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SOLAR ENERGY – AN ENERGETIC SOURCE FOR THE VEGETABLE AND FRUIT PRODUCTS DRYING IN BRASOV AREA

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Abstract: *The dried vegetables and fruits can have multiple usages, if they keep much better their food and commercial features. For drying process an important amount of energy is consumed. In the paper is analyzed the possibility of the solar energy use for drying those products, with the condition that the process of water evacuation to be rigorous checked up, without damaging the nutritious elements which they contain. In Romania the method is recommended for the south and east zones where the solar radiation intensity is bigger, and the vegetables and fruits have an important weight in the agricultural production. The heat needfulness for drying it can be assumed with solar panels, and the energy for the fans with photovoltaic panels.*
Keywords: *drying conservation, fruits, solar energy, vegetables*

1. INTRODUCTION

The fruits and vegetables for fresh consumption or for different industrial food products satisfy the needs of alimentation by their qualitative value determinate by the taste, nutritious components, aroma etc.
The preservation of the vegetables and fruits through dehydration represent a possibility of supplementary capitalization of the production from this area, especially for their utilization in the recipes of different food products (instant soups), but also for direct consumption.
On this idea there have developed and utilized numerous constructive schemes of drying installations, as: discontinuous dryers Muger – of chamber type; convective dryers of tunnel type; convective dryers with overlap bands; fluidization dryers; column type dryers for cereals; conductive dryers through contact; contiguous dryers bellow pressure etc. [4].
The higher cost of the energy necessary for drying in these installations, as well as the requirements enforced to the products in the drying process made practically impossible their utilization by the small farmers. The use of solar energy for drying of agricultural products may represent an acceptable and accessible opportunity for all agricultural farmers [1].
For this purpose there have been studied and built many types of dryers, in which the solar energy solves completely the problems of drying, also at heat source and for the air motion inside the dryer. There are known the realizations of German firm Babcok AG, of the research workers from California Polytechnic University, of the research workers from the Hohenheim University, but also another old dryers or much more modern dryers like the cabinet dryer, the band dryer, the dryer with natural convection.
In all these cases, the food drying must carry out a series of requirements through which the chemical components, the vitamins, initial color, taste, smelt etc will be fully preserved. Obtaining these performances assumes conducting the drying process after rigorous criteria, so that the elimination of surplus water not to degrade the valuable parts of the vegetables and fruits [2].

2. MATERIAL AND METHODS

For the realization of a proper dryer project which uses the solar energy is needed to know the values of the climatic parameters, such as: multiyear monthly average of the air temperature, the parameters of the solar radiation, the speed of the wind and the average number of hours in which the sun glows in a month.
For the computation of the solar global daily radiation (I_{za}) it is used the relation:

$$I_{za} = \frac{24}{\pi} \cdot C_s \cdot \left\{ \left[1 + 0.33 \cdot \cos\left(\frac{360 \cdot n}{265} \right) \right] \cdot \left[\cos\varphi \cdot \cos\delta \cdot \sin t_r + \frac{2\pi \cdot t_r}{360} \cdot \sin\varphi \cdot \sin\delta \right] \right\}, \tag{1}$$

in which: I_{za} - the medium daily radiation out of the atmosphere, in W/m^2·day; C_s – the solar constant, C_s = 1353 W/m^2·day; n – the considered day of the year (the first day being 01 January); φ – the place latitude, in degrees; δ – the place the n day of the year declination, in degrees; t_r – the hour angle corresponding to the sunrise, in degrees.

For the drying installation design a series of dates about the vegetables and fruits which will be processed are needed, such as: the physical and chemical properties, the sorption isotherms, the water content, the heat needfulness etc.

The physical and chemical properties of the vegetables and fruits are adverted to their size, the specific heat, the firmness of the structure and texture, the color, the aroma, the taste, the water, vitamins and mineral substances content. Some properties from this category are specified afterwards [3].

The physical properties of a product are represented by weight, size and volume. The weight is expressed in grams and varies in large limits, depending on species, variety, climatic conditions, culture etc. (Table 1).

Table 1: The values of some physical properties of the main species of fruits and vegetables [5]

Species	Weight, g	Specific weight, kg/m^3	Volumetric weight, kg/m^3	Pieces/kg
Cherries	3…10	1.0060…1.0725	510…620	50…330
Apricots	15…60	1.0034…1.0547	490…560	17…66
Peaches	40…260	0.9312…1.0394	500…580	4…25
Plums	10…65	1.0016…1.0942	500…610	15…100
Apples	70…250	0.6572…0.9264	400…530	4…14
Pears	30…500	0.9843…1.0125	450…580	2…33
Potatoes	30…300	-	650…700	3…33
Onion	40…500	-	400…600	2…25
Carrots	25…200	-	500…650	5…40

3. RESULTS AND DISCUSSION

For the 45° north latitude which passes through the middle of the Romania, through the utilization of the relation (1) were obtained the values shown in Table 2.

Table 2: Medium daily solar radiation on the Romanian territory

Month	15.01	15.02	15.03	15.04	15.05	15.06
I_{za}, W/m^2·day	3278	4786	6823	9095	10789	11513
Month	15.07	15.08	15.09	15.10	15.11	15.12
I_{za}, W/m^2·day	11167	9799	7693	5443	3653	2883

For the dimensioning calculus is recommended to use the medium values of the daily global solar radiation measured on clear sky, on the horizontal plane (I_{gzs}) for the 15th day of every month, in W/m^2·day (Table 3).

