Selcuk Journal of Agriculture and Food Sciences
SJAFS
http://sjafs.selcuk.edu.tr/sjafs/index
(2022) 36 (3), 380-386
Research Article
e-ISSN: 2458-8377
DOI:10.15316/SJAFS.2022.049

Natural Alternative Curing Agent in Fermented Sucuk Production: Sugar beet (*Beta vulgaris* var. *saccharifera* L.) Molasses

Nazik Meziyet DİLEK[1,*], Mustafa KARAKAYA[2]

[1] Selçuk University, Akşehir Kadir Yallagöz School of Health, Department of Nutrition and Dietetics, Konya, Türkiye
[2] Selçuk University, Faculty of Agriculture, Department of Food Engineering, Konya, Türkiye

ARTICLE INFO

Article history:
Received date: 21.06.2022
Accepted date: 30.08.2022

Keywords:
Fermented sucuk
Sugar beet molasse
Natural alternative curing
Nitrate
Nitrite

ABSTRACT

In this study, sugar beet molasses was used as a natural curing agent in the production of fermented Turkish sucuk in two different forms (molasse and powdered molasse). Some quality characteristics were determined during the ripening (1st, 3rd and 5th days) period of the obtained sucuk dough (0. day) and sucuk samples. In order to compare the effects of molasses and powdered molasses used as natural curing agents in sucuk, a control (K) group containing sodium nitrate was formed. The application of the natural alternative curing process in sucuk production causes a decrease in the pH value and TBA content of the samples during the ripening period, whereas causes an increase in the nitrosomyoglobin and residual nitrate contents. As a result of microbiological analysis, it was determined that the natural alternative curing process increased ($P<0.05$) the number of LABs and there was no significant change in the total yeast-mold numbers during the ripening period ($p>0.05$). In addition, total Coliform group bacteria were not detected in sucuk dough and sucuk samples on the last day (5th day) of the ripening period. Consequently, it has been determined that it is possible to reduce the amount of chemical nitrate by using sugar beet molasses and powdered molasses as natural curing agents in sucuk formulation.

1. Introduction

Meat and meat products are of highly rich resources in terms of nutritional elements such as protein, mineral, vitamin and mineral substance and have an important place in terms of healthy and balanced diet and meeting the need of food material of the increasing world population. In meeting dietary needs of society, nutritive features of foods as well as its effects of human health and microbiological quality are quite important. Therefore, like all other groups of food, also in the production of meat and meat products, it is necessary to provide a food safety at the top level.

When considered that meat is an expensive food material, to both prevent economic losses that may form and provide food safety, meat should be conserved with the suitable methods. While salt addition, one of the oldest methods used in meat conservation, decreases water activity, and impedes development of microorganisms, it accelerates the fat and pigment oxidation (Öztan, 2003; Honikel, 2008). The use of salt may cause these effects as well as negativities such as undesirable color formation in internal parts of muscular tissue, when used in high concentrations (Shahidi and Pegg, 2017). In order to prevent the negativities that form as a result of salt addition and bring a characteristic taste in meat products, curing process is applied (Gökalp et al 2004; Doğruer and Güner, 2005). In curing process, it is reported that curing agents such as the salt, nitrate, nitrite and spices, according to the sort of product, are added, and that it is aimed to improve in the specifications such as color, texture, taste, aroma and flavor of the product obtained and increase its durability over shelf life (Aksu and Kaya, 2002).

It is reported that nitrite, more active form of nitrate that is a passive curing agent, is reduced by bacteria with nitrate reductase activity and can be realized curing reactions in meat products (Terns et al., 2011). Nitrite is an important additive performing highly important functions such as developing characteristic cured meat color in meat products, flavor and tissue features and, especially *Clostridium botulinum*, impeding growth of microorganism and formation of oxidative rancidity (Ahn et al., 2004; Liu ve ark., 2010).

It is reported that, in addition to that nitrate/nitrite has positive effects, nitrite has also negative effects such

* Corresponding author email: *meziyettemel@hotmail.com*
This study was part of the pHD thesis of Nazik Meziyet DİLEK.

as N-nitroso compounds, which were identified that they are both carcinogenic, teratogenic and mutagenic, reacting with secondary amines in meat, and forming methemoglobin not having oxygen carrying feature, combining with hemoglobin pigments in blood (Pourazrang et al 2002; Zanardi et al., 2002; Cemek et al., 2007; Zarringhalami et al., 2009). In the recent years, consumer demands natural meat products, in which any chemical additive is not used. However, since nitrate and nitrite have a wide activity on characteristic properties of meat products, any alternative effective additive could not be identified at the level that can realize all functions of these additives. In recent studies, the various methods such as using new technological methods, microorganisms themselves, metabolites, natural additives and/or their combinations are tried to be developed, in order to reduce the use of nitrate and nitrite in formulations of meat products and content of residual nitrate and nitrite in product.

