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TRACEABILITY OF WINE - A CRITERION OF QUALITY AND FOOD SAFETY FOR THE CONSUMER

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Abstract. In the last decade, several factors have determined an increasing demand for wine supply chain transparency. Indeed, amalgamation, fraud, counterfeiting, use of hazardous treatment products and pollution affect the trust of consumers, who are more and more oriented to consider the so-called "*credence attributes*" rather than price. Thus, consumers demand detailed information on the overall process from the grape to the bottle. In this chapter, we present a system for traceability in the wine supply chain. The system is able to systematically store information about products and processes throughout the entire supply chain, from grape growers to retailers. Also, the system manages quality information, thus enabling an effective analysis of the supply chain processes. Effective wine traceability is based upon the accuracy of the information about the products contained in records held by the various supply chain partners.

Keywords: *procedures, production, Rară Neagră grapes, standardization, Supply Chain Model.*

Introduction

It is an important principle in ensuring food safety that products can be traced back to source, all along the supply chain [1]. All operators in the chain (from wine grape grower, to wine producer, to supplier of substances intended to be incorporated into wine, to distributor, to exporter, to retailer) must be able to identify any person or business from whom they have been supplied with wine or any substance intended to be incorporated into wine (one step back); and to whom they have supplied wine or any substance intended to be incorporated into wine (one step forward) [2].

Everyone must also have accurate records of each step in the process. The Wine of Origin system traces the bottle of wine all the way back to the vineyard and the new seal links the vineyard to the growing practices in that vineyard. This is a highly sophisticated degree of traceability, which is being universally applied across the wine industry [3].

The most internationally recognized definition of traceability defines it as the "ability to trace the history, application or location of an entity by means of recorded identifications" (ISO 8402) [4, 5].

There are however other definitions, such as the one contained in the General Food Law - Council Regulation (EC) No. 178/2002 [3] and the one established by the Codex Alimentarius Commission [7]. If properly used by each member of an extended supply chain, products and data, including information required to manage traceability and shelf life, can be exchanged through each link in the chain - facilitating the seamless flow of information with the flow of goods [8]. Traceability Tools can improve the efficiency of recording and exchanging information between supply chain participants. When used in conjunction with databases containing accurate and timely records, standards provide all supply chain participants with the technical capability to see the origin of a product, both in their own locations and across the entire supply chain [9].

At the simplest level, item numbering is what the name suggests – a system for identifying items by giving each one a unique number (e.g. a bottle will have a different number to a case). Numbering can be applied at every stage of production and distribution. It is used to identify products and services [9, 10].Global Location Number is a numeric code that identifies any legal (e.g. company, division), functional (e.g. accounts dept) or physical entity (e.g. plot of land) within a business or organization. Each location is allocated a unique number.

Global Trade Item Number is a number used for the unique identification of trade items worldwide. A trade item is any item (product or service) upon which there is a need to retrieve pre-defined information and that may be priced, ordered or invoiced for trade between participants at any point in any supply chain [10, 11].

Serial Shipping Container is a number, which is used for the unique identification of logistic units. A logistic unit is an item of any composition established for transport and/or storage, which needs to be managed throughout the supply chain. It provides an unambiguous identification for logistic units. All parties in the supply chain can use it as a reference number to the relevant information held in electronic or human readable files.

Application Identifier Attribute information is any variable information required over and above the trade unit or logistics unit identification, such as a batch number, production date or customer purchase order [12, 13].

Bar Codes allow automatic data capture, which is a key business solution in an efficient supply chain [14]. The numbering and bar coding system allows fast accurate and timely data input into computer systems, automating the flow of information into business processes. It also enables improved data capture and transfer of information, while reducing costs [15, 16].

The Wine Supply Chain Model of Rară Neagră grapes

According to current preferences and world wines consumption trends of autochthonous grapes, in the paper is a studied Rară Neagră autochthonous grape.

Rară Neagră grapes produce a red wine with flavors and aromas of black cherry, berries, plum, chocolate, and some herbs. Rară Neagră wine is popular with people trying to get accustomed to drier, more complex red wines because of its other characteristics, like low tannins which make it easier to drink than other reds wines.

The softer characteristics of Rară Neagră with the fruity flavors make it a red wine that is well-suited to lighter foods that will not overwhelm the flavors of the wine. More experienced wine drinkers sometimes see these characteristics as disadvantages and prefer Rară Neagră when mixed with other, more complex red grape varieties - especially those that are harsher alone and can benefit from softening. Nevertheless, it is possible to create complex, interesting wines from Rară Neagră grapes.

In Moldova Rară Neagră is a late-ripening variety that gives red wines which are typically rich in acid and may exhibit a pronounced fruity character, the Rară Neagră grapes specification are included in Table 1. It is responsible for the fame of the Purcari wines in the 18 th century, before Cabernet Sauvignon was introduced in Moldova. This variety is used as a main blend component in the Purcari wine, Negru de Purcari.

Rară Neagră tends to make pale, light-bodied, fruity red wines with notable acidity and a characteristic sour cherry note. The pink-berried color mutation tends to produce mineral white wines with lime notes that persist on the finish.

The wine supply chain has always been complex and fragmented and with more distant suppliers and ever-more demanding customers, the unique characteristics of this supply chain bring challenges to implementing an effective traceability system. The largest companies account for a significant percentage of the industry and have significant technology requirements. The remainder of the industry is comprised of small to medium enterprises, many of which have found niches in specialty products and branding.

Table 1.

Rară Neagră grapes specification.

Indicator	**Characteristic**
Description	
Group	Wine variety
Sinonim	Papa neagră, Băbească neagră
Maturing	Late maturing
Frost	Low
Damage degree	Resistant to filoxera, a bit of mold
Berry	
Size	Average
Formular	Flattened form, seldom rounded
Peel	Average density
Flesh	Juicy
Color	Blue
Bush	
The type of growth	Strong
Leave	Average size, rounded
Flower	Bisexual
Agriculture features	
The period from the bud burst to full maturity	145 days
Clusters	
Size	Medium
Formular	Conical form
Productivity	Yield 8-10 $t \cdot ha^{-1}$

There is also a myriad of other support companies that provide materials, transportation, storage and other services that are also impacted by traceability. Companies vary greatly in their technical capabilities; from phone, fax and paper based transactions, through robust e-commerce, bar code, and other internal systems. Their ability to identify implicated product, and perform track and trace activities is directly related to their technical capabilities. The Working Group determined that the wine supply chain could be broken down into the following key areas: o Grape Grower o Wine Producer o Bulk Distributor o Transit Cellar o Filler / Packer o Finished Goods Distributor o Retailer Each area was examined with a view to explaining traceability within that business process, and to determine the relevant GS1 standards to be deployed.

