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RESEARCH ARTICLE ARAŞTIRMA MAKALESİ

Production of dry fermented fish sausages by using different fish species and determination of the microbiological qualities

Farklı balık türleri kullanarak fermente balık sucuklarının üretimi ve mikrobiyal kalitelerinin belirlenmesi

Berna Kılınç[1]* ● Şükran Çaklı[2]

[1] Ege University, Fisheries Faculty, Fish Processing Technology Department, Bornova-İzmir, Turkey https://orcid.org/0000-0002-4663-5082
[2] Ege University, Fisheries Faculty, Fish Processing Technology Department, Bornova-İzmir, Turkey https://orcid.org/0000-0002-2419-9064

**Corresponding author:* berna.kilinc@ege.edu.tr
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Abstract: In this study frozen-thawed rainbow trout (*Onchorhynchus mykiss*) and seabass (*Dicentrarchus labrax*) fillets were used for preparing of dry fermented fish sausages. The total mesophilic aerob bacteria (TMAB), total psychrophilic aerob bacteria (TPAB), yeast–mould (YM), lactic acid bacteria (LB), *Enterobactericeae* (EB), *Staphylococcus aureus* (SA) changes of these dry fermented sausages were examined in the refrigerated storage at 6-8˚C. At the end of the storage period of 90 days, the results of the TMAB, TPAB, YM, LB, EB and SA counts of dry fermented seabass sausages were determined as 6.25, 7.01, 3.61, 5.31, <1.0 ve <1.0 log cfu/g, while, TMAB, TPAB, YM, LB, EB and SA counts of dry fermented trout sausages were found as 6.57, 7.20, 4.44, 5.14, <1.0 ve <1.0 log cfu/g, respectively. In this study both fermented fish sausages were determined as too much dried and exceeded the microbiological limit of TMAB at the end of the storage period of 90 days in the refrigerator. However, fermented seabass sausage reached the maximum level of YM count on the 10th day of storage, whereas fermented trout sausage reached this level on the 30th day of storage. Therefore, it is suggested that they should be packaged in vacuum packaging because of preventing too much drying and the growth of undesirable moulds. Additionally, the identification of microorganisms in fermented fish sausages would also be advised to determine desirable and undesirable microorganisms. Dry fermented fish sausage would be an alternative product to traditional dry fermented meat sausage in Turkey because of the health benefits of fish.

Keywords: Fish species, dry fermented fish sausage, microbiological quality

Öz: Bu çalışmada dondurulmuş çözündürülmüş alabalık (*Onchorhynchus mykiss)* ve levrek (*Dicentrarchus labrax)* filetoları kullanılarak balık sucukları üretilmiştir. 6-8˚C'de buzdolabında depolanan alabalık ve levrek sucuklarının toplam mezofil aerob bakteri (TMAB), toplam psikrofil aerob bakteri (TPAB), maya-küf (MK), laktik asit bakteri (LB), *Enterobactericeae* (EB) ve *Staphylococcus aureus* (SA) değişimleri incelenmiştir. Depolamanın 90. gününde fermente levrek sucuklarının TMAB, TPAB, MK, LB, EB ve SA bakteri sayıları sırasıyla 6,25; 7,01; 3,61; 5,31; <1,0 ve <1,0 log kob/g olarak tespit edilirken, alabalıktan üretilen fermente balık sucuklarının TMAB, TPAB, MK, LB, EB ve SA bakteri sayıları sırasıyla 6,57; 7,20; 4,44; 5,14; <1,0 ve <1,0 log kob/g olarak saptanmıştır. Çalışmada her iki fermente balık sucuğunun da buzdolabında 90 günlük depolama periyodu sonunda çok fazla kurudukları ve TMAB açısından mikrobiyolojik limit değerini geçtikleri saptanmıştır. Buna karşın, en yüksek MK değerlerine levrek sucukları depolamanın 10. gününde ulaşırken, alabalık sucukları depolamanın 30. gününde ulaşmıştır. Bu nedenle depolama esnasında çok fazla kurumanın ve istenmeyen küf gelişiminin önlenmesi için fermente balık sucuklarının vakum paketleme kullanılarak paketlenmesi önerilir. Ayrıca fermente balık sucuklarında mikroorganizmaların tanımlanması da arzu edilen ve istenmeyen mikroorganizmaların belirlenmesi için tavsiye edilir. Türkiye'de balık sucukları sağlığa yararlı olmaları nedeniyle geleneksel etten üretilen sucukların yerine alternatif olabilir.