Sugar beet (*Beta vulgaris* var. *saccharifera* L.) is first of all a crop, which is grown to produce sugar and which belongs in *Chenopodiaceae* family (Yardımcı et al. 2012). Since sugar beet, a rich resource in terms of nitrate and betalain pigments, contains bioactive phytochemicals like phenolic compounds, it can be used as natural antioxidant and color substance (Georgiev et al., 2010; Račkauskienė et al., 2015). It was reported that nitrite content in sugar beet was quite less but as a result of reduction of nitrate to nitrite by means of thermophilic bacteria, that nitrite content may increase (Hoffmann and Märländer, 2005). Molasses, a byproduct of sugar industry, is a non-crystallized syrup released during sugar production. Molasses naturally forms during sugar production and is easily obtainable product having relatively low cost (Roukas, 1996).

Molasses of beet sugar was previously used for the purposes such as animal feeding, alcohol production and providing fermentation medium (Paturau, 1989; Ahmedna et al. 2000). However, in the studies carried out, it was identified that molasses of beet sugar had antioxidant (Koprivica et al., 2009; Filipčev et al., 2010; Valli et al., 2012), anti-inflammatory (Miles et al., 2005), and anti-microbial activity (Onbaşlı and Aslim, 2008) and showed effects repairing DNA damage (Asikin et al., 2013). It was reported that molasses of sugar beet was used by microorganisms as sugar source for xanthan fermentation and, consequently, that xanthan obtained was used as a thickener in food industry (Moosavi and Karbassi, 2010). It was also reported that molasses of beet sugar was used in the production of various products for human nutrition such as cookie (Filipčev et al., 2012; Filipčev et al., 2014), bread (Filipčev et al., 2010; Filipčev, 2011), gluten-free product (Šimurina et al., 2008; Filipčev et al., 2016; Šimurina et al., 2017), ice-cream (Acan et al., 2020), probiotic yoghurt (Ghazal and Atallah, 2016). However, as a result of the literature reviews carried out, it was not met any studies regarding that molasses of beet sugar was used in meat products.

In this study, sucuk was produced by means of natural alternative curing process. For this purpose, using sodium nitrate, molasses and molasses powder, 5 different sucuk formulation was prepared. In sucuk batters obtained and in ripening period of sucuks, residual nitrate/nitrite contents and some physicochemical and microbiological properties of sucuks were determined. With this study, using molasses and molasses powder, alternative curing process was applied in the direction of consumer demands, and it was identified that production of sucuk may be possible.

2. Materials and Methods

Fresh boneless beef and beef fat were obtained from a local meat plant (Panagro Meat Plant) in Konya, Turkey. The meats and fats taken from the various sections of carcasses in such a way that they will represent all body were used in sucuk production. Beef meat and fat were initially ground through a 9-mm plate. The sucuk production was conducted in Panagro Meat Plant in Konya, Turkey.

The other additives used in sucuk production (garlic, cumin, pepper, black pepper, salt) were supplied from the various local markets in Konya. In the production of control group, chemical sodium nitrate (Merck, Germany), was used. In the production of sucuks, as starter culture, mixture of *Pediococcus pentosaceus* and *Staphylococcus carnosus* (BFL-T03, Christian Hansen, Hoers Holm, Denmark) was used at a level of 10^7 CFU/kg of sucuk batter. For sucuk casing, 38 mm collagen casings were used (Vemag, Maschinenbau, Germany). Molasses, used as alternative curing agent, was supplied from Pankobirlik Konya-Çumra. Molasses was used in sucuk formulations in two different forms as molasses and molasses powder.

Sucuk batters were divided into five different groups in terms of the nitrate sources used for curing. K: the control group contains 100 ppm chemical sodium nitrate. In the other groups (A, B, C and D), appropriate amounts of chemical sodium nitrate, molasses or powder molasses were added to contain 100 ppm nitrate.

Preparation of Sucuk Sample

Formulation and ripening conditions of sucuk samples are given in Table 1 and Table 2, respectively.

Analyses of pH, residual nitrate and nitrite, microbiological analyses (TMAB, LAB, total Coliform and total yeast-mold were performed on days 0, 1, 3 and 5. Additionally, TBARS and nitrosomyoglobin content were determined on days 1 and 5. Tests were made double iteratively and, in each iterate, carried out in such a way that each iteration includes three parallelism. So, each parameter for routine analyses was realized on $5 \times 3 \times 2 = 30$ samples according to factorial test design.

pH Analysis

pH values of sucuk batter and sucuk samples was determined by pH meter (WTW Series pH 720, Weilheim, Germany).

Thiobarbituric Acid (TBARS) Numbers Analysis

In sucuk samples, thiobarbituric acid (TBARS) number was determined (Gökalp et al., 1999). For this purpose, sample absorbance obtained after certain extraction stages was read in spectrophotometry in 530 nm and absorbance values obtained later were multiplied by 7.03 coefficient and TBARS contents were calculated as mg malonaldehyde/kg sample (mg MA/ kg sample).

Nitrosomyoglobin (NOMb) Analysis

In order to determine nitrosomyoglobin content, cured pigment and total pigment analyses were performed (Zaika et al., 1976). For the analysis of cured pigment, adding 40 ml of acetone and 3 ml of pure water onto sucuk samples of 10 g, in brown glass bottles, after quickly over 5 minutes, they were filtered. From the filtrates obtained, on spectrophotometry, a value of 540 nm was read against blind sample containing 40 ml of acetone and 3 ml of pure water. Absorbance values read, multiplying by the coefficient 290, the content of cured pigment was determined as ppm.

