THE GREEN FUTURE TECHNOLOGY APPLIED OVER POMES FRUIT

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Abstract. Ohmic heating takes its name from Ohm’s law. Ohmic heating is an alternative heating technique, using an electrical current passing through the food product. The food material switched between electrodes has a role of resistance in the circuit. In this study the pear puree made at laboratory scale had been undergone to the ohmic heating process using different voltage gradients (15/17/17.5/20V/cm) and different processing time intervals (0/3/5/10 min). It were measured the electrical conductivity, the temperature, electric current intensity, pear puree viscosity in order to determine the ohmic heating influence over some process and sample properties. After the purpose of study was reached that was found the proportional link between the temperature and electric conductivity increase, which also depends on the processing time. The bubbling temperature was established above the 60°C value for all the voltage gradients.

Keywords: ohmic heating, pear puree, electrical conductivity, viscosity.

INTRODUCTION

Ohmic heating is a developing technology with considerable potential for the food industry. It is based on the passage of electrical current through a food product that serves as an electrical resistance (Reznick, 1996; Sastry, 1989). Heat is generated instantly inside the food. The amount of heat generated is directly related to the current induced by the voltage gradient in the field, and the electrical conductivity (Sastry & Li, 1996). The applicability of ohmic heating depends on the product electrical conductivity. The potential applications of this technique in food industry are very wide and include, e.g. blanching, evaporation, dehydration, fermentation (Sastry et al., 2001) and pasteurization. The main advantages of ohmic processing are the rapid and relatively uniform heating achieved, together with the lower capital cost compared to other electroheating methods such as microwave and radio frequency heating (Icier, F., Ilicali, C., 2005). Ohmic heating technology has been accepted by the industry for processing liquids and solid–liquid mixtures, but not to date for solid foods (Piette et al., 2004) though a number of recent publications have been produced in the area of meat pasteurization (Özkan et al., 2004; Shirsat et al., 2004).

Fruit purees are to be potentially used in baby food productions. The thermal processes applied to the baby foods are critically important to guarantee their microbiological safety. The data on the electrical conductivity changes of fruit purees during ohmic heating is very important in designing ohmic heating systems to be used in baby food lines. (Castro et al. 2004) mentioned that it was important to evaluate the electrical properties of a food intended to be processed by ohmic heating by clearly demonstrating the significant differences of electrical conductivity between the several products tested (Icier, F., Ilicali, C., 2005).

Much research has been done on the electrical conductivity of liquid fruit products like juices and purees (Palaniappan and Sastry, 1991; Icer and Ilicali, 2005; Castro et al., 2004).

The aim of this study was to obtain electrical conductivity and temperature data for pears puree to be heated ohmically in food industry. Effects of temperature, time, viscosity and voltage gradients on ohmic heating rates of pears purees were studied.

Pears or *Pyrus communis* are a pome fruit belongs to the family apple. They can be eaten and used in the same way as the apple. Pears of all sizes and colors are available all around the year. When it is ripe and ready to eat, the pear has a honeyed flavor and with a great smell. Pears are available in various colors including green, golden yellow and red (http://www.fruitsinfo.com/pears.htm).

The pear (*Pyrus communis*) is a typical fruit of the temperate zones and it is cultivated in Europe, among other regions. Due to its nutritive properties good taste and low caloric level, the pear is a much appreciated fruit for the consumers. It has a low content of protein and lipids and is rich in sugars (Colaric et al, 2007; Blattny, 2003).

MATERIAL AND METHOD

Pear puree used for ohmic heating it was obtained at laboratory scale. The pears Williams variety were purchased by a local producer. Before heating the pears were subjected to some preliminary operations (washing, peeling, removing seeds, cutting) and after that it were mashed with a blender and transformed into puree. Pear puree thus obtained was surmised at an ohmic heating process using a batch ohmic system. The ohmic heating installation characteristics are presented in the following table (Table 1).