Anahtar kelimeler: Balık türleri, fermente balık sucuk, mikrobiyal kalite

INTRODUCTION

The improvement of safety and standardization of fermented meat products with the typical characteristics is very essential and can be achieved naturally or sometimes by using native starter cultures that influence appearance, colour, odour, flavor and texture of these products (Cruxen et al., 2019). The most important part of these fermented meat products are fermented fish products (Kılınç et al., 2006) that they have been also produced and consumed in some parts of the world (Kılınç, 2003; Kılınç, 2004). In many parts of the world fermented sausages are traditional products that they have been consumed by most of the consumers for centuries (Bou et al., 2017). Additionally, the process of the manufacture of these fermented meats is a very important part of the meat industry in many countries (Fernandez et al., 2000). The raw materials of the manufacture of fermented sausage are derived from variety of meats and fat tissue. Nonmeat ingredients such as water, salt, spices, sugars, ascorbates and phosphates have been also used for the manufacturing of sausages to improve the flavor and taste characteristics of sausages (Lonergan et al., 2019). The qualities of dry fermented products depend on many factors such as the microbial microflora, the chemico-physical variables and the hygienic procedure of these products during processing stage etc. (Suzzi and Gardini, 2003). Many dry fermented products have been produced in different formulation in the many parts of the world (Incze, 1998; Kılınç, 2004; Papamanoli et al., 2003; Nordvi et al., 2007; Ordonez et al., 2010; Vignolo et al., 2010; Papavergou, 2011; Khem et al., 2013; Holck et al., 2017; Sidira et al., 2019; Gonzalez-Mohino et al., 2020). Sucuk is one of the most important dry fermented meat product of Turkey. In Turkey, this product has been frequently produced from beef or lamb by adding spices, salt, and tail fat into these meats (Kaban and Kaya, 2006). Then prepared sucuk dough has been filled into casings before fermentation process, which occured under uncontrolled conditions (Bozkurt and Bayram, 2006). Fermentation could be formed by the natural microbial flora of sucuk (Kaya and Gökalp, 2004). The microflora of fermented products commonly have been consisted of lactic acid bacteria, coagulase negative coccus, enterococcus, and yeasts (Rantsiou and Cocolin, 2006). The lactic acid bacteria counts of fermented sucuks generally have been changed from 10^2 to10^4 cfu/g. However, these values were reported by Apaydın et al. (2009) could be risen during the process of fermentation. The microorganisms, which were responsible for the process of fermentation, notified by Kaya and Gökalp (2004) that were *Kocuria*, *Staphylococcus*, *Lactobacillus* and *Pediococcus*. According to Turkish Standards Institution; *Lactobacillus (L. plantarum, L. pentosus, L. curvatus, L. sake), Pediocoocus (P. pentosaceus, P. acidilactici, Micrococcus (Korucia varians)* and *Debaryomyces (D. hansenii)* have been used as the starter cultures for the production of sucuks (TSE, 2002). Con and Gökalp (2000) informed that the group of lactic acid bacteria were not only responsible for the process of fermentation, but also they could be inhibited spoilage and pathogenic bacteria during fermentation process. In recent years heat treatments have been applied on sucuks in terms of inhibiting the harmful microbial flora of sucuks. But, these heat treatments had bad effects on the formation of flavours described by Ercoşkun, (2006). Spices and ingredients, which have been added into sucuks, improved the flavour and colour characteristics of sucuks (Bozkurt and Erkmen, 2007). Sucuk has been produced through microbial fermentation and drying process (Aksu and Kaya, 2004). When looking at the literatures; many studies have been done about dry fermented meat products which have been produced from beef, sheep, goat, buffalo, camel etc. (Bozkurt and Erkmen 2002; Suzzi and Gardini, 2003; Kara et al., 2012; Atik, 2013; Yoo et al. 2016; Cunha et al., 2018; Adab et al., 2020). Many studies also have been done about dry fermented fish sausauges (Khem et al., 2013; Stollewerk et al. 2014; Wang et al., 2017) in the world. In addition to this, some studies have been done about fish sausages (Dinçer et al., 2007a, Dinçer et al. 2007b; Özpolat, 2012; Dinçer and Çaklı, 2015; Dinçer et al., 2017; Çoban, 2020), fish jambon (Eren, 2011) and shark meat sausage (Yılmaz and Berik, 2013), whereas limited studies have been done about dry fermented fish sausages (Arslan et al., 2001; Berik and Kahraman, 2010) in Turkey.

