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Effects of black carrot concentrate on some physicochemical, textural, bioactive, aroma and sensory properties of sucuk, a traditional Turkish dry-fermented sausage

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ABSTRACT

In this study, Turkish fermented sucuk samples were produced by incorporating of 0.5, 1 and 2 g/100 g black carrot concentrate (BCC) in the presence/absence of sodium nitrite and effects of BCC on some physicochemical, microbiological, bioactive, aroma, textural and sensory properties of sucuk were investigated after fermentation for 12 days. The highest total phenolic content value was determined in sucuk sample added with 2 g/100 g BCC and no nitrite and antiradical activities of the sucuk samples were significantly affected from addition of BCC. Incorporation of BCC did not show significant effect on the hardness values, while it improved the adhesiveness characteristics of the final product. Additionally, resilience values decreased with the increase of BCC concentration in the sample formulation. Volatile composition of the samples was influenced from nitrite and BCC levels in the sucuk samples and majority of the volatile compounds were terpenes. Increase of BCC concentration affected the exterior and interior a^* values of the samples. All the sucuk samples had considerably acceptable sensory properties.

1. Introduction

Sucuk, a traditional Turkish dry-fermented sausage is one of the most popular meat products in Turkey and similar meat products are also known in Europe and Middle Eastern Countries (Erkmen, 1997) (Gonulalan, Yetim, & Kose, 2004). Sucuk can be produced by two different methods like industrially or traditionally. In the traditional method, sucuk dough is prepared by incorporation of beef, sheep or water buffalo meat with other ingredients, namely tail fat, salt, sugar, garlic, nitrite and/or nitrate and some spices such as red pepper, black pepper and cumin. Fermentation of sucuk is performed by spontaneous microbiota or adding starter cultures (Erkmen, 1997; Kaya & Gökalp, 2004). In the production of industrial-type sucuk, however, sucuks stuffed into casings are firstly fermented for overnight at room temperature and, then heat treatment is applied to increase its internal temperature to 65–70 °C. This type of traditionally-cured meat product is characterized by use of nitrate and/or nitrite as curing agent (Binkerd & Kolari, 1975). Curing has been used for centuries to preserve meat and meat products (Møller, Jensen, Skibsted, & Knöchel, 2003). Other main function of curing is to provide color formation and color stability, which are among the most critical quality parameters for processed meats. Additives such as nitrite/nitrate agents react chemically with the heme pigments and then the red myoglobin ($MbFe^2$) is converted to bright red nitrosylmyoglobin ($MbFe^2NO$) (Møller & Skibsted, 2002). The chemical reactions involved in formation of cured-meat pigments are complex series of enzymatic, microbial and chemical processes in which pH, pigment concentration, curing agent distribution, moisture, temperature etc. are important (Chasco, Lizaso, & Beriain, 1996). Other functions of the nitrite agents are to inhibit lipid oxidation by means of antioxidant properties in meats, to contribute to desirable processed meat flavor, and to provide antibacterial activity against particularly germination of spores and toxin formation by means of *Clostridium botulinum* (Cassens, 1997; Martin, 2001; Sanz, Vila, Toldrá, Nieto, & Flores, 1997). In spite of its desired properties, a high intake of nitrite leads to several health hazards due to possible allergenic effects, vasodilator effects and the production of carcinogenic nitrosamines (Cammack et al., 1999). Therefore, European

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Food Safety Authority limited the usage amounts of the nitrate and nitrite (EFSA, 2003).

Carmine is a red natural colorant of cochineal extract, obtained from dried female bodies, of the insect *Dactylopius coccus* which belongs to the family of *Coccidea* and natives to Central and South America (Dapson, 2007; Kunkely & Vogler, 2011). Carmine as a natural colorant is frequently used in cosmetics, textiles, pharmaceuticals, food and dyeing industries. In last decades, consumption of carmine increased in all around the world because of prohibition of some synthetic chemical colorants. For this reason there has been increasing interest in developing new coloring alternatives such as carmine which is natural colorant (Méndez, González, Lobo, & Carnero, 2004). In contrast to other natural colorants (annatto, curcuma and chlorophyll etc.), it has been claimed by some researchers that carmine may contain a risk for human health (Baldwin, Chou, & Solomon, 1997; Beaudouin, Kanny, Lambert, Fremont, & Moneret-Vautrin, 1995; Chung, Baker, Baldwin, & Chou, 2001).

