GASIFICATION OF CAKE OF COCONUT MACAÚBA, OF EUCALYPTUS FIREWOOD AND CHARCOAL FOR DEHYDRATION

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1. INTRODUCTION

The drying of food products has been practiced for a long time, initially by direct exposure to the sun, being one of the oldest techniques of food preservation used by man. Although there is no energy cost, solar drying, it has some inconvenients, among which include: its dependence on climatic conditions, the high cost of labor and the need for a large space for drying.

The fruits because they have less perishable shelf life, to increase the shelf-life and to lower production costs and risks of contamination by microorganisms is necessary for the removal of free water, which can be made through dehydration. The term dehydration refers generally to the removal of water from a food by steaming. Due to the reduction of water free and the increase in osmotic pressure, microbial growth can be controlled. The final moisture of the dried product is generally less than 5%.

Brazil is a traditional importer of dried fruit and seasoned for many years had a variation in imports which more recently has been attenuated as a function of more intensive use of wider range of products over the years. Since the importation in 2007, the raisin reached a volume of 18.9 tons, followed by prune with a volume of 11.5 thousand tons and the third dry coconuts shelled, whether grated, with volume 2, 6 thousand tons. The biomass gasification serves the "yearning" to have a low emission of pollutants and enable the balance between consumption and carbon dioxide production (growth and burning of plants), thus is reported as a sustainable alternative to power generation, may even contribute to rural development and increased employment of skilled labor in underdeveloped countries.

This work is important as it provides a study and analyze the use of various types of biomass gasification process in order to hot air and quality for dehydrating fruits. The objective was to conduct a study of gasification of cake of coconut macaúba, eucalyptus firewood and charcoal as energy source for a system of dehydration of fruits. We used a reactor for gasification of biomass, the flow of small-scale competitor, with a combustion chamber of the gas in order to generate hot air and clean.

2. OBJECTIVE

The overall goal in development of this study was a comparative study of gasification of cake of coconut macaúba of eucalyptus firewood and charcoal as heat source for a system of dehydration of fruits. Using a reactor for gasification of biomass, the flow of small-scale competitor, with a combustion chamber of the gas in order to generate hot air and clean.

3. GASIFICATION

Gasification is defined as the conversion of any solid fuel gas energy by means of partial oxidation at elevated temperatures. This conversion can be performed in various types of reactors and various types of carbonaceous materials such as coal, charcoal, biomass, producing different mixtures of fuel gases.

3.1 COMPETITOR GASEIFIER

It is the most widely used type of gasifier, the fuel feed is made from the top, the flow of biomass and gasifying agent is given the same direction (from top to bottom). In it the areas of combustion and reduction are positioned as opposed to countercurrent gasifiers, this feature causes the gas produced has a high temperature (700 ° C) and low tar and volatile, which are cracked when crossing the active zones.

4. MATERIAL AND METHODS

The development of this work took place in the Department of Agricultural Engineering, Federal University of Viçosa, in the experimental processing of agricultural products.

The gasifier was built concurrent flow coupled to a combustor of the gas produced, composed of three sections: reactor, combustor and mixer. The base of the reactor was constructed of refractories bricks that has the function of protecting the metal parts and reduce heat losses by convection and radiation and coated externally mud brick. Upon exiting the mixer, the drying air is led to the dryer installed after the mixing chamber. Since the aim is use the air to drying of food products, its temperature was controlled at around 70 º C. The speed control of centrifugal fan was made indirectly, by use of a Variable Frequency Drive, which is designed to control and regulate the speed of electric motors, induction motors. The speed of the motor connected to the ventilator was made by varying the frequency of power supply.

