Biblid: 1821-4487 (2015) 19; 3; p 157-161 Expert Paper
UDK: 66.047.55:641.13 Stručni rad

APPLICATION OF COMBINED DRYING TECHNOLOGY IN THE PRODUCTION OF ORGANIC DRIED FRUITS AND VEGETABLES

PRIMENA KOMBINOVANE TEHNOLOGIJE SUŠENJA U PROIZVODNJI SUŠENOG VOĆA I POVRĆA ORGANSKOG STATUSA

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ABSTRACT

The control system of organic products in Serbia was established on the model of a control system which is prescribed by regulations of the European Union.

This paper describes the production processes of organic dried fruits and vegetables with combined drying technology which is developed at the Faculty of Agriculture in Novi Sad. Special attention is given to critical stages of drying that can threaten the organic status of the product. Since the osmotic solution, which is used in the drying process, becomes an integral part of the final product, it also must be organic. As a possible solution, usage of a solution of organic sugar cane or organic fruit syrup is recommended. Another critical point of drying is the process of sulphurisation. Sulphurisation is not allowed in organic production, the refore, in order to preserve the color of the final product, recommended treatments are treatments with ascorbic, citric or other organic acid.

Key words: *Drying of organic fruits and vegetables, combined drying technology, organic production.*

REZIME

Proizvodnja organskih proizvoda u Srbiji regulisana je važećim zakonom i pravilnicima o organskoj proizvodnji. Sistem kontrole organskih proizvoda u Srbiji je uspostavljen po ugledu na sistem kontrole koji je propisan regulativama Evopske Unije.

Preradna jedinica dužna je da dokumentuje prijem sirovine i bilans proizvoda različitog statusa.

Pored ovoga neophodna je higijena i čišćenje preradne jedinice kako ne bi došlo do kontaminacije organskih proizvoda. Postupak čišćenja, dozvoljena sredstva za čišćenje, kao i način vođenja evidencije o čišćenju postrojenja moraju biti u skladu sa zakonom o organskoj proizvodnji.

Tehnološki postupci u organskoj proizvodnji, sastojci, aditivi i pomoćne supstance koje se koriste u preradi organskih proizvoda ne smeju ugroziti organski status krajnjeg proizvoda i propisani su zakonom o organskoj proizvodnji. Skladištenje, pakovanje i označavanje proizvoda organskog statusa takođe je propisan važećim zakonom.

U radu prikazana je kombinovana tehnologija sušenja koja se razvija na Poljoprivrednom fakultetu u Novom Sadu i modifikacije koje je potrebno izvršiti da bi se tehnologija koristila u organskoj proizvodnji. Posebna pažnja posvećena je kritičnim etapama sušenja koje mogu da ugroze organski status proizvoda. Obzirom da osmotski rastvor, koji se koristi u procesu sušenja, postaje sastavni deo krajnjeg proizvoda i on takođe mora biti organskog porekla. Kao moguće rešenje predlaže se upotreba rastvora organskog šećera iz trske ili voćnih sirupa organskog porekla. Druga kritična tačka sušenja je proces sumporisanja. Sumporisanje nije dozvoljeno u organskoj proizvodnji pa se preporučuje tretiranje plodova askorbinskom, limunskom ili drugim kiselinama organskog porekla u cilju očuvanja boje krajnjeg proizvoda.

Ključne reči*: organsko sušeno voće i povrće, kombinovana tehnologija sušenja, organska proizvodnja.*

INTRODUCTION

Organic production is a production of agricultural and other products based on the application of organic production methods at all production stages, which excludes the use of genetically modified organisms and products consisting of or obtained from genetically modified organisms *(Law on Organic Production, 2010)*.

This kind of production is increasingly attractive for consumers which is particularly noticeable in more developed countries. An increase in the organic food demand and production has been recorded in the last few years in the developed countries of the European Union. According to the European Commission for Agricultural and Rural Development in a parallel manner, during the last two decades, number of organic food producers has been growing at a fast pace as well as areas of land for organic production. Every year in the European Union around 500,000 hectares of agricultural land is turned into the land for organic production *(European Commission, 2014)*. Increase in the organic production has been very evident in the USA in the last 2 decades. It is estimated that the sale of organic products has been increased by almost 20 % annually since 1990 (*Winter, C. and Davis, Sarah, 2006*).

