

## FROM A SMOKEHOUSE TO A VACUUM DEHYDRATOR

**B. Zlatković<sup>1</sup> and T. Vulić<sup>1</sup>**

**Abstract:** The tradition of fruit dehydration in Serbia has been long and anviable. It seems that Serbian machine-building in the area of fruit processing technology has given its greatest contribution in this field.

It has been one 100 years since the smoking house of Mr Stokovic, PhD was announced to be the best and the most promising plum dehydrator at the open competition organized in Topčider by the Ministry of Agriculture. It was the first real, almost continual fruit dehydrator where plums were moved at certain intervals closer and closer to the source of heat. Such a concept of plum dehydration from lower to higher temperatures was held on even later in perhaps our most famous dehydrator CER. Even the smoky smell was retained, but liquid fuel was used for technical purposes.

For a long time, it has been a well- known fact that vacuum dehydration has many advantages. In our country there have been many attempts to make fruit dehydrator of greater capacities in which vacuum would be used. Of course, there have been many problems, both technical and technological, but today a hundred years after accepting Stojkovic's smokehouse, it is our great honor to present to you the results of plum dehydration in a home-made vacuum condensation dehydrator.

We hope that now path is widely open to high quality dehydration, and not only for that plum, but for fruit susceptible to oxidation which is the reason our food industry has not produced it so far. This is probably a farewell to the most dangerous, but for the product quality, the most necessary operation – sulphuration.

**Key words:** fruit dehydration, dehydrators, vacuum dehydrators.

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## **I n t r o d u c t i o n**

Fruit (plums) dehydration is traditional for the people and the country of Serbia, not any and of tradition, but we would say it is a unique tradition which has lasted for more than a hundred years. Whether it is going to be preserved or broken and depends mostly on us.

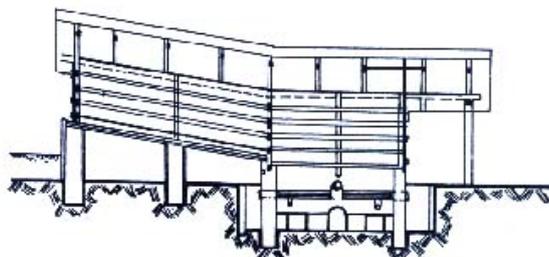
The aim of the present work is to remind of the very beginnings of the tradition of plums dehydration when smokehouses were used, and to explain the possibilities of preserving them through the analyses of the development of dehydrators. In this way, together with the survey of the smokehouse development in our country, the results of plums dehydration on a new vacuum condensation dehydrator of domestic production are given.

### **The development of fruit dehydrators in Serbia**

Even at the end of 19<sup>th</sup> century, when Serbia's export of dried plums was fairly large and when the demand for them was great, it was obvious that the market should be offered standardized and the best possible quality. That was the reason why "according to the approval of Mr. Minister of the National Economy three experimental plums dehydration were made at Topcider in 1898 managed by special Commission appointed by Mr. Minister. Besides, as suggested by the Commission and approved by Mr. Minister, two parallel dehydrations were done at the dry-kiln of Glavinic structure which had been built in Gornja Dobrinja in the district of Pozega, owing to the Pozega branch of Serbian Agricultural Society. Dehydrations on these dry-kilns were done under the supervision of the Commission appointed by Mr. Minister too."

Dehydration was done by using three different dry-kilns: classical domestic, new domestic (Glavinic's) and foreign (Rib's). The experiments were repeated the following year and then Glavinic's dry-kiln got "a green light" to spread over the villages of Serbia. Yet, "our domestic dry-kiln is one primitive tool which has been changed slightly since it come into use, so it is almost the same as it was 50 years ago. It could be still used before the war when the labour and fuel in the country were abundant and cheap and when our dried plum appeared on foreign markets only through many agents and very often under someone else's name. However, the circumstances changed completely since the end of the war. Now dried plum should be produced more economically both in labour and fuel terms and also of better quality, which will be able to compete successfully with the dried plum of other peoples on the world markets now open and accessible to us. Old domestic dry-kiln does not fully satisfy these conditions, so we are supposed to be looking for modern tool by which it will be changed." (2)

Feeling the need for modern dry-kiln, the Ministry of National Economy again invited tenders for the testing of dry-kilns used on the terrain in order to come to one model by parallel tests, which would be then recommended to the people. The following year 1912, after the repeated experiments of plum drying the Ministry announced that the dry-kiln of Dr Stojković was the best.



Picture 1. - The dry-kiln of Dr Stojković

The plums intended for drying are put on hurdle-gates, hurdle gates are placed in several lines into the dry-kiln away from the source of heat (smoke). At certain time intervals these hurdles are placed closer to the source of heat and the other ones replace them. And so on until the moment when hurdle-gates are exactly above the fireplace where the temperature is the highest. It is the end of drying there, but the beds for two more hurdle-gates are set on which the plums not dried enough by previous procedure are put.

