



Physical, chemical and antioxidant properties of solid and sour apple pekmez

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Abstract

Pekmez is a traditional Turkish food commonly produced from grape. It can also be produced from fruits containing high amounts of sugar like apple, plum, and apricot. Apple pekmez has been produced from fresh apples in Turkey using traditional techniques. Apple pekmez is produced as either liquid or solid. The acidity of apple juice is not reduced with pekmez soil, or CaCO_3 in sour apple pekmez production. In this study, physical, chemical, and antioxidant properties of solid and sour apple pekmez were determined. For this purpose, thirty samples of pekmez were analysed. Hunter *L* values of pekmez samples ranged between 15.06 and 24.42. Hunter *a* value was between +0.32 and +3.81 and *b* value was between +0.47 and +4.62. Additional analysed characteristics were water activity (0.550-0.867), total soluble solids (65-85%), total sugar content (258.60-739.40 g kg^{-1}), reducing sugar (167.20-617.60 g kg^{-1}), un-reducing sugar (1.80-198.70 g kg^{-1}), pH (3.04-4.58), total acidity (9.90-75.30 g kg^{-1}), crude protein (2.60-12.40 g kg^{-1}), ash (8.00-28.70 g kg^{-1}) and hydroxymethyl furfural (23.54-2133.52 mg kg^{-1}). Total phenolics value of the pekmez samples ranged between 4603.60 and 14,252.25 mg kg^{-1} , and total antioxidant activity (expressed as FRAP values) between 47.34 and 327.86 mmol g^{-1} . In this study, the correlation between total acidity, ash, total phenolics values and total antioxidant activity was significant ($p < 0.01$).

Key words: Apple, FRAP, color, pekmez.

Introduction

Pekmez is one of the traditional food products in Turkey which is commonly produced from grape by concentration of juices containing up to 70-80% soluble dry matter. Pekmez can also be produced from fruits containing high amounts of sugar like apple, plum, watermelon, apricot, sugar beet and fig^{1,2}. The raw materials and processing conditions differ geographically.

Although there is a great commercial potential in the industrial scale, most of the pekmez production in Turkey is done in small-scale family businesses or even in households. In general, grape and mulberry pekmez are produced in large pekmez plants while pekmez from the other fruits are produced in small pekmez plants or houses³.

Apple pekmez has been produced from fresh apples, in Samsun, Amasya and Tokat cities in Turkey using traditional techniques. The first step in apple pekmez production is washing and crushing the apples. Pressing the crushed apples by a pneumatical or mechanical press provides the juice. In this process hot pressing is preferred. Then apple juice is concentrated in open vessels while stirring with wooden bars. Apple pekmez is produced as either liquid or solid. The acidity of apple juice is not reduced with pekmez soil, or CaCO_3 in sour apple pekmez production.

While the information about the antioxidant activity of pekmez in general is scarce^{4,5}, there is no specific information about apple pekmez. Therefore, the purpose of this study was to determine physical, chemical, and antioxidant properties of apple pekmez.

Materials and Methods

Materials: Thirty pekmez samples were selected from local producers in Samsun, Turkey in this study.

Chemicals: Folin-Ciocalteu reagent, formic acid, hydrochloric acid, barbituric acid, sodium carbonate, and iron (II) sulfate hepta hydrate were purchased from Merck (Darmstadt, Germany). Acetone, methyl alcohol, and glacial acetic acid were obtained from Carlo Erba (Milano, Italy). Catechin was purchased from Sigma-Aldrich Chemie (Steinheim, Germany), and 2,4,6-tripyridyl-*s*-triazine (TPTZ) was obtained from Acros Organics (New Jersey, USA).

Color analysis: Color was evaluated by measuring Hunter *L* (brightness, 100 = white, 0 = black), *a* (+, red; -, green) and *b* (+, yellow; -, blue) parameters through a reflectance colorimeter (CR 300, Chromometer, Minolta, Japan). A white tile (No: 21733001) was used to standardize the instrument.