Table 1

The characteristics of the ohmic heating batch installation

Characteristics	Values	Unit
Distance between electrodes	100	mm
Diameter of the electrodes	5	mm
Electrodes type	Cylindrical stainless steel	
Heating surface aria	2600	mm^2

The pear puree viscosity was determined using Brookfield viscometer and the electric conductivity was determined with a conductivity meter model YK-2005CD.

The temperature, the current intensity and voltage were measured with the specific meters included by the ohmic heating installation.

Ohmic heating applied for pear puree is a process which is based on an electric current passing through the product using two stainless steel electrodes placed in the ohmic heating vat.

RESULTS AND DISCUSSION

For the experiments there was used a batch ohmic heating installation which was tested at different temperatures, voltage gradients and enjoin time intervals. The purpose of the experiments being to determine the dependence between temperature and electric conductivity variation and also the bubbling temperature for the pear puree, another aim of the study was to determine the acidity variation of the puree during heating and the samples viscosity evolution.

The pear puree was obtained at laboratory conditions. The experiments were repeated for three times.

Figure 1 shows the electrical conductivity dependence on temperature of pear puree processed by ohmic heating at 15/17/17.5/20 V/cm.

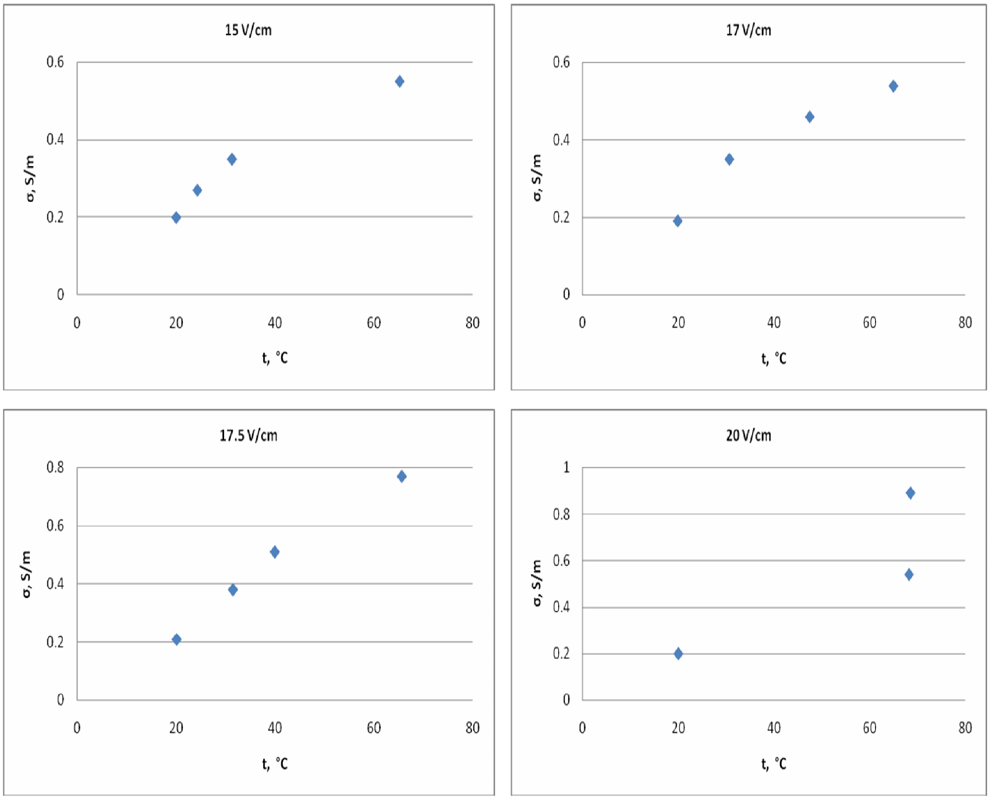

Fig. 1. The electrical conductivity dependence on temperature of pear puree processed by ohmic heating at different voltage gradients (15/17/17.5/20 V/cm)

The electrical conductivity is directly dependent on temperature increasing. The allure of the four slope is similar for the first three voltage gradients 15/17/17.5 V/cm; the increasing being linear, but the slope is different for 20 V/cm because in this case the values are exponential due to the gradient voltage highest value associated with the temperature rising (20/68.2/68.5°C). The highest value for electrical conductivity (0.89 S/m) is registered at 68.5°C for 20 V/cm and the lowest (0.19 S/m) it was marked at 19.9°C at 17 V/cm.