Rară Neagră is cultivated in the south of Moldova in the regions of Dobruja, making it the second most widely planted grape variety in Moldova. It is also found in Ukraine, Romania and New York, United States, where the grape is known as Sereksiya Charni.

Being an old grape variety, Rară Neagră has demonstrated significant clonal variations including Copceac – a variation with bigger berries, Coada Rândunicii (Swallowtail) - a variation with a bisected bunch and Coada Vulpii (Foxtail) - a variation that has a cylindrical prolongation of the bunch. It has also produced over the years two color mutations including a pink-berried mutation and a white-berried mutation known.

Ampelographers proved that Rară Neagră is a very old variety with the earliest mentioning of the grape dating back to the early 14 th century. Rară Neagră is a late-ripening grape variety that is also a mid to late budding vine which contributes to the grapes winter hardiness and resistance to the viticultural hazards of early spring frost. During the cold Eastern European winters, Rară Neagră is able to withstand temperatures as low as −18 °C (0 °F). However the very loose, medium-sized bunches of thin-skinned berries are very susceptible to the hazards of botrytis bunch rot, downy and powdery mildew as well as drought during the growing season. If yields are not kept in check by winter pruning and green harvesting, the vine can be very vigorous and prone to developing millerandage.

Conclusions

Today, food safety, guarantees of authenticity and origin and the range of healthy agro-food products on offer are three of the main consumer concerns in the vitivinicultural sector. For these reasons, traceability has become a useful and necessary tool for safeguarding the proper functioning and knowledge of the process of production, development and marketing of wine, grapes and all other products of vitivinicultural origin.

The objective of Wine Supply Chain Model of Rară Neagră grapes was to create a suitable environment in which to disseminate and discuss the current situation with regard to the global context of the traceability of grapevines and wine, with the vitivinicultural sector. In this paper, different aspects were addressed – such as the need to guarantee the authenticity and origin (from the start to the end of the process of production, development and marketing), both from a standardization and market perspective, as well as from a technical and scientific one – through contributions making it possible to understand and identify the most appropriate procedures and methods for controlling traceability.

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conducted at department of Oenology, Microvinification Center of Technical University of Moldova.

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PEACHES CONVECTIVE DRYING

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Abstract. This article deals with convective drying kinetics process of peaches that were collected in Republic of Moldova climatic area, namely SPRINGCREST, CARDINAL and REDHAVEN varieties. The kinetics study was performed for different temperatures: 50°C, 60°C, 70°C, 80°C, 90°C, for different drying agent velocities: 0.5 $m \cdot s^{-1}$, 1.0 $m \cdot s^{-1}$, 1.5 $m \cdot s^{-1}$, 2.0 $m \cdot s^{-1}$, 2.5 $m \cdot s^{-1}$, and for different thicknesses $2 \cdot 10^{-3}$m, $4 \cdot 10^{-3}$m, $6 \cdot 10^{-3}$m, $8 \cdot 10^{-3}$m, $10 \cdot 10^{-3}$m. For the determination of the optimal quality and conditions of drying parameters there was also performed an appearance analysis for each dried sample.

Keywords: *drying process, convective drying kinetics, drying agent temperature, velocity, humidity, drying duration*, *peaches*.

Introduction

Currently, globally, the peach is the third after the apple and the plum in terms of surface and production volume. [1] Republic of Moldova exports about 5-7 k tons of fresh peaches per year. [18]. Peaches are highly appreciated thanks to their excellent taste, which is determined, by a fine pulp and pleasant aroma. The high food value of peaches is due to a complex and equilibrated composition consisting of 87.5% water, 12.49% of total dry substances and (10.54 %) soluble dry substances. Sugar content is 8.4 $g \cdot 100^{-1}$ g of product as well as a treatable acidity of 0.5% (pH=4).

The chemical composition is generally represented by proteins (0.9 g $\cdot 100^{-1}$g of product), lipids (0.30 $g \cdot 100^{-1}$ g of product), carbohydrate (9.90$g \cdot 100^{-1}$ g of product); The minerals are represented by an increased content of K (190 $mg \cdot 100^{-1}$ g of product), P (20 $mg \cdot 100^{-1}$g of product), Mg (9 $mg \cdot 100^{-1}$ g of product) and Ca (6 $mg \cdot 100^{-1}$g of product). Peaches contain as well a variety of vitamins such as A (326 IU), C (6.6 $mg \cdot 100^{-1}$g of product), K (2.60 $mg \cdot 100^{-1}$g of product), E (0.70 $mg \cdot 100^{-1}$g of product), B3 (0.8 $mg \cdot 100^{-1}$g of product), B5 (0.20 $mg \cdot 100^{-1}$g of product), B8 (6.10 $mg \cdot 100^{-1}$g of product), Betaine (0.3 $mg \cdot 100^{-1}$g of product). [2-7].

Being a seasonal product, there are important quantities of peaches that remain unvalued as those have both short harvest and storing period. One of the most efficient method to preserve their value is drying. This processing method has many conveniences like reduced storing spaces, increased preservation terms and furthermore the obtaining of a new product bringing health benefits. Containing a lot of vitamins, fresh and dry peaches are low in calories and reach in sugars; they are a good source of carbohydrates, phytonutrients, antioxidants, carotenoids – that are of great importance for the healthy of eyes, flavonoids that protect against cancer and heart diseases.

Besides those listed, there are other health benefits like stimulating immune system, normalizing the intestinal transit, stimulating gastric juice secretion, as well as helping in different diseases treatment like gastritis, anemia, high blood pressure, asthma and bronchitis, renal lithiasis, etc. [8-13]. In the research process, three varieties of peaches cultivated in the Republic of Moldova were used, with different characteristics, as follows:

SPRING CREST *tree*, originally from Fort-Valley, Georgia, USA, is vigorous, high cropping and abundant blossom. The *fruit* is medium sized (70÷100 g), regulate and round with glossy, strong red blush over a yellow background *peel*, as well as low pubescence. The *flesh* is semi-freestone, yellow, melting with a medium texture, good aroma and no red infiltrations around the stone. Its *maturity* comes 22-24 days earlier than Red haven (first decade of August). As *technological particularities*, one can mention its early, high productivity and good transportation resistance, but alas, it requires heavy thinning to attain a commercial size and because of its early blossom it could be affected by the late spring frosts. Since 2015, it was approved for the Republic of Moldova Central, South and Southeast fruit-growing zones.