Production of food based on the principles of organic production comprises a set of advantages, particularly in health, ecological and economic terms. Based on the review of 343 expert papers from the field of organic production, a group of authors published a paper in the magazine British Journal of Nutrition (*Barański et al., 2014)* wherein a set of advantages of organic products over the products manufactured through conventional methods are mentioned. According to their research, a significantly higher level of concentration of a large number of antioxidants such as *polyphenolics*, then *phenolic acids, flavanones, stilbenes, flavones, flavonols* and *anthocyanins* has been determined. A large amount of these elements in the nutrition of people reduces the risk of chronic

diseases and illnesses such as cancer. In addition to this, a significantly higher amount of vitamins and minerals has been detected in the food of organic origin (*Barański et al., 2014)*

Uncontrolled use of pesticides, insecticides and fungicides during plant production, and insufficient control of constituents, preservatives and additives in the end product can cause a set of health problems. Requirement for organically produced food has been in a constant increase as a reaction to the finding regarding negative effects of accustomed manners of production. On the other hand, according to the research, organic food contains on the average 63 % more kalium, 73 % more iron and even 125 % more calcium than the products obtained through conventional agricultural production, and the share of dry matery in organic products goes up to 30 % *(Vlahović and Puškarić, 2013)*. Ecological principles of this kind of production are reflected in preservation of natural status of soil. No use of pesticides and mineral (artificial) fertilisers is allowed , thus accordingly such kind of agricultural production does not contaminate water flows. On the other hand, organic production is one of the most perspective branches of agro-industry. According to the research, the demand for healthier food is particularly emphasised among a highly educated population *(Košutić et al., 2013; Živković, Jasmina, et al., 2013)*. In addition to this, an easier and better range of organic products encourages an increasingly large number of food producers to opt for this way of production.

Organic production is a completely controlled production. Production of organic products in Serbia is regulated by an applicable law and rulebooks regarding organic production.

With reference to processing units certified for organic production there are certain rules of production which are controlled by accredited certification bodies.

Processing technology and equipment for combined drying of fruit and vegetables have been developed in a Biosystem Engineering Laboratory at the Faculty of Agriculture in Novi Sad since 2001. Main feature of combined technology is that osmotic dehydration is used as a pre-treatment preceding a convective drying of biomaterials (*Babić et. al., 2011*). The following original equipment has been made: osmotic dryer, sulphuring chamber, convection dryers with shelves, evaporation of the osmotic solution and solar heater of air. This equipment represents a unique entirety that provides carrying out and control of all technological operations of combined drying technology for fruit and vegetables. This paper describes basic stages of drying biomaterials through combined technology, i.e: transportation and reception of raw materials, sorting out and separation of damaged fruit and unwanted admixture, fruit washing, fruit preparation (separation of its shanks, whittling), removal of smaller damages, procedure of antibacterial and antioxidant protection of fruits, technology of osmotic and convective drying, storage, package and labeling of organic products. A special attention is paid to the modification of the existing combined drying technology in accordance with the rulebooks and laws on organic production with the aim of obtaining the end product with an organic status.

MATERIAL

The Fig 1, shows a technological scheme of the line for the production of dried fruit by way of combined technology. Depending on the fruit sort, fruit gathering is done manually or mechanically. Plastic or wood crates in a smaller size are used for packaging. Transport is most frequently performed by trucks and tractors with trailers. Gathering and shipping of raw materials must be complied with the capacity of drying drive.

Preparation of fruit (prior to a technological drying operation) implies sorting out, washing, peeling, cutting into slices or other shapes.