Because of the fast temperature increasing at 20 V/cm the bubbling temperature is reached very fast, so there are only three points for electrical conductivity measurement.

In Figure 2 is presented the electric conductivity variation depending on ohmic heating processing time at different voltage gradients 15/17/17.5 /20 V/cm).

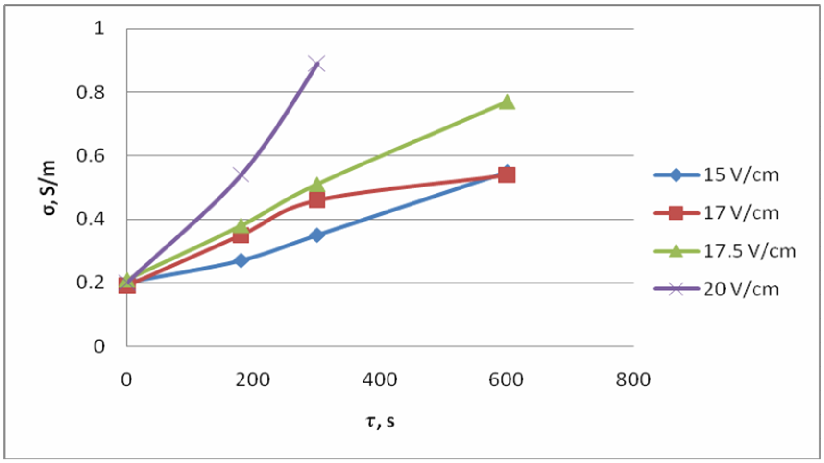

Fig. 2. Electric conductivity variation of pear puree depending on ohmic heating processing time at different voltage gradients (15/ 17/17.5/20 V/cm)

From this graph it can be observed that the ohmic heating process is evolving in the same time (600s) for the first three voltage gradients (15/ 17/17.5 V/cm) and in a different time interval (300 s) for the fourth voltage gradient (20 V/cm). So in this case the processing time is reduced at a half of the initial value.

The electric conductivity variation has almost a linear evolution for the three voltage gradients (15/ 17/17.5 V/cm), while for the last one (20 V/cm) the evolution is exponential.

All the electrical conductivities have the maximum threshold values around 0.89 S/m, so this value is obtained for 300 s and 20 V/cm. For voltage gradients lower than 20 V/cm respectively (15/ 17/17.5 V/cm) the electrical conductivities (0.35, 0.46, and 0.51 S/m) registered are with almost 50% decreased.

Another important aspect which can be observed from the graph is that for the 180 s time of processing the electrical conductivities values for 15 V/cm, 17 V/cm; 17.5V/cm are close to 0.27, 0.35, 0.38 S/m.

The results obtained in study can be compared with the results of other researchers, which are similar to ours. So F. Icier, C. Ilicali, 2005 demonstrated that the electrical conductivity of fruit purees is strongly dependent on temperature and dependent on ionic concentration and pulp content.

In the following graph (Figure 3) is presented the temperature variation depending on ohmic heating processing time at different voltage gradients (15 V/cm; 17 V/cm; 17.5 V/cm; 20 V/cm).

In the graph is presented the ohmic heating process which is unroll in the same time (600 s) and at the same maximum temperature (65.3, 65, 65.7 °C) for the first three voltage gradients (15 V/cm; 17 V/cm; 17.5 V/cm), but the process is different for the fourth voltage gradient 20 V/cm, which is developing in 200-300 s at 68.2-68.5 °C that is determining the time processing halfing comparing to the other voltage gradients.

In the fourth volage gradient case 20 V/cm it is registered the maximum processing temperature (68.5°C) in 300 s.

