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RESEARCH REGARDING DRYING OF AGRICULTURAL PRODUCTS BY USING SOLAR ENERGY

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Abstract: *This paper presents the results of researches regarding the using of solar energy for conservation by drying of vegetables and fruits. The research took into account two aspects: monitoring of climate characteristics and solar radiation, during summer when the excess fruit and vegetables can be preserved by drying and also to design a simple and reliable equipment for drying agricultural products from which to conduct temperature, humidity and air movement speed.*
Keywords: *conservation, vegetables, drying, solar energy*

1. INTRODUCTION

Humidity is a factor with deep implications on food quality causing a large response. Thus auto oxidation and coloring in brown may occur simultaneously in most foods. For every product there is an optimum moisture content at which the speed of oxidation and coloring in brown are minimal, providing a maximum storage quality (E.g. 3.3% for milk powder, for potato flakes 6-7%).
Regarding the particular behavior on drying fruits and vegetables should primarily be considered the taste specificities, so their edible part. For drying products from each category, it should be used a specific technology. For example, root vegetables is characterized by a robust growth in thickness, accumulation of large amounts of substances and water reserves, and the bark surface is composed by several rows of cells. The outer membrane has an impermeable protective role.
For drying, the bark must be removed, and then the roots are chopped into cubes or slices. Vegetables which from we are using the fruits, as the tree species (fleshy false fruit) have the skin surface (epicarp) consisting in two or more cell layers, with a protective role; on the outside row of cells there is a layer of wax or even finer or coarser piliferous, which can aggravate the drying process.
Nowadays, these features of the drying process of vegetable and fruit comes to explain the energy consumption necessary in order to perform this conservation procedure. These inputs are explicable only if considering anatomic and physiologic characteristics of fruits and vegetables and the high water content.

2. MATERIAL AND METHOD

Water plays an important and unique role in agricultural products. As part of the greater presence of plant structure, it affects a lot of physical, chemical and biological processes that occur during storage. Water concentration affects virtually all processes leading to deterioration of both microbiologically and enzymatically or nonenzymatically. Rates of action of various processes of deterioration depend mainly on plants water concentration. Water potential to participate actively in the processes of degradation can be characterized by indicator, water activity (aw), which is defined as the ratio of water vapor pressure in the product, at a given temperature, and saturation vapor pressure of pure water at the same temperature.
On balance, water activity is related to the value of relative humidity of surrounding atmosphere. Importance of water sorption equations were studied by many researchers, including the retention of nutrients during dehydration and storage life of the product in a particular type of packaging.
Equations are also needed to determine the thermodynamic functions of the ad and water absorption in foods, to calculate the drying time, and to simulate the drying systems. Drying simulation systems can be used to calculate drying time to determine their effects on the efficiency of drying parameters, or to minimize operating costs. Lately, the sorption curves have a growing importance, due to the increasing number of regulatory and legislative

recommendations on their use to characterize in terms of food quality and using water activity as a criterion for evaluation basis. The best method of drying is drying out in three stages:

- Pre-drying at 80° C;
- Basic drying at 60° C;
- Final drying at 40-60° C

The first two steps can be bivalent made using a burner with liquid fuels which brings preheated air temperature at the desired temperature.

The last step is done monovalent by indirect solar drying. Airflow is directed through the three stages with fans. The first stage occurs from surface water disposal product. In the second stage, proper drying, the product is dried to a final moisture content of 10 ... 15%. The third step can be performed at an ambient temperature 40 ° C, because the product with low water content is protected from damage. Main heat consumption is necessary for the draining water of the material is meant to be dry and could be calculated with:

$$t_m = \frac{t_i + t_e}{2} \ (^{o}C) \quad \textbf{(1)}$$

Where: t_i - dryer input temperature; ^{o}C t_e - dryer output temperature, ^{o}C. Air entering the dryer is given by:

$$q_1 = q_1' + q_1'' \ (kcal/kg) \quad \textbf{(2)}$$

where: q_1' - amount of heat in the air, kcal/kg; q_1'' - amount of heat in water from air, kcal/kg. The relations for calculating the two quantities of heat are:

$$q_1' = m_{air} * c_{air} * t_i (kcal/kg) \quad \textbf{(3)}$$

where: m_{air} – mass of air, kg; c_{air} - specific heat of air, kcal/kg; values of m_{air}, c_{air} are chosen such that: $m_{air} = 1- X_1$ $c_{air}=0,24$ and q_1'' is calculated with the formula:

$$q_1'' = m_{water} * c_{water} * t_i \ (kcal/kg) \quad \textbf{(4)}$$

Where: m_{water} - mass of water contained in air, kg; c_{water} - specific heat of water kcal/kg

Values of m_{water}, c_{water} are chosen such that: $m_{water} = X_1$; $c_{water} = 0,447$

Commonly used method for dehydrating fruit and vegetable industrially is hot air drying, with different types of dryers (tunnel, band, with areas). Depending on the characteristics of raw materials and finished products, certain technical conditions are required for dehydration of fruits and vegetables using hot air as can be seen in Tables 1 and 2.

