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THE EFFECT OF ACTIVE AND VACUUM PACKAGING ON THE QUALITY OF TURKISH TRADITIONAL SALTED DRIED FISH "ÇİROZ"

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Abstract:

Changes in biochemical and sensory attributes of Turkish traditional salted dried fish products "çiroz" during storage packaged by oxygen absorber and vacuum were investigated. For this purpose, total volatile basic nitrogen (TVB-N), trimethylamine nitrogen (TMA-N), TBA index values (TBA-i), free fatty acids value (FFA) and peroxide value (PV), sensory attributes and microbiological analyses were carried monthly during storage. According to sensory analysis and TVB-N results, the samples of çiroz packaged active and vacuum, spoilt on the 6th months at cold storage. TBA-i, FFA and PV of fatty oxidation parameter showed similarity in both groups of samples. Microbiological findings did not exceed limit values during storage in both groups. When comparing two types of packaging, it is concluded that the active package, which is a new approach, may be an alternative to vacuum packaging. This was determined by the study; oxygen-absorbing systems could be used to pack fish products sensitive to oil oxidation.

Keywords: Salted dried fish, Active packaging, Oxygen absorber, Vacuum packaging, Quality

Introduction

Salting and drying are one of the oldest methods used in fish preservation. These methods are effective in the production of traditional fish products. These methods can be used individually or in combination. The preservative effect of salting and drying is mainly due to the decrease in water activity. Thus, the growth of many spoilage organisms is prevented (Schormüller, 1968; Sikorski et al., 1990; Tülsner, 1996; Albarracín et al., 2011). Salted cod is a traditional fish product of choice in the northern Atlantic region, whereas salted sardine salted anchovy are traditional fish products preferred in the Mediterranean and the Black Sea. Salting and drying techniques are used together in some fish products. The product called klippfish is one of these. Klippfish are popular most particularly in Germany, Norway, Newfoundland, Iceland, and the Faroe Islands. This product can be made with whitefish; fatty fish is not preferred. The fish is beheaded and eviscerated, dry salted and the fish was sun- dried on rocks or wooden frames. Today drying process is usually done indoors by electrical heating. Especially preferred for klippfish is cod, may be produced from other whitefish, such as Pollock, haddock, blue whiting, ling and tusk (Schormüller, 1968; Xie and Myrland, 2010; Ceballos, 2012). Traditional salted dried fish products made in the Aegean and Marmara regions of Turkey and Greece are called çiroz. Unlike klippfish, fatty fish is preferred. Fatty fish such as Atlantic horse mackerel (*Trachurus trachurus*), Mediterranean horse mackerel (*Trachurus mediterraneus*)**,** chub mackerel (*Scomber japonicus*) and Atlantic mackerel (*Scomber scombrus*) are caught after egg casting (when they have lower fat content), are eviscerated, dry salted, then dried in slightly windy, low humidity air (Özden, et al., 2001; Kolcuoğlu, 2013). The products are often vacuum or air packed and stored at chilled temperatures.

Active packaging is a new concept of food packaging, was developed in response to changes in current consumption and market trends and is designed to improve fresh and processed sea food product quality and safety (Quintavalla & Vicini, 2002; Kerry et al., 2006). Active packaging refers to the incorporation of certain additives into packaging systems with the aim of maintaining or extending product quality and shelf-life. Packaging may be termed active when it performs some desired role in food preservation other than providing an inert barrier to external conditions (Floras, 1997; Ahvenainen, 2003). Active packaging systems involve oxygen scavenging, moisture absorption, carbon dioxide or ethanol generation, and finally antimicrobial systems (Coma, 2008). Oxygen absorbing systems provide an alternative to vacuum and gas flushing technologies as a means of improving product quality and shelf life (Kerry et al., 2006)

To the best of our knowledge, there is no information in the literature on the use of active packaging for the preservation of dried fish products. The aim of this study was to compare the effects of vacuum and active packaging on the shelf life and quality of salted dried fish stored at cold storage.

Materials and Methods

Çiroz was prepared from Atlantic mackerel (*Scomber scombrus* Linnaeus, 1758). Atlantic mackerel (246.9 ±60.1 g and 28.04 ±2.28 cm) was obtained from Bozo Balıkçılık, İstanbul fish market. The product preparation process is shown in Figure 1.

