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# Improvement of quality and shelf-life of *Sübye*, a traditional beverage of Turkey

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**Abstract**

*Sübye*, a traditional beverage of Turkey, is produced from melon seeds, sugar, and water. The standard production protocol for *Sübye* beverage includes mixing minced rehydrated melon seed mass with sugar to obtain *Sübye paste* in the ratio of 1:1.125 (w/w), respectively, and mixing 25% of the paste with water. The total moisture, sugar, fat, protein, and ash contents of the standardized beverage were found to be 84.24%, 11.65%, 1.52%, 1.35%, and 0.21%, respectively. A 99% suspension stability of the beverage was achieved after one day of storage by addition of a xanthan gum:guar gum combination (0.04%:0.5% and 0.05%:0.4%). No significant differences (p>0.05) were found between the gum-containing samples and control samples for the Hunter color values and for the sensory characteristics, such as mouthfeel, taste, and overall acceptability (except for appearance). Nisin:natamycin (2 ppb:30 ppm) was statistically found to be the most effective antimicrobial combination for aerobic mesophilic bacteria after storage for 6 days. Nisin:natamycin (2 ppb:30 ppm) and nisin:potassium sorbate (2 ppb:250 ppm) combinations were found the most effective antimicrobial combinations for mold and yeast count after storage for 3 days and 6 days, respectively.

**Keywords:** shelf life; non-alcoholic beverages; melon seeds; antimicrobial agents; gums.

**Practical Application:** *Sübye* is produced from melon seed, sugar, and water. No standardized method is available for production of this traditional melon seed beverage. In this study, the production protocol of this traditional beverage was standardized and chemical properties were determined. Shelf life of the beverage was extended by improving the quality characteristics using food additives, such as antimicrobial and thickening agents for future industrial-scale production.

## 1 Introduction

*Sübye* is a traditional melon (*Cucumis melo L.*) seed beverage consumed in Izmir and in its surroundings in Turkey. Examples of the beverages all over the world in which melon seed is used as a raw material are *Horchata de melon* from South Africa, *Melon Seed Drink* from South America, and *Pepitada*. *Pepitada,* consumed by Sephardic Jews at the end of the Yom Kippur fast, has similarities with the production technique of *Sübye*. It has been believed that the preparation method of *Sübye* was passed on from Jews living in Izmir and its surroundings (Karakaya et al., 1995; Akubor & Ogbadu, 2003; Kavroulaki, 2017).

The dried melon seeds used as a raw material in the production of *Sübye* are first rehydrated by soaking in water until they attain the moisture levels of the fresh seeds. Then, the rehydrated seeds are minced and mixed with a certain amount of sugar and kneaded into a paste. Finally, this *Sübye* paste is mixed with water and filtered. This filtrate is called *Sübye* beverage.

The composition of whole dried melon seeds was studied by many researchers. The results show that the contents of moisture, oil, protein, carbohydrate, fiber, and ash ranged between 4.90% and 7.78%, 25.00% and 35.36%, 14.91% and 29.90%, 5.85% and 22.94%, 19.00% and 23.30%, and 2.4% and 4.20%, respectively, depending on varieties and origins of the melon (Lazos, 1986; Tekin & Velioglu, 1993; Melo et al., 2000; Mello et al., 2001; Mian-Hao & Yansong, 2007; Yanty et al., 2008). The researchers also found out that the linoleic acid was the principal fatty acid in the melon seeds, followed by oleic, palmitic, and stearic acids, and the seed proteins were rich in arginine, aspartic, and glutamic acids.

There are limited studies on beverages in which melon seed was used as a raw material, and melons from two different genera of the Cucurbitaceae family were generally used as sources of the seeds in these studies. Some researchers have used the seeds from C*itrullus colocynthis* species of melon in genus *Citrullus,* and they determined some quality characteristics of milk-like beverages (Akubor, 1998; Akubor, 2003; Akubor et al., 2002; Akubor & Ogbadu, 2003). Others used the seeds from *Cucumis melo* var. *cantalupensis* (Karakaya et al., 1995; Baghaei et al., 2008; Sabanci et al., 2014). The beverage produced from *Cucumis* genus is generally named '*Cantaloupe Seed Beverage*' or '*Sübye*'. The researchers studied rheological, chemical, sensory, and microbiological properties of these beverages.