CARDINAL *tree*, originally from Fort-Valley, Georgia, USA, is medium vigorous, having mixed branches and, abundant, relative early blossom.

The *fruit* is medium sized (80÷140 g), asymmetric with claret red blush over a yellow background *peel*, as well as low pubescence. The *flesh* is clingstone, orange-yellow, medium melting with a fine consistent texture, good aroma and great sweet and sour flavor. Its *maturity* comes in the third decade of July. As *technological particularities*, one can mention its high productivity, good resistance, and medium frosts and drought resistance; prefers fertile and irrigated soils. Since 1980, it was approved for the Republic of Moldova Central and Southeast fruit-growing zones.

REDHAVEN *tree*, originally from Agricultural Experiment Station, Michigan, USA, is medium to vigorous, very reliable cropping, mid-season bloom and becomes fertile in the 3rd year after planting.

The *fruit* is medium to very large (130÷170 g), round or rounded-ovate with red streaks and red blush over 90% of the surface over an orange-yellow background *peel*, along with a low pubescence.

The *flesh* is semi-freestone, orange-yellow, medium melting, good aroma and good sweet and sour flavor, with small red infiltrations around the stone. Its *maturity* comes in the first decade of August. As *technological particularities*, one can mention its high regular productivity, being considered as etalon and one of the best peaches varieties; prefers fertile and irrigated soils, medium drought resistance, and somewhat susceptible to bacterial spot. Since 1980, it was approved for the Republic of Moldova Central and Southeast fruit-growing zones. [1]

Materials and methods

To study the drying process, the following peach varieties served as raw material: Springcrest, Cardinal and Redhaven. Fresh peach fruit was characterized by firmness, dry substance content and initial humidity. Table 1.

Table 1

Fresh peach fruit characteristic

Peach varieties	Firmness (Kg·f/cm$^{2)}$	Dry substances (%)	Humidity (%)
Springcrest	1,22	10,65	89,35
Cardinal	1,07	10,52	89,48
Redhaven	0,88	11,33	88,67

Drying installation (DRYER)

All experiments were performed applying the laboratory drying installation (figure 1) that permits convective drying process study. As drying agent, one can use air or other gases, like CO_2. Using the heater (4), the drying agent can reach a temperature spectrum of 20÷100°C, applying the temperature convertor (6) one maintains the needed temperature. In our case, we used five temperatures for the drying agent, specifically 50±0.5°C, 60±0.8°C, 70±1.0°C, 80±1.2°C and 90±1.5°C. To register drying agent's data, we used a group of temperature (DALLAS 8820 – error ± 0.1°C) and humidity sensors (DALLAS 8820 – error ± 0.5 %) (8), installed right before and after the connection between the agent recycling pipe and the drying chamber (1).

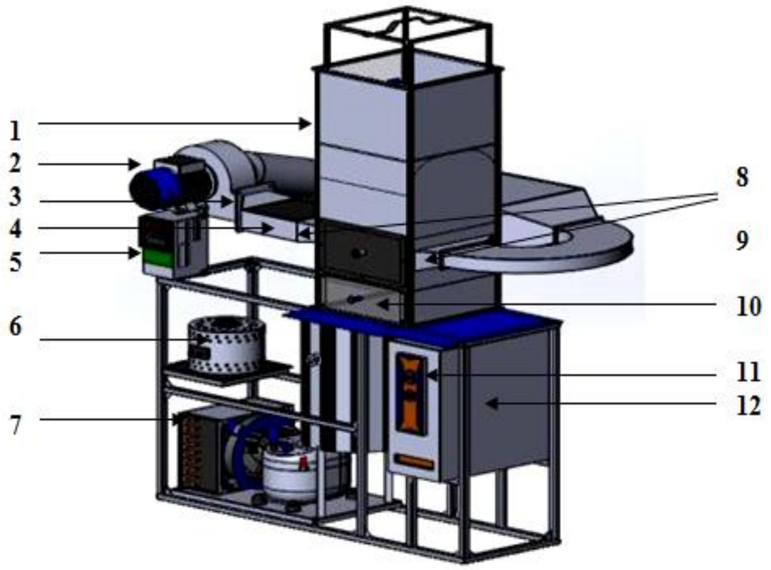


Figure 1. Experimental drying installation. *1 – drying chamber, 2 – electric motor, 3 – fan, 4 – electric resistors (heater), 5 – frequency converter, 6 – temperature controller, 7 – auxiliary device, 8 – temperature and humidity sensors, 9 – switches, 10 – electronic scale, 11 – control block SHF, 12 – electronic device for monitoring and recording of input and output data.*

The drying agent is being recycled with the help of a 0.16 kW ventilator (VORTICE SPA C15/2T) (3), which assures an up 3.0 m/s airflow velocity. In our case, we used five drying agent velocities, namely 0.5±0.05 $m \cdot s^{-1}$, 1.0±0.05 $m \cdot s^{-1}$, 1.5±0.06 $m \cdot s^{-1}$, 2.0±0.07 $m \cdot s^{-1}$and 2.5±0.08 $m \cdot s^{-1}$. Using frequency convertor (5), we can change ventilator (3) speed thus modifying and maintaining drying agent velocity. Agent drying velocity was measured applying an anemometer (AM50 – error ± 3.0%). Inside the working chamber, the peaches are arranged on a support installed on top of an electronic scale (G&G JJ2000 – error ±0.01 g) (10) this way permitting an online registering of drying process product mass dropping. For product surface temperature measurement during the drying process, one used an infrared thermometer (IR laser – error ±2.0°C or 2.0%). All listed sensors are connected to a

PC software IgiCOM & UTM Drier – V 2.0 thus granting us the possibility to create an online registration database of product drying mass dropping, drying agent temperature and humidity (figure 2). This way allowing us to monitor and control agent drying velocity and product surface temperature through the entire drying process.