Fish compounds were beneficial to health. However, many people prefer to eat little or no fish. Therefore, the development of convenient and new fish products, which were easy to eat to increase the fish intake, was necessary reported by Nordvi et al. (2007). In addition to this; there have been no production and consumption of dry fermented fish sausages which are made from fish species in Turkey. For this reason; the aim of this study was to produce dry fermented fish products from sea bass and rainbow trout. And also microbiological changes of these dry fermented fish sausages were determined during storage period.

MATERIAL AND METHODS

Material and the preparation of fermented fish sausages

In this study frozen at -18˚C for 3 months and then thawed rainbow trout (*Onchorhynchus mykiss*) and seabass (*Dicentrarchus labrax*) fillets were used. The preparation of dry fermented fish sausage is shown in Figure 1. Dry fermented fish sausages were prepared by using fish, beef tail fat, salt, garlic, red pepper, hot red pepper, black pepper, ginger, cinnamon, cumin, sucrose, allspice and potassium sorbate. All spices, which were sold as open, were bought from the spice shop in the Bornova province of Turkey. All formulations contain 1200 g fish meat, 75 g beef tail fat, 20 g salt, 41.0 g garlic, 30.3 g red pepper, 20.3 g hot red pepper, 9.4 g black pepper, 7.25 g ginger, 7.0 g cinnamon, 9.3 g cumin, 7.3 g sucrose, 3.72 g allspice, % 0.03 potassium sorbate in their recipe. After the fish meat was homogenized by using the blender, all spices were added and then they were mixed for 10 minutes. After leaving the mixture in the refrigerator (at 6-8 ˚C) overnight, the sausage filling machine (Sfinx, Czech Republic) were used to be stuffed this mixture into the natural casings to be about approximatelly 10 cm and the end parts were tied with rope and cut. Prepared rainbow trout and seabass sausages were put into refrigerator at 6-8 ˚C and the microbiological changes were examined during storage period.

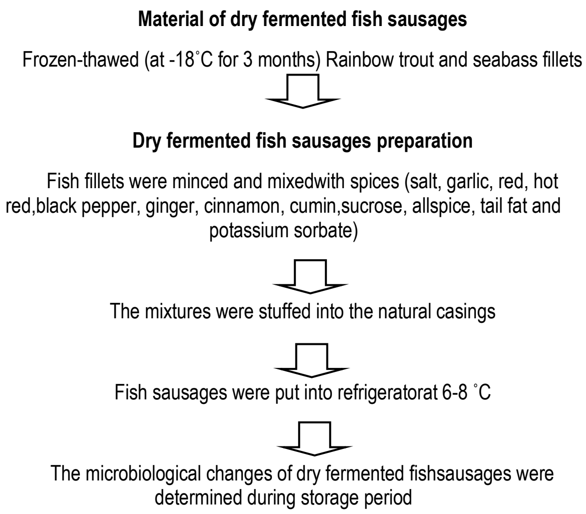

Figure 1. The preparation of dry fermented fish sausages

Microbiological analyses

Sampling for microbiological analyses

Three dry fermented fish sausages of each type were removed in the 1st, 5th, 10th and 15th, 30th, 60th and 90th day of storage period. 10 g of samples was removed from each dry fermented fish sausage and homogenized in a stomacher (IUL, Barcelona, Spain) containing 90 ml of 0.1% peptone water (Difco, 0118-17-0). Other serial dilutions were prepared from this solution. Double trial for each dilution were tested.

