An Experimental Study on Rheological Properties of Pestil Blends

Zehra Yildiz1, *, Ayse Sarımeseli2

1Department of Energy Systems Engineering, Technology Faculty, Mersin University, Mersin, Turkey
2Department of Chemical Engineering, Faculty of Engineering, Inonu University, Malatya, Turkey

Email address:
zyildiz@mersin.edu.tr (Z. Yildiz)
*Corresponding author

To cite this article:

Received: May 2, 2017; Accepted: May 17, 2017; Published: July 13, 2017

Abstract: The rheological and sensory properties kind (apricot, grape and mulberry molasses) blends were studied pestil (rollband) syrup of apricot, mulberry and grape at 25, 40, 50 and 70°C, rheological properties kind of pestil syrup (untreatment and treatment with sulphur) apricot molasses) blends were studied using sugar concentrations of 0%, 5% and 10%. The empirical power law model fitted the apparent viscosity vs rotational speed data. All blends exhibited pseudoplastic behavior. The syrup content and temperature influenced the flow behavior and consistency index values. Temperature sensitivity of the consistency index was assessed by applying an Arrhenius-type equation. \( E_a \) values ranged from 326.65 to 175.86 J mol s\(^{-1}\) as syrup content varied from apricot, grape to mulberry, respectively. Arrhenius constant, \( k \), however, correlated with mouthcoating.

Keywords: Rheology, Pestil, Apricot

1. Introduction

Malatya where is famous its apricots is not only the most important apricot production center in Turkey but also all the world's apricot production center. An analysis of data related to the world of dried apricot exports, ranks first with about 80-85% share of Turkey in the export of these products [1]. Apricot is widely grown in Malatya Province in Turkey where the fruit can be consumed both fresh fruit and dried fruits fruit such as pestil, fruit puree, jam, marmalade or as fruit juice [2].

Fruits are one of the oldest methods of long-term preservation of intact factor is to make the pestil. Pestil is a foodstuff which is made of fruits such as grape, mulberry, plum and apricot. Pestil is made from thin sheet of sun-dried the fruit pulp. This fruit leather is also called roll band. Roll band is a traditional popular food containing sugar in Turkey and other East Asian and Middle Eastern countries. Pestil on the other hand, can be obtained either from grape, mulberry or apricot and requires minimum processing. It has remarkable flour and sugar stability and resistance to oxidative deterioration. The process is known as a mixture which is gathered from the separation of the peel and sediment of fruits like grapes, apricots, plums, or other sweet and sour fruits, that are concentrated, dried in the sun and formed into plates.

It is generally known as pestil, and it is a healthy and natural product. It contains molasses and starch so it is a good source of carbohydrate. For this reason pestil is consumed mainly for energy. Pestil which has a high energy value became an important foodstuff in terms of nutrition sources. It has vitamins which is insoluble in water and vitamins. Beside this, pestil contains a great amount of minerals like K, Ca, S, P, Mg, Cu, Zn, I and Cl. Pestil blend can be considered as a typical example of a flour, sugar and mashed fruit. In many food systems, protein and lipids commonly interact and thus the ability of protein to form a stable blend is important and may help enhance sensory properties. Optical properties such as color, appearance, taste, smell and texture are important features in the selection and valuation of food materials [3-6]. A better understanding of the parameters that influence the sensory properties of food will enable food manufacturers to better design and control the properties of food products. For example, consumer acceptance of such products depends on their ability to spread on another material and has a direct relationship with viscosity and flow behavior [5, 7-8]. In the food industry, viscosity is one of the most important parameters required in the design of a technological process.
On the other hand, viscosity is also an important factor that
determines the overall quality and stability of a food system. High
protein, high mineral and vitamin content of pestil might offer a
promising nutritious and healthy alternative to consumers. Rheology
properties of food are one of the most
important indicators of their quality. Furthermore, rheological
or flow properties of process streams directly affect the design
and operation of process. Therefore, rheological characterization of samples, taken in some critical steps in
production, provides crucial insight into product quality
control and process economics. Therefore, the objectives of
this study were to prepare pestil blends from fruit syrup, rheological properties of the blends.

2. Materials and Methods

2.1. Preparation of Pestil Blends

The fruit syrups of grape, mulberry and apricot were used. Pestil with a carbohydrate content of 65.2%, protein content of
0.84% and fat content of 0.25% was used (composition given
by the supplier). The fruits juices is taken out by fruits have
been subjected to an the fruits pressure for ejecting intensively
by the supplier). The fruits juices is taken out by fruits have
separated from rotten ones and they are washed. It is boiled the
fruits pulp make from products such as pestil blends which is
obtained after filtering fruits. The flour which is made by
sieving the flour is added with sugar, is mixed in the boiler by
adding the pestil blends. The pestil blends is prepare after
warmed.