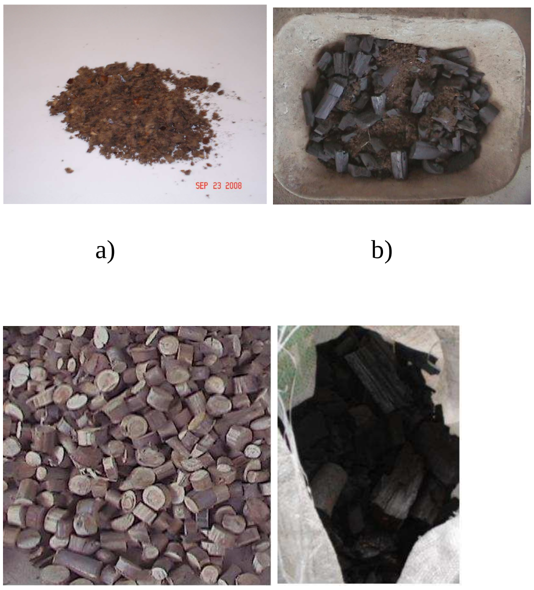
Figure 01 illustrates the final stage of construction of the system described above.

Figure 01: Completion of construction of the gasifier.

Measurements were based on the temperature at various points in the gasifier (drying zone, a zone of oxidation, the pilot flame, combustor and air outlet) and the environment, besides reading the air speed of entry and exit through the openings in the system, the relative humidity environment, energy consumption and air quality output, for different engine speeds.

In working conditions the lid of the reactor, which was made of sheet metal and used to allow the entry of biomass, remained closed to prevent entry of air from the top of reactor.

Figure 02 illustrates the biomass used for gasification.



a) b) c) d)

Figure 02: Biomass gasification used in: a) Cake of Coconut Macaúba, b) Cake of Coconut Macaúba mixed with charcoal, c) Eucalyptus firewood e d) Charcoal.

5. RESULTS AND DISCUSSIONS

In the following tables the places indicated by "*" means that the gasification experiments using pie macaúba not show satisfactory results, since: for all tests (100% pie macaúba 75% pie macaúba and 25% charcoal, 50% cake macaúba and 50% charcoal and 25% cake macaúba and 75% charcoal), the grid clogging gasification had been stopped.

Table 01 illustrates the values obtained for the thermal tension, mass flow, combustion rate and in relation to biomass gasified.

Table 01: Thermal Tension, rate of fuel consumption and combustion of biomass used.

Biomass	Cake of Coconut Macaúba	Eucalyptus Firewood	Charcoal
Thermal Tension ($kW.m^{-2}$)	*	410,06	222,37
Mass flow ($Kg.h^{-1}$)	*	6,00	2,96
Combustion rate ($Kg.h^{-1}.m^{-2}$)	*	58,95	29,13

MARTIN (2005), received thermal stress ranging between 1113 and 1447 $kW.m^{-2}$, using eucalyptus wood in a gasifier competitor.

For the analysis of Table 02, we can observe that all biomass used meet the moisture in the recommended range (less than 30%) for use as fuel in gasifiers competitors.

Table 02: Analysis of biomass used.

Biomass	Cake of Coconut Macaúba	Eucalyptus Firewood	Charcoal
Water content (%)	14,15	15,93	8,35
PCS ($KJ\ Kg^{-1}$)	26988,42	29432,84	29990,12
PCI_u ($KJ\ Kg^{-1}$)	23331,68	25043,42	27485,42

It is observed a much higher value of the PCS pie coconut macaúba when compared with other oilseeds, which is desirable from the standpoint of combustion.

During the experiment the atmospheric conditions (humidity and temperature) were more favorable to coal gasification plant. Since the higher temperature coupled with the lower value of humidity, contribute to the increase in oxidizing power, as can be seen in Table 03 and 04.

Table 03: Average relative humidity (%) of the ambient air during the experiment.

Speed (rpm)	Biomass		
	Cake of Coconut Macaúba	Eucalyptus Firewood	Charcoal
1685	*	71,62	66,23
1535	*	70,70	67,13
1385	*	69,08	67,97

Table 04: Average temperature (° C) ambient air during the experiment.

