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CAN FERMENTATION ALCOHOL BE SUBSTITUTED FOR WOOD AS A COOKING FUEL*

by

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I. INTRODUCTION

In the history of mankind a very essential event is the conquest of fire.

Fire was, in the very old days, considered as a privilege of the Gods and, for having stolen it, Prometheus was condemned by Zeus to an atrocious death : he was chained to a rock and tortured by a vulture which fed itself on his liver while he was still alive.

Why was fire so important ? Using it, our prehistoric ancestors were able to provide heat in winter time and to cook their food ; of course, to do so, they had to use a fuel, freely available, I mean wood.

Wood was very abundant and cutting or burning trees opened new land for cropgrowing and cattle raising.

If, in the industrialized countries the use of wood is to-day negligible as a fuel (it covers less than 1 % of the energy requirements), the situation is very different in many developing countries and using too much wood raises very important problems, specially in connection with desertification.

II. WOOD, THE FUEL BY EXCELLENCE IN DEVELOPING COUNTRIES

IMPORTANCE OF ITS MASSIVE USE ON DESERTIFICATION

I shall refer frequently in my lecture to a very interesting publication issued in 1978 by the French "Department of Cooperation" ("Ministère de la Coopération") under the title "Evaluation of new energy sources for the development of African countries".

It insists upon the importance of wood to satisfy a vital energetic need : cooking ! Wood is by far, the most widely used fuel and buying it in order to prepare one hot meal a day digs a deep hole into the budget.
In the Ouagadougou (Upper Volta) area, it has been found that the expenses for buying wood represented 20 to 30 % of the family income (1) !
Of course, those figures apply to the traditional African cooking : heating a big pot up to the boiling point of water and maintaining the ebullition during 4 to 5 hours.

With the growth of the urban population, the needs for wood in urban areas are increasing and it means more and more important transportation costs : In Upper Volta, wood has to be carried to town, by all means available from 40 and more km away.
In semi-suburban areas, in the Republic of Mali, the distances reach frequently 15 to 20 km. (2)

And, although desertification is a very complex problem, the Nairobi Conference of 1977 has insisted very strongly on the importance of deforestation as one of the most dangerous desertification factors.

In the Sahel countries, more than anywhere else, the problem is tragical, Mr. Idrissa Yaya, Projects and Program Manager at the CILSS, expressed recently in a very strong way his fears and his hopes : "Finding an alternate fuel to be substituted to wood would mean for the Sahel the same as finding crude oil in Europe". (3)

As you know, much better than I do, a great effort has been undertaken, by the channel of international and national organizations and also through individual initiatives,to find new energy sources.

Some results are very encouraging but if many attractive and promising ways are under development, in most cases, the energy, which is of great interest to pump or to heat water and to generate electric power, is not a proper source to replace wood, that is to have, at a given time, the possibility of generating for a few hours, a fairly substantial quantity of heat at a high enough level, at a cheap enough price, to enable the population to cook its food and to stick to its habits.

I must say that, in the published literature which I have consulted, I did not find any reference to ethanol. I think that one of the main reasons is that ethanol is not, nowadays, available in any significant quantities and you cannot express confidence in a non existing product !

But is it possible to change that situation and using natural, renewable and available resources, to produce ethanol by large volume and to use it properly as a cooking fuel ?

III. HOW HAS, UP TO NOW, ETHANOL BEEN USED AS A FUEL ?

The first devices consisted of a small tank which could be empty, or filled up with cotton waste, out of which emerged a wick. The heating power was low : such devices were used for cooking or for boiling water.

An improvement was found by developing equipment burning alcoholic vapours.

Such equipment is still found on the market and is used sometimes for lighting but mainly for cooking. Ethanol has to be put under pressure either by using a tank higher than the heating level or more often by handpumping air into the tank, the pumping operation having to be renewed when the flame lowers down.
Initial vaporization of the ethanol is obtained through the combustion of a part of liquid ethanol and then self maintained.

