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Effect of the replacement of sugar with spray dried grape pekmez (pekmez powder) on some properties of cookies

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RESEARCH ARTICLE

Abstract

Pekmez is a rich food product that contains many nutrients necessary particularly for children. Sugar, a part of cookie formulation, is known to affect physical, chemical and sensory properties of food products, as well as, giving a sweet taste. In this study, use of powdered form of pekmez instead of sugar in cookies was investigated. Liquid grape pekmez and maltodextrin as a carrier (40-60% v/w) were spray-dried using a spray-dryer unit. The obtained pekmez powder (PP) was used as a replacement of sugar at different ratios (0, 25, 50, 75 and 100%) for the production of cookies. In this respect, physical, chemical, sensory properties and total mineral content of cookies were determined. The results revealed that use of PP increased ash content of the cookies. PP addition decreased spread ratios, but increased hardness values, resulting in darker cookies in colour along with lower brightness. Optimum combinations in terms of sensory properties was 50% sugar plus 50% PP. PP addition increased potassium, magnesium, calcium, iron and zinc contents of the cookies. In conclusion, cookies which are consumed particularly by children were satisfactorily improved in terms of nutritional properties by replacement of sugar with PP.

Keywords: cookie, grape, nutrition, pekmez powder, spray dry

1. Introduction

Cookies hold an important position among the bakery products and in snack foods due to variety in taste, crispiness, digestibility and longer shelf life. These are popular among all age groups especially in children (Hussain *et al.*, 2006; Jayasena and Nasar-Abbas, 2011). Most bakery products can easily be enriched and fortified (Indrani *et al.*, 2007; Shewry *et al.*, 2012). A large quantity and variety of materials is industrially produced in powder form (Fitzpatrick *et al.*, 2004, 2007). In recent years, additives have been commonly used in the baking industry. Especially a number of artificial sweeteners, which are sweeter than sucrose and nontoxic, have been recently developed and used as a replacement of sugar. In development of sugar-free formulations, an alternative sweetener and a bulking agent are employed (Savitha *et al.*, 2008).

Pekmez, which dates back a hundred of years ago in Turkey, is one of the most popular traditional Turkish foods (Tosun and Ustun, 2003; Yoğurtçu and Kamışlı, 2006). The most common pekmez products are produced from mulberry and grape , almost in all regions of Turkey. These are obtained by concentration of juice up to 70-80% soluble dry matter content (Sengül *et al.*, 2005). Its shelf-life is extended by boiling without the additional of sugar or other food additives in open vessels or under vacuum to decrease the water content (Arslan *et al.*, 2005; Kaya and Belibağlı, 2002; Sengül *et al.*, 2005; Tosun and Ustun, 2003). Varieties of fruits and techniques used in pekmez production are different (Aksu and Nas, 1996; Kaya *et al.*, 2011; Sengül *et al.*, 2005; Yoğurtçu and Kamışlı, 2006). Apricot, apple, prune, watermelon, fig, carob, sugar beet and persimmon can also be used in pekmez production (Aksu and Nas, 1996; Demirözü *et al.*, 2002; Erdoğrul, 2008; İnan *et al.*, 2011; Karababa and Isikli, 2005; Şimşek *et al.*, 2004; Sengül *et al.*, 2005). It is a healthy and natural product. Pekmez

is generally consumed at breakfast as a jam or marmalade (Alpaslan and Hayta, 2002).

Pekmez which contains high amount of sugar and the sufficient amount of mineral, vitamin and organic acid is very important in human nutrition especially for babies, children, and sportsmen and in situations demanding urgent energy (Erdoğrul, 2008; Sengül *et al*., 2005; Tosun and Ustun, 2003). The product is a good and natural source of energy due to its high sugar content ranging between 50-80% (Kayışoğlu and Demirci, 2006). Pekmez easily passes into the blood without digestion because most of its carbohydrate is in the form of monosaccharide like glucose and fructose (Erdoğrul, 2008; Sengül *et al.*, 2005). Pekmez has an important function in working of the brain, which uses glucose as a main energy source (Tosun and Ustun, 2003). Pekmez also, contains valuable minerals such as in iron, phosphorus, calcium and potassium (Karababa and Isikli, 2005; Karakaya and Kavas, 1999; Tosun and Ustun, 2003; Yoğurtçu and Kamışlı, 2006).

