THE PROCEDURE FOR DRYING PLANT PRODUCTS IN CONVECTIVE DRYERS

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Abstract: *This paper shows the advantages of using convective dryers and their performance in terms of energy. These are meant for dehydration of vegetal products, in line with the global trend concerning conservation through the thermohydric technology of enzyme inactivation (dehydration).*
In the paper two concepts are promoted which are strictly up-to-date in the present context of deepening of energy and food crisis at global level: the concept of energy independence and the concept of food security and safety for consumers.

Keywords*: convective dryers, plant products, dehydration, energy independence, food security and safety*

1. Introduction

Convective drying remains, also nowadays, the best known and widespread process of removing moisture from the material, both due to the simplicity of the process, and especially due to the numerous opportunities to obtain, at low cost, high quality of drying in a short period of time.
Drying is a complex operation involving transient heat and mass transfer along with various processes, such as physical and chemical changes which, in turn, can cause changes in the quality of the product just like the mass and heat transfer mechanisms. Physical changes that may occur are: contracting, swelling, crystallization, glass transformation. In some cases, there may be chemical or biochemical reactions desirable or not which can affect the color, texture, smell, or other properties of the solid product.
In intensive drying processes it is intended to accomplish a uniform contact between the thermal agent and the biomaterial granules which is done in relatively homogeneous layer structures. This challenge is imposed by the fact that in the heat treatment of biomaterials there could occur significant degradation of the quality of the final product.
Drying is one of the traditional ways and yet always modern for storing on extended periods of time vegetables and fruits for direct consumption or for industrial processing without addition of preservatives and low power consumption for storage and reprocessing. Convective drying is an intensive thermal energy technology, which in many cases makes it dependent on the heat sources which are as cheap as possible, one reason for super concentration of drying plants. Rapid price decline in automation devices, the development of the automated management software and also the development of machine building technology have led to a decentralization of processing fruits and vegetables by drying, to the displacement of drying facilities at the place of harvest of the products to be dried. This makes the use of mobile dryers dependent on the use of diesel oil and LPG, which are fuels with high energy density, but sources of pollution through the emission of CO_2.
Vegetables and fruits throughout the history of humanity were the basic elements of food, due to their content in proteins, fat and carbohydrates, minerals such as potassium, sodium or magnesium etc., their use throughout the year being good for health. Pedoclimatic and relief conditions in Romania have made it possible that on this territory to be grown a variety of vegetables and fruit, of great importance, divided into more than 15 botanical families. However, these products are seasonal, have relatively short harvesting periods, and the perishable nature of

most of them is very high or medium, making their use as fresh products be possible only as a result of exquisite storage, which significantly increases costs.

2. The main advantages of vegetables and fruit preserved by drying

Drying of fruit and vegetables is the healthiest solution for long time preservation. Another advantage of the dehydrated fruits and vegetables is that they have a validity term greater than frozen or canned ones. Actually, dried and stored in optimal conditions, fruits and vegetables can be eaten even after several years.
An important economic aspect of dehydrated vegetables and fruits is that their storage does not pose serious problems because their volume is reduced significantly after the drying process. For example, two kilograms of raw fruit after drying will be a quarter of the initial volume.
There can be dehydrated almost all fruits and vegetables, with the exception of the vegetal fat-rich ones because they can become greasy. Grapes, plums, apples, pears, peaches, apricots, pineapple, bananas, tomatoes, carrots and herbs are best suited for this operation.
Dehydration can be done by simply placing the fruits and vegetables in the sun, as it was done hundreds of years ago; however the dehydration plant is the best solution, because the drying process in the drying facility will shorten significantly the time of dehydration of fruits and vegetables. In Moldavia, a grid called "lojniţă" is used for dehydrating apples, pears and plums, often resorting also to cold smoke. In this case, the process is called smoking (plums, apples and pears are preferred). There are used varieties that are not very sweet, because there is a risk after dehydration for resulting juice to leak.