One of the problems is to operate the pump as soon as the pressure drops and, of course, the heating power is not constant. The operator has to stay by the device practically all the time of the cooking operation. Equipment of that kind is mostly restricted to trailers, mobile homes or boats.

When such a system is used for lighting, the temperature which is reached by the combustion of ethanol is high enough to promote the incandescence of gas mantles. The problem of maintaining the pressure is the same as for cooking equipment.

Prior to World War II, there was a sizable use of briquettes improperly called "solidified alcohol" ; they were in fact made of metaldehyde, a solid product which sublimates without melting around 112/115° C.

Metaldehyde, commercialized under the name of "meta" in small briquettes with a good heating power was mostly used for camping.

This fuel, easy to use but rather expensive to make, had furthermore the disadvantage of being toxic. It is seldom found today and it has been replaced essentially by small butane bottles.

Ethanol has also been offered as a jelly. The preparation is rather easy, its use is not. But by packing the jelly in tubes, one can extract by pressure a certain amount of jelly, the main outlet being to help lighting up fires or barbecues in a less dangerous manner than by using liquid ethanol.

It is clear that under the various conditions which have been described, ethanol cannot be used to replace wood if one wishes to maintain the cooking habits of the developing countries.

A careful study of the matter (4) has reached the conclusion that, in fact, the best substitute for wood would be butane and that a substantial reduction of its price would probably induce a significant proportion of the urban located families to switch from wood or charcoal to butane.

Such an approach has been explored by the Government of the Republic of Senegal, very much concerned by the effects of deforestation.

The price per kg of butane in 4 kg containers in Senegal is 100 F. C.F.A. which means 2 F. F. per kg. (5) This price, relatively low, is nevertheless very much higher than the one at which it can be obtained in Egypt. In this country butane is sold at 0,32 F.F. (6) per kg and at such low a price this project is very successful in the Lower Nile Valley but, of course, this result is a consequence of a very substantial subsidy by the Government.

IV. DEVELOPMENT OF AN ETHANOL "POT-HEATER"

To promote the use of ethanol in a large scale for food cooking, one of the ways is to find out whether it is possible to operate in conditions rather similar to those which apply to butane.

We do not claim that it is the only possible way, but it is the one which we have followed.

Here are the main features of the "pot-heater" which after more than one year of researches has been developed in France and for which two patents have been applied.

a) The first point is to eliminate the hand operated pump and at the same time to eliminate the potential risks of an ethanol saturated compressed air atmosphere.

We have succeeded by using, as a pressurization agent, carbon dioxide, an inert gas, which is, as everybody knows, an important by-product of fermentation operations and specifically of alcoholic fermentation.

A small volume of compressed CO2 is connected with the alcohol tank through a pipe equipped with a pressure reducer and maintains a constant pressure in the tank, while the alcohol level drops.

A plunger enters the tank and through an appropriate tap the liquid alcohol rises from the tank, which is preferably located on the ground, up to the burner level. The flow for a given position of the tap varies with the pressure maintained in the tank which incidentally gives another possibility of regulation.

b) The second part of the problem was to design a rather powerful burner to heat the big pots normally used in the African countries, easy to light and easy to turn off.

After a thorough examination, our choice, based upon the study of the devices found on the market, was to use a vaporisation burner.

The study of an appropriate shape for the injector, the vaporizer and the burner itself which has requested a great deal of tests, allows us to present a device, simple to operate and powerful :

Simplicity ? The tank having been pressurized by CO2, the tap is slightly open up to a very apparent adjusting mark. Liquid ethanol flows into a cup which is placed under the vaporizer-burner set. Ethanol is lighted and after 30 to 40 seconds the burner, fed with vaporized ethanol, ignites spontaneously. The heat of the flame is regulated by acting on the tap and the vaporization as well as the combustion go on by themselves.
To stop the flame, one has only to turn the tap backward.

