PRODUCTION OF LIQUID AND WHITE SOLID PEKMEZ IN TURKEY

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ABSTRACT

The research was carried out to evaluate gelling and bleaching agents for white solid pekmez production. Grape juice with 26% total soluble solids as °Brix was used for the production of pekmez. Acidity was reduced with the application of sterile white soil containing 70.4% CaCO₃, followed by tannin–gelatin clarification and filtration. The grape juice was concentrated to 76% total soluble solids by vacuum. Gelling treatments were designed to produce a solid pekmez by adding high or low methoxyl pectins or carboxymethylcellulose (CMC). It was found that sufficient gelling could be achieved using less than 0.5% CMC and 1% for either pectin. Also, a desirable white color was obtained with 1.5% soapwort juice and 3% egg white with the combination of 1% pectins.

INTRODUCTION

Pekmez, produced for a long time in Turkey, is one of the most common names of a concentrated and a shelf-life extended form of grape juice produced by boiling without the addition of sugar or other food additives (Gokcen et al. 1982). Therefore, it can be assumed to be a natural food containing natural sugars such as glucose, fructose and minerals (Kaya and Belibagli 2002). Pekmez is produced from the juices of fruits such as grape, watermelon, apricot, prune, mulberry and sugar beet, all of which contain sugar. However, the grape is the most common fruit used in processing pekmez in Turkey. It is produced by concentrating juice up to 70–80% total soluble solids (TSS)
content (Batu 1991). *Pekmez* is consumed mainly at breakfast, particularly in winter, sometimes by blending with *tahin* (sesame paste) instead of jam or honey. *Tahin* is made from ground, hulled, dry roasted sesame seeds and is a popular food in Turkey (Alpaslan and Hayta 2002).

Earlier, approximately 37% of the grapes in Turkey were used for the production of *pekmez*, but it has been estimated to be only around 18% within the last decade (Batu and Aktan 1992). Figure 1 is a flow diagram of a typical *pekmez* processing operation (Batu and Yurdagel 1993). The first step in *pekmez* production is washing and crushing of the grapes. Juice is extracted using a pneumatic or mechanical press (Batu 1990; Kaya and Belibagli 2002). The grape juice is then boiled with a calcareous substance called *pekmez* soil containing sterile white soil which has high amounts of CaCO₃. *Pekmez* soil lowers the acidity caused by naturally existing tartaric and malic acids by precipitating them as calcium tartarate and calcium malate (Batu 1990; Kaya et al. 2003). Acidity is reduced with the application of *pekmez* soil, or CaCO₃ only, and then sedimentation is allowed to occur. When the acid has been decreased, the clarified grape juice is concentrated to the desired TSS (i.e., about 68–80%) under atmospheric conditions or through vacuum method. The product is called liquid *pekmez*. Traditionally, white solid *pekmez* has been produced by adding some gelling and bleaching agents to the liquid *pekmez*. Egg white, soapwort juice or powdered sugar are used as bleaching agents, and pectins, carboxymethylcellulose (CMC) or a form of white solid *pekmez* can be used as gelling agents. The concentrated grape juice is stirred and beaten to incorporate air into the solid *pekmez* throughout mixing. During this process, the penetration of air along with the bleaching agents causes the production of a white or cream-colored *pekmez* (Batu 1990; Tosun and Ustun 2002). The final product, called white solid *pekmez*, is hard in texture and has a pasty structure which can be easily spread on a slice of bread. The color depends on the process but is usually white.

*Pekmez* contains approximately 293 kcal/100 g of energy and is also an important source of organic acids and mineral materials. It also contains 100 mg/kg iron and 4000 mg/kg calcium. Grape juice and *pekmez* contain high amounts of glucose and fructose in almost equal quantities; no sucrose and very small amounts of proteins are present (Artık and Velioğlu 1993). Because most of *pekmez*’ carbohydrates are in the form of glucose and fructose, it easily passes into the blood without digestion. This is of nutritional importance, especially for babies, children, sportsmen and in situations demanding immediate energy (Batu 1993; Tosun and Ustun 2002).

