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DRYERS WITH CHAB CONCEPT FOR A SUSTAINABLE AGRICULTURE

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Abstract: *Drying agricultural products is one way of capitalizing economically and environmentally superior agricultural products. It makes an analysis of the necessary drying capacity using agricultural biomass waste to produce heat and biochar with CHAB concept. It follows that if it dries only 1% of the amount of fruits and vegetables consumed annually is needed in Romania trays surface for drying* $19,5{\cdot}10^3$ m^2*/year by 1000 achievable dryers with trays surface of 20* m^2 *to 200 dryers of 100* m^2*. Can capitalize pellet form about 13,500 t waste agricultural biomass with a minimum of 1.5 mil. Euro with a negative emissions balance of* $-19,6{\cdot}10^3$ CO_2*.t/year. The estimated values are below the dry product imports in 2014.*

Keywords*: dryers, vegetables, fruits, CHAB concept,* CO_2 *emissions*

1. Introduction

Drying is one of the traditional ways and yet always modern storage vegetables and fruit on long periodes for direct consumption or for industrial uses whitout preservatives and low power consumption for storage and reprocessing. Convective drying is a intensive heat technology which in many cases makes it dependent on sources of heat as cheap, which is one of the reasons a drying facilities super concentrations. Rapidly falling automation devices prices, development of automatic driving software and technologies changing in machine building led to a decentralization of processing by drying fruits and vegetables, a shift of driers to the place of harvest products for dry. This makes use of the mobile dryers are dependent on use diesel and PLG fuel with a high energy density but which are sources of pollution through emission of CO_2. [3, 5, 7, 9, 10, 15].

Currently emphasis is on reducing the emission of CO_2 into the atmosphere through the use of renewable energy, solar, biomass, wind, or geothermal. With wind turbines, the solar thermal and photovoltaic, are total negative balance but they produce energy when is wind or is light which require bulky energy storage devices and very expensive products. Because biomass can store and use energy when it is needed, even if he has an almost neutral CO_2 balance, remains the most versatile source for farms producing direct biomass used for energy production. [2, 5 , 8]

To sum up, biochar production and application to agricultural soils may create a triple wins scenario, where farmers get higher yields and compensation for environmental services; society gets reduced eutrophication and less negative environmental impacts from intense farming practices; and humanity gets sustainable food production at the same time as climate change effects and the connected risk of reaching climate tipping points are reduced.

Biochar contributes to a sustainable society in its true meaning for future generations by closing the cycles between arable land and human habitations. The technique is democratic, since it can be applied anywhere around the globe where plants are growing and it is not dependent of economic, technical or infrastructural development. It is independent of scale, too, so also home gardeners may transform garden waste into a soil improver to use in their own garden.

By using TLUD micro-gasification process (Top-Lit-Up-Draft) from biomass is produced combustible gas and residual charcoal - currently called biochar. The conversion to heat of the part of biomass is completely gasified with a yield of 95% and biochar remains about 25% of the energy input from biomass. Biochar is a sterile product that can be used to mix in compost as an amendment in agricultural soils to increase their production capacity. [8]

Because carbon from biochar incorporated in soil have a high half-life, he is sequestered large period of time and result a negative balance of CO_2.
The data provided by the Ministry of Agriculture, in period 2009-2012, the average annual consumption of vegetables per capita was 182 kg and the fruit of only 69 kg.

2. Sources of energy for convective dryers

For operating convective dryers consume heat for drying agent that for agricultural products is hot air. For the movement of the drying agent and for the automatisation electrical energy is required, but no more than 10% of the heating power. The production of heat from various sources liberates an amount of CO_2 (table 1), values for electricity, diesel and LPG is for Romania, for the pellets was made an estimate. [12]

TABLE 1: Mass of CO_2 equiv. released per kWh_{th}

Energy source	M.U.	Value
Electricity	$kg.CO_2/kWh_e$	0,617
Diesel	$kg.CO_2/kWh_{th}$	0,308
LPG	$kg.CO_2/kWh_{th}$	0,259
Pellets from residual agricultural biomass	$kg.CO_2/kWh_{th}$	0,021

For the production of heat and biochar from pelletized biomass is using TLUD micro-gasification process with CHAB concept. In table 2 presents the functional and ecological feature in a stationar load. The value relatively small average proportion of BC, only 15%, is typical for TLUD gasification which ensure the production of higher quality biochar with very little VOC (Volatile Organic Content), compared to methods of anoxic pyrolysis producing more than biochar but with more VOC. [6, 9, 11, 12].

TABLE 2: Production of heat and biochar from pellets in TLUD

Feature	M.U.	Value
Biochar (BC) average proportion	kg.bc/kg.bm	0,150
Pellets medium LHV	kWhth/kg.bm	5,000
Gasified biomass medium LHV	kWhth/kg.bmg	4,167
Pellets specific consumption	kg.pl/kg.mum	0,388
Carbon content in BC	kg.C/kg.bc	0,950
Carbon sequestered specific	kg.C/kg.bmg	-0,168
CO_2 sequestered specific	$kg.CO_2/kg.bmg$	-0,587
CO_2 sequestered specific	$kg.CO_2/kWhth.bmg$	-0,141

(bm – biomass; bmg – gasified biomass; mum – wet mass; bc – biochar; pl - pellets)

3. Features of convective dryers

In this paper they used functional, environmental and energy characteristics, for dryers worldwide that use pellets as a source of heat to the TLUD gasification process with CHAB concept. It examines the drying characteristics of fruit and vegetable for averages values from usual practice. [2, 3, 4, 5, 6,10].
In table 3 is presented the functional and ecologic characteristics and for drying fruits and vegetables. An introduced a new size, specific hourly load of drying surface with wet body ($kg.mum/m^2.h$) with that calculate the amount of drying capacity.