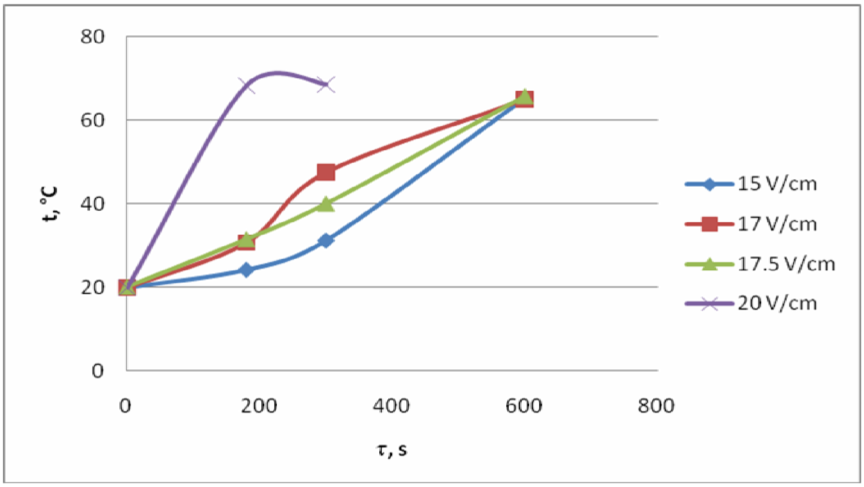

Fig. 3. The temperature variation depending on
ohmic heating processing time at different voltage gradients
(15/17/17.5/20 V/cm)

The graph shows that for 15 V/cm; 17 V/cm; 17,5 V/cm are registered the following temperaure values 31.3, 40.5, 47.5°C in 300 s and it also go through time intervals (200, 400, 600 s) followed by a linear increasing since to the maximum temperature 65.7°C.

Figure 4 presents the shear stress variation depending on shear rate over ohmic heating process at different gradients (15 V/cm; 17 V/cm; 17.5 V/cm; 20 V/cm).

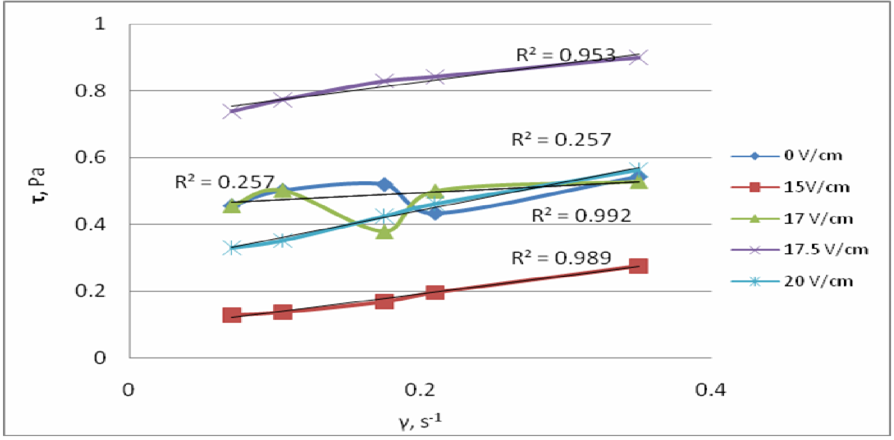

Fig. 4. Shear stress variation depending on shear rate
over ohmic heating process at different gradients
(15/17/17.5/20 V/cm)

During ohmic heating process at different voltage gradients (15/17/17.5/20 V/cm) the shear stress is increasing linearly depending on the shear rate rising.

The shear stress is reaching the maximum value (0.899 Pa) once with the maximum value reached by the shear rate (0.35 s^{-1}) for 17.5 V/cm, also the values shear stress for 17 and 20 V/cm are proximate (0.528/0.563 Pa), while for 15 V/cm the shear stress value is lower to the other determinations (0.276 Pa).

From the graph it can be observed that the variation of shear stress depends on shear rate is similar (0.462/0.4998 Pa) at 17 and 20 V/cm at a value of 0.21s^{-1} for shear rate.

