 5.5. The pH 5.5 was chosen because It has been demonstrate that S. cerevisiae shows an intracellular pH near 5.5 (.Imai and Oho (1995). The number of living cells at packing was $>2.0 \times 10^{10}$ per g.

Fermentation worts were prepared by diluting thick juice with distilled water, initially at a ratio of 1:1 w/w, and then obtaining solutions with an extract content of either 250 or 280 g/kg. The worts were acidified with 25% (w/w) sulfuric acid to pH 5.5 and supplemented with $(NH_4)_2HPO_4$ (0.3 g/L) only or with $(NH_4)_2HPO_4$ (0.3 g/L) and $MgSO_4 \cdot 7\ H_2O$ (0.1 g/L) as nutrients for yeast.

d) *Distillation*

When fermentation was complete, all ethanol was distilled from worts using a laboratory distillation unit consisting of a distillation flask, a Liebig cooler, a flask for collecting ethanol, and a thermometer. Raw spirits containing 20 to 23% (v/v) ethanol were refined to approximately 43% (v/v) in distillation apparatus equipped with a bi-rectifier unit (dephlegmator according to Golodetz), and subjected to chemical analysis .

e) Analytical Methods

Thick juice was analyzed by the methods recommended for the sugar industry (AOAC, 1995) Solid substance (total extract) was measured by using a hydrometer, which indicates the concentration of dissolved solids, mostly sugars, calibrated in g of saccharose per kg of water solution. Total nitrogen was determined by the Kjeldahl method. Volatile acids (expressed as acetic acid) were assayed using steam distillation. Reducing sugars and total sugars (after inversion with hydrochloric acid) were estimated by the Lane-Eynon method. Both were expressed in g of invert sugar per kg of thick juice. Saccharose concentration was calculated as the difference between total sugars and reducing sugars (taking into consideration a conversion coefficient of 0.95). Also pH was measured (with a digital pH-meter).

f) Fermentation Evaluation

The intake of total sugars (the percentage yield of sugar consumption during fermentation) was calculated as a ratio of sugars used during the fermentation to their content in the wort prior to this process, and expressed in percent. The yield of ethanol was calculated according to the stoichiometric Gay-Lussac equation in relation to total sugars and expressed as a percentage of the theoretical yield.

g) Methanisation

Methanisation can be carried out on any organic matter. In the case of our work, we chose the beet pulp (fermented beforehand or fresh) as substrate. The pulps will be introduced directly into the digester without further pretreatment for those which have previously been fermented; we add just the remains of the centrifugation. Fresh pulps will undergo in addition to the mechanical treatment (grinding) they have had, dilution. methanisation in mesophilic zone, was chosen exactly around 40 ° C. The given tRH is about 15 days (Boileau, A. S. , 2013).. The particularity of our system is to have as inner gas reservoir tubes. It will therefore be necessary to choose a digester capable of containing the entire substrate. two digesters were chosen, one for the fresh pulp and one for the fermented pulp. This will allow us to make comparisons and optimize our study. It should be mentioned here that the gas was not purified as it is used for combustion. It will be led directly into pipes and burnt with the burner provided for this purpose.

h) Statistical Analysis

All samples were prepared and analyzed in triplicate. Statistical analysis was carried out using the Micromal Origin ver. 6.0 software (Northampton, USA).

III. Results and Discussion

a) Production of Ethanol

- *1st test:* 2.5 kg of red beets + 1 piece of sucrose of 5 g + 10 g of yeast + 30 ml of water.

For this test, after fermentation and centrifugation 1.02 liters of fermented juice and 802 g of fermented pulps was obtained. After the first distillation, 87 mL of a non-flammable liquid, was collected, which indicated the sufficient or effective presence of ethanol in the mixture. Therefore a second distillation was carried out in order to improve the purity of the mixture. After the second distillation, a mixture of 13 mL was obtained with a density of 923 kg / m^3; The shape of the curves of the two distillations is given in Figure. 1 and 2.