TABLE 3: Features convective drying plants

Feature	M.U.	Vegetables	Fruits
Specific tray electrical power	kW_e/m^2.cas	0,020	0,020
Drying process yield	real	0,72	0,72
Preparation hot air yield	real	0,650	0,700
Dryer heat yield	real	**0,468**	**0,504**
Drying regime			
Initial relative humidity	kg.w/kg.mum	0,900	0,820
Final Relative Humidity	kg.w/kg.mum	0,080	0,180
Dry base	kg.mus/kg.mum	0,100	0,180
Discharged water mass	kg.w/kg.mum	0,891	0,780
Specific process heat consumption	kWh_{th}/kg.mum	0,860	0,753
Average power factor	P_{th}.avr/P_{th}.n	0,400	0,500
Tray specific loading	kg.mum/m^2.cas	10,000	7,000
Average batch drying time	h	11,000	6,000
Thermic energy special consumption	kWh_{th}/kg.mum	1,323	1,075
Tray heat specific consumption	kW_{th}/m^2.cas	1,954	1,756
Tray hourly loading	kg.mum/m^2.cas.h	0,909	1,167
Pellets specific consumption	kg.pl/kg.mum	0,373	0.304
Specific electricity consumption	kWh_e/kg.mum	0,0220	0,0171
Specific emissions			
Drying with diesel	kg.CO_2/kg.mum	0,421	0,342
Drying with LPG	kg.CO_2/kg.mum	0,356	0,289
Drying with pellets	kg.CO_2/kg.mum	-0,165	-0,134

(cas – tray; mum – wet mass; mus - dry mass)

4. Required drying capacity

Based on average annual consumption of 182 kg. vegetables and 69 kg. fruit per capita in Romania and taking as a basis drying the annual 1% of this amount as a result would annually produce 198 g. dried vegetables 152 g dried fruits per capite with a CO_2 negative balance of -0.393 kg.CO_2 / year.pers, presented in table 4.

TABLE 4: Sustainable impact drying vegetables and fruits with CHAB concept

Feature	M.U.	Value
Annual consumption of vegetables	kg.lum/year.pers	182,0
Annual consumption of fruit	kg.fum/year.pers	69,0
Drying share from consumption	real	***0,01***
Annual vegetable mass for drying	kg.lum/year.pers	1,820
Annual fruits mass for drying	kg.fum/year.pers	0,690
Weight dried vegetable	kg.lus/om.an	0,198
Weight dried fruits	kg.fus/om.an	0,152
Specific drying capacity for vegetables	m^2.cas.h/year.pers	2,002
Specific drying capacity for fruits	m^2.cas.h/year.pers	0,591
Annual drying capacity	m^2.cas.h/year.pers	**2,593**

Annual consumption of pellets	kg.pl/ year.pers	0,834
CO_2 emission from vegetables drying	kg.CO_2/year.pers	-0,165
CO_2 emission from fruit drying	kg.CO_2/ year.pers	-0,134
The annual CO_2 emission	kg.CO_2/ year.pers	**-0,393**

(lum – wet vegetables; fum –wet fruits; lus – dry vegetables; fus – dry fruits)

With these values can be calculated specific capacity needs of drying în (m2.cas.hyear.pers) for a locality, region or territory of Romania, presented în table 5.

TABLE 5: Drying Sustainable impact nationwide

Feature	M.U.	Value
People	milion	**15,0**
Annual mass dry vegetables	10^3 t.lum/year	27,3
Annual mass dry fruits	10^3 t.fum/year	10,3
Annual mass dry vegetables	10^3 t.lus/year	2,9
Annual mass dry fruits	10^3 t.fus/year	2,3
Required drying capacity	10^6 m^2.cas.h/year	38,9
Annual drying time	h/year	2000
Surface drying required	10^3 m^2.cas/RO	19,5
Dryer 20 m^2.cas required	system	973
Dryer 100 m^2.cas required	system	195
Annual consumption of pellets	10^3 t.pl/RO.year	13,33
Annual CO_2 emmision with diesel	10^3 t.CO_2/RO.year	**+15.03**
Annual CO_2 emmision with LPG	10^3 t.CO_2/RO.year	**+12.71**
Annual CO_2 emmision with pellets	10^3 t.CO_2/RO.year	**-5,891**

On first examination results are surprising. At the national level would be required convective dryers with an total drying area of 19,500 m2. This capacity can be achieved with 1000 small, mobile and cheap dryers with 20m^2 or 200 dryers with 200 m^2. With this drying capacity would dried 27,300 t fresh vegetables and 10,300 t fresh fruit with a CO_2 negative balance of -891 t.CO_2/RO.year. It annually produces 2900 tons of dried vegetables and 2300 tons of dried fruits, values much lower than importing them in 2014.

If you would increase the drying portion to 5% there would result five times higher values that are impressive in nationwide size, noting that national market for dried products exist.

5. Conclusions

Convective drying of fruits and vegetables is a source of healthy food and eco using of biomass for produced heat with CHAB concept.

Drying only 1% of annual consumption per capita of fruits and vegetables would produce annually 2900 tonnes dried vegetables and 2300 tonnes dried fruit, much lower than it was importing them in 2014.

To dry mass of vegetables and fruits require a drying capacity of 19,500 m^2 which should go into production in 1000 dryers of 20 m^2 or 200 dryers of 100 m^2, the task feasible in a short time and financial effort quickly recoverable.

To dry 5200 tons of wet bodies annually must gasified with concept CHAB 1250 tonnes of pellets, resulting a CO_2 negative balance of -5890 t.CO_2/year.

Results require a rapid development of drying fruits and vegetables to cover domestic consumption and to help promote healthful nutrition.

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