*Sübye* has to be stored at refrigeration temperature because of its susceptibility to microbial spoilage and its perishable nature. Under non-refrigerated conditions, in a few hours, both microbial growth and phase separation begins in *Sübye*. This present study consists of two parts. The objective of the first part of this study is to standardize the production technique of this traditional food product, *Sübye,* and to determine the chemical properties

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of this standardized product. The second part of this study aims to increase the shelf life of *Sübye* by improving the quality characteristics using some food additives, such as antimicrobial and thickening agents for future industrial-scale production.

## 2 Materials and methods

### *2.1 Materials*

Melon seeds *(Cucumis melo* L. v. *Inodorus)*, commercial *Sübye* beverage, and *Sübye* paste were obtained from a local supplier in Izmir. The additives used in the study included natamycin (DSM Food Specialties Dairy Ingredients Group, Netherlands), nisin (Beijing Oriental Rada Biotech Co., Ltd., China), potassium sorbate (Kimetsan, Turkey), guar gum and xanthan gum (Jung Busler, China) were of food grade.

### *2.2 Methods*

*Standardization of Sübye beverage production and determination of its composition*

*Sübye* is a beverage produced by kneading mashed melon seeds with sugar to obtain *Sübye* paste, mixing this paste with water, and filtering it. The production steps for *Sübye* beverage with their parameters are shown in Figure 1.

In this study, the *Sübye* beverages containing the paste in a concentration ranging from 20% to 30% were produced and subjected to sensory testing for consumer acceptability in order to standardize the amount of paste in the beverage. These concentrations were based on the dry matter content found in the commercial *Sübye* beverage.

In order to standardize *Sübye* paste production, *Sübye* pastes were prepared at a ratio of paste/sugar ranging between 1/1 and 1/1.5 by taking into account the paste/sugar used in the commercial *Sübye* paste production. *Sübye* beverages were then produced from these pastes at the standardized paste concentration and subjected to sensory testing for consumer acceptability.

***Water content:*** Water content of *Sübye* samples was determined gravimetrically using vacuum drying method applied to confectionery products (Association of Official Analytical Chemists International, 2000).

***Ash content:*** Ash content of *Sübye* samples was determined by ashing them at 550 °C - 600 °C in a muffle furnace (Association of Official Analytical Chemists International, 2000).

***Protein content:*** *Sübye* samples were weighed (10 g) into Kjeldahl tubes, and then dried at 80 °C due to high water content of the beverage. The drying process was continued until about 1 g of dry matter was obtained. Then total crude protein content of the samples was determined (Association of Official Analytical Chemists International, 2000).

***Total and reducing sugar content:*** The total and reducing sugar contents of *Sübye* samples were determined volumetrically according to the Lane Eynon method (Association of Official Analytical Chemists International, 2000).