“Good dehydrator is the product of profound theoretical and practical studies, long patience and persistent work”, wrote then Dr Stojkovic the author of the rewarded dehydrator. “Let the coming generations accept our not enough perfect work, let them improve and complete it and then offer it to our people in a better shape!” (2)

And so it was. After 50 years and after new wars, a new dry-kiln was developed in Serbia according to the same so-called counter stream principle. Even the smell of smoke was kept because the air with exhaust gases was used for drying. Of course, liquid fuel was used because it was technically more efficient and at that moment economically much profitable. It was the classical dry-kiln for fruit and vegetables CER (picture 2).

The dry-kilns were very attractive for the countries of Eastern Europe so by exporting them even better economical effects were achieved than by dried plums export.

In the mid of the last century, when industrialization euphoria ruled the economics, the concept was made under which the great centers for dehydration and finishing of dried plums should have been developed. On the other hand, it was confirmed that the burning-down products present in smoke or remaining on

the plum were an important factor of the risk of cancer. So, the customers started to give up even smoked ham and the production of smoked plum practically stopped. In other words, there were no bans but nobody in the world wanted to buy it. That is an already well-known story of benzopiren.



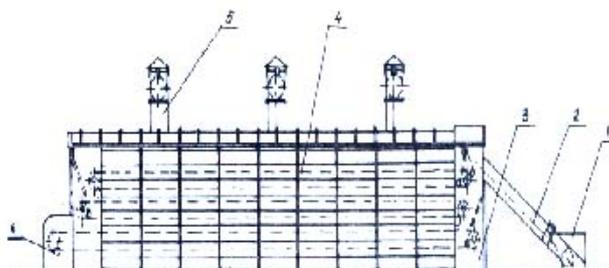
Picture 2. - Dehydrator CER

The factories that manufactured fruit dehydrators moved easily over to indirect way of heating. Fresh air from the atmosphere warms up in heat exchangers with the help of smoke coming out from burning of solid, liquid or gaseous fuels. Out of thermodynamics reasons, very soon it was converted into the usage of boilers. Now water steam became the holder of heat for warming up the air. In that way, great efforts were made to develop the system of burning down different fuels even the fuel which came out as a litter of fruit and vegetable processing itself (5).

On the other hand, the dehydrators with hurdle-gates demand a lot of labour. Because of that strip dry-kilns were becoming more and more dominant, for they enabled typical continual work. Yet, regardless of the way of putting the fruit into the tunnel such dry-kilns did not provide the possibility of changing the conditions (from the vien point of air) during the drying. This is how people came to the idea and achievement of segment dry-kilns (picture 3).

With high capacity and continual work it was now possible to provide the change of drying conditions in each segment of dry-kiln. The starting idea was to connect these dry-kilns with the computer which would, depending on the characteristics of drying material, regulate itself the characteristics of the air in each segment. Intensive was caried on improving the system for fruit and vegetables drying by using solar energy (6). Unfortunately, all these efforts were unsuccessful for several reasons. Above all, the speed of drying is small, so

during the day the fruits dry poorly. This is why it is necessary to dry them more in a classical convective way.



Picture 3. - Segment dry-kiln

One part of the water in the fruit is connected with weak energy – above all as macrocapillary and osmotic water. Out of that, the idea was got for fruit to sink it into the solution of saccharosys of high concentration (of high osmotic pressure) in order that water can leave the fruit and come into surrounding solution. The solution becomes more diluted and the fruit more concentrated. That is why the procedure of water separation from fruit is called osmotic dehydration (7, 8). Of course, it is possible to move only one part of the water in this way, which is not enough for preserving. The rest of the water must be then removed by convective procedure. On the other hand, in order to reduce the consumption of sugar, it is necessary to concentrate the solution after taking out and rinsing the fruits.

Speaking of osmotic dehydration, it is worth mentioning the idea that instead of sugar concentrated fruit juice is used, which would give additional nutritive value to the product.

#### **The vacuum of fruit drying**

It has been known long that drying in vacuum reduces considerably the risk of oxidation which brings about fruit obscuring (9). That is why this way of drying attracted great attention. Of course, the researchers in our country contribute considerably to the studies of this process and also to technical innovations. In that way, several types of dry-kilns have been designed, which differ in some technical details.

