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SCIENCE DIRECT®
Food Control 16 (2005) 73–76
FOOD CONTROL
www.elsevier.com/locate/foodcont

Rheological, physical and chemical characteristics of mulberry pekmez

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Received 16 February 2003; received in revised form 21 November 2003; accepted 26 November 2003

Abstract

The physical, chemical properties and the rheological behaviour of mulberry pekmez were investigated. Viscosity was measured at 30, 40, 50, 60 and 70 °C using a rotational viscometer equipped with spindle 5 at the speed of 5, 10, 20, 50 and 100 rpm. An empirical power-law model was used to describe the rheological behaviour of mulberry pekmez with correlation coefficients between 0.991 and 0.999. The mulberry pekmez exhibited a pseudoplastic behaviour. An Arrhenius equation was used to describe the effect of temperature on viscosity and E_a value of the mulberry pekmez was calculated as 17.97 kJ mol^{-1}.

Keywords: Mulberry; Pekmez; Concentrated fruit juices; Rheological properties

1. Introduction

Pekmez is one of the traditional food products in Turkey and it is commonly produced from grape and mulberry by concentration of juices up to 70–80 soluble dry matter content. Pekmez, consumed generally for breakfast (Alpaslan & Hayta, 2002), can also be produced from fruits containing high amounts of sugar like apple, carnob, plum, watermelon, apricot, sugar beet and fig. Since pekmez contains high amounts of sugar, mineral and organic acid, it is a very important food product in human nutrition (Demirözü, Sökmen, Uçak, Yılmaz, & Gülderen, 2002; Ustün & Tosun, 1997). Pekmez easily passes into the blood without digestion because most of its carbohydrate is in the form of monosaccarides like glucose and fructose. This is nutritionally important, especially for babies, children, sportsmen and in situations demanding urgent energy.

Pekmez has been produced with different techniques considering species of fruits used in production. For mulberry pekmez production, fresh mulberry is used as raw material. Firstly, mulberry is placed to boiling vessels after cleaning. Then, 8–10 l water is added for 20–30 kg mulberry. After adding water, the mixture is completely stirred, and is boiled by stirring for ≈1 h. It has various colors from light brown to dark brown depending on the process. After then, the mixture is cooled up to about 40–50 °C. It is pressed and then filtered in order to obtain clear mulberry juice. Mulberry juice is concentrated in open vessels to obtain 65–72 °Brix. Then, mulberry juice is cooled up to ≈40 °C; this product is called mulberry pekmez. Finally, mulberry pekmez is packaged and stored at room temperature (Aksu & Nas, 1996).

In the food industry, rheological characteristics of concentrated fruit juices are a significant property in addition to chemical and physical properties. Moreover, rheological characteristics depend on both the chemical composition of fruits and processing conditions. However, a knowledge of the flow behaviour of concentrated fruit juices will be useful in quality control, calculating energy usage, process control and equipment selection (Kaya & Belibağlı, 2002). Viscosity, a rheological property, is also considered as an important physical characteristic related to the quality of liquid food products (Saravacos, 1970).

There is a number of research about rheological (Alpaslan & Hayta, 2002; Kaya & Belibağlı, 2002) and chemical properties of grape pekmez (Batu, 1993; Batu & Yurdagel, 1993; Bozkurt, Göğüş, & Eren, 1999; Demirözü et al., 2002; Karakaya & Artık, 1990; Nas & Nas, 1987; Ozkök, 1989; Tosun & Ustün, 2003; Ustün & Tosun, 1997). However, there is little information about

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doi:10.1016/j.foodcont.2003.11.010

rheological and chemical properties of mulberry pekmez. Therefore, the purpose of this study was to characterize the rheological behaviour of mulberry pekmez and to determine chemical and physical properties.

2. Materials and methods

The commercial pekmez was supplied from local supermarket and all chemicals were reagent grade.