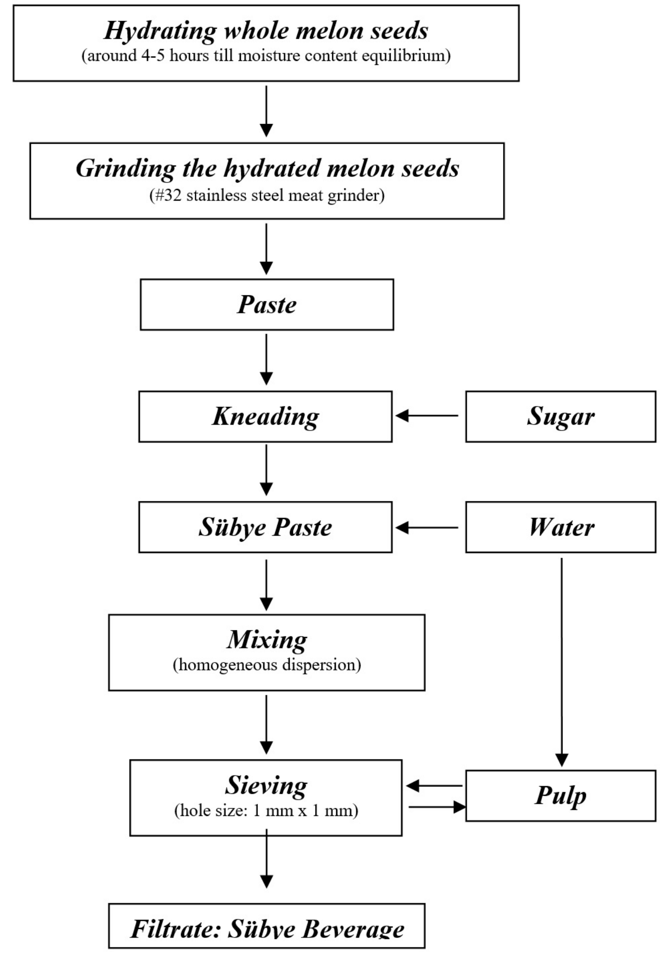


**Figure 1**. The production steps for *Sübye* paste and *Sübye* beverage (observation through the production in the *Sübye* manufacturer).

***Oil content:*** Oil contents of melon seeds and *Sübye* samples were determined gravimetrically using the Soxhlet method (Association of Official Analytical Chemists International, 2000).

*Selection of food additives and their concentrations*

Total aerobic mesophilic bacteria and mould and yeast count were performed using beverages produced from the commercial and the standardized pastes, and some species of bacteria and mould were determined. Taking these results into consideration, shelf-life studies for the *Sübye* beverage were conducted by adding nisin and potassium sorbate/natamycin to inhibit the growth of bacteria and yeasts/moulds, respectively.

According to Turkish Food Codex (Republic of Turkey Prime Ministry General Directorate of Legislation Development and Publication, 2013), sorbic acid and its salts are permitted antimicrobials to be used in non-alcoholic beverages (excluding dairy beverages) at a maximum concentration of 300 ppm. However, there is no information about concentrations of nisin or natamycin for the products similar to the *Sübye* beverage.

Based on previous studies (Shirk & Clark, 1963; Yamazaki et al., 2000; Stark, 2003; Stopforth et al., 2005; Walker & Phillips, 2008) and characteristics of the *Sübye* beverage, the combinations and concentrations of the aforementioned antimicrobials to be used in preliminary experiments were selected as follows: nisin (1 ppb and 2 ppb), potassium sorbate (250 ppm and 500 ppm), natamycin (10 ppm, 30 ppm), nisin:potassium sorbate (1 ppb: 250 ppm, 1 ppb: 500 ppm, 2 ppb: 250 ppm, 2 ppb: 500 ppm), and nisin:natamycin (2 ppb: 10 ppm, 2 ppb: 30 ppm).

*Sübye* beverages prepared by adding the antimicrobial additives and control samples without additives were stored at 4 °C for 6 days. Aerobic mesophilic bacteria, mould and yeast counts were performed at the beginning of the storage (day 0), day 3, and day 6 of the storage time. It was found through the preliminary experiments that nisin and natamycin had no inhibitory effect on microbial growth in the beverage at concentrations of 1 ppb and 10 ppm, respectively. In addition, it was found that potassium sorbate had the same effect on mould and yeast growth at the concentrations of 250 ppm and 500 ppm. Therefore, combinations of nisin:potassium sorbate and nisin:natamycin at concentrations of 2 ppb: 250 ppm and 2 ppb: 30 ppm, respectively, were added to the beverages. The antimicrobials were first dissolved in water at the determined concentrations, and then mixed with *Sübye* paste to produce the *Sübye* beverage.