The purpose of this study was to develop a valuable white solid *pekmez* using lumped, unmarketable raisins and to determine the optimum amounts of bleaching and gelling agents needed to produce white or a cream-colored pasty *pekmez*.
Lumped raisin

Washing and humidification

Mining

Extraction

Preseparation

Deacidification or neutralization by white soil containing 70.40% CaCO₃ or technical CaCO₃

Sedimentation and second separation

Clarification

Filtration

Vacuum concentration (at 565 mmHg and 66°C)

Liquid pekmez

Gelling (with pectins, carboxymethylcellulose) and Bleaching (with egg white, soapwort juice)

Solidification (at +6°C for 2–3 days)

Solid pekmez

Packaging

Storage or marketing

FIG. 1. PRODUCTION OF SOLID PEKMEZ FROM LUMPED RAISIN
MATERIALS AND METHODS

Preparation of Liquid Pekmez

Raisins (Vitis vinifera L. var. Sultana), which when lumped reduce their market value, were obtained from an export company in İzmir, Turkey. Grape juice was produced by mining the lumped raisins and extracting the sugar from the mined raisins using a reverse osmosis method. Extraction was done by mixing 10 kg of mined raisins with 30 L hot water at 70°C. Cloudy grape juice (pH 4.25 and 6.15 g/kg total acidity) was obtained. Acidity was reduced (pH 5.45 and 2.50 g/kg total acidity) with the application of sterile white soil containing 70.4% CaCO₃. Sedimentation was accomplished by applying a tannen-gelatin mixture. After filtration, a clarified grape juice containing 26% TSS as °Brix was obtained, followed by concentration from 26 to 76% TSS (pH 4.90 and 6.76 g/kg total acidity) by using vacuum method at 66–68°C.

Bleaching and Gelling

Soapwort juice (obtained from TARİŞ Alsancak, İzmir) and egg white were used as bleaching agents. High methoxyl pectin (HMP), low methoxyl pectin (LMP) (both obtained from Genu-Pectin, CP Kelco Ved Kelco Ved Banen, Lille Skensued, Denmark) and CMC (obtained from Noviant, Arnhem, The Netherlands) were used to produce gelling. Bleaching treatments were conducted until the 1% HMP added produced a pekmez having a constant cream-white color. This color was obtained by adding different amounts (0.5, 1.0, 1.5 and 2.0% of soapworth and 1, 2, 3 and 4% egg white) of bleaching and clarification agents. Gelling treatments were continued until the pekmez had a constant pasty texture. This texture was achieved by adding different amounts of gelling agents. Both gelling and bleaching agents were added at the same time during the chopping and mixing of the pekmez. Pectins and CMC were added at 0.5, 1.0, 1.5 and 2.0% (w/w) of the product. A complete dispersion of both pectins and CMC into the liquid pekmez was obtained during the chopping and mixing operations. Both bleaching and gelling treatments were done in a small-scale laboratory mixer (Sozer Machine, Imes Industrial Group, İstanbul, Turkey) at 1600 rotations/min. After the gelling treatment was completed, slightly hard or pasty pekmez was produced and then stored at 6°C for 2–3 days to make it pastier and obtain a white solid pekmez.

Physiological and Chemical Analyses

Color measurements of pekmez samples were carried out using a Hunter Laboratory color difference meter (Hunter Associates Laboratory Inc., Fairfax, VA) model D-25D2. Prior to measurement, the spectrocolorimeter was cali-
brated with a white reference tile (L: 94.9, a: -1.1, b: 1.9) (Hunter 1973). Texture analysis was done by using a bench top SUR BERLIN penetrometer (model PNR 6, Sommer Q Runge kg 01000, Bennigsenstr 23 Germany), with a 35 g probe. Penetration depth within 3 s was recorded (Gonul et al. 1988).

**Analytical Methods**

Total acidity and pH were determined according to the AOAC (1984). TSS content of the samples were determined at 20°C using a bench top PRI model ATAGO digital refractometer (ATAGO CO., LTD., Tokyo, Japan).

**Statistics**

All determinations were made in triplicate. The data were the mean of the three independent determinations and were statistically evaluated by analysis of variance. The means were compared to the least significant differences between treatments with a significance level of 0.05. The Minitab statistical package (Eagen University, Izmir, Turkey) was used for data analysis by the general linear model (Steeal and Torrie 1987).

**RESULTS AND DISCUSSION**

**Bleaching Treatment**

First, bleaching time was determined using 1% of HMP with the addition of either 4% egg white or 2% soapwort juice in the liquid pekmez at 76% TSS. During this period, to obtain the right bleaching time by reaching a constant sufficient white color, the reactants were mixed at 20 ± 2°C. Mixing treatments were carried out for 75 min and every 15 min. Samples were taken and their Hunter L-values (lightness) were measured (Table 1). A desired bleaching was not achieved during the first 15 min. Although there was sufficient bleaching after 30 min, an attractive, good, white color was formed approximately after 40 min of mixing. There was no significant difference in Hunter L-values of pekmez bleached with egg white or soapwort juice after 45 min of mixing. Gelling and bleaching treatments were conducted until the pekmez had a constant cream-white color by adding different amounts of egg white or soapwort juice. It was decided that 45 min of bleaching treatment was sufficient to get a homogenized cream-white color.