Pekmez is a liquid product, therefore prolonged storage causes problems related with some quality characteristics. Hydroxymethyl furfural (HMF) development is one of the most important problems occurring during its storage. Storage of pekmez in a dried form may be one of the most useful ways to inhibit or delay excessive Maillard browning, consequently decreasing HMF development during the storage period. Another purpose of drying is to extend the shelf-life by reducing water content (Yılmaz *et al*., 2009).

Pekmez, which is one of the widely consumed Turkish traditional foods, has considerable nutritional properties with respect to sugar. In this study, pekmez, a natural source of sugar, was used as a replacement of sugar in the production of cookies. For this purpose, grape pekmez was produced in a granulated form and the production process was carried out in a spray-dryer unit using a mixture of the granulated form of grape pekmez and maltodextrin as a carrier (40-60% v/w). Then, the obtained pekmez powder (PP) was used as a replacement of sugar at different ratios (0, 25, 50, 75 and 100%) in the production of cookies. The purpose of the present study, was (1) to produce cookies with spray dried pekmez powder as a replacement of sugar; and (2) to determine physical, chemical, nutritional and sensory properties of these cookies

2. Materials and methods

Materials

Wheat flour, sodium bicarbonate and ammonium bicarbonate were obtained from Saray Biscuit and Food Industry A.Ş. (Karaman, Turkey). All-purpose shortening, skimmed milk powder, salt, sugar and grape pekmez were procured from a local market in Konya, Turkey. High-fructose corn syrup (HFCS-F55) and maltodextrin (Dry MD-01915) were purchased from Cargill (İstanbul, Turkey). The samples were kept at +4 °C till the analysis.

Pekmez powder production

Grape pekmez and maltodextrin (as a carrier) (40-60% v/w) was spray dried using a Niro Atomizer laboratory type pilot drying unit in Enka Dairy and Food Products Co., Konya, Turkey. The procedure took 60 min with an inlet air temperature of 200 °C and an outlet air temperature not exceeding 70 °C. Particles size was in the range of 5-25 μm.

Production of cookies

AACC standard no. 10-54 method was used for cookie preparation (AACC, 2000). Following recipe was used for the preparation of cookies in Table 1. PP was used as a replacement of sugar at different ratios (0, 25, 50, 75 and 100%) for the production of cookies. All ingredients used were kept at room temperature. Cookie dough was mixed in a Hobart mixer (Hobart N50; Canada Inc., North York, ON, Canada). The dough was sheeted to a thickness of 5 mm and cut into round shapes using a 55 mm diameter dough cutter. The dough was transferred to aluminium trays and placed in a baking oven (Arçelik ARMD-580; İstanbul, Turkey). These were baked at 205 °C for 11 min. Afterwards the cookie samples were allowed to cool at room temperature (22 °C) and these samples were packaged in polyethylene bags, until used.

Analytical methods

Total dry matter and pH values of the grape pekmez samples were determined as outlined (AOAC, 1984). The pH was measured with a pH meter (pH 315 i/SET; WTW, Weilheim, Germany). Total sugar contents were analysed by the Lane-Eynon method (Cemeroğlu, 1992). The Kjeldahl method (method 46-12) was used to determine crude protein content of wheat flour sample and a conversion factor 5.70 was used (AACC, 2000). The AACC International methods

Table 1. Formulation of control cookie with no pekmez powder.