2.2. Experimental Methods

Model mixes were prepared in accordance with the
traditional pestil mixture composition, which is sugar, flour
and mashed fruit. Apricot pestil blends were prepared
untreatment and treatment with sulphur apricot. Apricots have a long time storage that sun dried after pretreatment with sulfur dioxide to prevent spoilage and to slow down enzymatic
and non-enzymatic reactions. However, by adding sugar to
pestil syrup of untreatment apricot to give the concentration of
0%, 5%, 10% (w/w) and mixing evenly with a spatula. The
levels of the sugar in pestil were selected to represent
acceptable range for consumers. Grape and mulberry pestil
blends were prepared by adding flour. The temperature was gradually increased with vigorous stirring until boiling which
was maintained for 15 min. The prepared mixes were cooled
to room temperature. Blends were directly subjected to
analysis.

2.3. Viscosity Measurement

The viscosity (Pa. s) of blends were determined at 25, 40,
50 and 70°C using a Brookfield rotational viscometer (Model
RVDV++, Brookfield Engineering Laboratories, Stoughton,
MA) equipped with spindle 3, 4, 5 at the speed of 0.5, 2, 5, 10,
30and 60 rpm. Enough sample in a 400 ml beaker was used to
immerse the groove on the spindle with guard leg [9].
Temperature was maintained using a thermostatically
controlled water bath. Flow behavior was described by the
power law model.

\[ \eta = k \gamma^{(n-1)} \]  

(1)

where \( \eta \) is the apparent viscosity (Pa s), \( \gamma \) is the rotational speed (s\(^{-1}\)), \( k \) is the consistency index (Pa s\(^n\)) and \( n \) is the flow behavior index (dimensionless).

3. Results and Discussion

The flow behavior index (n) and consistency index (k)
values, obtained by fitting the rotational speed versus apparent
viscosity data to a power law model (Eq. 1), are presented in
Table 1 and 2. [10] reported that fundamental rheological
information could be achieved from viscosity-rotational speed
data of Brookfield viscometers. The values of flow behavior
index, n, ranged from 0.117 to 0.608 and the consistency index,
k, ranged between 2.998 and 18.20 Pa s. The \( R^2 \) values from
fitting ranged from 0.950 to 0.999 for all samples. This model
was able to represent the experimental data reasonably well
with the \( R^2 \) value, which is a measure of the goodness of fit,
higher than 0.950. The model parameters obtained for each
pestil blends are displayed in Table 1-3.

Table 1. The consistency index (k) and flow behavior index (n) of apricot
pestil blends at different sugar concentration.

<table>
<thead>
<tr>
<th>Percentage of sugar</th>
<th>Apricot Pestil</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>k</td>
</tr>
<tr>
<td>0 (Dried apricot)</td>
<td>14,054</td>
</tr>
<tr>
<td>0 (Fresh apricot)</td>
<td>14,174</td>
</tr>
<tr>
<td>5</td>
<td>15,094</td>
</tr>
<tr>
<td>10</td>
<td>13,588</td>
</tr>
<tr>
<td>Treatment with sulphur</td>
<td>18,078</td>
</tr>
</tbody>
</table>

* \( k \) (Pas\(^n\)) and \( n \) (dimensionless) indices were obtained by fitting rotational
data to power law model, \( \eta = k \gamma^{(n)} \), where \( \eta \) is apparent viscosity, \( k \) is
consistency index and \( n \) is flow behavior index

Table 2. Power law parameters.

<table>
<thead>
<tr>
<th>Kind of Pestil Blends</th>
<th>T (°C)</th>
<th>25</th>
<th>40</th>
<th>50</th>
<th>70</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apricot</td>
<td>n</td>
<td>0.20</td>
<td>0.19</td>
<td>0.26</td>
<td>0.23</td>
</tr>
<tr>
<td></td>
<td>k</td>
<td>14.71</td>
<td>13.61</td>
<td>13.87</td>
<td>18.20</td>
</tr>
<tr>
<td></td>
<td>( R^2 )</td>
<td>0.993</td>
<td>0.987</td>
<td>0.992</td>
<td>0.999</td>
</tr>
<tr>
<td></td>
<td>n</td>
<td>0.567</td>
<td>0.604</td>
<td>0.608</td>
<td>0.568</td>
</tr>
<tr>
<td></td>
<td>k</td>
<td>2.998</td>
<td>3.723</td>
<td>4.972</td>
<td>9.126</td>
</tr>
<tr>
<td></td>
<td>( R^2 )</td>
<td>0.950</td>
<td>0.967</td>
<td>0.979</td>
<td>0.994</td>
</tr>
<tr>
<td>Grape</td>
<td>n</td>
<td>0.117</td>
<td>0.288</td>
<td>0.339</td>
<td>0.305</td>
</tr>
<tr>
<td></td>
<td>k</td>
<td>3.041</td>
<td>4.528</td>
<td>5.112</td>
<td>7.867</td>
</tr>
<tr>
<td></td>
<td>( R^2 )</td>
<td>0.997</td>
<td>0.995</td>
<td>0.997</td>
<td>0.992</td>
</tr>
</tbody>
</table>