Second, bleaching treatments were done to determine sufficient amounts of bleaching agent at 1, 2, 3 and 4% of egg white or 0.5, 1, 1.5 and 2% of soapwort juice. Hunter L-values of pekmez obtained from either egg white or soapwort juice are given in Fig. 2. Significant differences were found between
treatments. Hunter L-values slightly increased with the increase in bleaching agents. A significant increase was found between Pekmez clarified with 0.5–2% soapwort juice in combination with CMC and LMP. In a CMC and soapwort juice combination, a required bleaching level was not reached and the color was not white enough. A dark cream hue was observed even though 2% of CMC was used as the gelling agent. When both HMP and LMP were

TABLE 1. CHANGES IN HUNTER L-VALUES OF SOLID WHITE PEKMEZ (BLEACHED WITH EGG WHITE AND SOAPWORT JUICE + 1% HMP) DURING BLEACHING TIME

<table>
<thead>
<tr>
<th>Bleaching agents</th>
<th>Bleaching time (min)</th>
<th>Hunter L-values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Egg white (4%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>64.24a</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>72.81b</td>
<td></td>
</tr>
<tr>
<td>30</td>
<td>78.73c</td>
<td></td>
</tr>
<tr>
<td>45</td>
<td>79.52d</td>
<td></td>
</tr>
<tr>
<td>60</td>
<td>79.75d</td>
<td></td>
</tr>
<tr>
<td>75</td>
<td>80.81d</td>
<td></td>
</tr>
<tr>
<td>Soapwort juice (2%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>63.45a</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>68.41b</td>
<td></td>
</tr>
<tr>
<td>30</td>
<td>74.60c</td>
<td></td>
</tr>
<tr>
<td>45</td>
<td>79.53d</td>
<td></td>
</tr>
<tr>
<td>60</td>
<td>80.62d</td>
<td></td>
</tr>
<tr>
<td>75</td>
<td>81.41d</td>
<td></td>
</tr>
</tbody>
</table>

P < 0.01 level.
Significant differences between the treatments at the level of P = 0.05.

FIG. 2. CHANGES IN HUNTER L-VALUES OF SOLID PEKMEZ PRODUCED BY ADDING 0.5% CMC, 1% HMP, 1% LMP AND DIFFERENT AMOUNTS OF BLEACHING AGENTS
used together with 1.5% of soapwort, the desired white color was obtained but there was no significant difference when more than 1.5% was used. A maximum of 1.5% of soapwort juice was adequate to produce the desired white color of solid *pekmez* with the combination of 1% pectins. However, it was impossible to reach a desirable white color even after 2% of soapwort juice was used in combination with CMC.

A desired white color value was not achieved even after using 4% of egg white in combination with CMC. When pectins were used, a desirable white color was achieved when 3% egg white was used. Beyond that amount, the Hunter *L*-values were nonsignificant (Fig. 2). It was observed that CMC had a negative effect on color formation when used with either soapwort juice or egg white for bleaching. Treating the *pekmez* with CMC at a higher temperature might have resulted in a slightly darker color than the *pekmez* gelled with pectins.

Yazıcıoğlu and Gökçen (1984) indicated that dried yogurt, egg white, soapwort, powdered sugar, milk and milk powder have been used for bleaching *pekmez*. But there is little information on the appropriate amounts of those bleaching agents. Only the information about the amount of egg white used is available. It has been used at 5% for years. According to the result of this research, 5% egg white is too high for bleaching *pekmez*. It is not economical to use more than 3% because it renders no additional benefit in the attainment of the desired white color. In addition, it gives an egg taste that was undesirable to consumers (Batu 1990).

**Gelling Treatment**

HMP, LMP and CMC were used for gelling under open-pan conditions. Gelling time and temperature were determined with the pretreatment separately for each gelling agent. Gelling temperatures for CMC, HMP and LMP were found to be 95 ± 3°C, 86 ± 3°C and 90 ± 3°C, respectively. Gelling times were observed to be 25 min for CMC and 10 min for either HMP and LMP. Similar findings have been reported on firmness of *pekmez* (Anon 1984); CMC exhibited maximum viscosity and best stability at pH 7–9 and below pH 4.0. Pectins have a stable viscosity between pH 2.8 and 3.7 (Copur 1988). In this study, the pH values of solid *pekmez* were closed to 4.90. That is why pectins suspended easier in a relatively short time (within 10 min) when compared with CMC (within 25 min) for the same *pekmez*. Penetration depth of solid *pekmez* was found to be 21–24 mm/3 s. *Pekmez* was sufficiently pasty and could be spread easily on a slice of bread. To produce a solid *pekmez*, 0.5, 1.0, 1.5 and 2.0% of gelling agents were added into the liquid *pekmez* in a pan on a heater. Heating and mixing were done simultaneously. During heating gelling agents were blended continuously. Gelling and bleaching treatments
like adding different amounts of egg white or soapwort juice were conducted until the *pekmez* obtained a constant cream-white color.