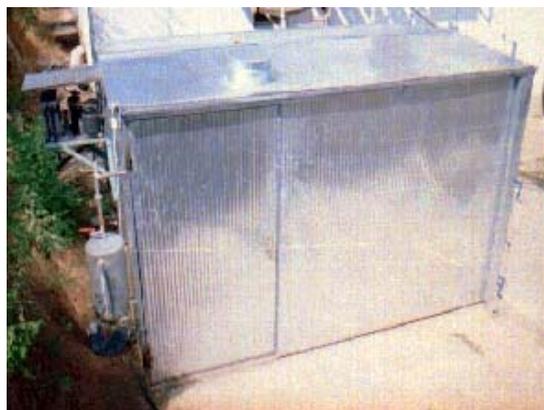
The idea of vacuum drying is based upon the fact that water boils at lower temperature, so the heat damages of the fruit are fewer. In that sense, there are different ways of vacuum applying.

A typical example is lyofilization when water in the fruit is frozen, and then in the conditions of very high vacuum there is the sublimation of ice. On this

occasion, the ice evaporates. Considering that the liquid water does not come out of the ice and it does not go through the product in the state of liquid, there is no erosion of mezocarp. This is how the fruit keeps its structure and the form as well. Although a lot of work has been done on this method of fruit dehydration, it has not been commercially used (10).

The quality that water boils at low temperature under reduced pressure is used for explosive dehydration (puff drying). The fruit is warmed up to the temperature of 60°C (still denaturing and obscuring do not happen) and then it is set quickly into the midst with the pressure which is low enough for the water to boil intensively at that temperature too. Thus, conditions are made under which the ambient pressure is lower than the pressure in the fruit, so again the structure and the form are kept. Unfortunately this modern method has not been examined yet or there is no information in our literature that it has been done.

However, the classical chamber-type dehydrators are used more often and the fruits are put into them, the air is taken out by vacuum pump, and then the warming is done. Now the main problem are secondary steams (coming from evaporation of the water from the fruits). If they are removed by condensation, we then speak of vacuum condensation dehydrators.



Picture 4. - Vacuum condensation dehydrator

Such a dehydrator (picture 4), with necessary experiment measuring outfits, was constructed in the village of Tmava near Prokuplje. In it dehydration of the Stenly sort of plum was done. The temperature in the center of the plum fruit during the dehydration was not over 60°C and the ambient pressure was 150 mbar. In this way, the fruits of plums can be dehydrated even below 20% of moisture. They are practically conserved then because the water activity is about 0.6 but they retain the natural colour and shape (picture 5).

Moreover, the absorption ability of dried fruits is such that it is necessary to take care of their storage considering they return quickly a part of moisture (depending on the relative moisture of the ambient air), which can bring about the emergence of mould.



Picture 5. - A) The look of plum fruit dried in vacuum  
B) The cut of the fruit before and after rehydration

This way of dehydration widely opening the road for quality drying, above all, of the fruit which is liable to oxidation and which our food industry has not produced because of that. This is probably a farewell to the most dangerous, but for the quality of final product necessary operation, sprinkling with flowers of sulphur.

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## OD PUŠNICE DO VAKUUM SUŠNICE

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### R e z i m e

Tradicija sušenja šljive u Srbiji je zaista duga i zavidna. Čini se da je srpska mašinogradnja u oblasti tehnologije prerade voća ovde dala najveći doprinos.

Nekako u ovo vreme se navršava 100 godina od kako je na javnom takmičenju, koje je tada u Topčideru organizovalo Ministarstvo za poljoprivredu, kao najbolja i najperspektivnija sušara za šljivu proglašena pušnica dr Stojkovića. To je bila prva prava, gotovo kontinuirana sušnica za voće. Lese sa šljivom su u određenim vremenskim intervalima pomerane sve bliže izvoru toplote. Takva ideja sušenja šljiva, od nižih temperatura ka višim, zadržana je i kasnije kod možda naše najpoznatije sušare CER. Čak je zadržan i miris na dim, s tim što se ovde iz tehničkih razloga koristilo tečno gorivo.

Već dosta dugo je poznato da sušenje u vakuumu ima velikih prednosti. Kod nas je bilo dosta pokušaja da se napravi sušara za voće značajnog kapaciteta, pri

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čemu bi se koristio vakuum. Naravno, bilo je mnogo problema, tehničkih i tehnoloških, ali danas, sto godina posle prihvatanja Stojkovićeve pušnice, imamo veliko zadovoljstvo da vam, promotivno prikažemo rezultate sušenja šljiva na jednoj domaćoj vakuum kondenzacionoj sušari.

Nadamo se da su sada zaista širom otvorena vrata za kvalitetno sušenje ne samo šljive. Naprotiv, pre svega voća koje je podložno oksidaciji i koje zbog toga naša prehrambena industrija nije ni proizvodila. Ovo je verovatno i poslednje zbogom za najopasniju, ali i za kvalitet gotovog proizvoda neophodnu operaciju – sumporisanje.

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