Ingredients	Weight (g)
Wheat flour	100.0
Sugar	42.0
All-purpose shortening	40.0
High-fructose corn syrup	1.5
Salt	1.25
Skimmed milk powder	1.0
Sodium bicarbonate	1.0
Ammonium bicarbonate	0.5
Deionised water	variable (13-17 ml)

were used for the determination of moisture (method 44-19) and crude ash (method 08-01) contents of the wheat flour and cookie samples (AACC, 2000). Water activity was measured with an Aqualab apparatus (model series 3TE; Decagon Devices Inc., Pullman, WA, USA). Pure water (1.000±0.003%) was used as standard for equipment calibration (Certel *et al*., 2009).

Analysis of cookies

A digital micrometer (0.001 mm; Mitutoyo, Minoto-Ku, Tokyo, Japan) was used to measure the dimensions (diameter and thickness) of the cookie samples. The spread ratio was found using the following formula:

spread ratio = diameter (D) / thickness (T)

The hardness of cookie samples after baking was measured in Newtons by a texture analyser using the procedure of Aydın and Öğüt (1991).

Colour measurements were performed using a Minolta Chroma Meter CR-400 (Minolta, Osaka, Japan). The L*, a* and b* values were determined according to the CIELab colour space system, where L* corresponds to light/dark chromaticity (changing from 0% dark to 100% light), a* to green/red chromaticity (changing from -60% green to 60% red) and b* to blue/yellow chromaticity (changing from -60% blue to 60% yellow). The instrument was calibrated with a white reference tile (L*=97.10, a*=-4.88, b*=7.04) before the measurements (Francis, 1998).

The mineral contents (potassium, magnesium, calcium, iron and zinc; K, Mg, Ca, Fe and Zn) of the cookie samples were determined using inductively coupled plasma atomic emission spectrometry (ICP-AES) (Vista series; Varian International AG, Cham, Switzerland) with an automatic sampler system. Approximately 0.5 g of sample was put into a burning cup, and 5 ml of HNO_3 + 5 ml H_2SO_4 was added. The samples were incinerated in a microwave oven (Mars 5; CEM Corporation, Matthews, MC, USA). The solution was diluted to 100 ml with water. Concentrations were determined by ICP-AES (Bubert and Hagenah, 1987).

Sensory evaluation of cookies

Cookie samples were evaluated by twelve panellists, who were familiar with the characteristics of cookies. Ages ranged from 23 to 42. Seven of them were females. All panellists were non-smokers. Instructions were previously given in full to panellists. The samples were brought to room temperature before testing. The samples were coded with letters and the order of sample presentation was completely randomised for serving to the panellists to guard against any bias. The panellists cleansed their palates with water before rating each sample. The panellists were asked to score the cookie samples in terms of taste, colour, odour, appearance and overall acceptability using a 5-point scale where 1 represented 'dislike extremely', 3 represented 'acceptable' and 5 represented 'like extremely' in a particular attribute.

Statistical analysis

A commercial software program (Tarist, version 4.0; Ege University, Izmir, Turkey) was used to perform statistical analyses. Data were assessed by analysis of variance. Means that were statistically different from each other were compared using Duncan's multiple range tests at 5% confidence interval. Standard deviations were calculated using the same software.

3. Results and discussion

Analytical results

The investigated characteristics of liquid grape pekmez were: total dry matter 76.19%, total sugar 70.27 g/100 g and pH 5.13. Besides, the approximate composition of wheat flour used in this study was 9.78% protein, 0.672% ash and 11.52% moisture.

Chemical properties of cookies

Some chemical properties of cookie samples were given in Table 2. Moisture, ash and water activity values of the cookie samples ranged between 4.04-4.78, 1.34-1.74 and 0.305-0.308, respectively. According to Table 2, there were no statistically significant changes in water activity, while moisture and ash values significantly changed when sugar was replaced by PP. The moisture content of control group produced with only sugar (100% S) were lower than that of the other cookie samples, and moisture content increased with PP addition. The cookies containing 100% PP had an average moisture content as 4.78±0.11%. Ash values

Table 2. Effect of replacement of sugar with pekmez powder on the chemical characteristics of cookies (mean values ± standard deviation)[1].

