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Effect of thermosonication on physicochemical, microbiological and sensorial characteristics of ayran during storage

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ABSTRACT

The aim of the study was to determine whether thermosonication extends the shelf life of ayran, an acidic milk drink. The effect of thermosonication at different temperatures (60, 70 and 80 °C) and times (1, 3 and 5 min) on the physicochemical and microbiological characteristics, and sensorial properties of ayran during storage were investigated. According to the results, thermosonication applied at 60 °C decreased lower the bacteria counts, although the *Streptococcus thermophilus* and *Lactobacillus delbrueckii* subsp. *bulgaricus* counts decreased as the temperature and time increased. The yeast and mold levels in samples treated with thermosonication were <1 log CFU mL^{-1} during storage period. The ayran samples had non-Newtonian behavior, and the consistency coefficients of the thermosonicated samples were significantly higher than that of the heat-treated samples. Regarding serum separation, the most effective thermosonication treatment was applied at 70 °C for 3 min. The sensory properties of the thermosonicated samples were better than the thermal-treated samples after storage.

1. Introduction

Thermal processes are the most common methods for preserving food products; however, demand for new techniques that have a lower negative effect on the nutritional value of the product is increasing; therefore, overall food quality increases [1]. Due to growing consumer demand for high-quality foods, new safe and effective techniques have recently been investigated to evaluate their potential for safe processing and food preservation [2,3]. An alternative technique is ultrasound, and the technique could improve the production of acidic fermented drinks such as ayran through post-pasteurization. Ultrasound could be used in ayran production for homogenization and pasteurization.

Interest in fermented dairy products has increased due to their nutritional quality and attractiveness [4]. Ayran, a special variety of acidic milk drink, is popular in many countries in Asia and the Middle East, including Turkey. In traditional ayran production, yoghurt is diluted with water in a concentration range of 30% and 50%, and table salt is added up to 1% to improve the taste. In industrial manufacture of ayran, the dry matter content of milk is standardized, then the milk is fermented with cultures that produce exopolysaccharide, and the product is diluted with water and added salt [5]. Finally, ayran is quickly cooled to stop fermentation.

Ayran is an unstable fermented product, and the quality tends to deteriorate due to sedimentation and the development of acidity during storage [6]. Viscosity and serum separation, which have a significant effect on the quality of fermented milk drinks such as ayran, are the main quality parameters. Serum separation adversely affects whey-based beverages such as ayran [7]. Due to low pH and viscosity, fermented milk drinks have sedimentation because proteins aggregate in milk [8]. In order to have durable ayran production, heat treatment (90 °C for 1 min), can be performed to extend the product's shelf life up to 1 month as post-pasteurization after fermentation. However, treatment increases loss of physicochemical and nutritional quality properties.

Serum separation in ayran could be prevented by using stabilizers [5]. However, the use of stabilizers not a priority in fermented milk beverages because stabilizers are considered additives. As a potential alternative to enhance the visual quality of ayran, acoustic energy can be used. Ultrasound may enhance firmness and reduce syneresis because the fat globules in such products are reduced to such a small size that they will no longer rise to the top of the product as a divided layer. Acoustic energy causes homogenization by decreasing the fat globules due to intense cavitation phenomena [4]. Acoustic cavitation is attributed to several mechanical and chemical facts. The impact of

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the food process and food quality attributes of acoustic energy can be explained by hot spots theory, which causes shockwaves and some chemical species [9].

Ultrasound has many dairy process applications such as microbial inactivation [10,11], mass transport [12], enzyme inactivation [13,14], and homogenization [4,15]. The advantages of ultrasound over heat treatment are the decrease in flavor loss, improvement in homogeneity, and increased energy savings [16]. We suggest ultrasound is a potential technique that can improve ayran characteristics such as serum separation, viscosity, and appearance while reducing yeast mold.

The effects of thermosonication on the physicochemical, microbiological, and rheological properties such as viscosity, flow behavior index, and consistency coefficient have not been reported in detail. The aim of the present study was to investigate the effect of ultrasound on the physicochemical (serum separation, viscosity, pH and color), microbiological (yeast, mold and lactic acid bacteria) and rheological properties (viscosity, flow behavior index and consistency coefficient) of ayran and compare the effects with those of samples prepared with the thermal treatment.

2. Materials and methods

2.1. Material

The cow milk used to produce the ayran samples was supplied by the Agriculture Faculty of Atatürk University in Erzurum, Turkey. The direct vat set yoghurt starter culture (*Streptococcus thermophilus* and *Lactobacillus delbrueckii* subsp. *bulgaricus*; code: YFL903) in ayran manufacturing was obtained from Peyma-Hansen, Istanbul.