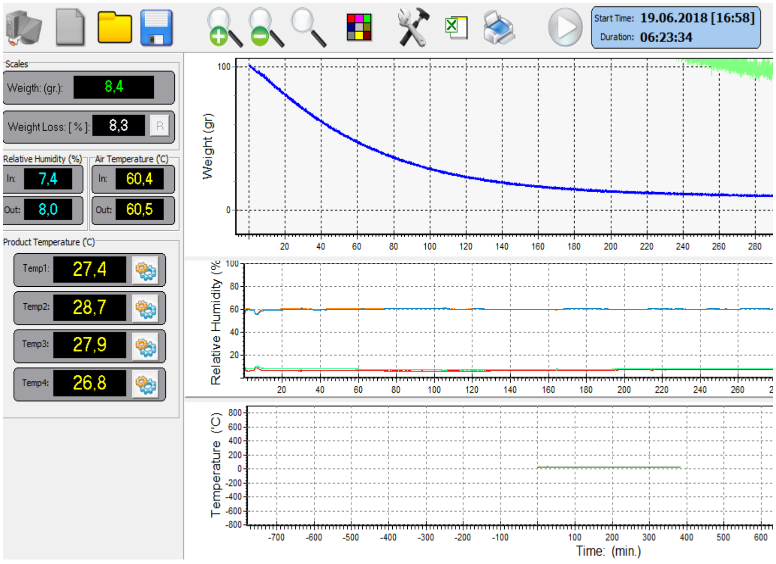


Figure 2. Data electronic processing. *1 – dial (indicates product's mass dropping curve), 2 – dial (indicates drying chamber input and output drying agent temperature) 3 – dial (indicates drying chamber input and output drying agent humidity).*

For the experimental drying process, there were selected 89.5±0.75% initial humidity ripe peaches. After being water washed and dried at room temperature, all the samples were tested for the technical requirements correspondence, including visual and tactile examination, and after confirming the fruits were sliced in well defined (3÷4 mm) rings. A 100±0.5 g portion of slices was arranged on the drying tray.

To study the kinetics of the drying process of peaches, the "*convection drying*" method was used, as it is a known and applicable method in research. [14, 15, 16]

There are multiple, technological process (*velocity, humidity, drying agent temperature*, etc.) and drying product, the peach, properties (*thermal conductivity, porosity, density, geometrical parameters,* etc.) parameters that affect the process of drying kinetics. [17, 22]

To study the kinetic curves of the drying process: the following thermal agent temperatures were used: 50°C, 60°C, 70°C, 80°C, and 90°C for all three varieties of peaches; different thicknesses of the product layer ($2 \cdot 10^{-3}$m, $4 \cdot 10^{-3}$m, $6 \cdot 10^{-3}$m, $8 \cdot 10^{-3}$m, $10 \cdot 10^{-3}$m) and different working agent speeds (0.5 $m \cdot s^{-1}$, 1.0 $m \cdot s^{-1}$, 1.5 $m \cdot s^{-1}$, 2.0 $m \cdot s^{-1}$, 2.5 $m \cdot s^{-1}$). To achieve high-precision experimental results, each experience was performed three times, maintaining the same technical conditions (temperature, humidity and speed of the working agent, temperature, pressure, and environmental humidity).

The processing of experimental data and the development of the electronic curves of kinetics of the drying curves was based on the IgiCOM & UTM Drier - V 2.0 PC software.

Results and discussions

Processed by convective method and different thermal agent temperatures, peaches drying curves shows a standard form, displaying stable moisture per time diminution (figure 3). [15, 21] From initial 89.5% to final 18.0% humidity drop duration depends on the drying agent temperature. Thus for the same 2.0 $m \cdot s^{-1}$ drying agent velocity and initial 89.46% humidity, but different temperatures, the drying period will be: for 50°C a 270 min length, 60°C a 225 min length, 70°C a 185 min length, 80°C a 160 min length and for 90°C a 110 min length.

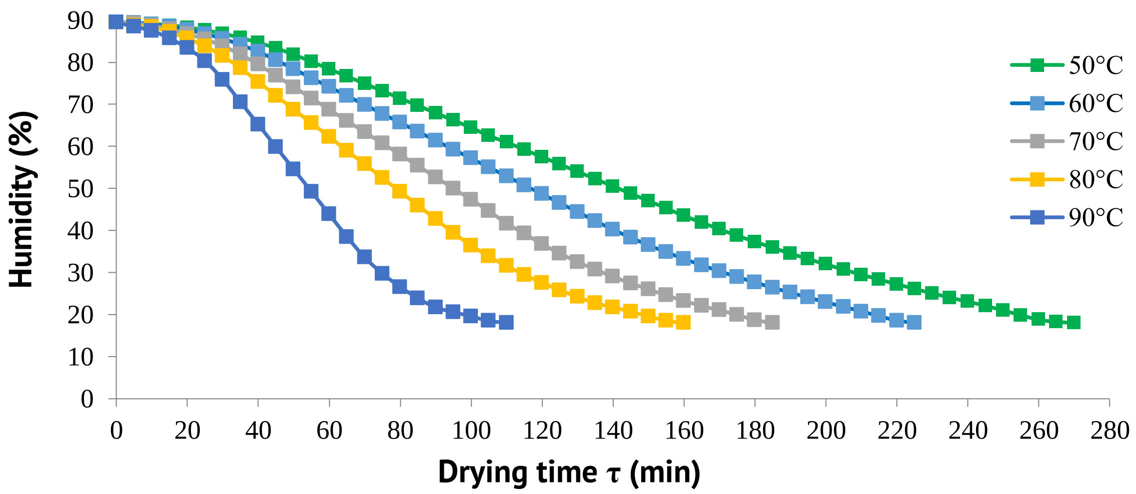


Figure 3. SPRINGCREST peaches different thermal agent temperatures drying curves *(Thermal agent velocity 2.0 $m \cdot s^{-1}$, thermal agent relative humidity 60.0%, slices thickness $3 \cdot 10^{-3}$m).*

Figure 4 shows peaches different thermal agent temperatures drying velocity curves. Their form also corresponds to the classical one, described in references. [19, 20, 21]

There are presented as well the three drying periods, namely 1 – of product heating, 2 – of constant drying velocity and 3 – of decreasing drying velocity.