Microbiological methods

The TMAB counts of dry fermented sausages were done according to method of (ICMSF, 1983). The Pour Plate Method was used for determining TMAB and TPAB counts of dry fermented fish sausages. One mililiter of inoculum were put into the petridishes and then Plate Count Agar (PCA, Oxoid, CM0325) was poured onto the inoculum. Inoculated petri dishes were incubated for 48 hrs at 30°C for the TMAB analysis. After incubation, colonies on petridishes were enumerated and converted into log cfu/g. The TPAB counts were determined according to method of (Merck, 1998). Plate Count Agar (PCA, Oxoid, CM0325) was also used for the TPAB count as the medium. One mililiter of inoculum was taken from each dilution and then put onto the petri dishes. Then approximately 15-20 ml of Plate Count Agar (PCA, Oxoid, CM0325) was poured onto the each inoculum. Inoculated petri dishes were incubated for 14 days at 4°C for the TPAB analysis. Colonies were enumerated as the TPAB counts and converted into log cfu/g. The LB counts of dry fermented fish sausages were done according to method of (DeMan et al., 1960). Double layer plate method was used for the determination of the LB counts of samples. One mililiter of inoculum was put into the petridishes and then Man Rogosa Sharpe Agar (MRSA) (LAB^M 93) was poured onto the inoculum as double layer. Inoculated petri dishes were incubated for 5 days at 30°C for determining the LB counts of samples. Colonies were enumerated after the incubation as the LB. For the YM counts; Qxytetracycline Yeast Extract Agar (LAB^M X89) was used as medium and the incubation period was for 3-5 days at 30°C. The YM counts were done according to method of (Harrigan and McCance, 1976) by using the Pour Plate method. The *Enterobacteriaceae* counts of dry fermented sausages were done according to method of (Vanderzant and Splittstoesser, 1992). Violet Red Bile Dextrose Agar (VRBD, Merck, 1.10275.0500) was used as medium for the EB counts. The inoculation was done by using the double layer plate method. After inoculation, incubation was done for 24 hrs at 37°C. The *Staphylococcus* bacteria counts were done according to method of (Mossel and Moreno-Garcia, 1985). For the SA counts of dry fermented sausages, Baird Parker Agar (BPA, Merck, 1.05406.0500) was used as medium and the egg yolk tellurite emulsion (Merck, 103785) was used as supplement. After inoculation, inoculated petri dishes were incubated for 30 hrs at 37°C (Mossel and Moreno-Garcia, 1985). All microbiological analyses were done triplicate.

Statistical analysis

Statistical analysis was performed by using the Statistical Program for Social Sciences (SPSS ver. 25.0). The effect of storage periods on to the groups were analyzed. Kruskal-Wallis and Mann-Whitney tests were used for determining the differences of bacteria counts between the groups (Gamgam and Altunkaynak, 2017). The level of significance was indicated as p<0.05 and the level of not significance was as p>0.05.

RESULTS AND DISCUSSION

The microbiological quality of fermented seabass sausage are shown in Table 1. At the beginning of fermentation process; TMAB, TPAB, YM, LB, EB and SA counts of fermented seabass sausages were determined as 2.49, 2.41, 1.15, 2.02, 2.09,<1.0 log cfu/g, while at the end of the storage period of 90 days, the results of the mesophilic, TMAB, TPAB, YM, LB, EB and SA counts of fermented seabass sausage were determined as 6.25, 7.01, 3.61, 5.31, <1.0 ve <1.0 log cfu/g, respectively.