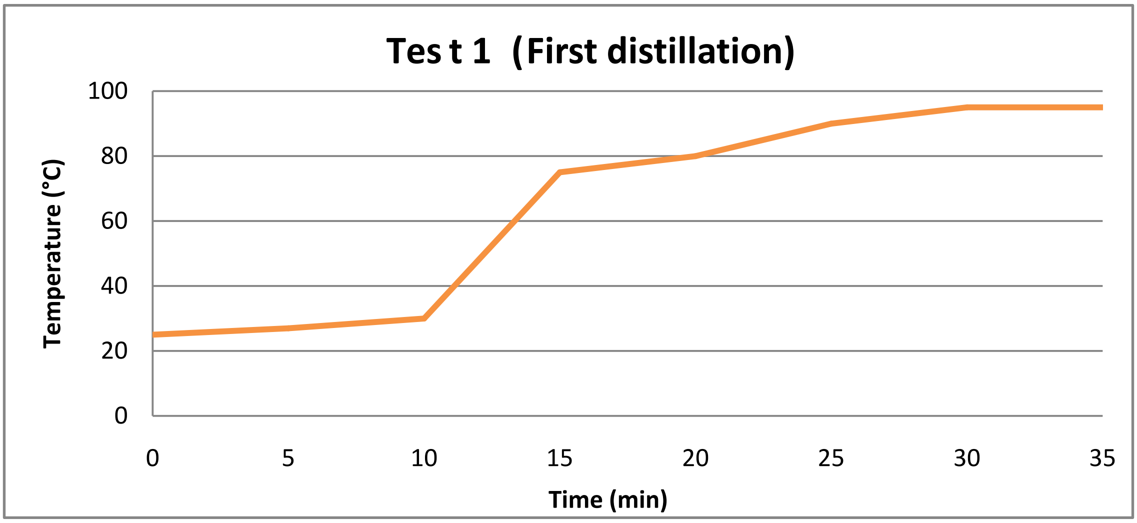

Figure 1: Variation of temperature with time in the first distillation in test 1

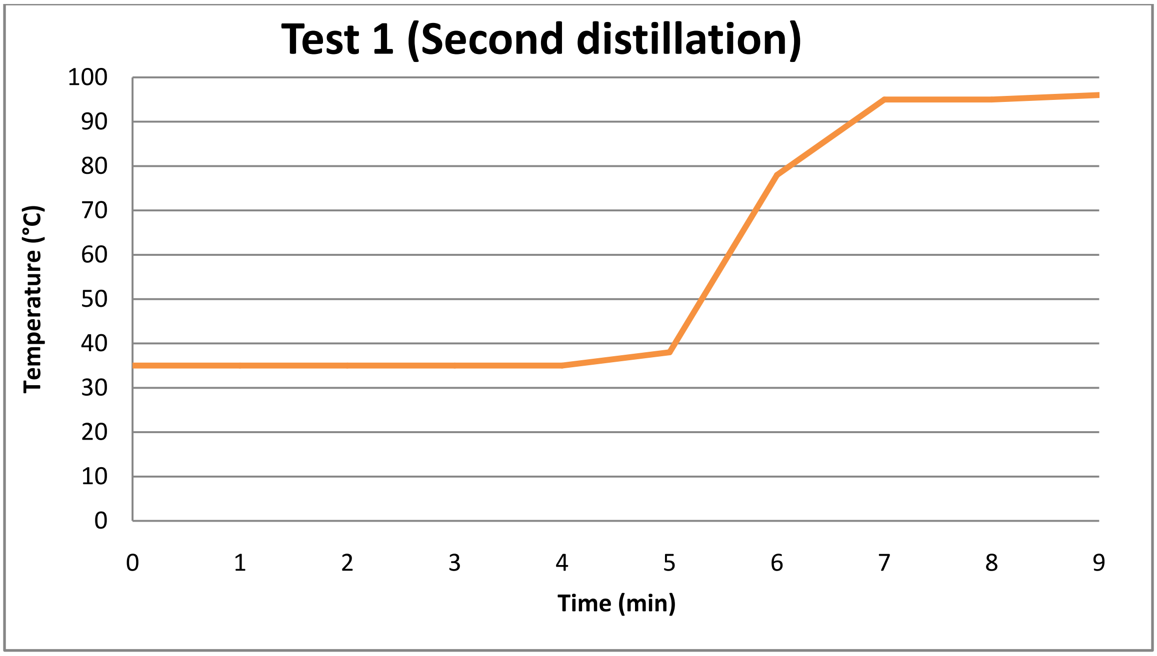

Figure 2: Variation of temperature with time in the second distillation in test 1

Figure 1 shows that during the first 10 minutes, a slow increase in temperature was notted. From the 10th to the 15th minute, there is a rapid increase in temperature which characterizes the phase change of at least one component of the mixture. From minute 15 to minute 25, the temperature continues to grow and stabilizes from the 30th minute. The distillation is then stopped. The shape of this curve is similar to that of Williamson K. L. et *al* (2007). It is characterized by good separation. However, the stabilization temperature is too high (95° C). This could be explained by the presence of a large proportion of water in the mixture and consequently the absence of inflammation.

In Figure. 2, the temperature is stable within the first 4 minutes. It rises slightly between the 4th and the 5th minute. From the 5th to the 7th minute, there is a rapid rise and stabilizes after the 5th minute. The distillation is stopped by cutting off the heat source. The stabilization temperature is always too high (96° C). Following the second distillation, the results are similar to those of the first: good separation but no ignition: This first test is therefore inconclusive.