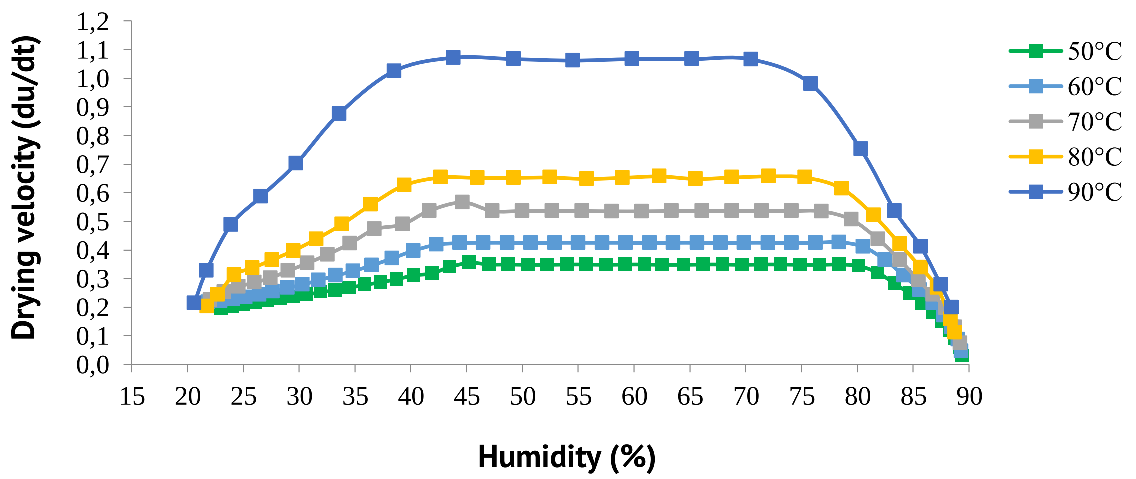


Figure 4. SPRINGCREST peaches different thermal agent temperatures drying velocity curves *(Thermal agent velocity 2.0 $m \cdot s^{-1}$, thermal agent relative humidity 60.0%, slices thickness $3 \cdot 10^{-3}$m)*

Graphics show that as thermal agent temperature increases from 50°C to 90°C the drying speed increases as well. Moreover, for the drying agent speed of 2.0 m/s and its relative air humidity of 60%, the drying rate increases from 0.35 m· s^{-1} to 1.05 m· s^{-1} according to a polynomial law Eq. (1):

$$\frac{du}{d\tau} = 0{,}0005 \cdot t^2 - 0{,}048 \cdot t + 0{,}976, \quad R^2 = 0{,}976 \tag{1}$$

At the same time, there has been observed some correlation between the duration of the constant drying rate and the temperature of the thermal agent. Thus, with the temperature increase of the agent, in the range of 50÷90°C, the duration of the second period – of the constant drying rate decreased from 155 min. to 70 min., which in turn reduces the duration of the drying process.

The mass transfer in the product is largely influenced by the humidity and temperature gradients, as well as by the thickness of the product layer that the humidity needs to pass. [22] This way, the kinetics of the peach drying process was as well studied at different thickness of the slices, namely $2 \cdot 10^{-3}$m, $4 \cdot 10^{-3}$m, $6 \cdot 10^{-3}$m, $8 \cdot 10^{-3}$m, and $10 \cdot 10^{-3}$m. (according to figures 5 to 7).

At convective drying of SPRINGCREST peaches at thermal agent's 2.0 m·s^{-1} speed, 60°C and relative humidity of 65%, the drying curves for different thickness of the slices bear the same character (Figure 5), different being only their inclination angle.

Moreover, the correlation between slices thickness variation and drying curves inclination angle is inversely proportional, which determines that the reduction of slices thickness accelerates the drying process, as confirmed by the drying velocity curves (Figure 6) showing an increase in drying rate while reducing the slices thickness. Thus, at $10 \cdot 10^{-3}$m slices thickness, a drying rate of 0.21 ± 0,024 %/min was recorded, while at $2 \cdot 10^{-3}$m thickness of – 0.47 ± 0.063 %·min^{-1}.

The decrease of the drying velocity with the increase of the peach slices thickness within $2 \div 10 \cdot 10^{-3}$m takes place according to Eq. (2):

$$\frac{du}{d\tau} = 214{,}3 \cdot 10^3 \cdot t^2 - 72{,}86 \cdot t + 0{,}496, \quad R^2 = 0{,}998 \tag{2}$$

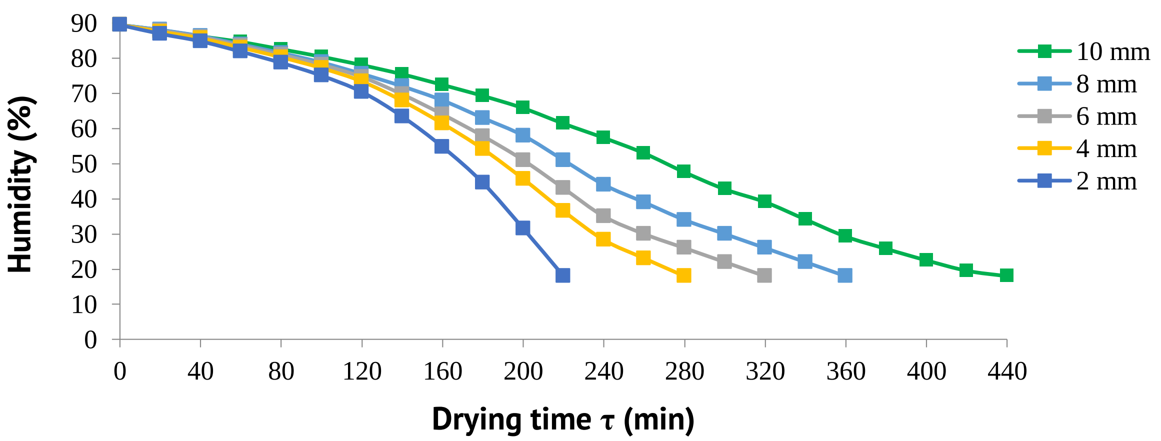


Figure 5. SPRINGCREST peaches different slices thickness drying curves *(Thermal agent velocity 2.0 m· s^{-1}, thermal agent relative humidity 65.0%, thermal agent temperature 60°C).*