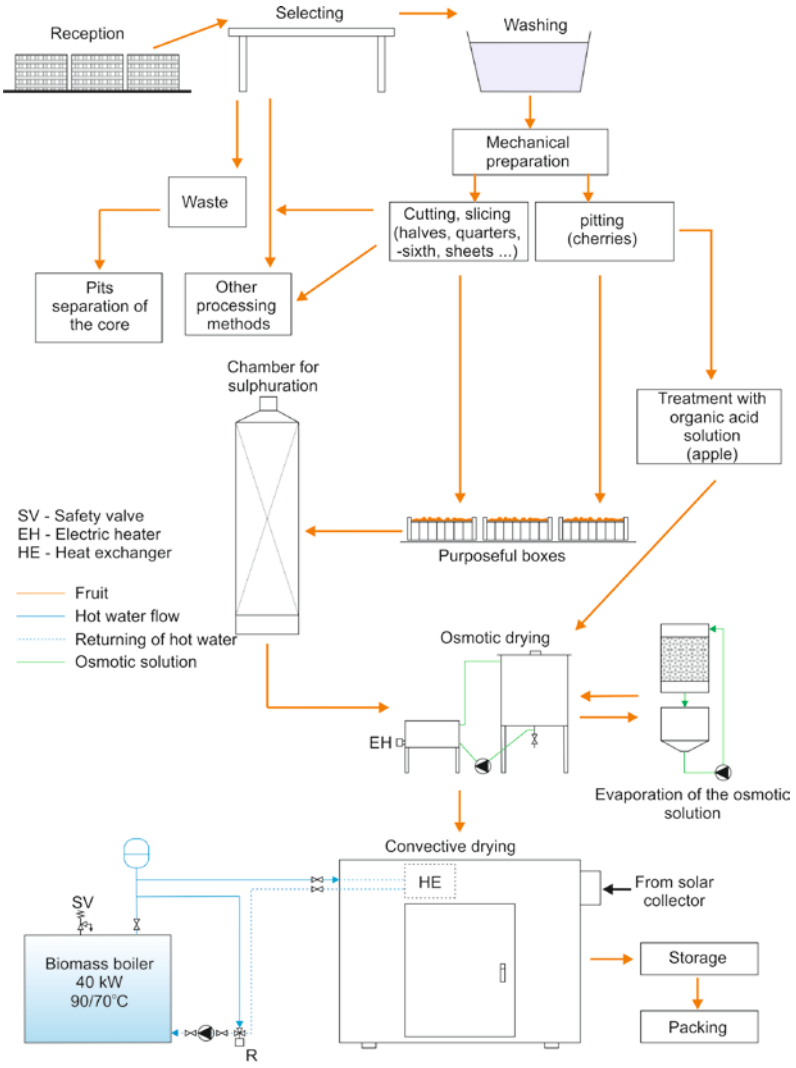

Fig. 1. Technological scheme of facilities for drying fruit and vegetables through combined technology (Babić and Radojčin, 2014)

After the reception and sorting out, fruit which meets the requirements of production is washed, regardless of the manner of preservation which is subsequently applied. Washing removes mechanical, chemical and biological dirt. Washing is performed in cold water. Fruit which is over-ripe or is not suitable for drying for any other reason (damaged, rotten…) is processed in some other way such as jam, marmalade, alcoholic beverage, making of fruit (powder, processing of stone kernel…).

If it is possible, a classification of fruit is recommended in order to put fruit into three classes according to its size. The first and the second class are dried, and the third which is the smallest one is used for other processing manners. Drying of fruit which is the same size results in balanced drying. Balance of fruit is

also important for the process of mechanical cutting or extrusion of stones from stone fruit. Fruit and vegetables are processed in different forms: whole fruit, halves, slices, hoops, squares, etc. Fruit prepared for drying is arranged in crates made out of white alimentary plastic.

The following stage of drying fruit by way of combined technology is sulphuring of fruit in a sulphuring chamber. Sulphuring is used as an antibacterial and antioxidant measure. Principle of sulphuring is based on burning a certain amount of sulphur in the lower part of the sulphuring device and exposure of fruit to the burning products. Process of sulphuring lasts for a few hours depending on the type of fruit.

However, use of sulphur dioxide as an antibacterial and antioxidant means is not allowed in processing products with organic status (*Rulebook on Organic Production, 2011)*. An adequate substitute for antibacterial and antioxidant protection is suggested hereinafter which is in accordance with the Law on Organic Production of the Republic of Serbia.

Following the process of antibacterial and antioxidant protection, crates with prepared fruit are arranged in an osmotic drier. During osmotic drying of fruit solution of water and saccharide (saccharose, glucose and fructose), whereas salt solutions are used for vegetables, primarily natrium-chloride *(Pavkov, 2012)*. Process of osmotic drying is intensified if a solution with a high level of dry matter is used (60 – 70 °Bx). During the selection of solution, care must be taken that the solutions used must not have negative effect on the quality of dried material, that is, the colour, smell, taste and content of nutritious matters *(Pavkov, 2012)*. Considering that osmotic solution that is used in the drying process becomes an integral part of the end product, it also has to be of organic origin.