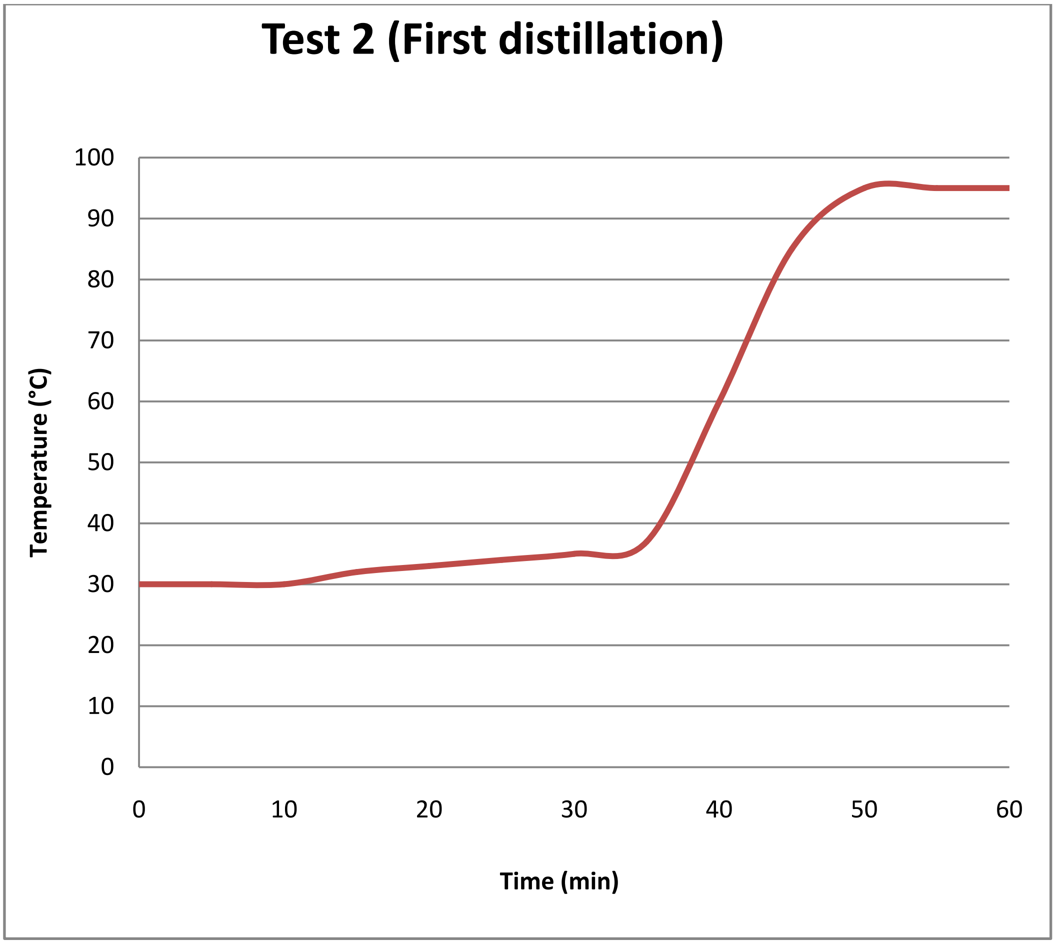

Figure 3: Variation of temperature with time in the first distillation in test 2

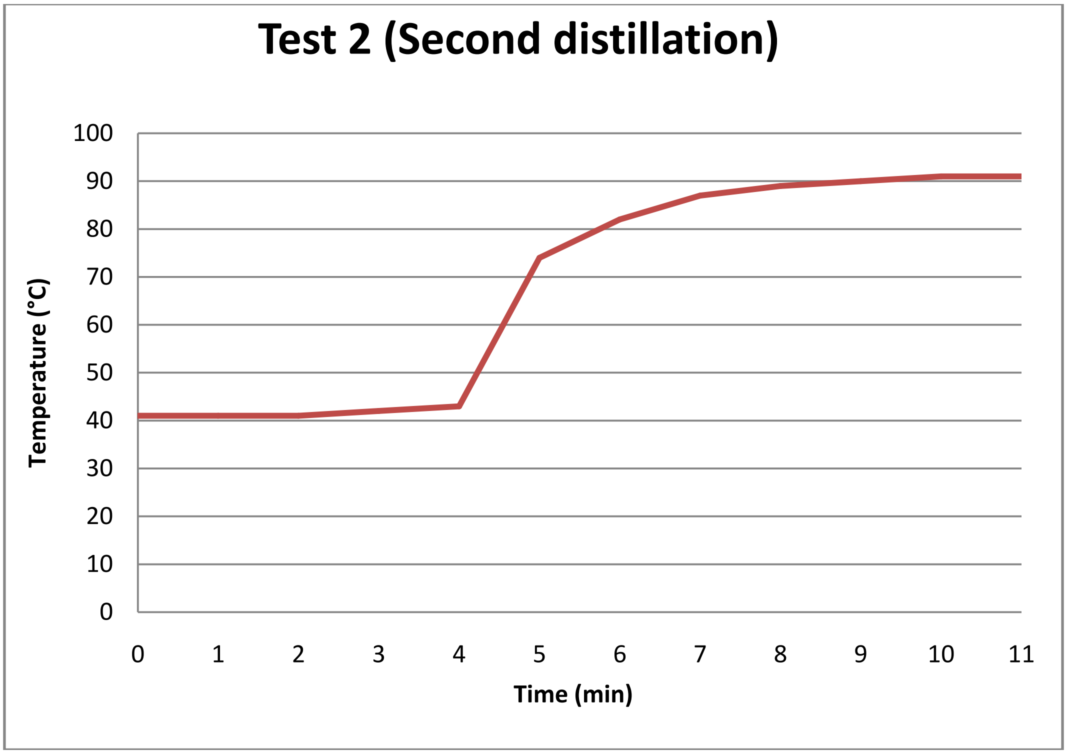

Figure 4: Variation of temperature with time in the second distillation in test 2

It can be seen on the shape of the curve shown in FIG. 3 that the temperature is stable for the first 10 minutes. It then rises slightly from the tenth to the thirty-fifth minute. Then from the thirty-fifth minute to the fiftieth minute, there is a rapid elevation which characterizes the phase change. Finally, the temperature stabilizes again and the distillation is stopped. It is demonstrated, based on the works of Boots K. *et* al. (2011), that the separation was good during the distillation. However, despite the good separation, It was observed a stabilization of high temperature (95 ° C), so the mixture does not ignite.

In Figure 4, it was observed that the temperature were stable during the first 4 minutes. It had then risen rapidly in one minute, then more slowly in 2 minutes. Finally, it had stabilized after the seventh minute and the distillation is stopped. Then, according to Boots K. *et* al. (2011), the second distillation of this test has a good separation: In addition, the point of stabilization acceptable (91 ° C), the collected liquid is flammable and odorous. 67 mL. After measuring the density, 776.11 kg / m ^{3} was found. Using alcohol tables, this mixture is an alcohol at 98.7 °. This test is therefore conclusive.

- *3rd test:* 5 Kg of red beets + 3 pieces of sucrose of 5 g + 25 g of yeast + 1 L of water. Following fermentation and centrifugation, we obtained 2.85 liters of fermented juice and 1.44 kg of pulp. The shape of the distillation curves is given in Figure 5 and 6.

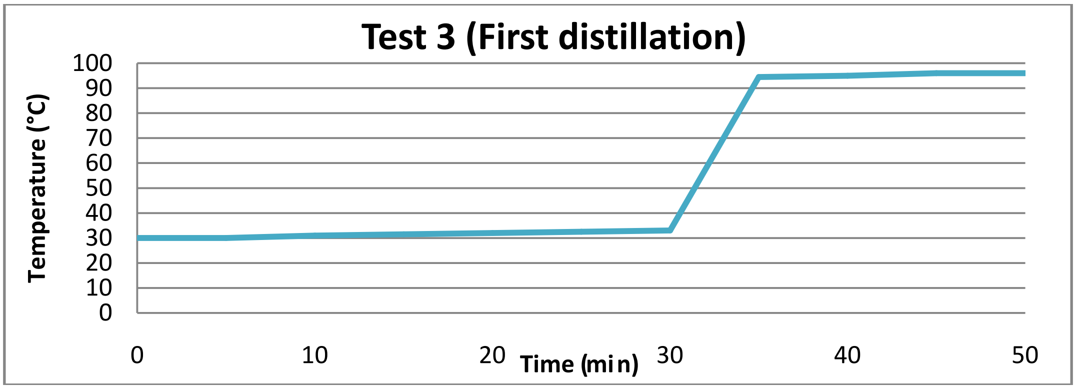

Figure 5: Variation of temperature with time in the first distillation in test 3

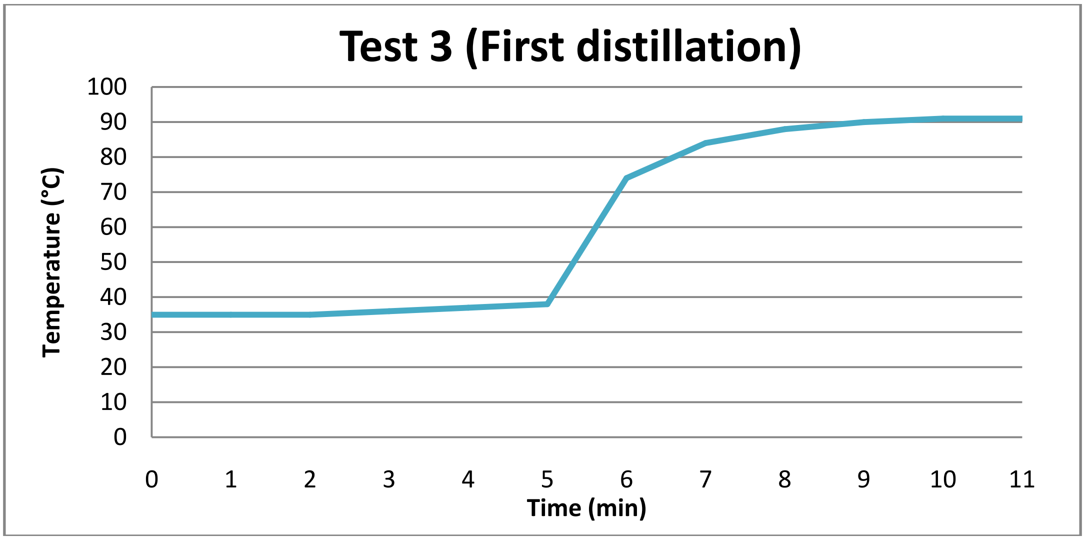

Figure 6: Variation of temperature with time in the second distillation in test 3

Figure 5 shows that for the first 30 minutes the temperature is almost stable (it only rises by 3 ° C.), then there is a sudden rise in 5 minutes and then stabilization. The distillation is stoppe the conclusion was, that according to Boots K. *et* al. (2011), separation approaches perfection. However, the stabilization temperature is still too high (96 ° C) and there is no ignition.

The second distillation curve of test 3 is recorded in FIG. 6. The following observations are made: the first 5 minutes, the temperature does not vary. The next minute there is an abrupt rise of 40 ° C, the two minutes after the continuous rise but it is 15 ° C, and finally the temperature stabilizes again from the ninth minute. The distillation is stopped. The separation is good, the temperature of stabilization acceptable (91°C), the smell test is positive and in addition there is inflammation. In addition, a total volume of 73 mL and a density of 795.21 kg / m^3 was found. According to the alcoholic tables, there is an alcohol of 94,5 °; this test is therefore conclusive. Similar result was obtained by Legrand, G. (2005).