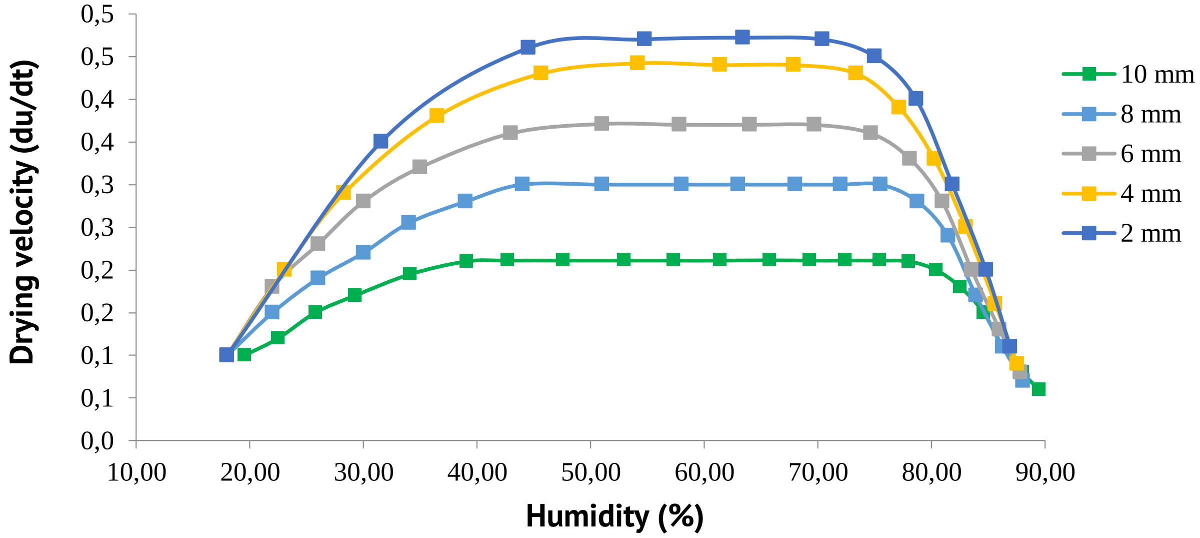


Figure 6. SPRINGCREST peaches different slices thickness drying velocity curves *(Thermal agent velocity 2.0 m· s^{-1}, thermal agent relative humidity 65.0%, thermal agent temperature 60°C).*

As mentioned earlier, the decrease in the peach slices thickness reduces the drying time, as shown in Figure 7. Using convective drying in a flow of 2.0 m/s, 60°C and 60% initial humidity air, one can observe, that $2\cdot10^{-3}$m thick peaches slices, have a minimum drying time of 220 min., $4\cdot10^{-3}$m thick has a drying time of 280 min., for a thickness of $6\cdot10^{-3}$m the duration is 320 min., for $8\cdot10^{-3}$m a 360 min. and for a thickness of $10\cdot10^{-3}$m the drying time is 440 min. The correlation between the drying time and the thickness of the product layer, of slices, within $2\div10\cdot10^{-3}$m bears a linear character Eq. (3):

$$\tau(\delta) = 0{,}0378 \cdot \delta - 6{,}224, \quad R^2 = 0{,}983 \qquad (3)$$

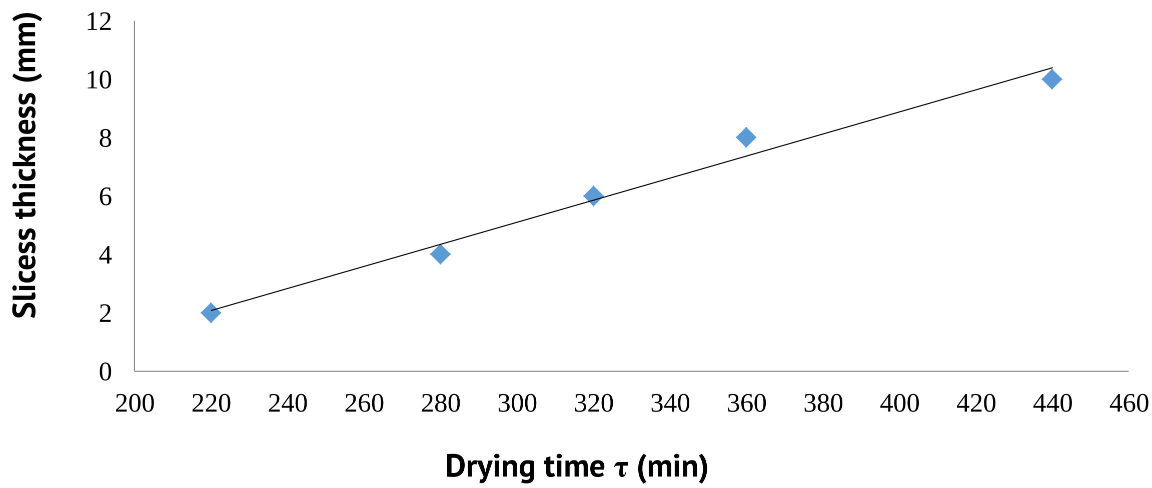


Figure 7. Correlation between SPRINGCREST peaches slices thickness and drying time *(Thermal agent velocity 2.0 m· s^{-1} thermal agent relative humidity 60.0%, thermal agent temperature 60°C).*

Wet products drying process, particularly peaches, among others are greatly influenced by the speed of the thermal agent. Figure 8 shows the drying curves and in Figure 9 curves of the drying speed of peaches cut in $3 \cdot 10^{-3}$m thickness rounds using thermal agent temperature of 60°C for different speeds. Both the drying curves and the drying speeds curves indicate an intensification of the process as the thermal agent speed increases [15, 17].