For total pigment analysis, similarly, 10 g of samples is weighed in brown glass bottles and 40 ml of acetone, 2 ml of pure water and 1 ml of concentrated HCL were added to it. The samples, slowly agitated, were kept in a dark medium over 1 hour and then filtered. From the filtrate obtained, a value of 640 nm was read in spectrophotometry against the sample containing 40 ml of acetone + 2 ml of pure water +1 ml of concentrated HCl. Absorbance values read was multiplied by coefficient 680, and total pigment content was determined as ppm.

Table 1
The formulations of the sucuk samples

Ingredients	Treatments				
	K	A	B	C	D
Meat (kg)	10	10	10	10	10
Fat (kg)	2.75	2.75	2.75	2.75	2.75
Garlic powder (g)	386	386	386	386	386
Salt (g)	135	135	135	135	135
Curing agent*(g)	1	189.9	305.6	0.5+95	0.5+152.8
Spices (g)	439	439	439	439	439
Ascorbic acid (g)	3	3	3	3	3
Starter culture**(g)	5	5	5	5	5

The curing agent used for each group was calculated to contain 100 ppm nitrate. K: sample with sodium nitrate (1 g); A: sample with molasse (189.9 g); B: sample with molasse powder (305.6 g); C: sample with 50% sodium nitrate + 50% molasse (0.5 g + 95 g); D: sample with 50% sodium nitrate + 50% molasse powder (0.5 g + 152.8 g).

Table 2
Fermentation conditions in sucuk production

Ripening period	Temperature (°C)	Relative humidity (%)	Air flow velocity (m/sn)	Time (hour)
Fermentation	0	90	0.5	4-5
Fermantation	18-19	85	0.5	12
Fermantation	22	80	0.5	24 (until the pH reached 5.2-5.3)
Drying	16	70	0.5	30
Drying	10	50	0.5	42 (until the water content of samples reached 33-34%)

Residual Nitrate and Nitrate Analysis

In sucuk batters and sucuk samples, the analyses of residual nitrate and nitrite were performed according to the method given by Cortesi et al (2015) and, as a result of analysis, the residual nitrate content was expressed as mg $NaNO_3$ per kg sample (mg/kg) and residual nitrite content, as $NaNO_2$ per kg sample (mg/kg).

Microbiological Analyses

In sucuk batters and sucuk samples, while the counts of total mesophilic aerobic bacteria (TMAB), lactic acid bacteria (LAB) and total yeast-mold were conducted according to the method given by Gökalp et al (1999), in the count of total *Coliform* bacteria, the method given by Sağdıç et al. (2011) was used. The results were expressed as $\log^{10}$ colony forming units per gram sucuk ($\log^{10}$ CFU/g).

Statistical Analyses

This study was performed in two replicates with triplicate sampling and a completely randomized design was employed. One way analysis of variance (ANOVA) was performed for all variables by using MINITAB release 18.0 programme. Differences among the mean values were compared with Tukey Multiple Comparison Test. The curing treatments (K, A, B, C, D) and ripening days (0, 1, 3 and 5) were analyzed as a fixed factor while the replicate was considered as a random factor (Snedecor and Cochran, 1980).

3. Results and Discussion

pH values

The average pH values of sucuks decreased to 5.145 in 5th day from 6.146 that is the beginning value. As a result of that starter cultures (lactic acid bacteria) added to sucuk batters ferments carbohydrates in medium and that lactic acid concentration increases, it was reported that sucuk pHs would decrease (Incze, 1992; Bover-Cid et al., 2001; Ammor and Mayo, 2007). In the first days of ripening, it was reported that the decreases occurring

in pH was necessary to inactivate microorganisms causing spoilage, form and protect the desired color and flavor and produce high quality and safe products (Ilıkkan et al 2009).

While the highest pH (5.698) was determined in K group, it was identified that group A and D had the lowest pH (respectively, 5.440 and 5.446). Due to the fact that molasses and molasses powder were used in sucuk production as alternative curing agent, in the formulation, another carbohydrate resource was not used (Table 1). In the formulation of group K, since there is not any carbohydrate resource, as a result of fermentation, lactic acid formation decreased, and this case led group K to have the highest pH values.

Thiobarbiturik Acid (TBARS) Number

TBARS number of sucuk samples in 1st and 5th days were given in Table 3. At the beginning of ripening period, TBARS number of samples vary between 0.44-0.57 mg MA.kg sample^{-1} ($P<0.05$). When ripening period is completed, in ready-to-eat sucuks, the highest TBARS number (0.50 mg MA.kg sample^{-1}) was determined in group K. When TBARS number of sucuk samples, to which alternative curing methods were applied, are compared to control group, they were found statistically significant low ($P<0.05$). It is thought that molasses or molasses powder, used as alternative curing agent, showed an effect slowing oxidation. This case may be resulted from antioxidant activity of sugar beet molasses (Koprivica et al., 2009; Filipčev et al., 2010; Valli et al., 2012). A similar result was obtained from the study by Yıldız Turp et al. (2016) and, as a result of the study, it was reported that oxidation forming in the samples, in which red beet powder is used in sausage formulation, proceeded more slowly compared to control group, and that this case may be associated with antioxidant activity of red beet powder.