- The 4th test was conducted as follow: 5 Kg of red beets + 3 pieces of sucrose of 5 g + 25 g of yeast + 0.5 L of water. After fermentation and centrifugation, 1.31 kg of fermented pulp and 2.7 liters of fermented juice was obtained. Then the distillation of the juice was realized. The shape of the distillation curves is shown in Figure 7 and 8.

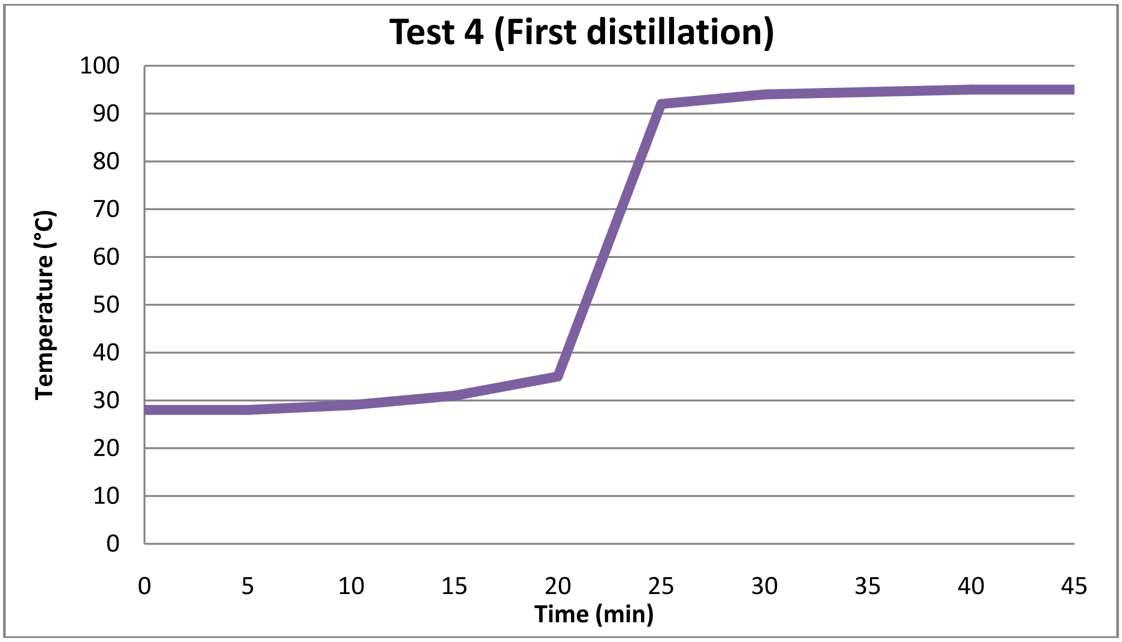

Figure 7: Variation of temperature with time in the first distillation in test 4

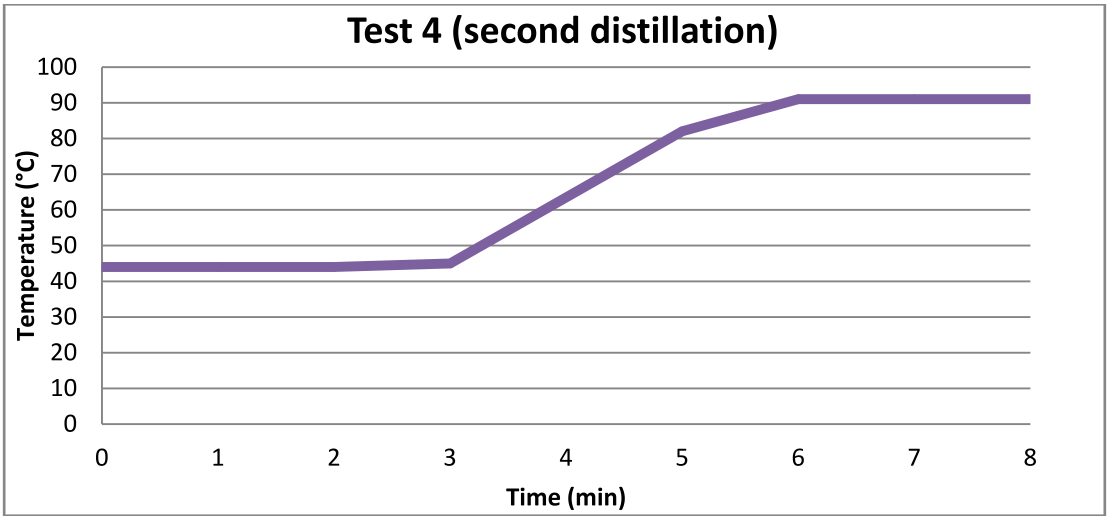

Figure 8: Variation of temperature with time in the second distillation in test 4

The first 15 minutes is a stable temperature, rising slightly from the 15th to the 20th minute, then more rapidly from the 20th to the 25th minute and stabilizing after 25 minutes. The distillation is stopped after 45 minutes. Figure 7, similar to that of Boots K. *et* al. (2011), allows us to conclude that there is a very good separation. But the stabilization temperature was too high (96°C) and there was no inflammation; a second distillation is then carried out.

From the course of the curve observed in Figure 8, it can be seen that during the first 3 minutes the temperature is stable. It then rises quickly from the 3rd to the 6th minute. Finally, it stabilizes after the 6th minute. The distillation is stopped in the 8th minute. On the basis of the results of Boots K. *et* al. (2011).

It can be indicate that the separation is very good. In addition, the stabilization temperature is acceptable (91°C). The flame and smell tests were positive. So we move on to the measures. There are 82 mL and 810 Kg/m^3. By consulting the alcohol tables, the conclusion is that, there is an alcohol at 90.2°. This test is therefore conclusive.

- *For 5th test:* 2.5 kg of red beet + 2 pieces of sucrose of 5 g + 14 g of yeast + 0.5 L of water.

Following fermentation and centrifugation, 1.6 liters of fermented juice was obtained. The shape of the distillation curves is shown Figure 9 and 10.