Samples[2]	Moisture (%)	Ash (%)	Aw
Control (100% S)	4.04±0.04^{b}	1.34±0.01^{e}	0.305±0.01^{a}
75% S : 25% PP	4.71±0.23^{a}	1.46±0.01^{d}	0.305±0.01^{a}
50% S : 50% PP	4.74±0.14^{a}	1.55±0.01^{c}	0.306±0.01^{a}
25% S : 75% PP	4.73±0.10^{a}	1.67±0.01^{b}	0.307±0.01^{a}
100% PP	4.78±0.11^{a}	1.74±0.01^{a}	0.308±0.01^{a}

[1] Means with the same letter in a column are not significantly different (P>0.05).
[2] PP = pekmez powder; S = sugar.
Aw = water activity.

also increased with PP addition. The highest ash values were determined in the cookies added with 100% PP. However control group had the lowest ash content. Thus, the replacement of sugar with PP and the increase in the ratios of PP in formulation (from 25% to 100%) raised the ash content of the cookies. This was an expected result, because pekmez is a very nutrient rich product. Karababa and Isikli (2005) reported that grape pekmez contained 3.72% ash. Another study reported that, ash contents ranged between 3.57 and 3.83% (Şimşek *et al*., 2004).

Physical properties of cookies

Physical characteristics; namely, diameter, thickness, spread ratio, hardness and colour (L*, a* and b*) of the cookies are given in Table 3. Spread ratio is the ratio of cookie diameter to cookie thickness and spreading of the cookie during baking is generally desired. Cookies which were made from soft wheat spread more than those made from hard and strong wheat (Doğan and Uğur, 2005). According to Table 3, diameter values decreased while thickness values increased when sugar was replaced by PP, and this led to a reduction in spread ratio of the cookies. The highest spread ratio values were obtained for the cookies of the control group (7.78±0.16) and spread ratios decreased with the rise in PP ratio. There were no significant differences between the control group and 75% S : 25% PP. These results show that replacement of sugar with PP influenced the characteristics of cookie dough and caused more compact cookies. Thus, the use of PP as replacement of sugar has more advantages particularly in the production of cookies from soft wheat (weak gluten) in order to improve texture of cookies and the cookies which are desired to spread lower.

As shown in Table 3, the hardness values of cookies increased by the replacement of sugar with PP. The cookies containing the highest PP concentration (100% PP) had the hardness values above the values of other treatments, and this was followed by the combinations 25% S : 75% PP (80.56±1.11 N), 50% S : 50% PP (76.54±0.97 N), 75% S : 25% PP (72.72±1.94 N). The lowest hardness values were determined for cookies made with 100% S. According to these results, the use of PP led to more compact cookie dough and cookies with harder characteristics. Ajila *et al.* (2007) reported that mango peel powder increased hardness of cookies.

Colour values of cookies are presented in Table 3. Brightness (L*) values of cookies declined and redness (a*) and yellowness (b*) values raised after the replacement of sugar with PP. The increase in sugar ratio directly resulted in cookies with higher L* values, so that the lowest L* were measured for the cookies made up with 100% PP. The samples in control group had the lowest a* and b* values, while the combinations 75% S : 25% PP, 50% S : 50% PP, and 25% S : 75% PP followed the control group, respectively. As expected, the cookies containing 100% PP had the highest a* and b* values. Because liquid grape pekmez has a very dark red colour, in fact Maillard reaction reduces its brightness, so redness and yellowness values increase (Tosun and Ustun, 2003). Therefore, the replacement of sugar with PP and increasing the ratios of this replacement gave rise to production of cookies which are darker in colour.