During technologic operation of osmotic drying a concentration of osmotic solution is decreased, therefore regeneration of the solution is required so that the solution can be used several times. An original device is designed for the purpose of osmotic solution, which uses warmed up air for regeneration of the solution. Due to sensitive colloidal admixtures in the solution used in the process of osmotic drying, the temperature of thermic regeneration must be low so that no unwanted chemical reactions are caused *(Babić, et al., 2009)*. Due to the relatively low temperature of the solution regeneration process, less energy is required for meeting the set conditions which creates a possibility to perform the procedure of regeneration by using solar energy for this process.

After osmotic drying, fruit is convectively additionally dried up to the desirable level of moisture. Convective drier projected at the Faculty of Agriculture in Novi Sad is carried out as a chamber drier with shelves. Warmed up air for drying blows in a vertical direction, across the fruit or vegetables arranged on the shelves. Drier as an energy source uses a combination of solar energy and biomass energy.

Convective drying is followed by finalization of the product. Ready product is sent to be measured, packaged and stored.

DISCUSSION

In order for a food product to have organic status, each production stage must be complied with the law and rulebook of organic production.

When speaking of the first production stage of dried biomaterial, i.e. picking fruit and vegetables of organic status, it is important to emphasise that all the people participating in the process of picking and transport of raw materials must have adequate training and get familiar with the principles of organic production. Processing unit must have an appropriate document which contains the date of the training, list of trained people and lecturers competent to carry out the training *(Organic Production Rulebook, 2011)*. If processing unit purchases raw material for drying, then it must possess a valid evidence of organic origin of raw material and an agreement entered into with the supplier of the raw material. In case of collection of wild plants from their natural habitat, a producer must submit an evidence as well which confirms that areas of product collection in the period of at least three years prior to the collection were not treated by any means that are not allowed for use in organic production *(Organic Production Rulebook, 2011)*.

Transport space on the vehicle must be clean and protected from the impact of dust or similar unwanted admixtures. If means of transportation were used for transporting goods of conventional status, cleaning must be performed by means prescribed by rulebook and law on organic production and it is necessary to keep a diary of cleaning transportation means.

During reception of raw material, processing unit is obliged to keep a detailed records of the raw material quantity and status and to form a unique number (lot number) for a specific amount of raw materials. Formation of the unique number of raw materials is extremely important since succession and balance of the production process are monitored based on that number. If a processing unit also performs processing of raw materials with different status (organic, conventional or from the period of conversion), reception, storage and processing must be separated in terms of time or space and it is necessary to keep adequate records of procession. If manipulation of raw materials is performed in plastic crates, such as it is the case of combined drying technology, it would be recommended that the crates with raw materials of organic status are clearly labelled (different colour of crates or in some other way).

With reference to washing and preparation of fruit and vegetables for drying procedure, people in charge of these stages of production must also undergo an adequate training and get familiar with the principles of organic production and processing unit must have a written evidence of the training conducted. Considering that washing of fruit and vegetables is done in water, analysis of water must be done in specific time intervals followed by record keeping confirming that such water analysis has been done. If technologic lines used in organic production are also used for product processing, i.e. raw material from conventional production, such lines should be thoroughly cleaned and washed prior to their usage. In accordance with the instruction of authorised organisation, producers make a record of the means and manner of cleaning technological lines (origin, supplier, application date, type and name, amount of used means for cleaning and desinfection) *(Organic Production Rulebook, 2011)*. After preparation of fruit and vegetables, combined technology anticipated process of sulphuring as an antibacterial and antioxidant protection. Since sulphur dioxide is not allowed in the productio of organic food product it is necessary to find an adequate substitute. As an antioxidant prevention, it is possible to use specific physical and chemical procedures. Application of sharp blades made of stainless materials for cutting fruit and vegetables, reduction of time between the stage of cutting and osmotic drying, deaeration of devices for cutting fruit and vegetables, if that is possible, *(Tepić, 2012)* can have a favourable impact on the reduction of fruit darkening. Vegetables can be thermically treated, by warm water or steam (blanching), which has an antibacterial role, in addition to its antioxidant role *(Tepić, 2012)*. After thermic treatment, it is necessary to cool the raw material as soon as possible, in order to prevent subsequent non-enzyme darkening *(Tepić, 2012)*. Out

of chemical antioxidant processes, application of organic origin acid is recommended (vine, apple or lemon) for the purpose of changing the optimum od enzyme reaction (decrease of pH) *(Tepić, 2012)*. Pieces of fruit are dipped into the acid solution. Acidification, i.e. addition of acid decreases pH value of the environment, and thereby the activity of phenolases and that way reduction of darkening. Using ascorbic acid can prevent enzyme brownening of specific fruit and vegetables. Ascorbic acid reduces dark coloured quinone to colourless hydroquinone *(Tepić, 2012)*.