Nitrosomyoglobin (NOMb) values

According to Table 3, at the end of ripening period, it was identified that group B had the highest nitrosomyoglobin content (30.56%) and group K had the lowest nitrosomyoglobin content (17.50%). It was determined that addition of molasses or molasses powder into sucuk samples as alternative curing agent caused more nitrosomyoglobin formation. It was reported that nitrate/nitrite, obtained from natural resources, enabled the values of nitroslhemochrome, total pigment and color formation to be higher (Choi ve ark., 2020; Jeong et al., 2020).

Residual Nitrate and Nitrite content

The residual nitrate and residual nitrite contents of sucuk batters and sucuk samples were shown in Table 4. Residual nitrate contents of sucuk batters were determined in the range of 69.42-77.15 ppm. In the 1st day of ripening period, residual nitrate content, which was in the range of 66.88-75.50 ppm in all sample groups, decreased to 16.97-41.72 ppm range in 5th day. As a result of the activities of starter culture used in sucuk production, nitrate was reduced to nitrite and nitrite, to nitric oxide and, thus, residual nitrate content largely decreased in ripening period ($P<0.05$).

In the group K, the amount of residual nitrate decreased more than the alternative cured sucuk samples, and they contained a lower amount of residual nitrate at the end of the ripening period (in the ready-to-eat product). This can be explained by the fact that the pH value of the group K is higher than the other groups. In the groups, in which molasses and molasses powder were used, it is thought that lower pH values impeded that starter cultures with nitrate reductase activity and, thus, may have led to higher residual nitrate contents. Eisinaitė et al (2020) obtained similar results. Independently the resource of nitrate used (synthetic or freeze-dried powdered celeriac), they reported that the bacteria reducing nitrate in low pH values was inhibited and that there was high residual nitrate in final product.

Over ripening period, fluctuations occurred in the residual nitrite contents of all groups but these fluctuations was not found statistically significant in group K ($P>0.05$). It is thought that these increases and decreases resulted from continuing of reduction of the residual nitrate to nitrite in sucuks. It was reported that *Staphylococcus carnosus*, among starter cultures used in sucuk production, and those having nitrate reductase enzyme, among microorganisms included in natural flora, played role in reduction of nitrate to nitrite. (Macdougall et al., 1975; Sebranek, 1979; Pinotti et al., 2002). In the only 3rd day of ripening period, the difference between the residual nitrite contents of the samples was found significant ($P<0.05$) and it was determined that group K contained the lowest residual nitrite (3.49 ppm). This result is complied with literature findings, and it was reported that the samples containing natural nitrate/nitrite had higher residual nitrite content than the samples of control group containing chemical nitrate/ nitrite (Bertol et al., 2012; Sullivan et al., 2012; Horsch et al., 2014). Myers et al. (2013) expressed that this case was associated with quicker decomposition of chemical nitrite.

For cured meat products to be able to conserve the existing cure color, it was reported that it was useful for final product to contain residual nitrite at the level of 10-15 ppm (Sindelar and Milkowski, 2011). It is thought that the residual nitrite contents we determined in the study were lower may be resulted from the difference of the formulation, raw material and ripening conditions.

Table 3
TBARS and NOMb values of sucuk samples (Mean ± Standard error)

Analyses	Ripening Period (Day)	Treatments				
		K	A	B	C	D
TBARS*	1	0.44±0.02^{Ba}	0.57±0.03^{Aa}	0.46±0.03^{Ba}	0.46±0.00^{Ba}	0.51±0.00^{ABa}
	5	0.50±0.00^{Aa}	0.37±0.00^{Eb}	0.41±0.00^{Ca}	0.44±0.00^{Ba}	0.39±0.00^{Db}
NOMb**	1	17.82±0.25^{Ca}	19.78±0.44^{Ba}	14.81±0.13^{Db}	19.15±0.33^{BCb}	22.49±0.53^{Ab}
	5	17.50±0.11^{Ca}	24.48±2.05^{Ba}	30.56±1.71^{Aa}	27.99±0.27^{ABa}	29.29±0.06^{ABa}

Within the same row, values with different uppercase superscript letters indicate significant differences (P<0.05) Within the same column, values with different lowercase superscript letters indicate significant differences (P<0.05) K: sample with sodium nitrate (1 g); A: sample with molasse (189.9 g); B: sample with molasse powder (305.6 g); C: sample with 50% sodium nitrate + 50% molasse (0.5 g + 95 g); D: sample with 50% sodium nitrate + 50% molasse powder (0.5 g + 152.8 g). *mg MA/kg sample, **(%).

