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Effect of dried nut fortification on functional, physicochemical, textural, and microbiological properties of yogurt

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ABSTRACT

In this study, walnut, hazelnut, almond, or pistachio were incorporated to produce functional yogurts. The effects on physicochemical and instrumental textural characteristics and syneresis, contents of folic acid, selenium, tocopherols, and n-3 and n-6 (omega) fatty acids, and viable counts of *Streptococcus thermophilus* and *Lactobacillus bulgaricus* were evaluated during storage. Fortified yogurts demonstrated higher protein and total solid contents and lower syneresis compared with control yogurt on d 21. Addition of nuts, except walnut, also increased *S. thermophilus* and *L. bulgaricus* counts. The concentrations of folic acid, α-tocopherol, selenium, and n-3 and n-6 fatty acids were higher in fortified yogurts compared with the levels found in the respective nut types. However, a decreasing trend was observed in all components during storage. Consequently, each nut could be incorporated into yogurt because of a specific functional property. For instance, walnut could be preferred for omega acid enrichment.
Key words: nut, fortification, yogurt, functional

INTRODUCTION

Yogurt has an important role in human nutrition due to its nutritional value from proteins, lactose, calcium, and water-soluble vitamins. Although its many healthy and nutritious effects are well known, milk and its products are not usually considered as a rich source for bioactive components. As consumers demand healthy foods with good taste, some functional milk products have been produced by means of enrichment and fortification in recent years. In this manner, yogurt has begun to attract new consumer groups because of its pleasant taste and increased health benefits.

Food fortification is defined as the supplementation of one or more components, regardless of whether it is naturally found in the food, to improve the properties of newly designed functional food products (Świeca et al., 2014). Functional foods have the potential to improve mental and physical status and to reduce risks of diseases; these characteristics generally stem from some useful components, called bioactive compounds (Biesalski et al., 2009).

Nuts constitute a good source of bioactive compounds, such as UFA, high-quality vegetable protein, fiber, minerals, tocopherols, phytosterols, and phenolic compounds (Ros, 2010). Thus, nuts provide many health benefits, such as a reduced incidence of several chronic diseases including cardiovascular disease (Kris-Etherton et al., 2001), a lower risk of BW gain and obesity (Bes-Rastrollo et al., 2009), and a cholesterol-reducing effect (Chisholm et al., 2005) in human beings. Among the various bioactive compounds present in nuts, folic acid, selenium, n-3 and n-6 fatty acids, and vitamin E are among the most important because of their reported beneficial health effects; dairy products do not particularly constitute a good source of these components. For example, cow milk provides 5 to 7 μg/100 g of folic acid (Boeneke and Aryana, 2008), but the daily recommended intake of dietary folate is 400 μg for an adult and 400 to 600 μg for pregnant women (Menard, 1997). Folic acid is considered an important vitamin in the prevention of neural tube defects. Similarly, the recommended daily intake of selenium is 55 μg for adults and 70 μg for pregnant women and nursing mothers (Palomo et al., 2014). Tocopherol acts as an antioxidant in the body, protecting cell membranes, active enzyme sites, and DNA from free radical damage; recommended daily intake of tocopherol is 15 mg (Ribarova et al., 2003). Folic acid, selenium, and tocopherol have been shown to reduce the risk of cancer and cardiovascular disorders (Roman et al., 2010). Omega fatty acids are reported to prevent the metabolic syndrome caused by risk factors such as cardiovascular disease, abdominal obesity, hypertension, and high fasting glycemia (de Camargo Talon et al., 2015). The recommended daily intakes of eicosapentaenoic (**EPA**) or docosahexaenoic acid (**DHA**) and α-linolenic acid are 250 mg and 2 g, respectively (European Council, 2006). The main

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sources of n-6 fatty acids are corn and soybean oils, which include high amounts of linoleic acid, and n-3 fatty acids are found at high levels in dried nuts, such as walnut and flaxseed, and in oily fish (Benito et al., 2006); however, because of their characteristic fishy flavor, the use of marine sources in dairy products is very limited.