3. The drying of vegetal products in convective dryers using warm currents and facilities for this type of drying

Convective drying remains, also nowadays, the best known and widespread process of removing moisture from the material, both due to the simplicity of the process, and especially due to the numerous opportunities to obtain, at low cost, high quality of drying in a short period of time.
The wet material gets into contact with the drying agent - hot air or combustion gases – receiving from it, by convection, 80-90% of the total quantity of heat necessary for the drying process. The parameters (speed, temperature, relative humidity, etc.) of the drying agent, as well as the connection between humidity and material determine the heat and mass transfer in the drying process. In the process, the drying agent changes its temperature, relative humidity and even circulation speed, and the wet material changes its density, specific heat, thermal conductivity and even dimensions. The drying process is a complex process during which many parameters (coefficients of heat and mass transfer, the viscosity of the water, surface tension, etc.) change, so that for exact knowledge of the development of the process there is necessary a correlation between the known theoretical results and the direct experimental research carried out for each material.

Experimentally, the peculiarities of the drying process of wet material are given by the drying curves (which show the change in humidity over time), the drying speed curves (which show the variation of drying rate with moisture or over time), the variation of material temperature and drying agent over time etc.

From the point of view of heat transmission in order to eliminate moisture the drying can be:
- Convective drying - heat transfer by convection from air or other gases to the material subjected to drying;
- Conductive drying - heat transfer by conduction, by means of a heat transfer surface;
- Dielectric drying - dielectric heating of the material in a HFC (high frequency currents) field;
- Radiant drying - heat transfer by radiation.

4. The general functional diagram of a convective dryer

The component parts of a dryer type chamber with trolleys and shelves are: *1*- the dryer chamber; *2*- trolleys (carriages) with racks or shelves; *3*- fan; *4*- external radiator for heating the mixture of air; *5*,*6*- internal radiators for intermediate heating of drying agent; *7*- choke for the adjustment of exhaust air recirculation.
Its operation is an elementary one; ambient air is introduced into the drying plant after initially was passed through a heat exchanger. This one is meant to provide the introduced fresh air with the temperature necessary to the drying process for that phase. The air is then passed on in the installation to a system of choke valves, which is intended to control the flow of thermal agent introduced into the drying chamber, thus being achieved in a simple manner the dosing of hot air; this one, taken by a fan, is sent through a pipe system to the drying chamber where there are previously placed the vegetal products that are to be subjected to the drying process.