Table 4
Residual nitrate and residual nitrite content of sucuk batters and sucuk samples (ppm) (Mean ± standard error)

Analyses	Ripening Period (Day)	Treatments				
		K	A	B	C	D
Residual nitrate	0	72.05±1.42^{BCa}	69.42±0.76^{Ca}	73.87±0.96^{ABa}	77.15±1.03^{Aa}	73.16±0.05^{BCa}
	1	68.25±0.28^{Bb}	66.88±3.19^{Ba}	70.38±1.97^{ABa}	75.50±0.11^{Aa}	73.03±0.08^{ABa}
	3	17.82±0.62^{Dc}	49.16±2.43^{Ab}	48.50±1.66^{Ab}	38.84±1.41^{Bb}	27.15±1.13^{Cb}
	5	16.97±0.72^{Bc}	41.72±1.16^{Ab}	40.31±0.84^{Ac}	36.25±3.15^{Ab}	25.87±3.51^{Bb}
Residual nitrite	0	3.00±0.06	2.90±0.07^{c}	2.90±0.07^{c}	2.95±0.06^{d}	3.00±0.07^{d}
	1	4.10±0.04	4.13±0.08^{b}	4.14±0.09^{b}	4.10±0.04^{c}	4.36±0.04^{c}
	3	3.49±0.07^{C}	5.22±0.05^{Ba}	5.21±0.14^{Ba}	5.25±0.11^{Bb}	6.04±0.18^{Aa}
	5	4.73±0.93	4.82±0.33^{ab}	5.06±0.09^{a}	5.61±0.04^{a}	5.19±0.28^{b}

Within the same row, values with different uppercase superscript letters indicate significant differences (P<0.05) Within the same column, values with different lowercase superscript letters indicate significant differences (P<0.05) K: sample with sodium nitrate (1 g); A: sample with molasse (189.9 g); B: sample with molasse powder (305.6 g); C: sample with 50% sodium nitrate + 50% molasse (0.5 g + 95 g); D: sample with 50% sodium nitrate + 50% molasse powder (0.5 g + 152.8 g).

Microbiological quality

Microbiological counts of sucuk batters and sucuk samples were presented in Table 5. Curing process did not affect the TMAB (P>0.05). Ripening period increased of TMAB counts of sample in only group K and A (P>0.05). Aksu and Kaya (2004) reported that the TMAB counts of sucuks varied between 7.49-8.63 log CFU/g and, in the 3rd day of ripening period, that this number increased to 8.39 log CFU/g.

In the 1st day of ripening period, the LAB counts, which was in the range 5.80-6.48 log CFU/g, increased by fermentation conditions and, in 5th day, increased to the levels of 8.83-9.28 log CFU/g'. However, there was no different between the LAB counts of samples in 3rd and 5th days (P>0.05). This case is accounted for adaptation of starter cultures added to sucuk formulation to the fermentation conditions (Bover-Cid ve ark., 2001; Kaban and Kaya, 2006).

At the end of ripening period, it was determined that group D had the highest LAB counts (9.28 log CFU/g). Additionally, it was observed that group A, B and C (containing molasses, molasses powder, 50 % sodium nitrate + 50% molasses), had more LAB counts, when compared to group K. It is thought that this situation may be resulted from the addition of molasses and molasses powder used as curing agent and that it was additional resource of carbohydrate for lactic acid bacteria. The results are complied with literature data. Similarly, Ekici ve ark. (2015) reported that the LAB counts of sucuks were between 8.36-8.71 log CFU/g.

Table 5
Microbiological counts of sucuk samples (log CFU/g) (Mean ± standard error)

Analyses	Ripening Period (Day)	Treatments				
		K	A	B	C	D
TMAB	0	5.11±0.10^{b}	4.99±0.17^{b}	5.18±0.28	5.18±0.04	5.34±0.11
	1	6.00±0.05^{a}	5.96±0.04^{a}	5.91±0.35	6.15±0.00	6.04±0.23
	3	5.88±0.28^{a}	5.48±0.14^{ab}	4.86±1.00	5.54±0.65	5.64±0.26
	5	5.94±0.21^{a}	5.72±0.13^{a}	5.69±0.28	5.79±0.04	5.51±0.08
LAB	0	6.05±0.02^{ABb}	5.80±0.08^{Bb}	6.13±0.18^{ABb}	6.25±0.01^{Ab}	6.08±0.02^{ABc}
	1	6.00±0.19^{ABb}	5.80±0.00^{Bb}	6.00±0.06^{ABb}	6.17±0.18^{ABb}	6.48±0.10^{Ab}
	3	9.06±0.00^{Aa}	9.09±0.06^{Aa}	9.05±0.01^{Aa}	9.16±0.01^{Aa}	9.03±0.08^{Aa}
	5	8.83±0.04^{Ca}	9.18±0.04^{ABa}	9.15±0.03^{Ba}	9.17±0.03^{ABa}	9.28±0.01^{Aa}
Total yeast-mold	0	3.30±0.45	2.99±0.16	3.59±0.11	3.23±0.28	2.76±0.52
	1	3.65±0.06	3.47±0.33	3.68±0.10	3.41±0.00	3.44±0.35
	3	3.42±0.04	3.22±0.13	3.62±0.23	3.21±0.15	3.51±0.00
	5	3.42±0.04	3.22±0.13	3.62±0.23	3.21±0.15	3.51±0.00
Total *Coliform* bacteria	0	ndg	ndg^{b}	ndg^{b}	ndg	ndg^{c}
	1	1.27±1.80	2.46±0.19^{a}	2.57±0.11^{a}	2.52±0.00	2.56±0.23^{a}
	3	1.73±0.18	0.00±0.00^{b}	0.00±0.00^{b}	0.89±1.26	1.97±0.10^{b}
	5	ndg	ndg^{b}	ndg^{b}	ndg	ndg^{c}

Within the same row, values with different uppercase superscript letters indicate significant differences (P<0.05) Within the same column, values with different lowercase superscript letters indicate significant differences (P<0.05) K: sample with sodium nitrate (1 g); A: sample with molasse (189.9 g); B: sample with molasse powder (305.6 g); C: sample with 50% sodium nitrate + 50% molasse (0.5 g + 95 g); D: sample with 50% sodium nitrate + 50% molasse powder (0.5 g + 152.8 g). ndg: No detectable growth

When Table 5 is examined, it is seen that the curing process and ripening period did not affect the total yeast-mold counts of samples (8.36-8.71 log CFU/g) (P>0.05).