Speed (rpm)	Biomass		
	Cake of Coconut Macaúba	Eucalyptus Firewood	Charcoal
1685	*	18,32	21,19
1535	*	20,84	20,70
1385	*	20,49	20,21

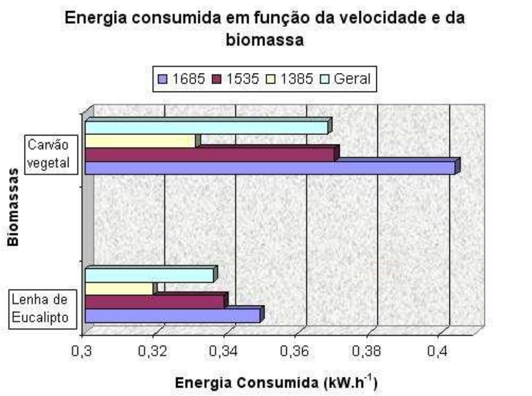
The average values measured by thermocouples: T0, T1, T2, T3 and T4 drying zone, a zone of oxidation, the pilot flame, combustor and exhaust, the temperatures for each biomass can be seen in Table 05. Can be observed that coal gasification plant had on average higher values.

Table 05: Mean values of the temperatures read by the thermocouples during the gasification of biomass.

Biomass	Temperature in the thermocouples (°C)				
	T0	T1	T2	T3	T4
Cake of Coconut Macaúba	*	*	*	*	*
Eucalyptus Firewood	107,84	670,66	230,40	55,10	69,50
Charcoal	196,45	870,69	204,33	77,56	67,89

Graph 01 illustrates the power consumed (kW.h-1) by the motor-frequency converter, depending on engine speed (rpm) for gaseificações with the biomass used in the experiment. One can observe a decrease in energy consumption using slower speeds (electrical power consumed is the product of the speed torque), as the load is constant and implementation of a speed below the nominal suits drying characteristics. It is therefore evident the importance of variation of speed on systems that work under the torque and speed partial, since the use of an electric motor at a constant speed produces an unnecessary power consumption of the process. Thus, varying the speed of a process means savings.

From the standpoint of analysis of energy consumption according to the gasification of biomass, can be seen that the gasification made from eucalyptus firewood that had been the lowest energy consumption.



Graph 01: Energy consumption in terms of speed and biomass.

In determining the thermal and overall efficiencies, which can be seen in Table 06, the inlet and outlet gases were considered as ideal gas, ha and hg were obtained by interpolation of table thermodynamics to air (A.7) can be found in Van Wylen et al. (2003).

Table 06: Average values of system performance during the gasification of eucalyptus wood.

Parameters	Cake of Coconut Macaúba	Eucalyptus Firewood	Charcoal
Time gasification (h)	*	2,07	2,09
Consumption of biomass (kg. h^{-1})	*	6,00	2,96
Primary air velocity in the combustor (m.s^{-1})	*	2,58	3,27
Airspeed output (m.s^{-1})	*	9,43	13,27
Thermal efficiency (%)	*	29,72	31,65
Overall efficiency (%)	*	60,06	63,34

The thermal efficiencies and overall values are consistent with those obtained in the literature. SANTOS (2003), average thermal efficiency obtained 46.71%. Martin (2005), received thermal efficiency of 37.90% and 76.57% overall, which also names SAGLIETTI (1991) and Oliveira (1996), obtained average thermal efficiency of 28% and 30%, respectively.

6. CONCLUSIONS

Based on the results and discussions presented, it can be concluded that: The association of the reactor for gasification of biomass to the combustor of the gas produced can be considered an alternative to generate heat for the dehydration of fruits, competing with traditional methods, because the system was easy to construct and refueling the reactor, built with system fully operation, allowed its operational stability and continuity.

Not recommended for use cake of coconut macaúba pure or combined with charcoal for the supply of hot air through gasification, using a system similar to that. Because, for all tests realized were clogging the grid.

It is concluded that the most recommended fuel for heating air for drying fruit is charcoal, because among all the biomass studied, that was the one that provided hot air quality with the lowest consumption of raw material.

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