In this study, thickening agents were also used in the *Sübye* beverage to prevent the serum phase separation due to suspension characteristics of the beverage. *Sübye* is consumed cold, so guar gum and xanthan gum were included in the study because of their property of hydrating in cold water, as well as their synergistic effects with each other. Based on previous studies (García-Ochoa et al., 2000; Mudgil et al., 2014), guar gum and xanthan gum were used individually, ranging between 0.01 - 0.05% and 0.1 - 0.5%, respectively, and also were used in xanthan gum:guar gum combination in the following percentage concentrations: 0.01:0.01, 0.02:0.02, 0.01:0.05, 0.03:0.3, 0.04:0.3, 0.04:0.4, 0.04:0.5, 0.05:0.4, and 0.05:0.5. Casas et al. (2000) reported that optimum solubility temperatures of xanthan gum and guar gum in water are 40 °C and 60 °C, respectively. Therefore, the food additives were dissolved in hot water at the determined concentrations, and then mixed with *Sübye* paste to obtain the *Sübye* beverage. The beverages were stored at 4 °C for 1 day due to the effect of microbial growth on suspension properties of the beverage, and then their serum phase separations were determined as percentages.

***Color measurement:*** Color parameters were measured by CIE LAB Color System. L* for lightness, –a for greenness, and +b for yellowness values of *Sübye* samples were determined by using Minolta Chroma Meter CR- 400 model colorimeter (Minolta Ltd., Japan). Color measurements were done for the control and the gum-containing samples.

***Serum phase separation analysis:*** *Sübye* samples were poured in 15 mL test tubes and stored at 4 °C for one day. At the end of the storage, volumes of the serum phase were measured, and their ratio percentages to the total sample volumes were determined.

***Microbiological analysis:*** *Sübye* samples (10 mL) were transferred into 90 mL 0.1% peptone water under aseptic conditions. From appropriate tenfold dilutions, pour plate counts were made using the following media and incubation conditions: Plate Count Agar (PCA, Merck 105463) for aerobic mesophilic bacteria count, 37 °C, 24 h ± 2 h incubation (Association of Official Analytical Chemists International, 2000); Dichloran Rose-Bengal Chloramphenicol Agar (DRBC, Merck100466, KGaA, 64271, Darmstadt, Germany) for mould and yeasts, 25 °C, 3 - 5 days incubation (Tournas et al., 2001).

***Sensory evaluation:*** Sensory evaluation of *Sübye* samples prepared with different concentrations of both *Sübye* paste/water and *Sübye* paste/sugar was performed via the standardized process for *Sübye* beverage and samples containing thickening agents. The evaluations were conducted with twelve panelists (6 females and 6 males, ages ranging from 20 to 45 years old) using ranking test in order of decreasing preference in the aspects of appearance, mouthfeel, flavor, and overall appearance of the beverage (Altug & Elmaci, 2005).

***Statistical analysis:*** *Wallis* test, as a nonparametric test, was applied to evaluate the results of color, chemical, and sensory analyses of the *Sübye* beverage statistically. Statistical analyses were applied to the data using One–Way ANOVA test to determine the effects of antimicrobials and storage time on microbiological results of *Sübye* beverage. Tukey's honestly significant differences (HSD) test was used for multiple comparisons to evaluate the effects of food additives and storage time on the product. *Dunn's* test was applied to determine the effect of thickening agents on sensory characteristics of the beverage. The statistical analyses were conducted using the software packages of SPSS (Statistical Package for the Social Sciences, SPSS for Windows, release 17.0.3, USA) and NCSS (Number Cruncher Statistical System, version 07.1.21, Utah, USA). Duplicate independent *Sübye* beverage productions were carried out. Two parallel independent samples were taken for each analysis from each production (n = 4). Results were statistically evaluated at the level of significance of 95% ($p<0.05$).