No significant difference (P>0.05) is found between each sample groups for total *Coliform* bacteria in terms of curing process. While total *Coliform* bacteria were not determined in sucuk batters, the total *Coliform* bacteria counts were between in the range of 1.27-2.57 log CFU/g at the beginning of ripening period (1st day) decreased to the range of 00-1.97 log CFU/g in the 3rd day. In the last day of ripening period (5th day) the total *Coliform* bacteria could not be determined in samples. It can be account for this case with the that lactic acid bacteria, which prevail to the medium in fermentation process reduce medium pH and thus, inhibe the total coliform bacteria. Also, it is thought that the total *Coliform* bacteria are inhibited as a result of the antimicrobial effects of nitrite, which is formed with the reduction of nitrate obtained from chemical or molasses.

4. Acknowledgements

This study was funded by the Scientific Research Projects (SUBAP- Konya, Turkey) of Selçuk University Coordinating Office (Project Number 20111002). This study was part of the pHD thesis of Nazik Meziyet Dilek.

5. References

Acan BG, Toker OS, Aktar T, Tamturk F, Palabiyik I, Konar N (2020). Using spray-dried sugar beet molasses in ice cream as a novel bulking agent. *International Journal of Food Science & Technology* 55 (3): 1298-1310.

Ahmedna M, Marshall W, Rao R (2000). Production of granular activated carbons from select agricultural by-products and evaluation of their physical, chemical and adsorption properties. *Bioresource Technology* 71 (2): 113-123.

Ahn HJ, Kim J H, Jo C, Lee JW, Yook HS, Kim HY, Byun MW (2004). Combined effects of gamma irradiation and a modified atmospheric packaging on the physicochemical characteristics of sausage. *Radiation Physics and Chemistry* 71 (1-2): 53-56.

Aksu Mİ, Kaya M (2002). Farklı kürleme yöntemleri ve starter kültür kullanılarak pastırma üretimi. *Turkish Journal of Veterinary and Animal Sciences* 26 (4): 909-916.

Aksu Mİ, Kaya M (2004). Effect of usage *Urtica dioica* l. on microbiological properties of sucuk, a turkish dry-fermented sausage. *Food Control* 15 (8): 591-595.

Ammor MS, Mayo B (2007). Selection criteria for lactic acid bacteria to be used as functional starter cultures in dry sausage production: An update. *Meat Science* 76 (1): 138-146.

Asikin Y, Takahashi M, Mishima T, Mizu M, Takara K, Wada K (2013). Antioxidant activity of sugarcane molasses against 2, 2′-azobis (2-Amidinopropane) dihydrochloride-induced peroxyl radicals. *Food Chemistry* 141 (1): 466-472.

Bertol TM, Fiorentini AM, Santos MJH, Sawitzki MC, Kawski VL, Agnes IBL, Costa CD, Coldebella A, Lopes LS (2012). Rosemary extract and celery-based products used as natural quality enhancers for colonial type salami with different ripening times. *Food Science and Technology* 32 (4): 783-792.

Bover-Cid S, Izquierdo-Pulido M, Vidal-Carou MC (2001). Effect of the interaction between a low tyramine-producing *lactobacillus* and proteolytic staphylococci on biogenic amine production during ripening and storage of dry sausages. *International Journal of Food Microbiology* 65 (1-2): 113-123.

Cemek M, Akkaya L, Birdane YO, Seyrek K, Bulut S, Konuk M (2007). Nitrate and nitrite levels in fruity and natural mineral waters marketed in Western Turkey. *Journal of Food Composition and Analysis* 20 (3-4): 236-240.

Choi JH, Bae SM, Jeong JY (2020). Effects of the addition levels of white kimchi powder and acerola juice powder on the qualities of indirectly cured meat products. *Food Science of Animal Resources* 40 (4): 636-648.

Cortesi ML, Vollano L, Peruzy MF, Marrone R, Mercogliano R (2015). Determination of nitrate and nitrite levels in infant foods marketed in Southern Italy. *CyTA-Journal of Food* 13 (4): 629-634.

Doğruer Y, Güner A (2005). Effect of using sodium and potassium nitrate on degrading and residue level of nitrate and nitrite contents of pastirma during the storage period. *Acta Alimentaria* 34 (2): 141-144.

Eisinaitė V, Tamkutė L, Vinauskienė R, Leskauskaitė D (2020). Freeze-dried celery as an indirect source of nitrate in cold-smoked sausages: Effect on safety and color formation. *LWT-Food Science and Technology*, 109586.