Sensory properties of cookies

Sensory properties of cookies made with different ratios of sugar/PP combinations are presented in Table 4 and Figure 1. Panellists were asked to evaluate taste, colour, odour, appearance and overall acceptability during sensory analysis. It can be seen in Table 4, that use of different ratios of sugar/PP combinations significantly affected all of the sensory scores ($P<0.05$). According to the results, the cookies containing 50% S : 50% PP combination had the highest scores for overall acceptability. Besides, the samples of control group and cookies produced with 75% S : 25% PP combination got also high scores, whereas the samples

Table 3. Effect of replacement of sugar with pekmez powder on the physical characteristics of cookies (mean values ± standard deviation)[1].

Samples[2]	Diameter (D) (mm)	Thickness (T) (mm)	Spread ratio (D/T)	Hardness (N)	Colour values		
					L*	a*	b*
Control (100% S)	75.55±0.31^{a}	9.72±0.22^{b}	7.78±0.16^{a}	63.70±1.39^{d}	76.43±0.71^{a}	0.29±0.07^{e}	27.09±0.31^{e}
75% S : 25% PP	73.93±0.49^{b}	9.96±0.36^{ab}	7.44±0.32^{ab}	72.72±1.94^{c}	73.83±1.42^{b}	2.04±0.55^{d}	28.30±0.22^{d}
50% S : 50% PP	73.36±0.48^{b}	10.07±0.24^{ab}	7.29±0.21^{bc}	76.54±0.97^{bc}	70.38±1.51^{c}	3.72±0.28^{c}	29.21±0.58^{c}
25% S : 75% PP	73.27±0.53^{b}	10.33±0.21^{a}	7.10±0.14^{bc}	80.56±1.11^{ab}	67.66±0.57^{d}	4.64±0.13^{b}	30.53±0.13^{b}
100% PP	73.10±0.39^{b}	10.41±0.21^{a}	7.03±0.18^{c}	83.30±1.66^{a}	65.38±0.53^{e}	5.49±0.10^{a}	31.33±0.15^{a}

[1] Means with the same letter in a column are not significantly different ($P>0.05$).

[2] PP = pekmez powder; S = sugar.

a* = green (negative values)/red (positive values); b* = blue (negative values)/yellow (positive values); L* = light/dark.

Table 4. Effect of replacement of sugar with pekmez powder on the sensory properties of cookies (mean values ± standard deviation)[1].

Samples[2]	Taste	Colour	Odour	Appearance	Overall Acceptability
Control (100% S)	4.1±0.14^{ab}	3.8±0.50^{ab}	4.2±0.19^{b}	4.2±0.24^{ab}	4.1±0.25^{ab}
75% S : 25% PP	4.3±0.50^{ab}	4.1±0.47^{ab}	4.3±0.39^{ab}	4.5±0.16^{a}	4.3±0.22^{ab}
50% S : 50% PP	4.7±0.13^{a}	4.5±0.21^{a}	4.5±0.33^{ab}	4.6±0.17^{a}	4.6±0.26^{a}
25% S : 75% PP	4.1±0.08^{b}	4.0±0.15^{ab}	4.6±0.22^{ab}	3.9±0.15^{b}	4.0±0.10^{b}
100% PP	3.9±0.30^{b}	3.6±0.48^{b}	4.7±0.22^{a}	3.8±0.24^{b}	3.5±0.13^{c}

[1] Means with the same letter in a column are not significantly different (P>0.05).
[2] PP = pekmez powder; S = sugar.