## 3 Results and discussion

The results from this study were mainly evaluated in two steps: determination of the standard processing technique for *Sübye* beverage and effects of the additives on shelf life of the standardized product. In the first step, *Sübye* paste, obtained from a local manufacturer, was mixed with water at concentrations ranging between 20% and 30% to produce *Sübye* beverages. Then, the beverages were subjected to sensory testing for consumer acceptability. The results are shown in Part A of Table 1.

It was found that the differences in the sensory characteristics of mouth feel, flavor, and overall appearance among *Sübye* beverages at concentrations of 25% - 30% were not statistically significant ($p>0.05$). However, a significant difference was determined in the appearance of the beverages, and the *Sübye* beverage prepared at a concentration of 25% was found to be the most liked beverage by the panelists ($p<0.05$). Therefore, the concentration of 25% for *Sübye* paste was accepted for paste/water mixture standardization. In order to standardize the components of *Sübye* paste, a sensory ranking test was performed on the beverages produced from *Sübye* pastes, both taken from local

**Table 1**. The results of sensory ranking test performed on *Sübye* beverages prepared at different concentrations of Sübye paste/water (*Part A*) and of *Sübye* paste/sugar (*Part B*).

| Part A: Sübye Paste/Water Concentration (m/m, %) | Mean values of the sensory characteristics | | | |
|---|---|---|---|---|
| | Appearance | Mouthfeel | Flavor | Overall appearance |
| 20 | 2.3 ± 0.9$^{B}$ | 2.7 ± 0.3$^{B}$ | 2.7 ± 0.2$^{B}$ | 2.7 ± 0.2$^{B}$ |
| 25 | 1.5 ± 0.7$^{A}$ | 1.5 ± 0.7$^{A}$ | 1.6 ± 0.1$^{A}$ | 1.5 ± 0.1$^{A}$ |
| 30 | 2.2 ± 0.2$^{B}$ | 1.8 ± 0.2$^{A}$ | 1.7 ± 0.2$^{A}$ | 1.8 ± 0.2$^{A}$ |
| *p* value | 0.008 | 0.001 | 0.001 | 0.001 |
| Part B: Paste/Sugar Ratio (m/m) | | | | |
| 1/1 | 2.7 ± 0.3 | 2.9 ± 0.3$^{B}$ | 2.6 ± 0.4 | 2.6 ± 0.4$^{AB}$ |
| 1/1.125 | 1.8 ± 0.3 | 1.8 ± 0.2$^{A}$ | 2.1 ± 0.2 | 1.7 ± 0.3$^{A}$ |
| 1/1.5 | 3.0 ± 0.4 | 2.3 ± 0.3$^{AB}$ | 2.4 ± 0.4 | 2.6 ± 0.3$^{AB}$ |
| Local manufacturer | 2.5 ± 0.4 | 3.2 ± 0.4$^{B}$ | 3.1 ± 0.4 | 3.2 ± 0.3$^{B}$ |
| *p* value | 0.107 | 0.020 | 0.204 | 0.029 |

The results are expressed as mean±standard error of four independent measurements (n=4). Different capital letters within a column show significant difference for each property (p<0.05).

manufacturers and prepared at a paste/sugar ratio of ranging from 1/1 to 1/1.5 (Part B of Table 1).

As shown in Part B of the Table 1, no significant differences were observed in appearance and flavor sensory characteristics of four *Sübye* beverages prepared using different paste/sugar concentrations. On the contrary, *Sübye* beverage prepared at a paste/sugar concentration of 1/1.125 was found significantly different in mouthfeel and overall appearance ($p<0.05$). Therefore, it was found to be the most-liked beverage by the panelists. Chemical analyses were performed on the *Sübye* beverages, obtained from local manufacturer and produced after standardization of the concentrations of paste/water and paste/sugar in order to compare their quality characteristics (Table 2).