Carrot (*Daucus carota* L.) is a valuable source of health-promoting compounds such as carotenes, anthocyanins (Kammerer, Carle, & Schieber, 2004). Although orange carrot is the major species, purple or black carrots which are much older than orange carrots, are not still well known in the western countries. Black carrot is grown and consumed in Turkey, Afghanistan, Egypt and the Far East traditionally (Rubatzky, Quiros, & Simon, 1999; Simon, 2000). Recently, black or purple carrots have received increasing interest as a source of natural food colorants (Kammerer et al., 2004) because of the legal restrictions for synthetic colorants and increasing consumer demand for natural ones. Because of high levels of anthocyanins, they have an attractive bluish-purple color and can be used as a natural food colorant because they have high heat, light, and pH stability (Kirca, Ozkan, & Cemeroglu, 2006). It was reported that the anthocyanin content of black carrot cultivars was in the range of up to 1750 mg/kg fresh weight (Mazza & Miniati, 1993). The main active components of black carrots were cyanidin-based pigments, and the anthocyanin profile of black carrots was reported by several investigators (Kammerer et al., 2004). To overcome the disadvantages of replacing synthetic antioxidants and colorants with natural ones in meat and meat products, investigations have been focused on antioxidant effects and color properties of plant based materials such as rosemary extract, pomegranate rind and its' seed powder, kinnow rind, salt, green tea extract, orange fiber, pomegranate fruit juice. Results showed that these additives have been demonstrated the higher free radical scavenging activity, the lower TBARS values and residual nitrite levels, more acceptable texture, color, odor and taste properties compared to the samples prepared without the additives (Bozkurt, 2006; Devatkal, Narsaiah, & Borah, 2010; Devatkal & Naveena, 2010; Nassu, Gonçalves, Da Silva, & Beserra, 2003; Yalinkiliç, Kaban, & Kaya, 2012). Thus, the aim of this study was to investigate the effect of natural black carrot concentrate (BCC) on some physicochemical, microbiological, textural, bioactive, aroma and sensory properties of Turkish type dry-fermented sausage.

2. Materials and methods

2.1. Materials

Fresh beef and tail fat used in the sucuk production were purchased from a local butcher in Kayseri, Turkey. Other sucuk ingredients such as salt, garlic, red pepper, black pepper, cumin and pimento were provided from a local supplier in Kayseri, Turkey. Black carrot concentrate (BCC) was kindly donated by a company (Erkon Konsantre Co.) in Ereğli, Turkey. BCC is obtained from black carrots by physical concentration methods. Manufacturing methods are similar with other vegetable processing (Anonymous, 2014). Total soluble solid content, pH and density values of BCC were 65.8 g/100 g, 3.41 and 1.325 g/cm^3, respectively.

2.2. Sucuk production

Sucuk (~1 kg) dough was prepared with composing following ingredients: 800 g beef meat (size:3 mm) 200 g tail fat, 25 g salt, 10 g minced fresh garlic, 4 g sugar, 7 g red pepper, 5 g black pepper, 9 g cumin and 2.5 g pimento. Sugar was added after dissolving in sterile warm water and afterward the dough was mixed homogeneously by kneading the batter. Following the preparation of the sucuk dough, it was divided into 9 batches. Based on the base formulation BCC at different concentrations, 0.5, 1 and 2 g/100 g and/or 150 mg/kg sodium nitrite ($NaNO_2$, Merck, Darmstadt, Germany) were incorporated into the each batch. Carmine was added at the level of 200 mg/kg in the production of sucuk. Experimental design for sucuk samples (S1–S9) were prepared as showed in Table 1.

After weighing the essential ingredients, each batch was thoroughly mixed by kneading with hands for 30 min, and stuffed into the artificial collagen casings by using a filling machine (Tefal Le Hachoir 1500, Ecully Cedex, France). The filled sucuk samples were ripened consecutively for 3 days at 90% relative humidity (RH) and 24 °C for 4 days at 85% RH and 22 °C for 5 days at 80% RH and 18 °C in a controlled fermentation cabinet (Nüve, TK 252, Ankara, Turkey).

2.3. Sampling of sucuk

At the end of the fermentation for 12 days, samples were taken in triplicate in two repetitions for the physicochemical, bioactive, textural and sensory evaluation. For this aim, the casing of the sucuk is removed and the sucuk is homogenized using an Ultra turrax homogenizer before analysis except textural and sensory evaluation. For textural and sensory analysis, they were cut using a knife in certain size as a circle. For the microbiological analysis, the samples were analysed in sterile conditions. All the analyses were conducted within 60 min of sampling.

2.4. Physicochemical analysis

The moisture content of the sucuk samples was determined according to the standard procedures of AOAC (2000) using oven method. To determine the pH value, 10 g of the sucuk sample was weighed and homogenized with 90 mL of distilled water using an Ultra turrax (IKA T18 Basic, Staufen, Germany). Then the pH value of the mixture was measured using a calibrated pH meter (WTW, Inolab 720, Burladingen, Germany). To determine the weight loss of the sucuk samples during fermentation, the weights recorded at the first day and 12th day of storage were used. It was calculated using the following formula:

Table 1
Experimental design for the sucuk samples.

Code	Properties	Sodium nitrite (mg/kg)
S1	Control	–
S2	Carmine	–
S3	0.5 g/100 g BCC	–
S4	1.0 g/100 g BCC	–
S5	2.0 g/100 g BCC	–
S6	Control	150
S7	0.5 g/100 g BCC	150
S8	1.0 g/100 g BCC	150
S9	2.0 g/100 g BCC	150

BCC: black carrot concentrate, S1–S9: Sucuk samples.