Ekici L, Ozturk I, Karaman S, Caliskan O, Tornuk F, Sagdic O, Yetim H (2015). Effects of black carrot concentrate on some physicochemical, textural, bioactive, aroma and sensory properties of sucuk, a traditional Turkish dry-fermented sausage. *LWT-Food Science and Technology* 62 (1): 718-726.

Filipčev B, Lević L, Bodroža-Solarov M, Mišljenović N, Koprivica G (2010). Quality characteristics and antioxidant properties of breads supplemented with sugar beet molasses-based ingredients. *International Journal of Food Properties* 13 (5): 1035-1053.

Filipčev B, Bodroža-Solarov M, Šimurina O, Cvetković B (2012). Use of sugar beet molasses in processing of gingerbread type biscuits: Effect on quality characteristics, nutritional profile, and bioavailability of calcium and iron. *Acta Alimentaria* 41 (4): 494-505.

Filipčev B, Šimurina O, Bodroža-Solarov M (2014). Quality of gingernut type biscuits as affected by varying fat content and partial replacement of honey with molasses. *Journal of Food Science and Technology* 51 (11): 3163-3171.

Filipčev B, Mišan A, Šarić B, Šimurina O (2016). Sugar beet molasses as an ingredient to enhance the nutritional and functional properties of gluten-free cookies. *International Journal of Food Sciences and Nutrition* 67 (3): 249-256.

Filipčev BV (2011). Sugar beet molasses: An ingredient to enhance micronutrients and functionality in bread. *Food and Feed Research* 38 (2): 101-108.

Georgiev VG, Weber J, Kneschke EM, Denev PN, Bley T, Pavlov AI (2010). Antioxidant activity and phenolic content of betalain extracts from intact plants and hairy root cultures of the red beetroot *Beta vulgaris* cv. detroit dark red. *Plant Foods for Human Nutrition* 65 (2): 105-111.

Ghazal G, Atallah A (2016). Production of probiotic yoghurt fortified with bee honey, beet molasses, date honey and pomegranate honey. *Egyptian Informatics Journal* 44: 102-117.

Gökalp H, Kaya M, Zorba Ö, Tulek Y (1999). Et ve Ürünlerinde Kalite Kontrolü ve Laboratuar Uygulama Kılavuzu. Atatürk Üniversitesi Ziraat Fakültesi Yayınları, No: 318, Erzurum-Türkiye.

Gökalp YG, Kaya M, Zorba Ö (2004). Et Ürunleri İşleme Mühendisliği, Atatürk Üniversitesi Ziraat Fakültesi Ofset Tesisi, Erzurum-Türkiye.

Hoffmann CM, Märländer B (2005). Composition of harmful nitrogen in sugar beet (*Beta vulgaris* L.)-amino acids, betaine, nitrate-as affected by genotype and environment. *European Journal of Agronomy* 22 (3): 255-265.

Honikel KO (2008). The use and control of nitrate and nitrite for the processing of meat products. *Meat Science* 78 (1-2): 68-76.

Horsch A, Sebranek J, Dickson J, Niebuhr S, Larson E, Lavieri N, Ruther B, Wilson L (2014). The effect of ph and nitrite concentration on the antimicrobial impact of celery juice concentrate compared with conventional sodium nitrite on *Listeria monocytogenes*. *Meat Science* 96 (1): 400-407.

Ilıkkan H, Ercoşkun H, Vural H, Şahin E (2009). The effect of addition of hazelnut oil on some quality characteristics of Turkish fermented sausage (sucuk). *Journal of Muscle Foods* 20 (1): 117-127.

Incze K (1992). Roh fermentierte, getrocknete fleischerzeugnisse. *Fleischwirtschaft (Frankfurt)* 72 (1): 8-19.

Jeong JY, Bae SM, Yoon J, Gwak SH (2020). Investigating the effects of chinese cabbage powder as an alternative nitrate source on cured color development of ground pork sausages. *Food Science of Animal Resources* 40 (6): 990-1000.

Kaban G, Kaya M (2006). Effect of starter culture on growth of *Staphylococcus aureus* in sucuk. *Food Control* 17 (10): 797-801.

Koprivica G, Misljenovic N, Levic L, Kuljanin T (2009). Influence of the nutrients present in sugar beet molasses and saccharose solutions on the quality of osmodehydrated carrot. *The National Society of Processing and Energy in Agriculture (PTEP) (Serbia)* 13 (2): 184-187.

Liu DC, Wu SW, Tan FJ (2010). Effects of addition of anka rice on the qualities of low-nitrite chinese sausages. *Food Chemistry* 118 (2): 245-250.

Macdougall DB, Mottram DS, Rhodes DN (1975). Contribution of nitrite and nitrate to the colour and flavour of cured meats. *Journal of the Science of Food and Agriculture* 26 (11): 1743-1754.

Miles EA, Zoubouli P, Calder PC (2005). Differential anti-inflammatory effects of phenolic compounds from extra virgin olive oil identified in human whole blood cultures. *Nutrition* 21 (3): 389-394.

Moosavi A, Karbassi A (2010). Bioconversion of sugar-beet molasses into xanthan gum. *Journal of Food Processing and Preservation* 34 (2): 316-322.