2.1. Chemical and physical analyses

Total and soluble dry matter, protein, ash, pH and titratable acidity were determined according to standard method AOAC (1984); pH was determined with a ATI ORION 420A model pH meter; titratable acidity, expressed as percentage of citric acid, was determined with 0.1 N NaOH up to pH 8.1; solubles dry matter was determined with an Abbe-Zeis refractometer; protein content was determined by the Kjeldal method (Nx6.25).

Total sugar, invert sugar and sucrose contents were analysed by the Lane-Eynon method (Cemeroğlu, 1992). Hydroxymethylfurfural (HMF) was determined by the IFJJP (1964) with a spectrophotometer (Schimadzu, UV-120-01 Model) at 550 nm.

For color analysis, the instrument was calibrated with a white reference tile before measurements. Color of mulberry pekmez was analysed by measuring Hunter L (brightness; 100: white, 0: black), a (+: red; −: green) and b (+: yellow; −: blue) parameters with a colorimeter (Model CR 200, Chromometer, Minolta, Japan).

2.2. Rheological behaviour

The viscosity (Pa s) of mulberry pekmez was measured at 30, 40, 50, 60 and 70 °C using a rotational viscometer (Model Poulten RV-8, Selfe Elee Ltd., Wickford Essex SSII 8BJ, England) equipped with spindle 5 at the speed of 5, 10, 20, 50 and 100 rpm. Three readings were taken per sample at 30 s intervals. A 300 ml beaker was used for viscosity measurements and a thermostatic water bath was used to control the processing temperature within the (30–70 ± 1) °C range.

2.3. Statistical analysis

In this study, five different speed levels (5, 10, 20, 50 and 100 rpm) and temperatures (30, 40, 50, 60 and 70 °C) were selected as experimental factors. The experiment was set up as 5×5 the factorial experimental design, and the analysis was carried out according to completely randomized blocks design with three replications (Gürbüz, 1993).

3. Results and discussion

3.1. Chemical and physical characteristics

The chemical and physical characteristics of mulberry pekmez are given in Table 1. As shown in Table 1, mulberry pekmez contained high amounts of total sugar, which is composed of approximately 100% invert sugar as glucose and fructose. This is very important in human nutrition because of its easy digestibility and these sugars provide a readily available energy source since they easily pass to blood (Kavas, 1990). In addition, glucose, energy source of the brain, enhances the transport of tryptophan through the blood–brain barrier and it is useful in seratonin synthesis that has a function in brain working (Birch & Parker, 1979). However, this pekmez contains very small contents of sucrose and protein.

HMF, an indicator of quality deterioration, occurs as a result of excessive heating in foods containing carbohydrates (Cemeroğlu, 1982). Therefore, high amounts of HMF are not desired in processed fruit juices. The Turkish Standard Institute recommends a maximum HMF concentration of 75 $mg\,l^{-1}$ for first quality mulberry pekmez (TS, 1996). In this study, a low HMF content of mulberry pekmez was found here (viz. 6.34 $mg\,l^{-1}$).

As shown in Table 1, *L*, *a* and *b* values were measured 19.57, +15.91 and −0.14, respectively. A high redness (*a*) value is not desired because it occurs as a result of excessive caramelization of sugars. Therefore, a low redness (*a*) and a high brightness (*L*) values indicate a good quality pekmez (Aksu & Nas, 1996).

3.2. Rheological behaviour

Several rheological models have been employed to fit data on fruit juices. The rheological behaviour of mulberry pekmez was described by the power law model (Chhinnan, McWaters, & Rao, 1985; Heikal & Chhinnan, 1990):

Table 1
The chemical and physical characteristics of mulberry pekmez

Parameters	Values
Total dry matter	74.33%
Soluble dry matter	72%
Total sugar	60.22 g/100 g
Invert sugar	59.56 g/100 g
Sucrose	0.66 g/100 g
Ash	2.02%
Protein	0.36%
Hydroxymethylfurfural (HMF)	6.34 mg/l
pH	5.15
Titratable acidity (citric acid)	0.52%
Color	*L*: 19.27 *a*: +15.91 *b*: −0.14