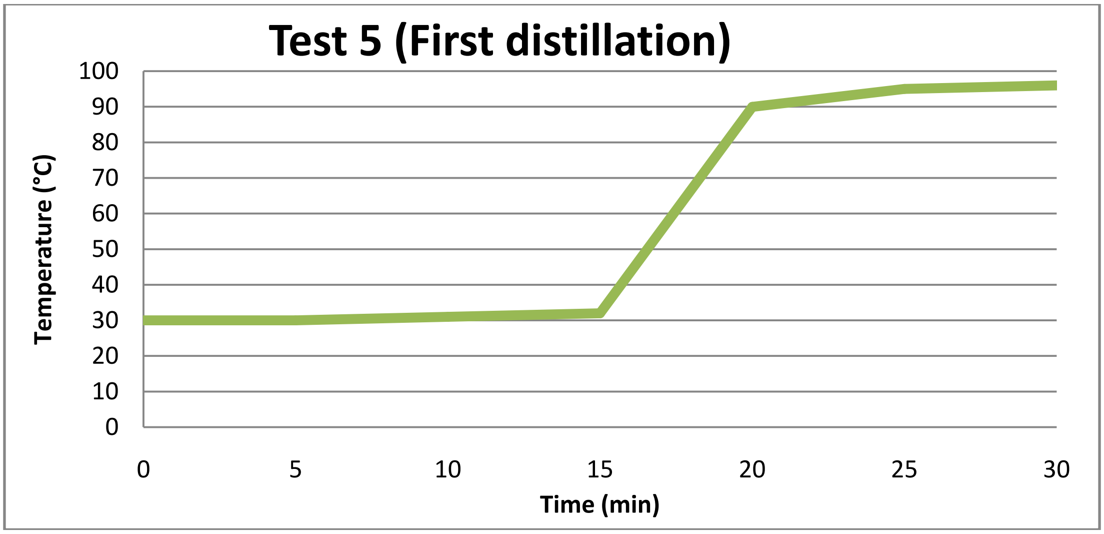

Figure 9: Variation of temperature with time in the first distillation in test 5

For this first distillation of test 5, we observe a stable temperature during the first 15 minutes. There is then a rapid rise between minute 15 and minute 20. Then the temperature stabilizes gradually and the distillation is stopped at the 30th minute. According to BORDA (1980) and Boots K. *et* al. (2011), we are in the presence of a very good separation. However, the absence of ignition and the too high stabilization temperature (96°C.) lead to a second distillation.

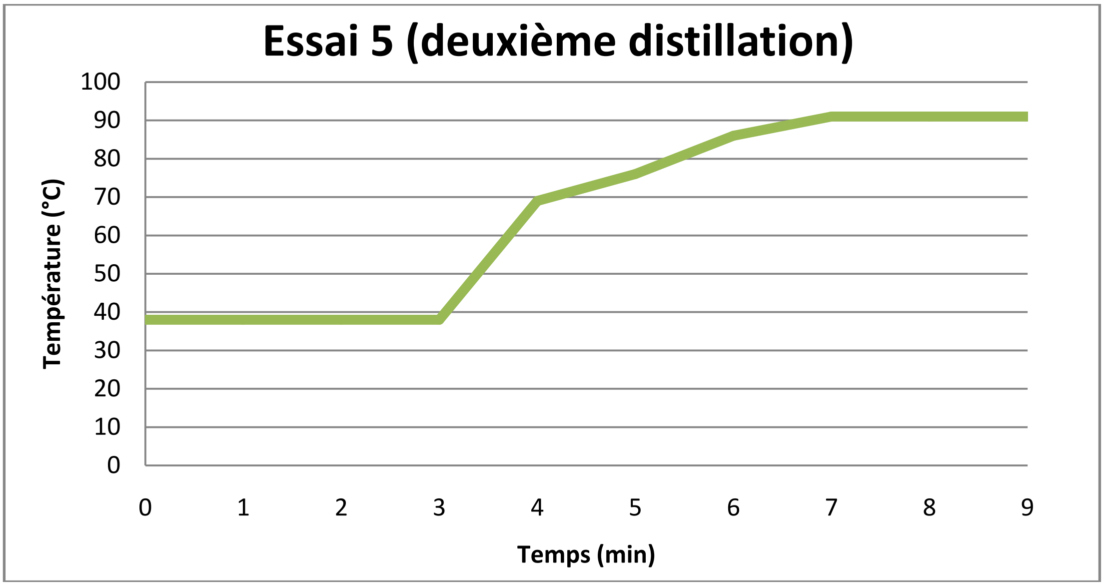

Figure 10: Variation of temperature with time in the second distillation in test 5

In Figure 10, we observe a stable temperature during the first 3 minutes. Then, from the 3rd to the 6th minute, we have a progressive evolution. Finally the temperature stabilizes after the 7th minute and the reaction is stopped in the 9th minute. At the end of this second distillation, there is a product which has an odor of alcohol and which ignites. After measurement, a volume of 40 mL and a density of 800.00 kg / m^3 are found. By consulting the alcohol tables, the conclusion was that we are in the presence of an alcohol at 96.7°.

This test is therefore conclusive.

- *The 6th test was conducted as follow:* 2.5 kg of red beets + 2 pieces of sucrose of 5 g + 14 g of yeast + 0.25 L of water. After fermentation and centrifugation, 1.48 liters of fermented juice are obtained. We have carried out two distillations of which the appearance of the curves is the subject of figures 11 and 12.

In Figure 11, it has been observed that the temperature was practically stable during the first 15 minutes. Then there was a rapid rise from the 15th to the 20th minute and then to stabilize. The distillation lasted for 25 minutes.

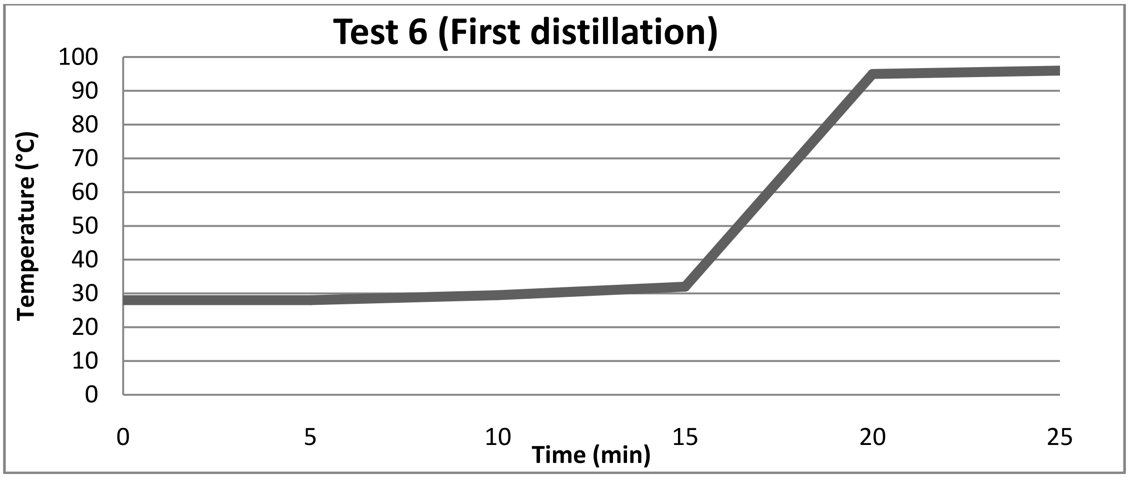

Figure 11: Variation of temperature with time in the first distillation in test 6