Determination of general parameters: Water activity was measured using a Testo 400 (Germany) water activity measurement device. General parameters were measured following official methods⁶; soluble solids content was measured with an Abbe refractometer (ATAGO, Japan). Total sugar, reducing sugar and un-reducing sugar were quantitated by the Lane-Eynon method. pH was measured with a pH meter (Nel-890, Turkey); total acidity was determined by titration with 0.1 M NaOH up to pH 8.1 and expressed as percentage of malic acid. Crude protein was analyzed by the Kjeldahl method ($\text{Nx}6.25$). Ash content was determined by

incineration in a muffle furnace at 550°C.

The hydroxymethyl furfural (HMF) was determined quantitatively following the procedure described by the IFFJP⁷, based on the colorimetric reaction between barbituric acid, p-toluidine and HMF through formation of a red coloured complex. The intensity of red colour was measured spectrophotometrically at 550 nm.

Total phenolics: Diluted sample was introduced in a 100 ml volumetric flask; 5 ml of Folin-Ciocalteu's reagent was added and mixed. The mixture was left at room temperature for 5 min. A volume of 10 ml of saturated sodium carbonate solution (7.5%, w:v) was added to the mixture and then mixed gently. A control solution was also made by mixing water and the reagents. The solution was filled to 100 ml with distilled water. The mixture was kept at room temperature for 30 min, and the absorbance was read at 720 nm using the spectrophotometer. The standard calibration curve was plotted using catechin equivalent⁸.

Antioxidant activity: An aliquot of the acetone/methyl alcohol/water/formic acid (40:40:20:0.1) extracts of pekmez samples were dried at 30°C under vacuum, using an evaporator (Heidolph 4001, Germany)⁹. Then the samples, redissolved in the same amount of water, were mixed with 0.95 ml of ferric-TPTZ reagent (prepared by mixing 300 mM acetate buffer, pH 3.6, and 10 mM 2,4,6-tripyridil-s-triazine in 40 mM HCl and 20 mM FeCl₃ in the ratio of 10:1:1) and measured at 593 nm. Iron (II) sulfate hepta hydrate was used as a standard and the antioxidant activity was expressed as mmol g⁻¹ FRAP¹⁰. All spectrophotometric analyses were performed using UV-visible spectrophotometer (Jasco V-530, Japan).

Statistical analysis: Mean, standard deviation and correlation analyses were calculated using SPSS 11.0 for Windows software package.

Results and Discussion

The results of examined properties of pekmez samples are shown in Table 1. There were wide variations in physical and chemical properties of apple pekmez. Their brightness (*L*) values were low, and redness (*+a*) values were high. Low redness and high brightness values indicate a good quality pekmez². The dark brown colors develop because of either Maillard or caramelization reactions.

Table 1. The physical, chemical and antioxidant properties of solid and sour apple pekmez.

Parameter	Range	Mean±standard deviation
Hunter values		
<i>L</i>	15.06-24.42	19.16±2.50
<i>+a</i>	0.32-3.81	1.36±0.92
<i>+b</i>	0.47-4.62	2.91±0.89
Water activity	0.550-0.867	0.737±0.075
Soluble solids (°Bx)	65.00-85.00	75.13±6.51
Total sugar (g kg ⁻¹)	258.60-739.40	469.764±113.70
Reducing sugar (g kg ⁻¹)	167.20-617.60	412.80±102.80
Unreducing sugar (g kg ⁻¹)	1.80-198.70	54.10±60.80
pH	3.04-4.58	3.76±0.38
Total acidity (g kg ⁻¹)	9.90-75.30	32.60±20.40
Crude protein (g kg ⁻¹)	2.60-12.40	6.30±2.70
Ash (g kg ⁻¹)	8.00-28.70	15.30±4.50
HMF (mg kg ⁻¹)	23.54-2133.52	691.23±585.05
Total phenolics (mg kg ⁻¹)	4603.60-14252.25	9554.27±2289.76
FRAP (mmol g ⁻¹)	47.34-327.86	139.62±70.44

Apple pekmez samples had low water activity values. As water activity is the amount of water that is available to microorganisms, many microorganisms prefer a water activity of 0.99 and most need a water activity higher than 0.91 to grow. Water activity has been used as an important parameter to determine critical point necessary for a stable product, and to predict microbial and chemical spoilage in foods. It is also crucial for food processing and storage.