According to the results in Table 2, standardized production of *Sübye* beverage was achieved without modifying chemical properties of the conventional *Sübye* beverage, as no significant difference was observed ($p>0.05$) between the chemical properties of the samples. Karakaya et al. (1995) chemically analyzed the conventional *Sübye* beverage in their study, and they found that the moisture, ash, protein, fat, and carbohydrate contents of the beverage were 86.36%, 0.27%, 1.28%, 1.92%, and 10.17%, respectively. Thus, results obtained in the current study are concurrent with previous findings.

In second step of the study, the effects of additives on shelf life of the standardized product were investigated. The selected antimicrobials were added to the standardized *Sübye* beverage and then stored at the selected storage temperature. The effects of the antimicrobials on microbial growth of the beverage during storage are shown in Table 3.

It was found that the effect of storage time ($p = 0.046$ and $p = 0.012$ for aerobic mesophilic bacteria and mould and yeast counts, respectively) and the interaction between the antimicrobials used in the beverage and the storage time ($p=0.00$ for the both counts) were significant for microbial growth. It was observed that the aerobic mesophilic bacteria count in the *Sübye* beverage containing natamycin alone as an antimicrobial remained constant, and the differences between the counts through the storage were not significant ($p>0.05$). However, the aerobic mesophilic

**Table 2**. Chemical properties of the *Sübye* beverages.

| *Sübye* Beverage | Mean values of chemical properties (m/m, %) | | | | |
|---|---|---|---|---|---|
| | Water | Ash | Protein | Oil | Sugar |
| Local manufacturer | 85.9 ± 1.3 | 0.2 ± 0.0 | 1.4 ± 0.2 | 1.5 ± 0.4 | 10.1 ± 1.1 |
| Standard | 84.2 ± 0.2 | 0.2 ± 0.0 | 1.3 ± 0.1 | 1.5 ± 0.5 | 11.6 ± 0.5 |
| *p* value | 0.121 | 0.439 | 0.699 | 0.699 | 0.439 |

The results are expressed as mean ± standard error of four independent measurements (n = 4).

bacteria count in the *Sübye* beverage containing nisin:natamycin combination decreased through the first 3 days of the storage, and then remained constant through the rest of the storage. No significant differences were observed between the counts after the 3$^{rd}$ day of the storage ($p>0.05$). These results showed that the effects of natamycin and nisin:natamycin combination on the aerobic mesophilic bacteria count of the *Sübye* beverage on the 3$^{rd}$ and 6$^{th}$ day of the storage are significant compared to those of the other antimicrobial applications used in this study ($p<0.05$). The results also showed that the use of nisin alone as an antimicrobial had no effect on the aerobic mesophilic bacteria counts during storage, though a combined use with natamycin was effective at both 3$^{rd}$ and 6$^{th}$ days, as well as a combined use with potassium sorbate at the 6$^{th}$ day of the storage.

Although nisin has been reported by various studies to have an inhibitory effect on the growth of Gram-positive bacteria and on the spore formers (Thomas & Delves-Broughton, 2005; Komitopoulou et al., 1999; Yamazaki et al., 2000), this effect apparently depends on certain factors, such as suspension stability, pH, temperature, and nutritional contents of the food (Thomas & Delves-Broughton, 2005). In this study, the inability of nisin to be effective as an antimicrobial in *Sübye* beverage can include the following reasons; high pH level of 6.7, heterogeneous granulated texture, and, particularly, a high initial microbial load. On the contrary, Pol & Smid (1999) indicated that adverse effects of these factors on the ability of antimicrobial activity of nisin could be prevented by means of combined use with other antimicrobials that also comply with the results of this current study. It was also observed that the combination of nisin:potassium sorbate had a statistically significant inhibitory effect on mould and yeast growth, while other combinations had no significant effects during 6 days of storage.

The effects of thickening agents at determined concentrations on serum phase separation of the *Sübye* beverage during storage are shown in Table 4.

Applications of xanthan gum:guar gum combination in the percentage ratios of 0.04%:0.5%, 0.05%:0.4%, and 0.05%:0.5% showed the best results in reducing the serum phase separation of the *Sübye* beverage. Casas et al. (2000) observed that combined use of gums was more effective than using them alone.