The products (75 g per pouch) was placed in low density polyethylene/ethylene vinyl alcohol/low density polyethylene pouch (LDPE/EVOH /LDPE; thickness: 55 µm, O_2 transmission: 5 cm^3/m^2/day/24 h; vapour permeability: 7.50 g/m^2/24 h). Samples was divided into two groups. In first group (AP) was added inside the package three OxyFree 504 type iron based O_2 absorber (Süd-Chemie Company, İstanbul, Turkey). The first group pouches were heat sealed using a Henkovac model vacuum sealer (ML's-Hertogenbosch Nederland). The second group (VP) were vacuum packaged using a Henkovac model vacuum machine and all samples were stored at 2 ±2°C.

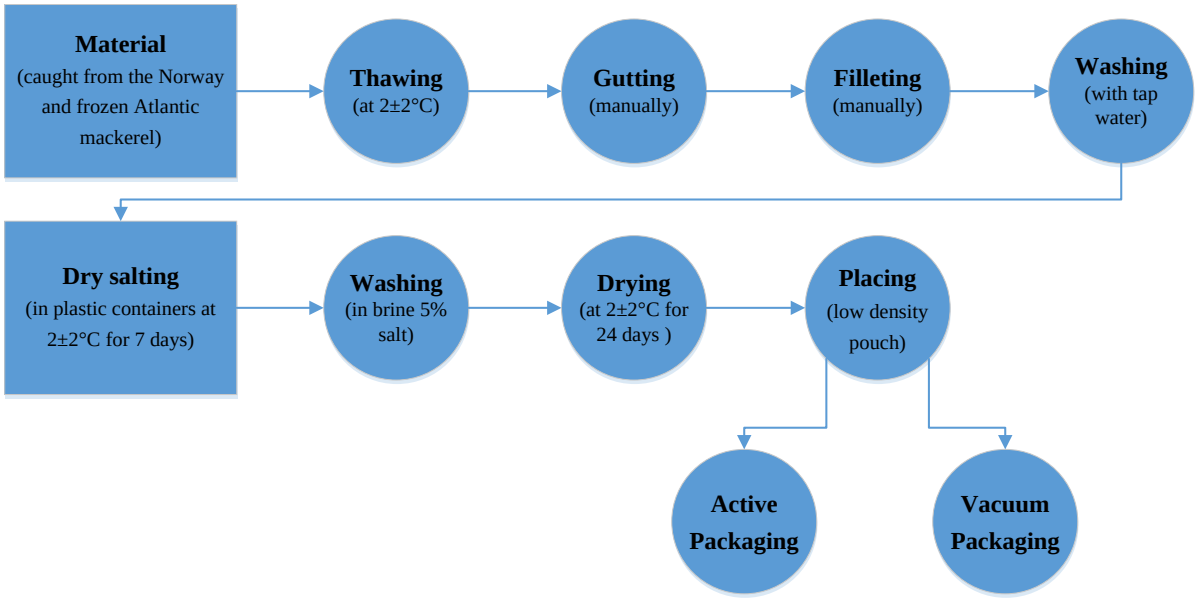

Figure 1. The production process of Turkish traditional salted dried fish "çiroz"

Sensory analysis: Sensory testing was performed after the fallowing desalting procedure. The fillets were soaked in drink water (ratio 1:5) for 30 min. This process is repeated three times. The fillets were drained and served with 2% citric acid, lemon and olive oil. The attributes of çiroz were evaluated by a panel of five experienced judges on each month of sampling in individual booths under controlled conditions of light, temperature and humidity. Sensory analysis was performed using the methods of Erkan and Bilen (2010). Desalted çiroz samples were assessed on the basis of appearance, odour, taste and texture characteristics using a nine-point descriptive scale. A score of 9-7 indicated ''very good'' quality, a score of 6.9–5.0 "good or acceptable quality", a score of 4.9–1.0 "unacceptable quality". The appearance, odour, taste and colour of the samples were evaluated, and the mean values of these attributes were presented.

***Chemical analysis*:** Moisture, protein, ash, water and salt content of product were measured by Mattissek et al. (1992) method. Total volatile basic nitrogen (TVB-N, mg/100g fish flesh), trimethylamine nitrogen (TMA-N, mg/100g fish flesh), TBA index values (TBA-i, mg/ malondialdehyde (MDA)/kg), free fatty acids value (FFA, oleic acid %) and peroxide value (PV, meq O_2/kg fish flesh) was determined according to the method described by Erkan & Bilen (2010).