The next stage of the process of combined drying technology is a process of osmotic drying. Considering that osmotic solution that is used in the drying process becomes an integral part of the end product and that it also must be organic, there is a proposal to use the solution of organic sugar from the sugar cane or fruit syrups of organic origin as a potential solution. Supply and use of such osmotic solutions will impact production efficiency. Accordingly, sustainability of combined drying technology for fruit depends on the efficiency of regeneration of solution *(Babić, et al., 2009)*, that is, in order for a combined drying technology to be economic, it should be used several times. The reason for changing physical-chemical, structural and use parameters of the solution is a matter adopted by the solution and integrated into its composition during osmotic drying process. That matter is water from fruit and vegetables both in its original form and in its constitution of gels of colloidal structure. It can be concluded from the above mentioned that the process of solution regeneration must remove unwanted admixtures. Regeneration of the solution is performed through methods such as: microfiltration, vacuum steaming and evaporation. It should be taken into consideration that according to the analysis of material balance based on the model of fruit moisture 85 % (compared to the moisture base) and osmotic drying of fruit with 85 % to 75 % of humidity, acceptable combination that bring calculated saving of 30 % regarding consumption of thermal energy *(Babić et al., 2005)*.

The following stage of production after osmotic drying is convecive dryng. If raw material of conventional status was previously dried in a convective drier , adequate cleaning of convective drier must be performed.

After the end of the drying process, organic product must be packed in accordance with the law on organic production with appropriate labeling of the product. Domestic processed certified organic product can be labeled as " organic product", with the national sign and code/logo of the authorized control organization which performed at the final stage of production certification of that product, if it contains at least 95 % of ingredients of agricultural origin that are produced in accordance with the law that regulates organic production *(Organic Production Rulebook, 2011)*.

During storage, organic products must be clearly labeled. Products of organic status are kept separately from the rest of agricultural products. It is necessary to take necessary measures to provide identification of the shipment of organic products and to disable mixing or replacement with products from conventional production. Additionally, appropriate hygienic measures must be taken, whose effectiveness is checked prior to the storage of organic products and all of the above mentioned must be adequately recorded.

If organic products are packed and labeled, they can be kept in the same storage rooms together with the products from conventional production, in a separate part designated in accordance with the law regulating organic production *(Organic Production Rulebook, 2011)*.

CONCLUSION

Production of food based on the principles of organic production has a set of advantages particularly in health, ecological and economic terms. Organic production is entirely controlled production. Production of organic products in Serbia is regulated by applicable law and rulebooks of organic production. System of control of organic products in Serbia has been established according to the model of the system of control prescribed by regulation of the European Union.

As regards processing units certified for organic production, there are certain rules of production which are controlled by accredited certification bodies. Processing technology and equipment for combined drying of fruit and vegetables have been developed in a Biosystem Engineering Laboratory at the Faculty of Agricultural in Novi Sad since 2001, whose main characteristic is osmotic dehydration as pre-treatment of convective drying of biomaterials. The paper describes basic stages of dried biomaterial production.

In order for this drying technology to be used in the process of organic production it is necessary to perform specific modifications of the existing technology. A special attention has been paid to the critical stages of drying that can threaten organic status of the product. Considering that osmotic solution used in the drying process becomes an integral part of the end product, it also must be of organic origin. As a possible solution, use of solution of organic sugar from sugar cane or fruit syrup of organic origin is suggested. The second critical point of drying is sulphuring process. Sulphuring is not allowed in organic production, thus fruit with a tendency to get darker is recommended to be treated by ascorbic, lemon or other acids of organic origin with the aim of preserving the colour of the end product. Darker fruit sorts such as sour cherries, sweet cherries, plums, etc., or fruit dried as a whole can be dried without antioxidant treatment.The possibility of monitoring raw material and production from the first stages of production to the final finalisation and delivery of the product is extremely important during the organic production. In addition to this, law and rulebook of organic production has established a set of measures which reduce the risk of contamination of organic products. These measures are reflected in the implementation of "Good production ethics" and "Good hygienic practice", as well as adequate skillfulness of people who participate in the production process.

ACKNOWLEDGEMENT: This paper is a result of the research within the project TR 31058, 2011-2015, supported by the Ministry of Education, Science and Technology, Republic of Serbia.

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Received: 10.03.2015. Accepted: 01.04.2015.