Among the best results shown in Table 4, it was noted that the combination of xanthan gum:guar gum (0.05%:0.5%) was not included in this study because of excessive consistency of the beverage even though the result for this combination was 0.7%. The effects of other best gum combinations on the sensory properties of the beverage were also evaluated, and the results are shown in Table 5.

Although no statistically significant difference ($p>0.05$) was observed among *Sübye* samples in the aspects of the sensory properties of mouth feel, flavor, and overall appearance, statistically significant difference between control and the gum-added samples was found in the aspect of sensory characteristic of appearance ($p<0.05$). The control sample was determined as the most-liked sample by the panelists, based on its appearance. The reason for negative evaluation of the gum-containing *Sübye* beverages could be the formation of xanthan gum and guar gum particles in a cold environment, even after they were dissolved in hot water. In order to prevent adverse effects of these gums, other thickening agents having a synergistic effect with xanthan gum, such as locust bean gum and gum arabic, might be considered. The color measurement results of the beverage for these best gum combinations are shown in Table 6.

The data in the Table show that no significant differences ($p>0.05$) were found between the gum-containing samples and control samples for the Hunter color values.

**Table 3**. The effects of the antimicrobials on microbial growth of the *Sübye* beverage during storage.

| Antimicrobial combinations added to the *Sübye* beverage | Aerobic mesophilic bacteria count (log cfu/mL) | | |
|---|---|---|---|
| | Storage time (days) | | |
| | 0 | 3 | 6 |
| Control | $6.26 \pm 0.00^{Ba}$ | $6.36 \pm 0.00^{Ba}$ | $7.13 \pm 0.02^{Aa}$ |
| nisin *(2 ppb)* | $6.23 \pm 0.02^{Ba}$ | $6.35 \pm 0.02^{Ba}$ | $7.12 \pm 0.02^{Aa}$ |
| potassium sorbate *(250 ppm)* | $6.23 \pm 0.01^{Ba}$ | $6.31 \pm 0.02^{Ba}$ | $6.96 \pm 0.02^{Aab}$ |
| nisin: potassium sorbate *(2 ppb:250 ppm)* | $6.19 \pm 0.00^{Ba}$ | $6.26 \pm 0.01^{Bab}$ | $6.89 \pm 0.02^{Ab}$ |
| natamycin *(30 ppm)* | $6.18 \pm 0.08^{Aa}$ | $6.10 \pm 0.01^{Ab}$ | $6.04 \pm 0.04^{Ac}$ |
| nisin:natamycin *(2 ppb:30 ppm)* | $6.18 \pm 0.05^{Aa}$ | $5.87 \pm 0.04^{Bc}$ | $5.74 \pm 0.13^{Bd}$ |
| | Mould and yeast count (log cfu/mL) | | |
| | 0 | 3 | 6 |
| Control | $4.25 \pm 0.00^{Ba}$ | $4.35 \pm 0.01^{ABa}$ | $4.44 \pm 0.02^{Ab}$ |
| nisin *(2 ppb)* | $4.19 \pm 0.03^{Ba}$ | $4.27 \pm 0.01^{Ba}$ | $4.41 \pm 0.03^{Ab}$ |
| potassium sorbate *(250 ppm)* | $4.24 \pm 0.04^{Ba}$ | $4.35 \pm 0.02^{ABa}$ | $4.42 \pm 0.01^{Ab}$ |
| nisin:potassium sorbate *(2 ppb:250 ppm)* | $4.18 \pm 0.01^{Aa}$ | $4.27 \pm 0.01^{Aa}$ | $4.23 \pm 0.05^{Ac}$ |
| natamycin *(30 ppm)* | $4.17 \pm 0.06^{Ca}$ | $4.30 \pm 0.02^{Ba}$ | $4.75 \pm 0.00^{Aa}$ |
| nisin:natamycin *(2 ppb:30 ppm)* | $4.18 \pm 0.08^{Ba}$ | $4.09 \pm 0.01^{Bb}$ | $4.74 \pm 0.22^{Aa}$ |

The results are expressed as mean±standard error of four independent measurements (n=4). Different capital letters within a row and different small letters within a column show significant difference for each property ($p<0.05$).