Table 1. The results of the microbiological counts of dry fermented seabass sausage during storage period

Day	Microbiological analyses of dry fermented seabass sausage					
	TMAB (log cfu/g)	TPAB (log cfu/g)	YM (log cfu/g)	LB (log cfu/g)	EB (log cfu/g)	SA (log cfu/g)
1	2.49±0.14 ^{a}	2.41±0.18 ^{a}	1.15±0.21 ^{a}	2.02±0.03 ^{a}	2.09±0.13 ^{a}	<1.0 ^{a}
5	3.91±0.07 ^{b}	3.83±0.03 ^{b}	1.81±0.04 ^{b}	2.26±0.01 ^{b}	1.85±0.05 ^{b}	<1.0 ^{a}
10	4.31±0.18 ^{c}	4.60±0.19 ^{c}	2.02±0.09 ^{c}	3.35±0.05 ^{c}	<1.0 ^{c}	<1.0 ^{a}
15	4.85±0.09 ^{d}	4.93±0.05 ^{d}	2.21±0.05 ^{cd}	4.02±0.03 ^{d}	<1.0 ^{c}	<1.0 ^{a}
30	5.37±0.29 ^{e}	5.52±0.15 ^{e}	2.34±0.06 ^{de}	4.49±0.13 ^{e}	<1.0 ^{c}	<1.0 ^{a}
60	5.43±0.10 ^{e}	5.67±0.07 ^{e}	2.44±0.11 ^{e}	4.75±0.07 ^{f}	<1.0 ^{c}	<1.0 ^{a}
90	6.25±0.37 ^{f}	7.01±0.19 ^{f}	3.61±0.11 ^{f}	5.31±0.06 ^{g}	<1.0 ^{c}	<1.0 ^{a}

n=3 (Mean value ± Standard deviation), the mean value within each column with different small letters are statistically different (p<0.05) according to storage period. TMAB: Total mesophilic aerob bacteria, TPAB: Total psychrophilic aerob bacteria, MY: Yeast-Mould, LB: Lactic acid bacteria, EB: Enterobactericeae , SA: *Staphylococcus aureus*

The microbiological quality of dry fermented trout sausage are given in Table 2. At the beginning of fermentation process; TMAB, TPAB, YM, LB, EB and SA counts of fermented trout sausage were found as 2.47, 2.35, 1.00, 1.95, 1.24 and <1.0 log cfu/g, while at the end of the storage period of 90 days; TMAB, TPAB, YM, LB, EB and SA counts of fermented trout sausage were found as 6.57, 7.20, 4.44, 5.14, <1.0 ve <1.0 log cfu/g, respectively.

Table 2. The results of the microbiological counts of dry fermented trout sausage during storage period

Day	Microbiological analyses of dry fermented trout sausage					
	TMAB (log cfu/g)	TPAB (log cfu/g)	YM (log cfu/g)	LB (log cfu/g)	EB (log cfu/g)	SA (log cfu/g)
1	2.47±0.07^{a}	2.35±0.06^{a}	1.00±0.00^{a}	1.95±0.07^{a}	1.24±0.34^{a}	<1.0^{a}
5	3.82±0.18^{b}	3.83±0.02^{b}	1.59±0.16^{b}	2.32±0.19^{b}	1.15±0.21^{b}	<1.0^{a}
10	4.34±0.19^{c}	4.37±0.17^{c}	1.88±0.04^{c}	3.90±0.07^{c}	<1.0^{c}	<1.0^{a}
15	4.91±0.06^{d}	4.96±0.01^{d}	1.93±0.04^{cd}	4.21±0.06^{d}	<1.0^{c}	<1.0^{a}
30	5.01±0.05^{e}	5.04±0.06^{e}	2.11±0.09^{de}	4.42±0.17^{e}	<1.0^{c}	<1.0^{a}
60	5.02±0.09^{e}	5.29±0.81^{e}	2.25±0.07^{e}	4.55±0.07^{f}	<1.0^{c}	<1.0^{a}
90	6.57±0.08^{f}	7.20±0.14^{f}	4.44±0.33^{f}	5.14±0.10^{g}	<1.0^{c}	<1.0^{a}