Myers K, Montoya D, Cannon J, Dickson J, Sebranek J (2013). The effect of high hydrostatic pressure, sodium nitrite and salt concentration on the growth of *Listeria monocytogenes* on RTE ham and turkey. *Meat Science* 93 (2): 263-268.

Onbaşlı D, Aslim B (2008). Determination of antimicrobial activity and production of some metabolites by *Pseudomonas Aeruginosa* B1 and B2 in sugar beet molasses. *African Journal of Biotechnology* 7 (24): 4614-4619.

Öztan A (2003). Et Bilimi ve Teknolojisi. TMMOB Gıda Mühendisleri Odası Yayınları.

Paturau JM (1989). By-products of the cane sugar industry. An introduction to their industrial utilization. *The Journal Sugar Series* 11.

Pinotti A, Graiver N, Califano A, Zaritzky N (2002). Diffusion of nitrite and nitrate salts in pork tissue in the presence of sodium chloride. *Journal of Food Science* 67 (6): 2165-2171.

Pourazrang H, Moazzami A, Bazzaz BF (2002). Inhibition of mutagenic n-nitroso compound formation in sausage samples by using L-ascorbic acid and α-tocopherol. *Meat Science* 62 (4): 479-483.

Račkauskienė I, Pukalskas A, Venskutonis PR, Fiore A, Troise AD, Fogliano V (2015). Effects of beetroot (*Beta vulgaris*) preparations on the maillard reaction products in milk and meat-protein model systems. *Food Research International* 70: 31-39.

Roukas T (1996). Ethanol production from non-sterilized beet molasses by free and immobilized *Saccharomyces cerevisiae* cells using fed-batch culture. *Journal of Food Engineering* 27 (1): 87-96.

Sağdıç O, Öztürk İ, Yılmaz MT, Yetim H (2011). Effect of grape pomace extracts obtained from different grape varieties on microbial quality of beef patty. *Journal of Food Science* 76 (7): 515-521.

Sebranek JG (1979). Advances in the technology of nitrite use and consideration of alternatives. *Food Technology (USA)* 33 (7): 58-62.

Shahidi F, Pegg RB (2017). Processing of nitrite-free cured meats. *Advanced Technologies for Meat Processing*, CRC Press, pp. 513-534.

Šimurina OD, Filipčev BV, Lević LB, Pribiš VD (2008). Application of sugar beet molasses in the production of tea biscuits. *Food and Feed Research* 35 (4): 201-205.

Šimurina OD, Radunović AZ, Filipčev BV, Jevtić-Mučibabić R, Šarić LĆ, Šoronja-Simović DM (2017). Quality improvement of gluten-free bread based on soybean and enriched with sugar beet molasses. *Food and Feed Research* 44 (1): 65-72.

Sindelar JJ, Milkowski AL (2011). Sodium nitrite in processed meat and poultry meats: A review of curing and examining the risk/benefit of its use. *American Meat Science Association White Paper Series* 3: 1-14.

Snedecor G, Cochran W (1980). Statistical Methods. Iowa State University Press, Iowa, USA.

Sullivan GA, Jackson-Davis AL, Niebuhr SE, Xi Y, Schrader KD, Sebranek JG, Dickson JS (2012). Inhibition of *Listeria monocytogenes* using natural antimicrobials in no-nitrate-or-nitrite-added ham. *Journal of Food Protection* 75 (6): 1071-1076.

Terns MJ, Milkowski AL, Claus JR, Sindelar JJ (2011). Investigating the effect of incubation time and starter culture addition level on quality attributes of indirectly cured, emulsified cooked sausages. *Meat Science* 88 (3): 454-461.

Valli V, Gómez-Caravaca AM, Di Nunzio M, Danesi F, Caboni MF, Bordoni A (2012). Sugar cane and sugar beet molasses, antioxidant-rich alternatives to refined sugar. *Journal of Agricultural and Food Chemistry* 60 (51): 12508-12515.

Yardımcı N, Kılıç HÇ, Ürgen G (2012). Eskişehir ili şeker pancarı üretim alanlarında görülen bazı virüs hastalıklarının DAS-ELISA yöntemiyle belirlenmesi. *Süleyman Demirel Üniversitesi, Ziraat Fakültesi Dergisi* 7 (1).

Yıldız Turp G, Kazan H, Ünübol H (2016). Sosis üretiminde doğal renk maddesi ve antioksidan olarak kırmızı pancar tozu kullanımı, *Celal Bayar Üniversitesi Fen Bilimleri Dergisi* 12 (2).

Zaika LL, Zell TE, Smith J, Palumbo S, Kissinger J (1976). The role of nitrite and nitrate in Lebanon bologna, a fermented sausage. *Journal of Food Science* 41 (6): 1457-1460.

Zanardi E, Dazzi G, Madarena G, Chizzolini R (2002). Comparative study on nitrite and nitrate ions determination. *Annali della Facolta di Medicina Veterinaria, Universita di Parma* 22: 70-86.

Zarringhalami S, Sahari M, Hamidi-Esfehani Z (2009). Partial replacement of nitrite by annatto as a colour additive in sausage. *Meat Science* 81 (1): 281-284.