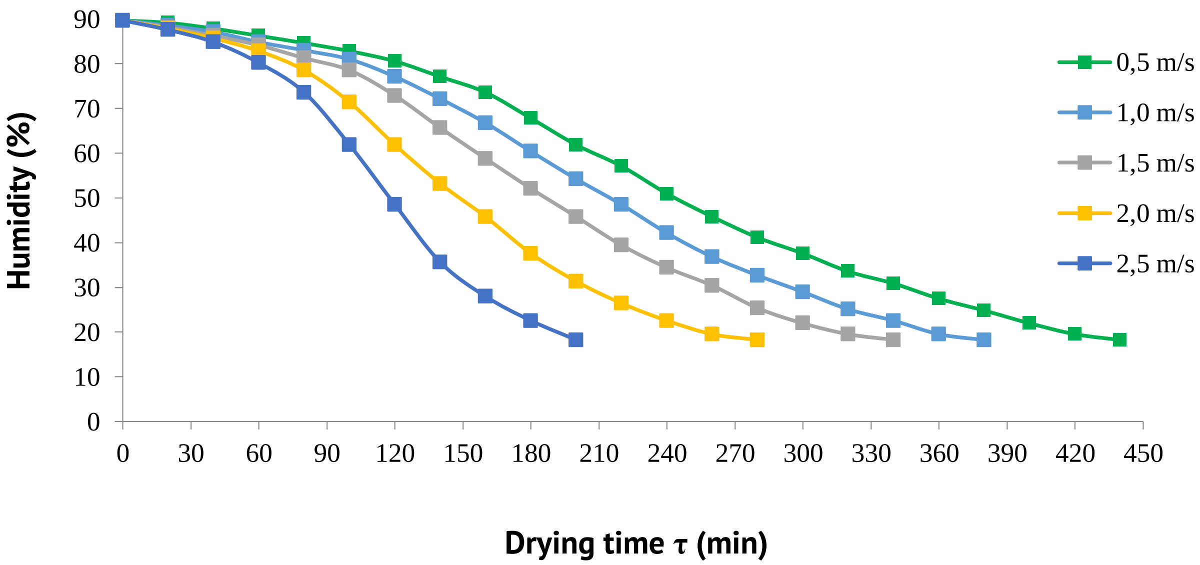


Figure 8. Peaches different thermal agent velocities drying curves *(Thermal agent relative humidity 65.0%, thermal agent temperature 60°C, slices thickness $3 \cdot 10^{-3}$m).*

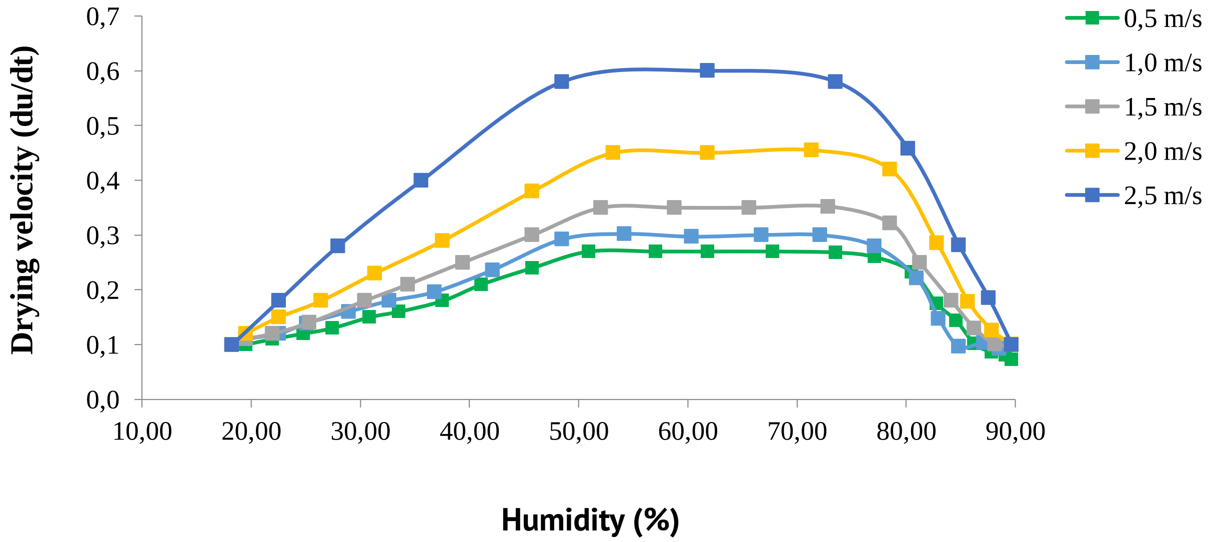


Figure 9. Peaches different thermal agent velocities drying velocity curves *(Thermal agent relative humidity 65.0%, thermal agent temperature 60°C, slices thickness $3 \cdot 10^{-3}$m).*

The following results were obtained from the analysis of Figure 8 and Figure 9: at the speed of 0.5 $m \cdot s^{-1}$, a drying time of 440 min was obtained, at 1.0 $m \cdot s^{-1}$ – 380 min., at speed of 1.5 $m \cdot s^{-1}$ – 340 min., at of 2.0 $m \cdot s^{-1}$ – 280 min., and for 2.5 $m \cdot s^{-1}$ for 200 min.

According to Figure 10, the dependence of the drying time of the thermal agent speed ($t = f(v)$) in the range of 0.5÷2.5 m· s-1 is linear Eq. (4)

$$\tau(v) = -0{,}0085 \cdot v + 4{,}291, \quad R^2 = 0{,}987 \tag{4}$$

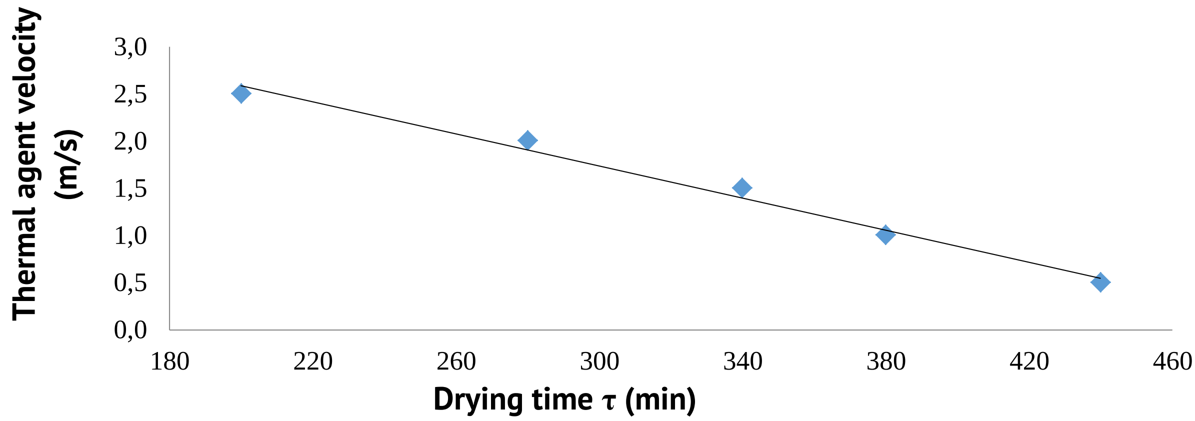


Figure 10. Correlation between peaches drying time and thermal agent velocity *(Thermal agent relative humidity 65.0%, thermal agent temperature 60°C, slices thickness 3·10-3m).*

During the kinetics research of the peach drying process, such varieties as SPRINGCREST, CARDINAL and REDHAVEN were studied. Both drying and drying velocity curves have the same character, indicating that small differences in physical, mechanical and thermal properties of different varieties have little influence on the transfer phenomena in the drying process. The drying times of different varieties differ in average by ±10÷15 min., which is 8÷6% (Figure 11).