2.2. Proximate analysis

The amounts of the total solid matter [17], titratable acidity, fat [18] and protein [19] were determined for the raw milk and prepared ayran samples. The pH value of each ayran sample was measured using a pH meter (model WTW pH-340-A, Weilheim, Germany).

2.3. Ayran production

The cow milk sample (12.01% total solids, 3.88% fat, 3.10% protein, 0.16% titratable acidity and pH of 6.71) was standardized to a 1.8% fat ratio of raw milk by using water. The milk was pasteurized at 90 °C for 10 min and then rapidly cooled to 44 ± 1 °C. The milk was quickly inoculated with the thermophilic starter culture (*S. thermophilus* and *L. bulgaricus*) at an inoculation rate of 0.2 g L^{-1} for all samples. Then, the inoculated milk was incubated at 44 ± 1 °C until pH 4.64. After incubation, ayran was cooled at 20 °C, and 0.75% salt was added. Finally, ayran was mixed thoroughly and stored at 4 °C overnight. The following day, 300 mL of the control ayran sample was transferred into sterile glass cups. The untreated fresh ayran samples were evaluated as control.

2.4. Thermosonication and thermal treatment

The thermosonication treatment was performed at different temperatures (60, 70 and 80 °C) and times (1, 3 and 5 min) by using an ultrasonic bath (Model No. RK103H, Bandelin, Berlin, Germany) that works at a frequency of 35 kHz. Each experimental unit was immersed in a separate Erlenmeyer flask filled with 300 mL ayran samples. All treatments were performed in duplicate. Thermal treatment was carried out at 90 ± 1 °C for 1 min and in a glass beaker of 300 mL in a water bath.

2.5. Microbiological analysis

Serial dilutions were prepared with sterile 0.1% buffered peptone water. Appropriate dilutions were poured and plated in duplicate. To count *S. thermophilus*, M17 agar (Oxoid Ltd., UK) was used, and the plates were incubated aerobically at 37 °C for 48 h. *L. bulgaricus* was counted on MRS agar (Oxoid Ltd., UK) by incubating the plates anaerobically at 37 °C for 72 h. Potato dextrose agar (PDA) (Merck) acidified with 10% sterilized lactic acid to pH 3.5 ± 0.1 was used to determine the total yeast and mold. The plates were incubated at 25 °C for 5–7 days [20]. All analyses were carried out in duplicate.

2.6. Viscosity

The viscosity (mPa s) of the ayran samples was measured at speeds of 10, 12, 20, 30, 50, 60 and 100 rpm using a rotational viscometer (Brookfield model LVT, LV viscometer, Brookfield Engineering Laboratories, Inc., Middleborough, MA). The analysis was carried out at 10 s intervals in 150 mL beakers and was repeated at least 3 times. Rheological models were used to fit the viscosity data of the ayran samples. The rheological behavior of the samples was described by the power-law model described in Eq. (1):

$$\eta_a = K\gamma(n-1) \tag{1}$$

where η_a, K, γ and n are accepted as the apparent viscosity (mPa s^{-1}), consistency coefficient (mPa s^{-1}), shear rate (s^{-1}), and flow behavior coefficient, respectively.

2.7. Volumetric serum separation

The samples were stored in measuring cylinders of 100 mL at 4 °C for 30 days. The volumetric serum separation was determined weekly as an indication of instability.

2.8. Color measurement

The color values of the fresh ayran samples (L^*, a^* and b^* values) were determined as a Hunter scale with a Minolta colorimeter (Minolta, CR 300, Osaka, Japan) calibrated with a white tile (Minolta calibration plate). The measured parameters L^*, a^* and b^* are defined as an indicator of lightness (0 indicates black, and 100 indicates white), redness (positive values indicate red; negative values indicate green), and yellowness (positive values indicate yellow; negative values indicate blue), respectively [21].

2.9. Sensorial analysis

The ayran samples were assessed organoleptically at 1 and 30 days of storage by a panel of eight laboratory staff members, who were well experienced and familiar with ayran. Coded ayran samples were left at room temperature for 10–15 min and were served with a glass of water and a slice of bread for the panelists to cleanse their palates between samples. The ayran samples were graded for eight sensory attributes, including color, odor, texture, flavor, acidity, saltiness and consistency, and the general acceptability of the samples were scored on a point scale of 1 (poor) to 9 (excellent). The ayran samples were evaluated according to Bodyfelt et al.'s [22] method, and the sensory criteria were modified for the characteristics of ayran.

2.10. Statistical analysis

Data obtained from the ayran samples were statistically evaluated using analysis of variance (ANOVA), and the differences among the means were compared with Duncan's multiple range