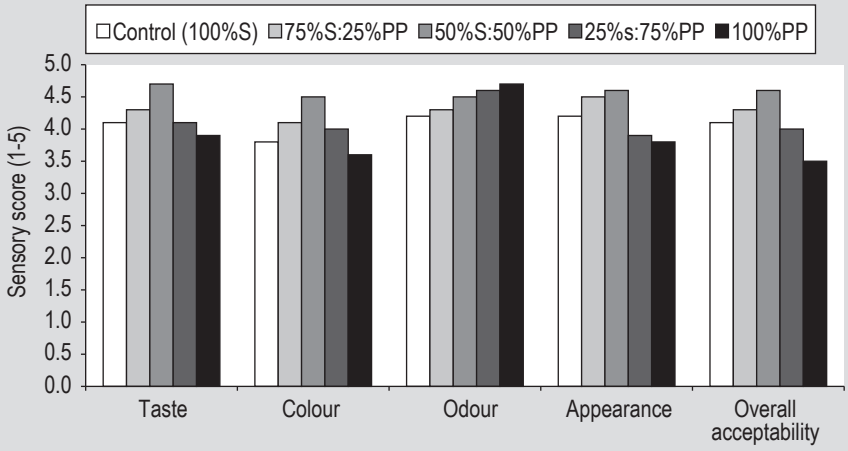

Figure 1. Sensory properties of cookie samples containing pekmez powder. PP = pekmez powder; S = sugar.

containing PP ratios more than 50% had lower scores. Taste and appearance were the most effective parameters on this result. The cookies prepared with combinations of PP above 50% had lower overall acceptability scores than those of cookies made with 100% S. In conclusion, the most preferred cookies in terms of sensory properties were the ones containing half-and-half sugar and pekmez.

Total mineral content of cookies

There were significant changes in total mineral contents (TMC) of cookies containing different ratios of sugar/PP combinations (Table 5). The replacement of sugar with PP and increasing the ratios of this replacement raised TMC of the cookies. Cookies containing 100% S had the lowest values of K, Mg, Ca and Fe minerals. These were followed

Table 5. Effect of replacement of sugar with pekmez powder on the total mineral content (mg/100 g) of cookies (mean values ± standard deviation)[1].

Samples[2]	Potassium	Magnesium	Calcium	Iron	Zinc
Control (100% S)	132.38±2.56^{e}	17.42±0.07^{e}	44.29±0.57^{e}	1.84±0.01^{d}	0.75±0.03^{b}
75% S : 25% PP	153.21±3.56^{d}	17.81±0.10^{d}	48.82±0.98^{d}	1.88±0.01^{cd}	0.76±0.03^{b}
50% S : 50% PP	176.49±3.87^{c}	18.48±0.11^{c}	53.30±0.88^{c}	1.93±0.01^{c}	0.78±0.04^{ab}
25% S : 75% PP	197.12±3.35^{b}	19.13±0.13^{b}	58.81±0.59^{b}	2.06±0.01^{b}	0.81±0.01^{ab}
100% PP	219.32±3.27^{a}	19.75±0.08^{a}	62.03±0.64^{a}	2.14±0.03^{a}	0.86±0.03^{a}

[1] Means with the same letter in a column are not significantly different (P>0.05).
[2] PP = pekmez powder; S = sugar.

by 75% S : 25% PP and 50% S : 50% PP combinations. The cookies prepared with 100% PP contained the highest ratios of K, Mg, Ca, Fe and Zn minerals. According to the control, K, Mg, Ca, Fe and Zn contents (mg/100 g) increased from 132.38±2.56, 17.42±0.07, 44.29±0.57, 1.84±0.01 and 0.75±0.03 to 219.32±3.27, 19.75±0.08, 62.03±0.64, 2.14±0.03 and 0.86±0.03 in cookie sample containing 100% PP, respectively. This was an expected result. It was reported by many studies that pekmez is a very rich source of major and minor minerals. (Demirözü *et al*., 2002; Karababa and Isikli, 2005; Kayışoğlu and Demirci, 2006). Thus, the use of PP instead of sugar which has a high content of minerals led to an increase in TMC content of the final product.

4. Conclusions

In this study, the use of powdered form of pekmez as a replacement of sugar in cookies was investigated. According to the results, replacement by 50% was found to be acceptable in terms of sensory properties and contributes to the nutritional value of cookies due to the increase in total mineral content. Also,there were changes in physical properties of the cookies. As a conclusion, it is advisable to replace sugar with pekmez powder in products such as biscuits and cookies which are very well accepted by most children.

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