It can be seen in Fig. 3 that 0.5% of CMC gives a desirable texture (23.95 mm/3 s), that is, easily spreadable on a slice of bread. *Pekmez* cannot easily be spread on a slice of bread when CMC was used over 0.5%. The effects of HMP and LMP on gelling of *pekmez* were investigated and were found that approximately 1% of either HMP or LMP gave a good spreadable texture on a slice of bread (as 23.40 and 22.10 mm/3 s, respectively). When pectins were lower than 1%, *pekmez* had a slightly liquid consistency and did not spread properly. When they were used at more than 1%, the texture was too hard. Therefore, sufficient amounts of those three gelling agents were found to be 0.5% for CMC and 1% for both HMP and LMP. Although there was no significant difference on gelling formation between HMP and LMP, 0.5% of LMP gave a slightly more liquid consistency. This may be caused by the methylation level of LMP because gels containing pectin with low percent of methylation give lower hardness in the texture of *pekmez* (Batu 1990; Arslan 1994).

**Storage Treatment**

Storage treatments were conducted by using solid *pekmez* samples of 0.5% CMC and 1% both HMP and LMP but for bleaching only 3% of egg...
white was used. Then the samples were kept at 6C for 40 days. During this storage period, every 10 days one sample was taken from each treatment to measure the changes in Hunter $L$-values and texture (Table 2). Either Hunter $L$- or penetration depth values decreased significantly with increasing storage time. Hunter $L$-values of pekmez with CMC were darker than those produced with either pectin but the one solidified with LM P was found to be the whitest one. The decrease in Hunter $L$-value could be caused by either increasing nonenzymic browning or hydroxymethylfurfural formation (Bozkurt et al. 1999; Tosun and Ustun 2002).

Penetration depth values decreased, meaning that the solid pekmez developed a harder texture during storage. The decrease in penetration depth was higher in pekmez samples gelled with CMC than those gelled with LMP. In this research, no external Ca was added into the pekmez. That is why pekmez samples gelled with LMP were slightly softer than the other treatments. In order to make harder pekmez with LMP, the addition of water soluble calcium salts is required (Anon 1984; Batu and Serim 1991).

**CONCLUSION**

In order to produce a white solid pekmez, treat it with 1% of either LMP or HMP, or with 0.5% of CMC to achieve a pasty pekmez that can be spread on

**TABLE 2. CHANGES IN PENETRATION DEPTH AND HUNTER $L$-VALUES OF WHITE SOLID PEKMEZ GELLED WITH CMC (0.5%) AND BOTH HMP AND LMP (1%) DURING 40 DAYS OF STORAGE**

<table>
<thead>
<tr>
<th>Storage period (day)</th>
<th>Gelling agents</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CMC</td>
</tr>
<tr>
<td>Penetration depth (mm/3 s)</td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>24.82a</td>
</tr>
<tr>
<td>10</td>
<td>23.48b</td>
</tr>
<tr>
<td>20</td>
<td>22.98b</td>
</tr>
<tr>
<td>30</td>
<td>22.22c</td>
</tr>
<tr>
<td>40</td>
<td>22.12c</td>
</tr>
<tr>
<td>Hunter $L$-values</td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>76.50a</td>
</tr>
<tr>
<td>10</td>
<td>75.16b</td>
</tr>
<tr>
<td>20</td>
<td>71.33c</td>
</tr>
<tr>
<td>30</td>
<td>70.43d</td>
</tr>
<tr>
<td>40</td>
<td>69.50e</td>
</tr>
</tbody>
</table>

CMC, carboxymethylcellulose; HMP, high methoxyl pectin; LMP, low methoxyl pectin. Significant differences between the treatments at the level of $P \leq 0.05$. 
a slice of bread. The color of pekmez with CMC and soapwort juice combination produces a darker tone than the CMC and egg white combination. It was observed that there is no significant difference in color of pekmez produced with either HMP or LMP as gelling agents and bleached with both soapwort juice and egg white. The optimum ratio of soapwort juice is 2 and 1.5% when used with CMC or both pectins, respectively. The optimum egg white ratios are 2 and 3% when used with CMC and pectins.

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