The regression coefficient values R^2 varies between 0.953 and 0.992, values registered for the pear puree treated at 15, 17.5 and 20 V/cm excepting the value for the untreated puree and treated at 17 V/cm which is 0.257.

So if the regresion factor (R) values are closed to 1 the mathematical model choose for the data is the most adequate.

Figure 5 shows the dynamic viscosity evolution depending on the shear rate during the ohmic heating process.

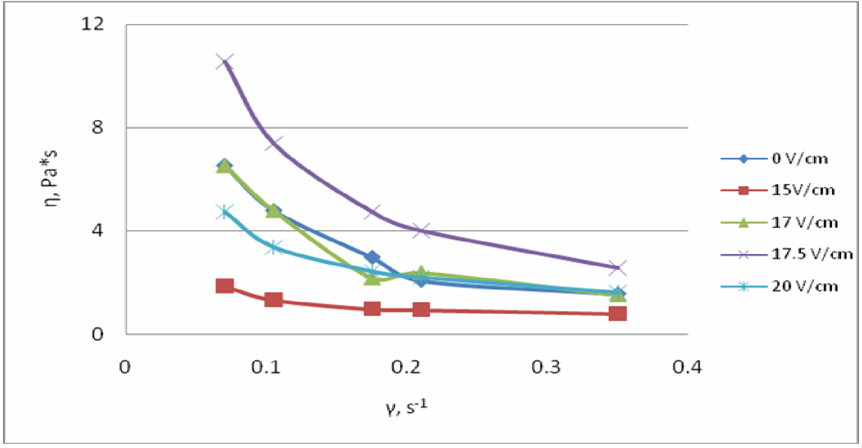

Figura 5. The dynamic viscosity evolution depending on shear rate during ohmic heating process at different voltage gradients 15/17/17.5/20 V/cm

The graph expressed that the dynamic viscosity maximum value (10.56 Pa*s) which is registered for 17.5 V/cm and at 0.07 s^{-1}. Once with the shear rate increasing and the maximum value reaching (0.35 s-1) is observed a decreasing of the dynamic viscosity values for all four voltage gradients (15/17/17.5/20 V/cm).

For 17 and 20 V/cm the dynamic viscosity values are closed 2.17/2.38/2.2/2.43 Pa*s. These values are reported to a shear rate of 0.2 s^{-1}.

To the highest value of the shear rate 0.35 s^{-1} are registered proximate values for the dynamic viscosity like 0.79/1.51/1.61 Pa*s for 15/17/ 20 V/cm, while the corresponding value for the 17.5 V/cm voltage gradient is 2.57 Pa*s.

The graphs which determine the rheological behavior of the pear puree show a pseudoplastic rheological behavior of the pear puree treated by ohmic heating because represents the type of fluid with a dynamic viscosity in decreasing with the shear rate increasing.

CONCLUSIONS

As a general conclusion of the study over ohmic heating process applied over the Williams pear puree, the electrical conductivity is directly dependent on temperature and time increasing. Also the electric conductivity rise is dependent on the voltage gradient used by the installation.

The electrical conductivity of pear puree increase linearly with time during the ohmic heating at 15/17 and 17.5 V/cm, while for 20 V/cm the electrical conductivity rise exponentially. Also the same thing is reflected for the temperature increasing.

The ohmic heating time processing is inversely with the voltage gradient used, as the voltage gradient increased, the time decreased. The bubbling is marked by a temperature above 60°C reached especially at higher voltage gradients.

The viscosity of pear puree depends inversely on time processing and decreased linearly, while the time increasing. So the rheological behavior of the pear puree is pseudoplastic.

The study can be compared with the results obtained by other researchers and their results were similar to ours. So F. Icier, C. Ilicali, 2005 demonstrated that the electrical conductivity of fruit purees is strongly dependent on temperature and dependent on ionic concentration and pulp content. Also they discovered the electrical conductivity of the fruit purees increased with temperature rise, linearly and the bubbling occurred above 60°C especially at higher voltage gradients.

Ohmic heating time is dependent on the voltage gradient used. As the voltage gradient increased, time decreased (F. Icier, C. Ilicali, 2004).

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