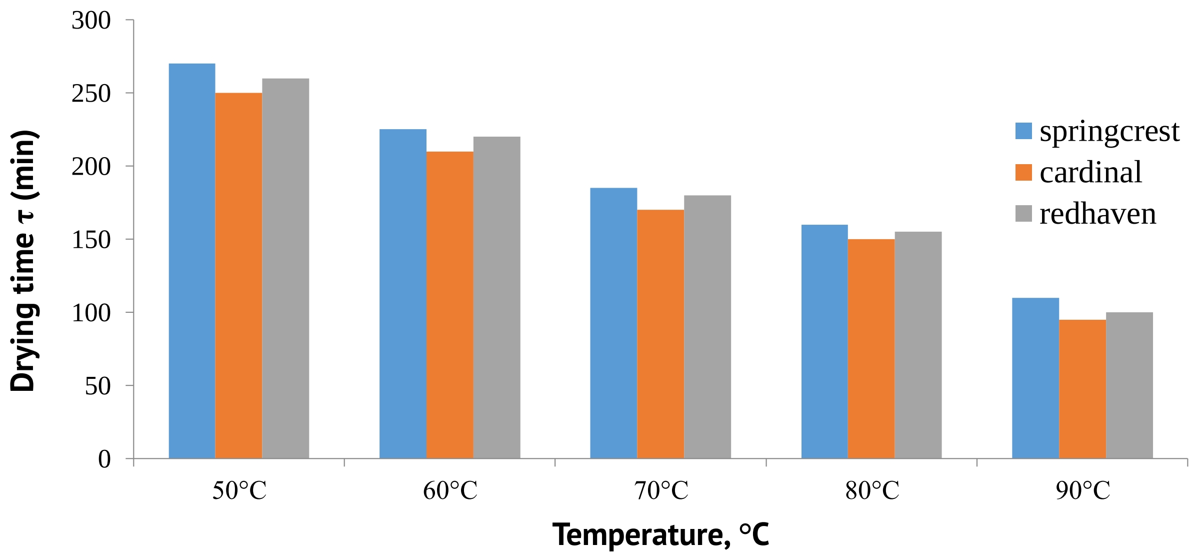
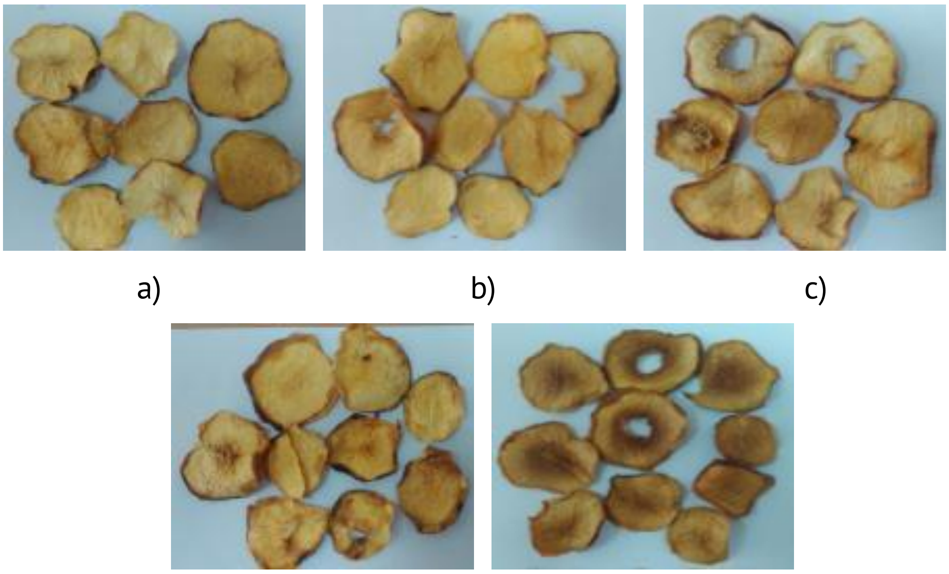


Figure 11. Correlation between peaches variety and drying time *(τ = f (variety)).*

As a result of drying process kinetics study, dry product samples were obtained for different temperatures and speeds of the thermal agent, and different thickness of the rounds. Of particular interest is the external appearance of dried peaches at different temperatures, since drying, as a thermal process, may be accompanied by various unwanted effects such as sugar caramelization, browning polyphenols, etc. Figure 12 shows SPRINGCREST dry peach samples with a thickness of $3.0 \cdot 10^{-3}$ m, the drying being carried out by convection at different thermal agent temperatures at a speed of $2.0\ m \cdot s^{-1}$ and a relative humidity of 60%.



a) b) c)

d) e)

Figure 12. SPRINGCREST peaches aspect dried using: thermal agent 2.0 m/s velocity and 60.0% relative humidity: *a) 50°C; b) 60°C; c) 70°C; d) 80°C; e) 90°C temperature*.

The pictures show that dried peaches at temperatures between 50°C and 60°C are more attractive than those dried at temperatures of 70°C, 80°C and 90°C, indicating that at the given temperatures the undesirable caramelization phenomena and peach browning do not take place yet.

Conclusion

The study of peaches convective drying kinetics at the temperature of the thermal agent in the range of 50÷90°C, speed of $0.5 \div 2.5\ m \cdot s^{-1}$ revealed that the increase both thermal agent temperature, speed and decreasing the thickness of the rolls from 10 to $1 \cdot 10^{-3}$m, leads to an intensification of the process. However, temperatures above 60°C cause an acceleration of the undesirable sugar caramelization and browning phenomena, Figure 12. Therefore, for the convective drying of peaches, the temperature of 60°C with the speed of the heating agent $2.0\ m \cdot s^{-1}$ and the thickness of the rolls $3\ 10^{-3}$m are recommended for getting an optimal drying process. The character of the drying curves is classical and does not differ from that of the fruits and vegetables described in the specialized literature [14-16, 19-22].

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