**Table 4**. Effects of the thickening agents on serum phase separation of the *Sübye* beverage for one day of the storage.

| Thickening agent combinations added to the *Sübye* beverage (%) | Volume ratio of serum phase to total sample (%) |
|---|---|
| *Control* | 66.7 |
| *Xanthan Gum (0.04)* | 29.6 |
| *Xanthan Gum (0.05)* | 25.9 |
| *Guar Gum (0.4)* | 23.1 |
| *Guar Gum (0.5)* | 18.5 |
| *Xanthan Gum:Guar Gum (0.04:0.4)* | 1.5 |
| *Xanthan Gum:Guar Gum (0.04:0.5)* | 1.0 |
| *Xanthan Gum:Guar Gum (0.05:0.4)* | 1.0 |
| *Xanthan Gum:Guar Gum (0.05:0.5)* | 0.7 |

The results are expressed as mean±standard error of four independent measurements (n=4).

**Table 5**. The results of sensory ranking test performed on *Sübye* beverages containing thickening agents.

| Thickening agent combinations added to the *Sübye* beverage (%) | Mean values for the sensory characteristics | | | |
|---|---|---|---|---|
| | Appearance | Mouthfeel | Flavor | Overall appearance |
| *Control* | 1.3 ± 0.1[B] | 1.8 ± 0.2 | 1.8 ± 0.2 | 1.6 ± 0.2 |
| *Xanthan Gum:Guar Gum (0.04:0.5)* | 2.4 ± 0.2[A] | 2.0 ± 0.2 | 2.1 ± 0.2 | 2.1 ± 0.2 |
| *Xanthan Gum:Guar Gum (0.05:0.4)* | 2.3 ± 0.1[A] | 2.2 ± 0.2 | 2.1 ± 0.2 | 2.2 ± 0.2 |
| *p* value | 0.001 | 0.224 | 0.321 | 0.053 |

The results are expressed as mean±standard error of four independent measurements (n=4). Different capital letters within a column show significant difference for each property ($p<0.05$).

**Table 6**. The Hunter color values for *Sübye* beverages containing thickening agents.

| Thickening agent combinations added to the *Sübye* beverage (%) | Hunter Color Mean values | | |
|---|---|---|---|
| | *L* | *-a* | *+b* |
| *Control* | 75.56 ± 0.63 | 1.24 ± 0.12 | 2.44 ± 0.01 |
| *Xanthan Gum:Guar Gum (0.04:0.5)* | 74.85 ± 0.63 | 1.43 ± 0.07 | 2.51 ± 0.08 |
| *Xanthan Gum:Guar Gum (0.05:0.4)* | 75.66 ± 0.67 | 1.16 ± 0.02 | 3.33 ± 0.02 |
| *p* value | 0.565 | 0.180 | 0.180 |

The results are expressed as mean±standard error of four independent measurements (n = 4).

## 4 Conclusion

In this study, production method of the *Sübye* beverage was standardized. Effective combinations of nisin with natamycin and potassium sorbate were statistically more effective on inhibiting microbial growth than the use of nisin alone. However, this positive effect of the antimicrobials was not enough to extend the shelf-life of the *Sübye* beverage because of the high initial microbial load of the melon seeds. Therefore, further studies, including determination of the microbial flora in detail, the use of these and other antimicrobials and application of new methods such as ultraviolet radiation, pulsed electric field, ohmic and induction heating, and ultrasound are suggested to decrease this microbial load and extend the shelf-life of the beverage. Furthermore, applications of xanthan gum:guar gum combinations in the respective percentage ratios of 0.04%:0.5% and 0.05%:0.4% to the beverage are also recommended, having reduced initial microbial load to extend its shelf life for improving serum phase separation problem.

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