n=3 (Mean value ± Standard deviation), the mean value within each column with different small letters are statistically different (p<0.05) according to storage period. TMAB: Total mesophilic aerob bacteria, TPAC: Total psychrophilic aerob bacteria, YM: Yeast-mould, LB: Lactic acid bacteria, EB: Enterobactericeae, SA: *Staphylococcus aureus*

TMAB, TPAB, YM, LB counts of fermented seabass and trout sausages were increased during storage period. Significant differences (p<0.05) were determined in microrganism counts during storage, but not significant differences (p>0.05) were determined in microorganism counts between the groups according to time of storage. TMAB counts of dry fermented seabass and trout sausages were determined as 2.49 and 2.47 log cfu/g on the first day of storage. After 90 days of storage period, TMAB counts of fermented seabass and trout sausages increased to 6.25 and 6.57 log cfu/g, respectively.

TPAB counts of fermented seabass sausage increased from 2.41 to 7.01 log cfu/g, while TPAB counts of fermented trout sausages increased from 2.35 to 7.20 log cfu/g at the end of the storage period. The initial YM counts of fermented seabass and trout sausages were found as 1.15 and 1.00 log cfu/ g., respectively. After 90 days of the storage, these values increased to 3.61 log cfu/g for the fermented seabass sausage and 4.44 log cfu/g for the fermented trout sausage. The LB counts of both fermented sausages increased during storage period. The LB counts of fermented seabass sausages were determined as 2.02, 2.26, 3.35, 4.02, 4.49, 4.75, 5.31 log cfu/g on the 1th, 5th, 10th, 15th, 30th, 60th and 90th day of storage period, respectively. The LB counts of fermented trout sausage increased from 1.95 log cfu/g to 4.21 log cfu/g on the 15th day of storage. During storage period the LB counts of fermented trout sausage found as 4.42, 4.55, 5.14 log cfu/g, on the 30th, 60th, 90th day of storage, respectively. The EB counts of fermented seabass and trout sausages were determined as 2.09 and 1.24 log cfu/g at the begining of the storage, respectively. However, this bacteria counts inhibited on both fermented sausages on the 10th day of storage. The SA was not determined in any of fermented sausages during storage period.

According to the Kruskal Wallis test, there was no significant difference (p>0.05) between the mean values of fermented seabass and trout sausages in terms of the TMAB counts (p-value=0.772). However, the difference between days was statistically significant (p<0.05) for both fish species in terms of the TMAB (p-value=0.000). The Mann Whitney test was done for determining the differences between the days. The difference between the days was not significant (p-value=0.818) on the 30th and 60th days of storage while the difference between all other days was statistically significant (p<0.05) in both groups. There was no significant difference (p>0.05) between the average values in terms of the TPAB counts of fermented seabass and trout sausages (p-value=0.792). However, the difference between two fish species in terms of the days for the TPAB counts found to be statistically significant (p-value=0.000). The Mann Whitney test was also done for determining the differences between the days. The difference between the days was not significant (p-value=0.132) on the 30th and 60th days of storage, while the difference of the TPAB counts between all other days was statistically significant (p<0.05) in both groups. According to the Kruskal Wallis test, there was no significant difference (p>0.05) between the mean values of YM counts for fermented seabass and trout sausages (p-value=0.792), but the difference between days for the two fish species was statistically significant (p-value=0.000). The difference between the days was checked by using the Mann Whitney test. The difference between the days was not significant on the 10th and 15th days of storage was (p-value=0.180), 15th and 30th days of storage was (p-value=0.180), 30th and 60th days of storage was (p-value=0.180). However, the difference between all other days was found as statistically significant (p<0.05). There was no significant difference between the mean value of of LB counts of fermented seabass and trout sausages (p-value=0.85), but the difference between days was statistically significant (p<0.05) for the both fish species (p-value=0.000).