Power ? The burner, fitted on an appropriate and sturdy stand which forms what we have christened "pot-heater" (in French "chauffe-marmite") has given the following results :
To raise quickly to the boiling point 5 liters of water and to maintain a moderate boiling during 4 hours. which is essential to perform the traditional African cooking, the consumption of ethanol at 95° GL was 354 g, i. e. approximately 0,45 liter.

The thermal efficiency is of the order of 58 % which is satisfactory enough.

Of course, the device which we have built is only a prototype and now with the help of the potential users many refinements have got to be studied to come out with a line of "pot-heaters" well adapted to the needs of the market, the basic operating principles remaining the same.

Many questions will be raised, such as :

Is it better to build pot-heaters with a fixed tank or to use renewable tanks, as is the case with butane ? Personally, I am in favour of the second solution which presents a certain number of good points, but it is not essential.

Another point is to determine the capacity of the tank.

At any rate, we believe that we can say with confidence that the device does exist, that it works without moving parts, with the exception of the tap, and that probably up to 95 % of its parts can be manufactured, by local industry, in the interested countries.

V. HOW WOULD THE USE OF ETHANOL FOR COOKING AFFECT WOOD CONSUMPTION AND CONSEQUENTLY DEFORESTATION ?

Let us assume that a normal family eats one hot meal a day : it will use, yearly, approximately 1.8 hl of ethanol, that is 144 kg.

Although our information on the consumption of wood for cooking is not too accurate, the data gathered in Upper Volta(7) the country on which we have the most detailed figures, induce us to believe that the yearly consumption of wood for a family is in the order of 4.8 metric tons of wood.
It means that 4.8 mt of wood could be replaced by 144 kg of ethanol.

The difference is so enormous that it requires some explanations. It is assumed that commercial wood has a heat of combustion of 3,400 K.cal/kg while the heat of combustion of ethanol is 7,000 K.cal/kg for pure ethanol and 6,650 K.cal/Kg for a 95° G.L. ethanol.
4,800 kg of wood liberate 16.32×10^6 K.cal
and 144 kg of ethanol liberate 0.96×10^6 K.cal.

But, if one admits that the efficiency of a wood hearth is normally 5 %, the heat supplied to the pot will be only 81×10^4 K.cal while with a yield of 58 % the heat supplied to the pot, in a "pot heater" will be 55×10^4 K.cal.

The order of magnitude is the same, and the correlation becomes very close if the wood is damp : 25 % water reduces the heat supplied by wood to approximately 60.75×10^4 K.cal !

Indeed, the impact of the use of ethanol for stopping or slowing down deforestation depends upon the quantities which would become available for cooking.

For the sake of reasoning, let us admit that ethanol units will be located just outside sugar factories and that they will use molasses as their raw material.
Roughly, one can say that, if all the molasses produced in a sugar factory go to the production of ethanol, 1 hl of ethanol will correspond to 1 ton of sugar.

In other words, being understood once more that molasses will go 100 % to fermentation, a sugar plant producing 30,000 mt of sugar per year will be able to make 30,000 hl of ethanol, which if ethanol is used exclusively for cooking, will replace 80,000 mt of wood.

The most recent figures we have got concerning the city of Ouagadougou (Upper Volta) show that the yearly consumption of wood, for cooking purposes is of 118,000 mt. (8)

Approximately 2/3 of that quantity could be replaced by 30,000 hl of ethanol, reducing by 2/3 the deforestation in the Ouagadougou area. It does not mean that deforestation would disappear and that the reforestation program would be stopped, but it could be very substantially reduced.

Of course, such a result will not be obtained overnight. It will require time and efforts and an intensive promotion program with serious financial implications.

And we must not forget that there are many uses for molasses and many uses for ethanol !

But deforestation is such a terrible threat and reforestation such a fantastic effort that we would not consider as abnormal to give a high priority to the erection of fermentation units for the production of ethanol from molasses, and to channel as much as possible of the ethanol produced toward "pot-heaters".

And, after all, if the sugar factories do not generate enough available molasses, why not, provided that economical conditions permit it, follow the Brezilian example and make ethanol directly from cane juice or from manioc.