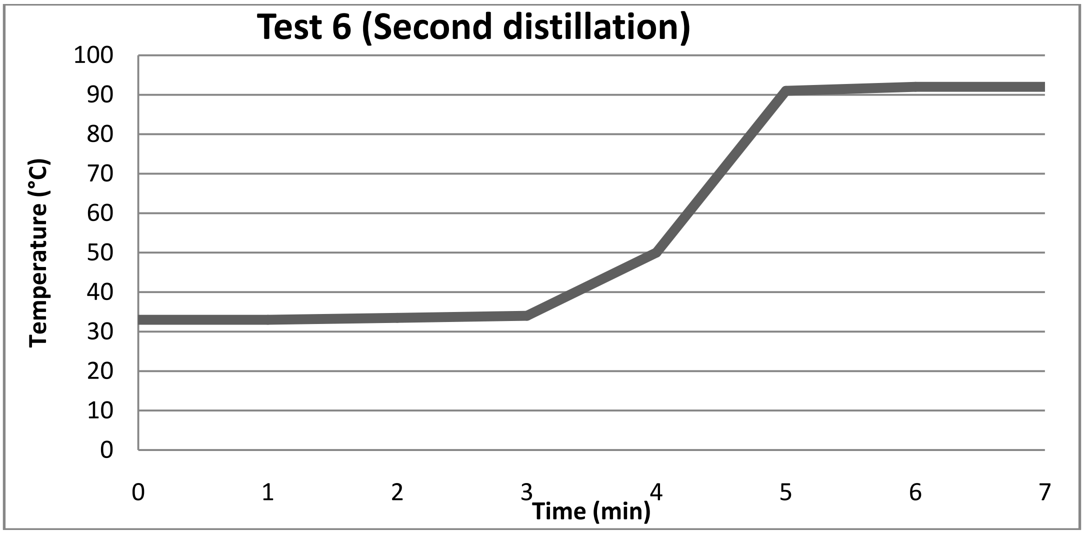

Figure 12: Variation of temperature with time in the second distillation in test 6

The conclusion can be taken according from the work of Grandbois, D. (2004). and Boots K. *et* al. (2011), that there has been a good separation. However, the mixture has retained the smell of beetroot and is non-flammable. In addition, the stabilization temperature is too high (96°C.).

In Figure 12, a stable temperature was observed for the first 3 minutes. Then there was a rapid rise from the third to the fourth minute. This was followed by a slower rise from the fourth to the fifth minute. Finally, the temperature stabilized again after the fifth minute. The distillation lasted 7 minutes. The result of this distillation gave a mixture having the smell of alcohol and flammable. After measurement, 47 mL of volume and 900.10 kg / m^3 of density were found. The alcoholic tables led to the conclusion that it is an alcohol at 61.9°. This trial was conclusive.

- In the 7th test, the ingredients were as follows: 5 kg of red beet + 3 pieces of sucrose of 5 g + 25 g of yeast + 1 L of water. After fermentation and centrifugation, 0.91 liters of fermented juice is obtained. The distillation curves are shown in Figure 13 and 14.

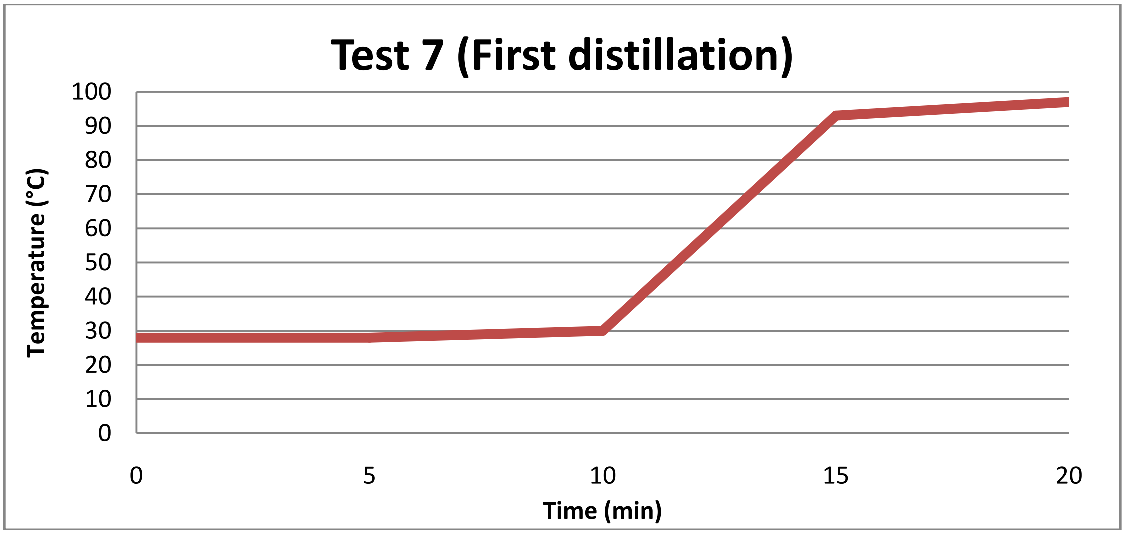

Figure 13: Variation of temperature with time in the first distillation in test 7

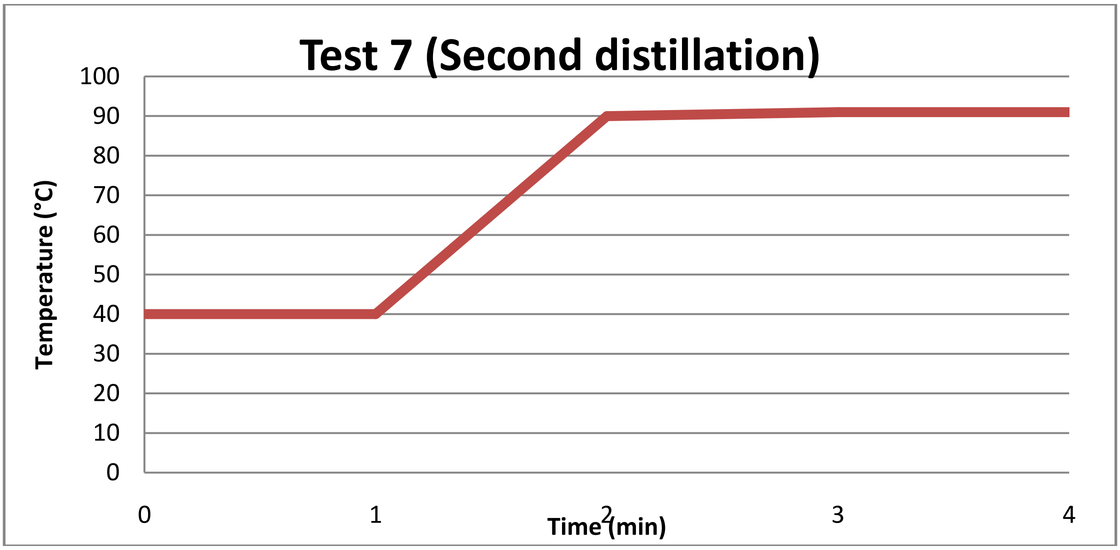

Figure 14: Variation of temperature with time in the second distillation in test 7

In FIG. 13, a stable temperature was noted during the first 10 minutes. From the tenth to the fifteenth minute, there was a rapid rise followed by a stabilization. The distillation was carried out for 20 minutes. The mixture which was obtained was not odorous and did not ignite. the stabilization temperature was too high (97°C). A new distillation of the mixture was carried out again.