The difference between all days was checked by using the Mann Whitney test. Statistically significant difference ($p<0.05$) between all days were determined between the both groups.

The TMAB count was not only a good indicator for deciding the acceptability of fermented food products but also, it should be considered together with the number of LB of these products whether or not they were suitable for consumption (Ünlütürk and Turantaş, 2003). Ekici et al. (2015) reported that the TMAB counts of dry fermented sausages were determined as ~8.5 log cfu/g. In another report, the TMAB in fermented sausages was reported to be between 6.00 and 7.00 log cfu/g (Ekici and Omer, 2018). In our study, the TMAB counts of fermented seabass and trout sausages were determined as 6.25 and 6.57 log cfu/g at the end of the storage period of 90 days. During storage period at 6-8 ˚C, the TPAB counts of the both fermented fish sausages were determined higher than the TMAB counts of the fermented fish sausages after 5th day of storage. The total number of TMAB in fermented sausages obtained under hygienic conditions should be below 6.0 log cfu/g (Öksüztepe et al., 2011). Both fermented seabass and trout sausages exceeded this limit (6.0 log cfu/g) on the 90th day of storage in our study.

Arslan and Soyer (2018) reported that sausages were exposed to the high humidity during the fermentation process, which could be caused the growth of both desirable and undesirable fungi on the surface of sausages. Furthermore, controlled molds growth was reported that they gave sausages a typical flavor as a result of degredation of lipids and proteins. However, uncontrolled mould growth was indicated that they could be responsible for the discoloration of the surface of sausages as well as spoilage. In our study, the YM counts of fermented sea bass sausage changed from 1.15 to 3.61 log cfu/g, while the YM counts of fermented trout sausages changed from 1.00 to 4.44 log cfu/g after 90 days of storage. Arslan et al. (2001) found that the number of YM counts were determined increasing in all groups of fermented *Cyprinus carpio* sausages from 1 to 30th day of storage. At the end of the 30th day of storage; the YM counts of four different *Cyprinus carpio* sausages were found to be as 4.59, 4.88, 4.79 and 4.60 log cfu/g.

In this study the authors reported that the excessive number of the YM counts of fermented products could be due to the growing the ability of the YM in these type of products easily. Besides, the authors denoted that the fermented products could be contaminated with the food additives, particulary from the spices (Arslan et al., 2001). In another study; the YM counts of the traditional fermented sausages were described as varied from 3 log cfu/g to 5 log cfu/g (Erkmen and Bozkurt, 2004). Ekici et al. (2015) defined that exhibited significant variations among the YM counts of samples ranging from 3.54 log cfu/g to 5.21 log cfu/g. The yeast and mould counts of Milano type of traditional fermented sausages were found as 4.2 ±0.08 and 4.8 ±0.03 log cfu/g, respectively (Haouet et al., 2017). In our study, the YM count of the dry fermented seabass sausage increased to 3.61 log cfu/g, while the YM count of fermented trout sausage increased to 4.44 log cfu/g at the end of the storage period. Our results were well accordance with the above studies (Arslan et al., 2001; Erkmen and Bozkurt, 2004; Ekici et al., 2015; Haouet et al., 2017) about the number of YM of fermented products.

According to Institute of Turkish Standards (2002), the maximum level of the YM counts of dry fermented meat product was defined as microbiologically to be 2.00 log cfu/g.

In the study, fermented seabass sausage reached this limit on the 10th day of storage, whereas fermented trout sausage reached this limit on the 30th day of storage. The high number of YM on dry fermented sausages could be from the spices that used in the study. For this reason, the authors thougt that the spices should be prefered at the best hygienic quality for producing dry fermented fish sausages. The LB counts of both fermented fish sausages increased during storage period. At the end of the storage period; the LB counts of fermented seabass sausage increased from 2.02 to 5.31 log cfu/g while the LB counts of fermented trout sausages changed from 1.95 to 5.14 log cfu/g.