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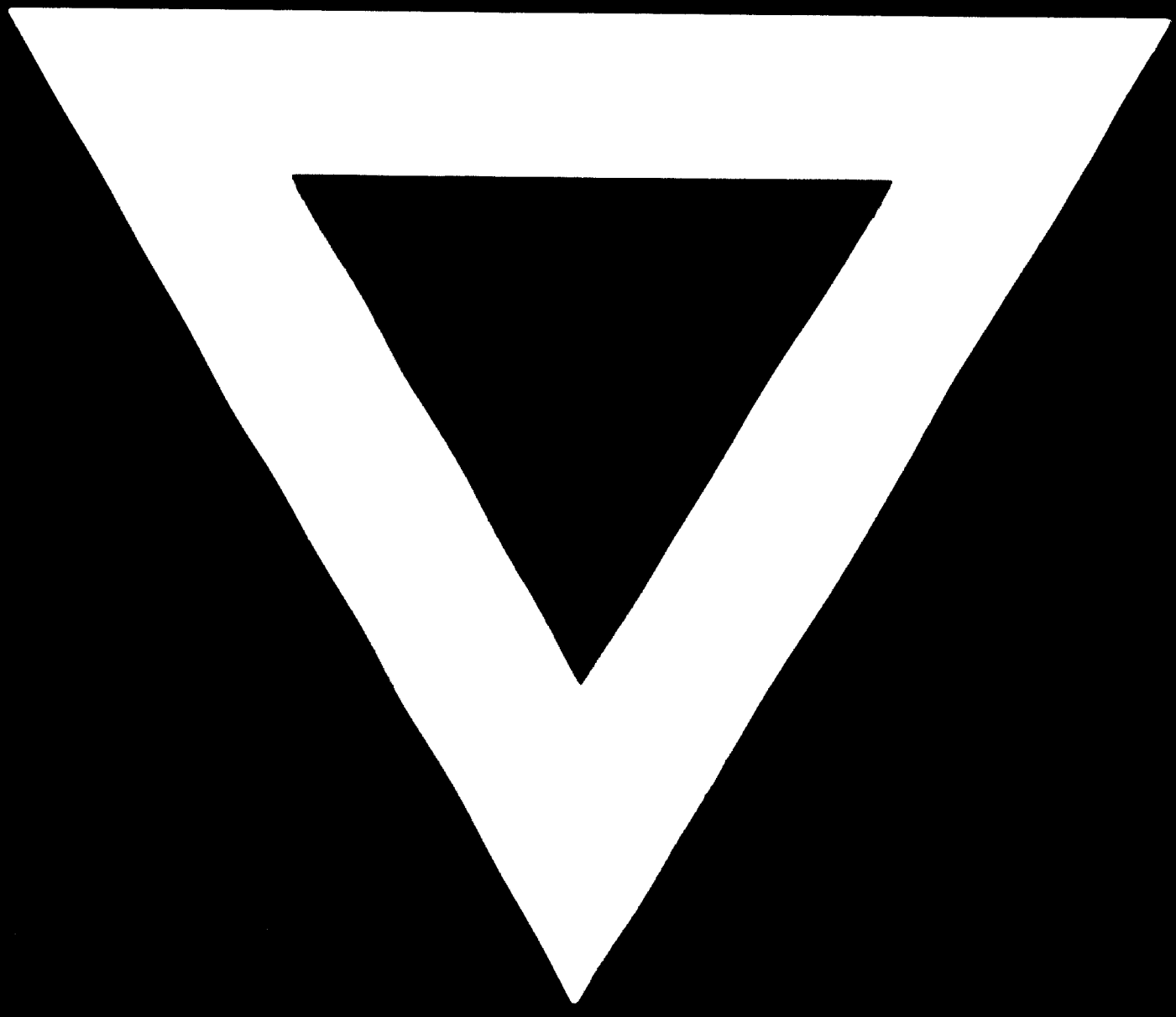

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