The Figure 14 had shown a stable temperature during the first minute. The next minute was a rapid rise and the last two minutes the temperature stabilization was noted. The separation curve was good and the mixture was odorous and flammable. A volume of 54 mL and a density of 969.3 Kg/m^3 were obtained. The correspondence of the tables made it possible to note the presence of an alcohol at 22°. This test is conclusive.

It should be mentioned here that the densities measured on the mixtures were made at 40°C for the first four tests (fermentations with pulp) and 25° for the last three (fermentation without pulps). During the flame test, all the flames were blue. Table 1 summarizes the results obtained for the production of alcohol.

Table 1: Results of alcohol production

Number of test	Volume of alcohol produced (mL)	Degree of alcohol produced	Flammable?	Remarks
1	13	Not exploitable	No	Test non conclusive.
2	67	98.7°	Yes	Test with pulp, good separation.
3	73	94.5°	Yes	Test with pulp, good separation.
4	82	90.2°	Yes	Test with pulp, good separation, some losses in the junction
5	40	96.7°	Yes	Test without pulp, good separation.
6	47	61.9°	Yes	Test without pulp, good separation, some losses in the junctions.
7	54	22°	Yes	Test without pulp, good separation, some losses in the junctions

b) Production of Biogas

In the perspective of producing biogas, two digesters have been set up: the first (Figure 15) for pre-fermented pulps and the second (Figure 16) for fresh pulp. The production was observed for 18 days. At the end of this period, a production of 19 liras of biogas for the digester 1 and a production of 12 liters of biogas for the digester 2 were recorded. This result is different to the result obtained by Fry, L. J. (1975), GTZ, (1989), Corrot, G. (1989) and Funda C. E. (2011). Those authors produced biogas in 25 days. The different observed in our experiment related to the production of biogas would be to the high biological degradability of the beet in general, and particularly in the digester 2.

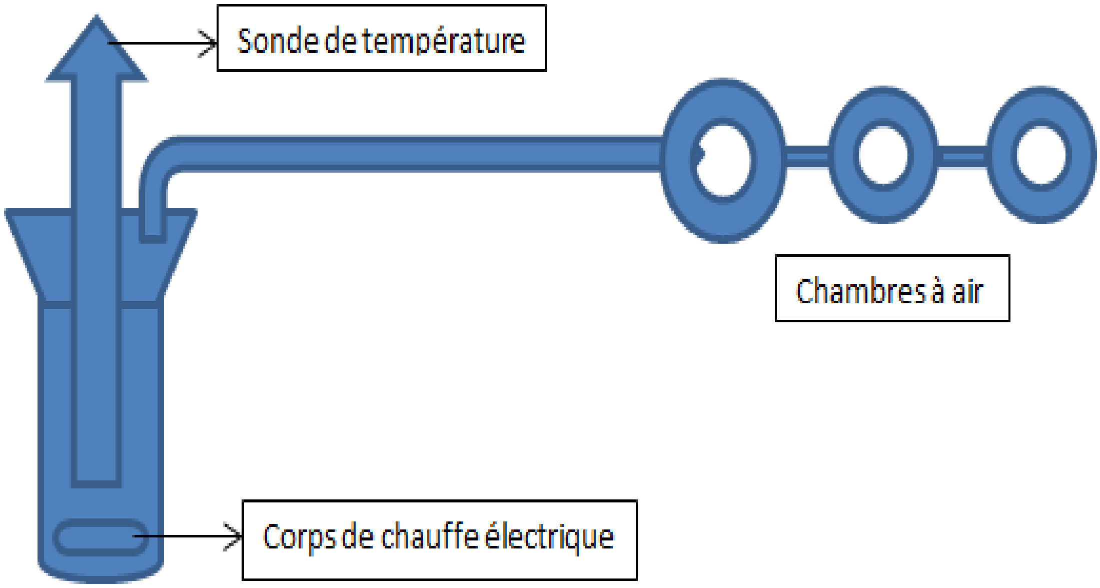

Figure 15: Digester 1

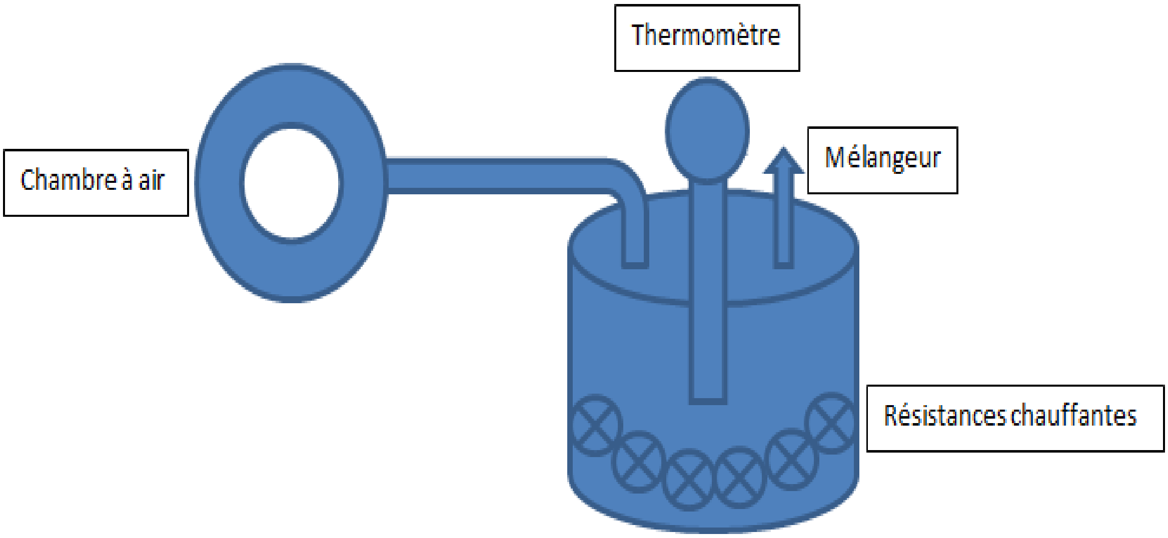

Figure 16: Digester 2

c) *Energy Balance Sheet*

i. *Energy Expenditure*

Energy expenditure is grouped in two: energy costs related to the production of alcohol and those related to the production of biogas.

ii. *Production of Alcohol*

Table 2 summarizes the different energy expenditures we have identified in our trials of ethanol production from red beet.