In one report; high number of LB in the fermented sausages was reported by the authors that this group of bacteria was to be the predominant flora of the fermented sausages (Arslan and Soyer, 2018). In another report; the LB counts of fermented sausages were reported to be responsible for the quality development of these products during processing as well as the qualities of fermented sausages could be affected by the LB during marketing (Yaman et al., 1998). Adab et al. (2018) reported that the acidifying activity of the LB that an important role in the stability of the dry fermented meat products, following the inhibition of the growth of the pathogenic and spoilage microorganisms. In our study, the results of the increasing of the LB counts in the dry fermented fish sausages were in agreement with those of (Yaman et al., 1998; Arslan and Soyer, 2018; Adab et al. 2018).

The authors revealed in one study that the addition of the spice, especially cinnamon into the dry fermented sausages was an advisable to improve the sensory quality and also the inhibition of the growth of *Enterobacteriaceae* (Sun et al., 2018). The result of our study was well correlated with this above study (Sun et al., 2018) about the inhibition of the growth of the EB in dry fermented fish sausages. The EB count of fermented sausages was a good indicator for the sanitary of the production conditions (Arslan and Soyer, 2018). In one report, the number of EB species in the processing period of fermented meat products decreased due to the acidification. Moreover, fast acidification was resulted in a significant reduction in the number of this type of bacteria was reported by (Lücke, 1985). In another study, the authors also indicated that the EB count decreased during the production process of the fermented meat product (Kaban and Kaya, 2009). In our study, the EB count decreased in the both groups of the fermented fish sausages on the 5th day of storage and then it was determined to be lower than the detection limit on the 10th day of storage. Our results were determined well correlation with these above investigations (Lücke, 1985; Kaban and Kaya, 2009) about decreasing and inhibition of this type of microorganisms in dry fermented sausages.

Kaban and Kaya (2006) reported that *S. aureus* was an important foodborne pathogenic bacteria in fermented meat sausage. In one report the authors showed that pathogenic and spoilage bacteria could not grow in the finished fermented fish sausages because of good hygienic procedure of processing. In their study the authors determined the decreasing of bacteria during processing. Additionally, they reported that the pathogenic bacteria was not detected during storage (Stollewerk et al., 2014). Scetar et al. (2013) also reported that the good hygienic quality during the entire processing and storage as no pathogens were detected in their study. Similar results were observed in our study with these above studies that the SA was not detected in the both groups of fermented fish sausages during storage period in the refrigerator.

CONCLUSION

In conclusion, dry fermented fish sausage can be a healty alternative product to fermented meat products in Turkey because of health benefits of fish. In our study; we produced fermented fish sausages by using seabass and trout fillets in laboratory conditions. However, cheap, discarded and economical fish species can be evaluated for producing fermented fish sausages as well. In the study, both fermented fish sausages were determined as too much dried and exceeded the microbiological limit (6.0 log cfu/g) of TMAB on the 90 th day of storage in the refrigerator at 6-8˚C. Moreover, the maximum level of the YM counts of dry fermented meat product was defined as microbiologically to be 2.00 log cfu/g according to the Turkish Standards (2002). Therefore, fermented seabass sausage reached this limit on the 10th day of storage, whereas fermented trout sausage reached this limit on the 30th day of storage. As a result, it is suggested that fish sausages should be packaged in vacuum packaging because of preventing too much drying and the growth of undesirable moulds. Additionally, good hygienic qualified spices or natural compounds should also be used for preventing the growth of undesirable moulds on dry fermented fish sausages. Limited studies have been done about the production and determination of the qualities of dry fermented fish sausages. For this reason, much more studies should be advised to be done about dry fermented fish sausages. The studies should also be done about the identification of microorganisms of fermented fish sausages during storage period to determine desirable and undesirable microorganisms. The production, standardization and consumption of dry fermented fish sausage just like traditional dry fermented meat products in Turkey would be possible in the near future.

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