* \( k \) (Pas\(^n\)) and \( n \) (dimensionless) indices were obtained by fitting rotational
data to power law model, \( \eta = k \gamma^{(n)} \), where \( \eta \) is apparent viscosity, \( k \) is
consistency index and \( n \) is flow behavior index

The smaller the \( n \) values the greater the departure from
Newtonian behavior. Viscosity of apricot pestil in the
treatment with sulphur is higher (higher \( k \) value) than
untreatment apricot pestil and the consistency index decreased.
The increase in sugar concentration resulted in lower viscosity
(lower \( k \) values) for all temperatures tested and the
consistency index decreased with increasing temperature in the treatment apricot pestil. The higher solid contents generally cause an increase in the viscosity resulting from mainly molecular movements and interfacial film formation [11-13]. The addition of sugar may also lead to a decrease in viscosity as in the case for semi-liquid maize dough [13].

Most fluid foods do not have the simple Newtonian rheological model and more complex models is need for describe their rheological behavior. Their viscosities regard as shear stress, shear rate and temperature. The rheological model most often used to describe to Power Law model for rheological behaviour of fruit pulps, juices, and puree. The power law model used to the flow behavior of pseudoplastic foods [5]. From Table 2, it can be observed the value of $n$ is smaller than 1 in all cases, concluding that all pestil blends present pseudoplastic characteristics. Table 2 show that the experimental data are in agreement with the power law models it can be noted that the models present high $R^2$ values. Models were proposed to correlate the dependency of the rheological parameters with the temperature.

From typical curves could be seen that all pestil blends had a non-newtonian and pseudoplastic behaviour. A change in the rheological behaviour of all pestil blends with increasing the temperature was observed (Figs. 3-5). The apparent viscosity decreases with the temperature in all cases.

The flow behavior index ($n$) of blends at 50°C indicated that they were more pseudoplastic (lower $n$ values) than blends prepared at 25, 40, 50 and 70°C for all concentrations. Heating may rupture molecular entanglement and bonds may stabilize the molecular structure and reduce the effective molecular volume in protein and sugars resulting in a decrease in viscosity. All blends showed pseudoplastic flow behavior irrespective of temperatures (Figures 1-5).
**Table 3. Arrhenius-type equation parameters for pestil.**

<table>
<thead>
<tr>
<th>Kind of Pestil Blends</th>
<th>k (Pa s⁻¹)</th>
<th>E_a (J mol⁻¹)</th>
<th>R²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grape pestil</td>
<td>7,055447</td>
<td>326,6847</td>
<td>0.9693</td>
</tr>
<tr>
<td>Mulberry pestil</td>
<td>27,47015</td>
<td>175,8577</td>
<td>0.7186</td>
</tr>
<tr>
<td>Apricot pestil</td>
<td>70,1148</td>
<td>190,2204</td>
<td>0.9830</td>
</tr>
</tbody>
</table>

k (Pa s⁻¹) and E_a (J mol⁻¹) parameter were obtained from Arrhenius type equation:

\[
\ln k = \ln k_0 + \frac{E_a}{R} \frac{1}{T_a},
\]

where \( k_0 \) is the Arrhenius constant, \( E_a \) is the activation energy, \( R \) is the universal gas constant and \( T_a \) is the absolute temperature.

The decrease in viscosity as the speed (shear rate) was increased has been related to the increased alignment of constituent molecules of the tested system [14]. Temperature sensitivity of the consistency index was assessed by applying an Arrhenius-type equation. The parameters are shown in Table 3. \( E_a \) values ranged from 326,65 to 175,86 J mol⁻¹ as grape, mulberry and apricot pestil, respectively.

### 4. Conclusion

This study developed blends from grape, mulberry and apricot pestil such as energetic food and healthy alternative product to the consumers. The empirical power law model fitted the apparent viscosity rotational speed data. Pestils made all blends from grape, mulberry and apricot showed pseudoplastic flow behavior on the temperatures. The rheological parameters of the grape, apricot and mulberry pestil blends at different temperatures may have useful implications for design and processing in the food industry.

### References