Table 2: Energy consumption related to ethanol production

Energy consumption element	Energy consumed
Distillation (250 W; 1h)	6000Wh
Blender (450 W; 1h)	250 Wh
Extractor (250 W; 0.5h)	225 Wh
Balance (0.75 W; 1h)	0.75 Wh
Centrifuge (814 W; 1h)	814 Wh
Oump (48 W; 1.8h)	86.4 Wh
Total for Ethanol production	7.37 KWh

Production of biogas

Energy consumption element	Energy consumed
Heaters	129.75 Wh
Heating resistors	171.29 Wh

The production of ethanol gave an energy expenditure of 7.37 KWh, while that of biogas gave 171.29 Wh. This gives a total expenditure of 7, 54 KWh. Similar result was found by Guy Roulier. (2015)

d) *Energy Gains*

Energy gains are recorded in four areas: alcohol production, biogas production, water heating and fertilizer fertilizer production.

i. *Production of Alcohol*

Table 4 gives the energy values of the alcohol of the various tests. It is to be recalled that the first 4 tests were carried out with the pulp and the last 3 without. In test 2, 2 L of water were put , in test 3, 1 L, in tests 5 and 6, 0.5 L and in the test 7, 0, 25 L.

Table 4: Energy produced by alcohol

Test 1	Test 2	Test 3	Test 4	Test 5	Test 6	Test 7	Total alcohol
--------	0.42KWh	0.45KWh	0.49KWh	0.25KWh	0.21KWh	0.10KWh	1.92 KWh

It has been noted here that for pulp fermentation, the amount of energy produced decreases with the addition of water. On the other hand for the fermentation without pulp it is the opposite. This result was different to the result obtained by Gunnerson, C. G. and Stuckey, D. C. (1986) those authors found the increase of the production with the addition of water.

ii. *Production of Biogas*

Table 5 represents the energy production of biogas.

Table 5: Energy produced by biogas

Digester 1	Digester 2	Vinasse	Total biogas
0.12 KWh	0.07 KWh	14.38 KWh	14.57 KWh

The energy produced by Vinasses (14.38 KWh) are higher than those obtained from digesters. This result was closed to the result obtained by Henning, R. and Andres, C. (1986.)

iii. *Heating Water*

The temperature rise of the water used to condense the alcohol during each test was on average 15 ° C. and 5 liters of water were used for each test. A a total energy production of 0.7 KWh was obtained.

iv. *Production of fertilizer*

The potential of digestate in terms of fertilizer is estimated at 0.36 KWh for nitrogen, 0.04 KWh for phosphorus and 0.6 KWh for potash. That makes a total of 1 KWh.

The total energy gain is 18.19 KWh

The yield is 58.54%, which is almost double the conventional yield.

Ethanolic fermentation is an exothermic process. The heat released is 1.2 MJ / kg of ethanol produced. The evacuation of the calories produced, which is not problematic with the current small operating procedures, could certainly become so by doubling or tripling the productivities, as could also become the entrainment of ethanol in the effluents, with a concomitant increase the production and superficial velocities of CO_2 release. The process we propose is more ecological because it emits no waste and uses less energy. All energies are recovering and exploiting. Similar result was obtained by DE WULF AGRO (2015)

The methanisation of the pulps makes it possible to supply the distillation energy and to heat the digester. The anaerobic digestion of the vinasses contributes to the distillation without fossil energy input and makes it possible to obtain a non-acidic, odorless and mineral-rich liquid residue, directly applicable to the fields, which is not the case for an acidic vinasse . The return to crops of liquid residues avoids the purchase of fertilizers; the nitrogen cycle is closed. The impact on the environment is remarkable; no polluted water, no fossil energy, remarkable CO_2 balance. For the agro-food industries and for energy production, this initiative can be a lifeline.

References Références Referencias

1. ADER. (2015). Le tournant énergétique économique [En ligne]. (05 Août 2015). http://www.ader.ch/FR/comite/464-liste-des-membres-du-comite.html
2. Alard, V., Journet M., et Béranger C. (2002). A la recherche d'une agriculture durable: étude de systèmes herbagers économes en Bretagne, éditions Quae. 340 pages.
3. Badertscher, E. (1964). Sucre de betteraves: Sucre de canne et sucre de betterave, historique. Lausanne: ADER. 10 pages.
4. Ballerini, D. (2006). Les biocarburants: état des lieux, perspectives et enjeux de developpement. Paris: Editions TECHNIP. 343 pages.
5. Bates, L. (2007). Le biogaz. Royaume uni: practical action. 8 pages.
6. Boileau, A. S. (2013). La méthanisation: éléments de reflexion. Nantes: terres d'avenir. Agricultures et territoires. 52 pages.
7. Boots, K.; Juskey, C.; Sipaj, A.; Frankiewiez, P. (2011). Waste Heat Recovery from a Power Plant for the Purpose of Ethanol Distillation; Technical Report; UOIT: Oshawa, ON, Canada,. Shah, R.K.; Sekulic, D.P. Fundamentals of Heat Exchanger Design; John Wiley & Sons Inc.: Hoboken, NJ, USA, 2003.
8. BORDA (1980). Biogas manual for the realization of biogas programmes, Bremen, FRG, pp.1-116.
9. Bourdaire, J-M. (2011). World Energy Outlook to 2020. AIE 197 pages.
10. Claudine, C. (2014). Fiche technique méthanisation. ADEME. France. 19 pages.
11. Cned (2009). Sciences de la vie et de la terre 3^{e}: sommaire de la séquence 12. France: Cned. 135 pages._Collection Sciences de la Vie et de la Terre.
12. Corrot, G. (1989). Pulpes surpressées ensilées: étude de la contamination butyrique, essai d'amélioration de la qualité. Compte rendu n°89041 ITEB Paris: 67 pages.
13. Cortial Nicole. (2015). Les combustibles [En ligne]. (05 Août 2015) in. http://nicole.cortial.net/physbts.html
14. DE WULF AGRO.(2015). Betteraves sucrières. [En ligne]. (10 Juin 2015) in http://www.dewulfagro.be/betteraves_sucrieres.html
15. Fry, L. J. (1975). Practical building of methane power plants for rural energy independence. Hamsphire, USA. 58 pages.
16. Funda Cansu Erten (2011). Improving biogas production by anaerobic digestion of different substrate: Calculation of potential energy outcomes. Master thesis in Applied environmental science. Hôgskolan Halmstad. 47p.
17. Grandbois, D. (2004). Préparation et purification de l'éthanol. Québec:Colège Shawanigan. 12 pages.
18. GTZ, (1989). Biogas plants in animal husbandry. Deutsches Zentrum für Entwicklungstechnologien-GATE.
19. Gunnerson, C. G. and Stuckey, D. C. (1986). Integrated resource recovery anaerobic digestion. Principles and practices for biogas systems, 152 pages.
20. Guy Roulier.(2015). La betterave: Ses atouts santé. Nature mania [En ligne]. (21 Mai 2015) http://www.naturemania.com/bioproduits/betterave.htm
21. Henning, R. and Andres, C. (1986). Bericht über H_2S-Untersuchungen. Report on investigations on

H_2S reduction in biogas. Oekotop GmbH and GATE/GTZ, Berlin, FRG. German

22. Legrand, G. (2005). Le bon usage de la pulpe surpressée: la pulpe de betterave. IRBAB, Belgique. Collection les guides techniques de l'IRBAB. 60 pages.
23. Williamson, K.L.; Minard, R.; Masters, K.M (2007). Macroscale and Microscale Organic Experiments, 5th Ed. Hougton Mifflin Co.:Boston, p 774.