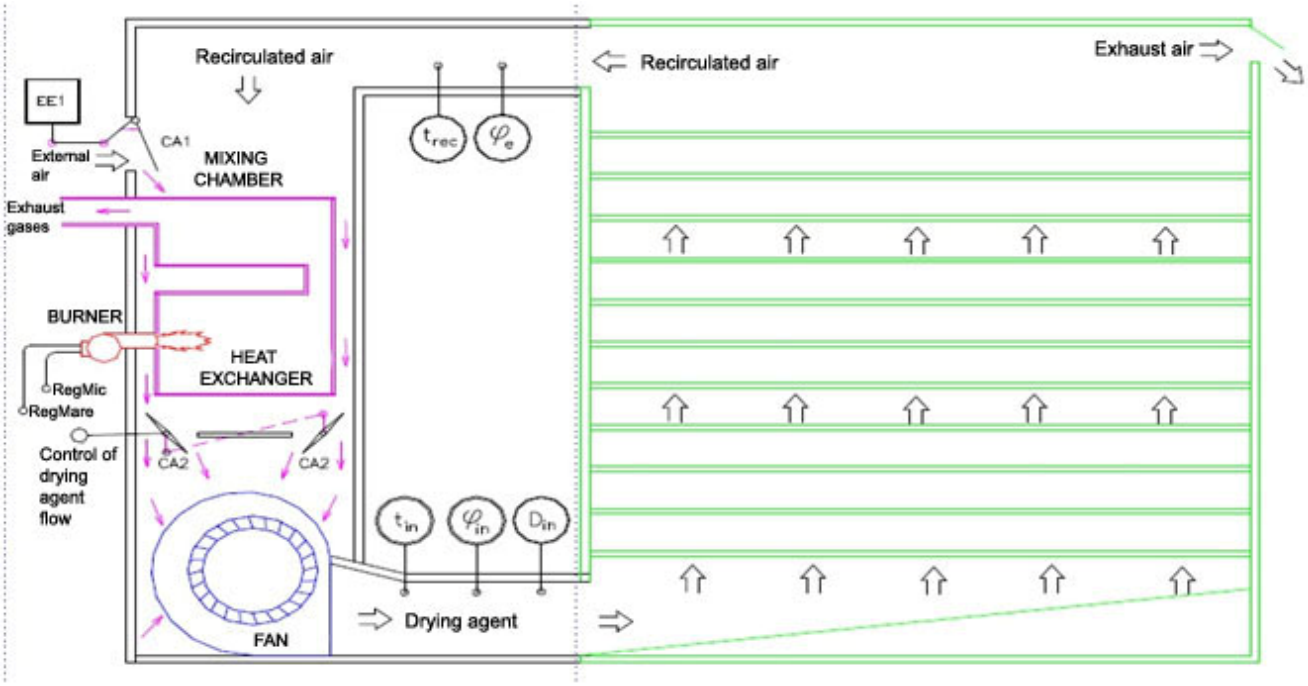

Fig. 1 The general functional diagram of a convective dryer type chamber with trolleys and shelves.

After going through the entire chamber, the air is already moist, because it has taken over part of the moisture of vegetable products, following that part from that one to be discharged, and the other part be recirculated, thus reducing the amount of fuel used for heating the air.
This diagram focuses on energy saving and promotion of work processes as profitable as possible in terms of energy, important features in the field of convective dryers.

5. Types of drying

Batch drying:

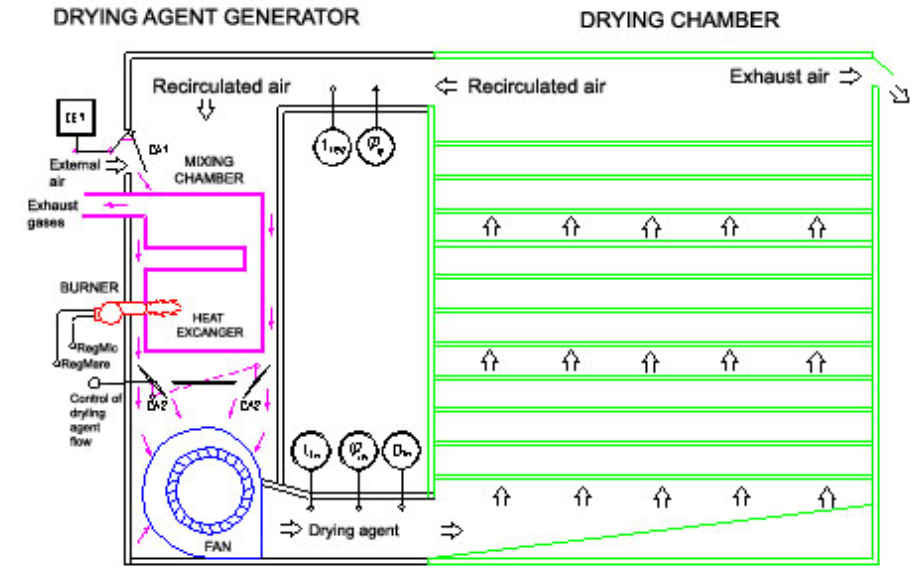

Fig. 2 Diagram of a convective dryer with circulation through layer panels

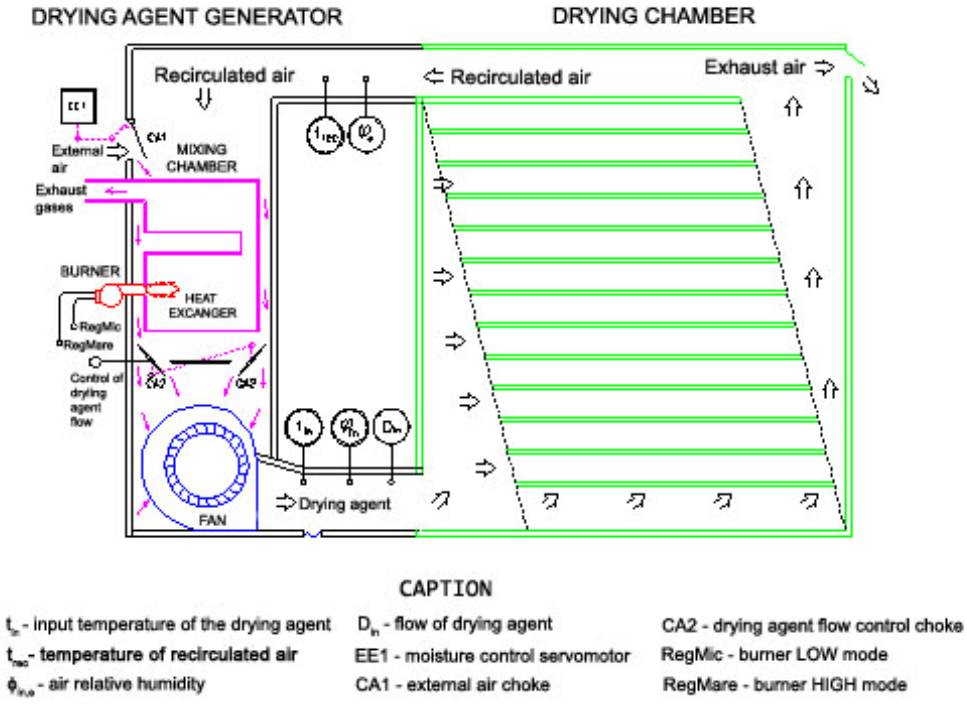

Fig. 3 Diagram of a convective dryer with tangential circulation panels

The advantages of this type of drying are:

- material to be dried is spread evenly across panels that are stacked on trolleys or slideways;
- hot air is introduced with an automatically controlled temperature, constant, or greater at the beginning and lower at the end of drying;
- temperature and humidity at the output are measured and there is calculated the average temperature at the material surface;
- there is adjusted the ratio external air/thermal agent recirculated in order to control the surface temperature of the material to be dried;
- if constructively possible, there is changed periodically the direction of travel of drying agent in order to obtain even drying.

Semi-continuous drying:

- material to be dried is spread evenly across panels that are stacked on trolleys which are inserted and pulled out periodically;
- hot air is introduced with an automatically controlled temperature;
- temperature and humidity of drying agent at the output are measured and there is calculated the average temperature at the material surface;
- there is adjusted the ratio external air/thermal agent recirculated in order to control the surface temperature of the material to be dried;
- circulation of the drying agent and the trolleys is done: in co-current, counter-current or mixed flow.

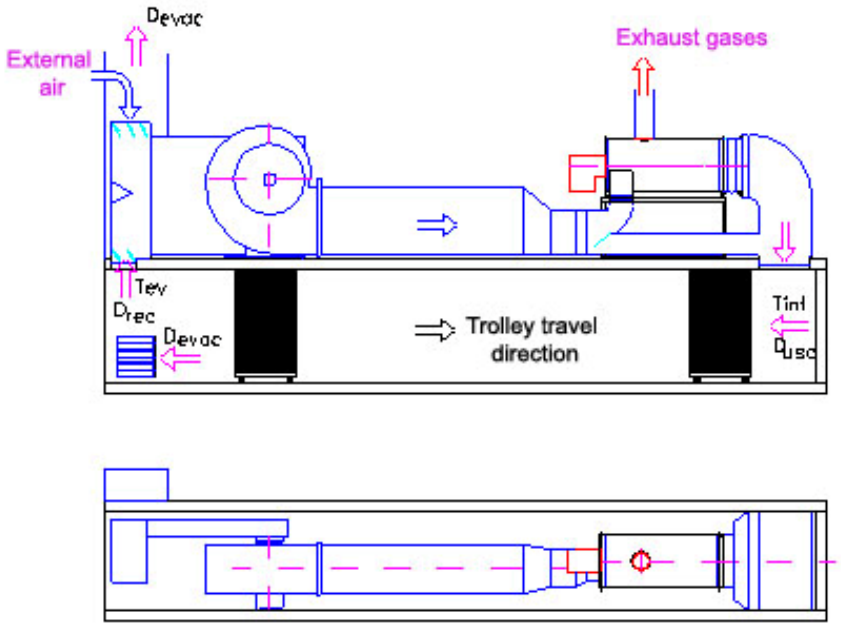

Fig. 4. Fruit and vegetable dryer tunnel type - functional diagram

6. Conclusions

One of the easiest ways to keep the quality of fruits and vegetables is their preservation by drying or dehydration. While drying is performed based on natural heat transfer of water from vegetal

products to the outside, dehydration assumes that the same transfer is performed under strict human control, by using adequate technical equipment.
Industrial scale dehydration of food products, characterized by relatively high production costs, is widely used as the final products have low weight and volume and, through strict control of technological operations, there is ensured compliance with the current regulations on hygiene and food safety.
Convective drying is the most common method of removing moisture from fruit and vegetables, both due to the simplicity of the process, and especially due to the numerous opportunities to obtain, at low cost, high quality of drying in a short period of time.

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