Another advantage of using nuts as a fortifier in yogurt is their substantial dietary fiber (Bertolino et al., 2015) and protein contents (Harris and Ferguson, 2013). Taking this into account, nut supplementation may effectively increase the TS content of yogurt, which is important for gel formation, firmness, viscosity, and syneresis of yogurt (Matumoto-Pintro et al., 2011); likewise, nuts could be classified as sources of prebiotics with nondigestible carbohydrates (Sah et al., 2016).

Many studies have been done on fortifying and expanding the nutritional quality of yogurts, including the addition of folic acid (Boeneke and Aryana, 2008), selenium (Palomo et al., 2014), phenolic compounds (Pelaes Vital et al., 2015), and dietary fiber (Sah et al., 2016); however, only one study examined the addition of hazelnut to yogurt (Bertolino et al., 2015), in which the effect of dietary fiber on the mechanical properties of yogurt was investigated. In studies in which foods have been fortified with folic acid, selenium, and omega fatty acids, synthetic forms of these components obtained from industrial suppliers were used instead of natural components extracted from a food or a natural food itself. Although the addition of nuts increases the cost of yogurt about 42 to 86%, such products would be preferred due to their high nutritional benefits.

In recent years, use of natural ingredients, instead of artificial supplements, has gained importance in terms of food safety. The main objective of the current study was to fortify yogurt with natural dried nuts, such as walnut, hazelnut, almond, and pistachio, which are rich in bioactive compounds, and to determine the effect of dried nuts on the functional, physicochemical, instrumental textural, and microbiological properties of yogurt during 21 d of storage. We hypothesized that the composition of certain bioactive components examined in nuts would be useful for the production of new functional products.

MATERIALS AND METHODS

Materials

Raw bovine milk was supplied by the Ankara University Dairy Plant (Ankara, Turkey). The starter culture containing *Streptococcus thermophilus* and *Lactobacillus delbrueckii* ssp. *bulgaricus* (DVS CH1, Chr. Hansen, Hørsholm, Denmark) was prepared according to the manufacturer's instructions. All chemicals used for analysis were purchased from Merck (Darmstadt, Germany) and standards were supplied by Supelco/Sigma-Aldrich (St. Louis, MO) with 99% purity. Ultrapure water was produced by ELGA PureLab Option-Q System (Buckinghamshire, UK).

Dried Nut Samples

The hazelnut, walnut, almond, and pistachio nuts each came from single lots, purchased in roasted and unsalted form from Kesimal Dried Nuts Company (Ankara, Turkey). Each nut was analyzed and certified by provider as aflatoxin-free. All nuts were ground individually with a stainless steel laboratory blender (Waring Commercial Blender, Torrington, CT). The particle size of the ground nuts was standardized to 0.5 mm using sieves (Mesh Series, Endecotts Ltd., London, UK) and underwent a second roasting at 150°C for 20 min in an industrial continuously working oven to obtain a sterilized nut and firm structure.

Yogurt Production

Yogurt samples were produced in the Department of Dairy Technology, Ankara University (Ankara, Turkey). Fresh raw milk with 3.6% (wt/vol) fat content was standardized to 3.0% (wt/vol), and TS content was standardized to 16% by the addition of skim milk [containing 9.0% (wt/vol) TS and 0.1 (wt/vol) fat]. Standardized milk was homogenized under pressure of 1.5×10^7 N/m^2 at 70°C and placed into stainless steel containers. Following homogenization, the milk was heated at 90°C for 5 min, and then rapidly cooled to 45°C and inoculated with starter culture at a rate of 2% (vol/vol). Incubation was carried out at 43°C until the pH of 4.6 was achieved at an approximate incubation period of 4 h. At that point, fermentation was stopped by cooling to 4°C. In total, 25 kg of set-type yogurt was produced in each repetition. After the coagulum was broken with a skimmer and divided into 5 equal portions, 4 portions were supplemented with respective ground nut samples at a ratio of 5% (wt/wt), which was decided upon during preliminary studies, and the last portion was used as control sample. All productions were made in triplicate and each yogurt sample was stored at 4°C until analyses were performed on d 1, 7, 14, and 21.

Microbiological Analyses

Viable counts of *S. thermophilus* and *L. bulgaricus* were analyzed to identify the effect of nut addition on