Apple pekmez contained high amounts of total soluble solids and total sugar. Therefore, it is a good source of energy. It can also be stored for a long time without deterioration. Total sugar values were lower than the values reported before which ranges between 60.22 and 78.39%^{2,11,12}.

The pekmez samples had high total acidity values as pH values were low. The acidity values were higher than the range of 0.08-1.24% for gun pekmez as reported by Toker and Hayoglu¹². In our study total acidity values were generally high because pekmez earth was not added during the production of sour-apple pekmez, and also some producers were using mountain apple (Acuk called in Turkey), which is well known for its high acidity and sour taste.

Apple pekmez contained high amounts of HMF which is not desired in pekmez. HMF is a recognized indicator of nonenzymic browning used as an index of deteriorative changes which take place during excessive heating and/or storage of foods. In fresh foods, the HMF level is close to zero as opposed to higher levels in processed foods. HMF is the principal decomposition product of the acid-catalyzed reaction of the glucose and fructose, and it is commonly used as a quality indicator^{13,14}.

Bozkurt *et al.*¹⁵ showed the effect of increasing temperature in boiled juice resulting in significantly high HMF accumulation and brown pigment formation. Kus *et al.*¹⁴ reported that in the traditional method of pekmez production, a longer time of evaporation process is necessary to meet desired soluble solids content. The high HMF content of pekmez was probably due to the length of this process. Batu¹⁶ found the HMF concentration as 681.40 ppm in boiled grape juice produced by the traditional method. On the other hand, Kus *et al.*¹⁴ reported the HMF concentration in a range of 12.8-3500 ppm for several types including mulberry, grape and pomegranate boiled juice. From these findings, the results obtained in this study were in an agreement with those reported in the literature.

As shown in Table 1, there are also wide variations in total phenolics and antioxidant activity values of apple pekmez. High FRAP values corresponded to a great extent to a high phenolics content as well. The pekmez samples with low antioxidant activity exhibited relatively low total phenol content.

Consumption of fruits and vegetables has been shown to be effective in the prevention of chronic diseases, such as cardiovascular diseases and cancer¹⁷, and phytochemicals including phenolics, flavonoids and carotenoids from fruits and vegetables may play a key role in reducing chronic disease risk. Apple is a rich source of phytochemicals, and epidemiological studies have linked the consumption of apples with reduced risk of some cancers, cardiovascular diseases, asthma, and diabetes¹⁸. Apples have been found to have very strong antioxidant activity^{17,18}. Yet, it is no information about antioxidant activity of apple pekmez. Alasalvar *et al.*⁴ found that ORAC value of cherry laurel pekmez was 19,981 µmol TE g⁻¹. They also reported a positive correlation between total phenolic content and

antioxidant activity of cherry laurel pekmez.

In this study, correlation coefficients between the other parameters and antioxidant activity values (Table 2) were also evaluated. The correlation between total acidity, ash, total phenolics values and total antioxidant activity was significant ($p < 0.01$). In addition, it was found that there was only negative correlation between *L* values and total antioxidant activity values ($p < 0.05$).

Table 2. Correlation between other variables and antioxidant activity.

Parameter	Correlation coefficient
Hunter values	
<i>L</i>	-0.439*
+ <i>a</i>	-0.225
+ <i>b</i>	-0.346
Water activity	-0.043
Soluble solids	0.327
Total sugar	-0.123
Reduced sugar	-0.119
Unreduced sugar	-0.027
pH	-0.327
Total acidity	0.639**
Crude protein	0.105
Ash	0.499**
HMF	0.035
Total phenolics	0.655**

*Correlation is significant at the 0.05 level.

** Correlation is significant at the 0.01 level.

Conclusions

Apple pekmez is a traditional food in Turkey with a high total acidity value and total soluble solids content. Besides its good total phenolics content and total antioxidant activity it is also good source of energy. Moreover, it can be stored for a long time without any deterioration. Main downside of it seems to be high hydroxymethyl furfural content, and its very dark color.

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