Table 3: Medium values of the solar radiation in Romania

Month	Measured values		Calculated values		Definitive values	
		%		%		%
January	2330	3.48	2240	3.60	2394	3.67
February	4080	6.10	3170	5.08	3459	5.41
March	6040	9.03	5145	8.27	4986	7.79
April	7235	10.81	6720	10.79	6711	10.49
May	8100	12.10	7715	12.38	8023	12.54
June	8480	12.69	8515	13.67	8595	13.44
July	8085	12.08	8040	12.90	8325	13.01
August	7230	10.80	6625	10.63	7254	11.34
September	6005	8.97	5400	8.66	5628	8.79

October	4220	6.31	3980	6.39	3947	6.17
November	3040	4.54	2765	4.44	2639	4.11
December	2070	3.09	1990	3.19	2061	3.22

From the analysis of the global daily solar radiation values measured on clear sky day on horizontal plan (I_{gzsm}), of the daily definitive solar radiation (I_{gzs}) and of the medium daily solar radiation from out of the atmosphere (I_{za}) is justified the adoption of the definitive values suggested in Table 2.
In Table 4 is presented the ratio between the global daily solar radiations measured on a clear sky day (I_{gzsm}), respectively the global daily definitive solar radiations (I_{gzs}) and the medium daily solar radiation from out of the atmosphere.

Table 4: Ratio I_{gzsm}/I_{za} and I_{gzs}/I_{za}

Day	15.01	15.02	15.03	15.04	15.05	15.06
I_{gzsm}, W/m^2·day	2330	4080	6040	7235	8100	8490
I_{gzs}, W/m^2·day	2394	3459	4986	6711	8023	8595
I_{za}, W/m^2·day	3278	4786	6823	9095	10789	11513
I_{gzsm}/I_{za}	0.711	0.852	0.885	0.795	0.751	0.737
I_{gzs}/I_{za}	0.717	0.723	0.731	0.738	0.744	0.746
Day	15.07	15.08	15.09	15.10	15.11	15.12
I_{gzsm}, W/m^2·day	8085	7230	6005	4220	3040	2070
I_{gzs}, W/m^2·day	8325	7254	5628	3947	2629	2061
I_{za}, W/m^2·day	11167	9799	7692	5443	3653	2883
I_{gzsm}/I_{za}	0.724	0.730	0.781	0.775	0.832	0.718
I_{gzs}/I_{za}	0.745	0.740	0.732	0.725	0.720	0.715

For the efficient utilization of solar energy is also needed to know the diffuse daily radiation of which values measured on the ground level around the parallel of 45°are shown in Table 5.

Table 5: Characteristics of diffuse daily solar radiation (I_{dzs}) and measured duffuse solar radiation (I_{dzsm})

Day	15.01	15.02	15.03	15.04	15.05	15.06
I_{dzs}, W/m^2·day	564	697	928	1186	1378	1452
I_{gzs}, W/m^2·day	2349	3459	4986	6711	8023	8595
I_{dzs}/I_{gzs}	0.240	0.201	0.185	0.177	0.171	0.169
I_{dzsm}, W/m^2·day	430	735	1015	1065	1160	1426
I_{gzsm}, W/m^2·day	2330	4080	6040	7235	8100	8490
Day	15.07	15.08	15.09	15.10	15.11	15.12
I_{dzs}, W/m^2·day	1410	1251	1035	787	583	515
I_{gzs}, W/m^2·day	8325	7254	5628	3947	2629	2061
I_{dzs}/I_{gzs}	0.167	0.172	0.184	0.199	0.222	0.250
I_{dzsm}, W/m^2·day	1255	1165	865	655	735	500
I_{gzsm}, W/m^2·day	8085	7230	6005	4220	3040	2070

Considering that the direct solar radiation is the difference between the global daily definitive solar radiation (I_{gzs}) and the diffuse solar radiation (I_{dzs}) are obtained the values included in Table 6.

Table 6: Values of the direct solar radiation on the Romanian territory

Daily sum, W/m2·day	Month											
	01	02	03	04	05	06	07	08	09	10	11	12
	1785	2762	4058	5525	6645	7143	6915	6003	4593	3160	2046	1546

For the conversion of the solar energy in Romanian conditions is recommended as the banking angle of the solar receptors against the horizontal line to be of 45°, which allows the appreciable decrease of the loads caused by the wind action and the decrease of the distances among the solar receptors. The average number of sunny days on the warm season is determined through multiplication of average hour duration of sun glowing with the number of days from the warm period of the year (01.04…01.11), respectively 156 days. In the warm season the average day used for dimensioning the solar installations is considered to have 9 hours and an intensity of solar radiation I = 580 W/m^2.

Knowing the features of the vegetables and fruits and tracing their sorption and desorption isotherms it can be drawn the energy balance through the utilization of solar panels as the source of energy for dryers with enforced production. On the strength of the sorption and desorption isotherms it can be conducted the drying process in such way that physical-chemical proprieties of the dried products to be much closer to the ones of fresh products.

4. CONCLUSIONS

- The preservation through drying of some vegetables and fruits present many economic interests, as much for the agricultural producers, and for the national economy. Difficulties in this process are generated by high energy costs required for drying.
- The utilization of solar energy for the drying of vegetables and fruits represent an acceptable alternative for the energy from unregenerate sources, on condition that the technical used-up equipment to be properly projected and exploited.
- An accordingly drying of every vegetables and fruits presupposes a better preservation of their physical-chemical features ensured as much through a properly sizing of the technical equipment, and through an appropriate management of the drying process.
- On the strength of the thermal balance of a dryer it can be sizing the heat sources, and the necessary (the flow) of the air which must be assured by the fans powered by photovoltaic panels.

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