Table 1: Technical data for drying vegetables

Name of the product/	Type of the drier	Drying temperature °C	Product humidity %	Efficiency %
Potatoes	Tunnel or band	70...85	7	12...16
Carrots	Tunnel in counter-current flow + room	50...70...80	7...8 4	6...12
White roots	Tunnel in counter-current flow	35...50	4	4...8
Horseradish	Tunnel with 2 zones + room	60...65	7...8	5...8
Beetroot	Tunnel with 2 zones + room	50...95	10...15	7...10
Cabbage	Room or tunnel with 2 zones	50... 95	5	4...6
Onion	Tunnel	50...70	7	8...11

Table 2: Technical data for drying fruits

Name of the product	Type of the drier	Drying temperature °C	Product humidity %	Efficiency %
Plums	Tunnel or band	60...75	18...20	25...35
Apples	Tunnel or band	55...75	Maximum 24	10...12

Ultra dried apples	Vacuum chamber	50	3	9
Pears	Tunnel	Maximum 65	Maximum 26	12...17
Apricots	Tunnel	Maximum 65	15...20	16...25
Peaches	Tunnel	Final maximum 70	15...20	13...25
Cherries and sour cherries	Tunnel (counter-current flow)	Maximum 70	15...20	24...30

The principal objective of experimental research involves the factors influencing the performance of a photovoltaic panel and the default of a solar panel.
To address this objective should be attending and addressing the following subsidiary objectives:

- •Monitoring the intensity of solar radiation in the area to locate the object that is turning the solar energy;
- •Monitor temperature, humidity and velocity of air movement in the zone;
- •Establishing the influence of photovoltaic panel angle on electric power supplied;
- •Establishing the influence of climatic factors indicated for the temperature achieved within the dryer with a given solar heating system.

In this research there have been used several devices and instruments such as: Pyranometer type SDL-1 Solar Data Logger to measure solar radiation intensity; complex apparatus for measuring temperature, humidity and velocity of air movement; accumulator battery, controller, inverter, multimeter, lamp control, fan, solar photovoltaic panel type Tech, as presented in Figure 1.

Figure1: Machinery and tools used in experimental research

The sun drying method for the plant products can give good results if applied properly. The positive effects are not confined only to save fuel but also the basic principles of slow and gradual drying that can give a qualitatively satisfactory product.
Be noted, though, and disadvantages of the method namely: relatively high period of the drying process; significant impact on the weather conditions are major drawbacks of drying. In the current juncture, the rationalization of energy consumption has become a problem for the entire planet, it must shift to use the sun energy for drying vegetables and fruits. In addition to simple systems, which consist in direct exposure of the products to sunlight, there are complex systems that use solar radiation collection devices.
They have the advantage of reducing the drying process by 2 ... 3 times, while achieving a higher quality product.
The principle solution of operation of these devices is to capture solar energy to heat air or other heat carrier agent and directing it into the special facilities for drying.
Drying using solar energy gives good results, it saves energy, is slow but in terms of quality is very good. In this case, the trays for drying must be placed in sunny locations and free of dust. The supports for the grates used for drying can be carried in frames, and their height should not exceed 20 cm. The amount of vegetables or fruit per square meter should not exceed:

- ▪Fruits: 8 ... 10 kg cherries, sliced apricots 4 ... 5 kg, pears 13 kg, plums 10 kg;

▪Vegetables: 3 ... 5 kg bean peas, peppers 4 ... 5 kg, whole Kapi pepper 10 kg , slices Kapi pepper 5 kg, bell pepper slices 8 kg.
Using solar energy is deeply rooted in time and operation of the endless heat is common in practice. Preparation of domestic hot water is a wide range of application of solar energy, both technically and economically. Current requirements of environmental protection and the necessity of acquiring energy independence, are primordial factors for development of the alternative solutions. Energy provided by solar radiation is converted directly and can help to prepare domestic hot water and electricity production, with the great advantage that is "free", clean and protect natural resources.
Photovoltaic panels can provide a secure source of energy for short periods and where electricity is needed and does not have an electric grid. Photoelectric solar batteries are composed from a large number of photocells. As long as a photocell generates a lower voltage there has to be more of these cells linked in series so the solar battery can be used as an energy source.
Solar dryer tunnel type consists in a flat solar collector covered with a transparent plastic sheet, a dry tunnel, a photovoltaic panel and two axial fans, as in Figure 2. To simplify construction and reduce production costs, solar collector is connected directly to the drying tunnel, without any auxiliary channels for directing air. Both the solar collector and dryer itself is mounted on metal supports having a height of 1 m, to facilitate handling during loading and unloading the products from the dryer. Due to the modular design, drying tunnel length can be increased to 20 m for drying products in arid regions.

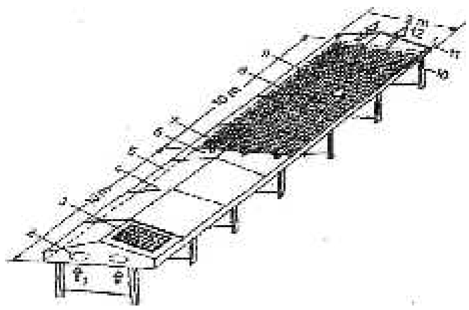

Figure 2: Solar dryer tunnel type, Hohenheim model

3. CONCLUSION

Vegetables and fruit can be preserved by dehydration, a process which removes much of the water content. Remove water is up to providing the product conservability.
The humidity varies widely, so the fruit is preserved at 18 ... 20%, vegetables between 8... 10% and other products to a moisture content of 2 ... 4%.
Dying fruits and vegetables using solar energy is used since ancient times, because solar energy is inexhaustible, but free in terms of costs. Vegetables and fruits were dried years ago directly from the sun stretched on racks or even on film. This is also used, even today, when research on the use of solar energy used for drying vegetables and fruits has evolved greatly.
The energy sources that could replace fossil fuels, solar energy offers the greatest safety and accuracy. Direct capture of solar energy involves artificial methods, called solar collectors.

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