Microbiological analysis

Samples (25g) obtained from çiroz fillet, were transferred aseptically to a Stomacher bag (Seward Medical, London, UK) containing 225 mL of 0.1% peptone water (Merck, 107228) and homogenized for 60 s using a Lab Blender 400, Stomacher at high speed (Stomacher, IUL Instrument, Spain). For microbial count, 0.1 mL samples of serial dilutions (1:10, diluents, 0.1% peptone water (Merck, 107228, Darmstadt, Germany) of fish homogenates were spread on the surface of agar plates. Plate count agar (PCA) was used for psychrotrophic bacteria and incubated at 7°C for 10 days. Anaerobic counts were determined by PCA incubated under anaerobic conditions (with 5 % CO_2 incubator, HF 90 model, Shanghai, China) at 30°C for 24-48 h. Extremely halophilic bacteria were enumerated in halophilic agar (25 % NaCl) incubation after at 30ºC for 7 day. Results are expressed as a logarithm of colony forming units (log cfu) per gram of sample. Thus, the detection limit of psychrotrophic, anaerobic and extremely halophilic bacteria counts was <1.00 log cfu/g. All the analyses were performed in duplicate. For anaerobic sulphite-reducing *Clostridium* count, 25 g of sample were homogenized and incubated at 30°C for 14 days in Differential Reinforced Clostridial *Broth* (*DRCM*, Merck 1.11699) under anaerobic condition. Results were expressed as log MPN/g of samples (Bell et al., 2005).

***Statistical analysis*:** For each group, data from two independent replicate trials were pooled and the mean values and standard deviations were determined. Differences between groups were determined by Tukey test and were considered to be significant when $p<0.05$.

Results and Discussion

Acceptability scores for sensory properties of active and vacuum packaged çiroz samples decreased (significant, $p<0.05$) during the storage. The acceptability limit for sensory scores was reached after 5 months for the two groups' samples. Not significant difference ($p>0.05$) was observed between the groups during the storage. There was no reported scientific study for the sensory acceptability of çiroz or dried fish samples. It is reported that the shelf life dried fish products is about one year, although it varies according to the salting and drying process, fish species, packing type and storage condition (Tülsner, 1994). The shelf life of active packed fish products were found higher than that of aerobically packaged products (Mexis et al., 2009).

The amount of salt used in dry salting was twenty percent of the total fish weight. The salt content in product and the salt content in tissue water of product also moisture content of salted fish was measured after seven days of salting process, were found as 12.25 ±0.5 %, 24.13 ±0.3 % and 35.5 ±0.5 %. If the amount of salt in the tissue water of product is above 24 percent, it is defined as heavily salted product (Tülsner, 1996). The salt content in product, the salt content in tissue water of product and moisture content of products were found as 15.0 ±0.7 %, 41.09 ±0.5 % and 18.5 ±0.2 % after 24 day of drying process. For fresh fish and çiroz samples, the chemical composition values were determined as follows: moisture 50.1 ±1.1 mg/100g and 18.5 ±0.2 mg/100g, ash 1.3 ±0.1 mg/100g and 5.2 ±0.3 mg/100g, total protein 20.4 ±2.0 mg/100g and 38.28 ±2.0 mg/100g, total fat 25.08 ±0.8 mg/100g and 37.42 ±0.6 mg/100g. This is in agreement with the conclusions made by literature data (Guizani et al., 2008; Selmi et al., 2010; Bae et al., 2011).

The relationship between results of TVB-N and sensory data was found excellent for vacuum and active packaging çiroz samples. Sikorski et al. (1990) reported that the limit of acceptability for fatty fish was 20 mg TVB-N/100 g of flesh. The release of total volatile bases increased up to 21.20 ±3.40 mg/100 g for çiroz in vacuum packaging and 17.08 ±3.48 mg/100 g in active packaging at the last day of sensory acceptability for each packaging condition. The statistical analysis of TVB-N data showed that not significant differences ($p>0.05$) were found between packaged in active and vacuum çiroz samples after 5 months of storage. Similarly, TMA-N value of samples increased throughout storage. However, there were no significant differences ($P>0.05$) between the TMA-N values at every stages of storage of çiroz in vacuum packaging and active packaging. The limit values of TMA-N were reported as 5 mg/100g for fatty fish species (Sikorski et al., 1990). This limit value was not exceeded throughout the storage in active and vacuum packaged samples.

Atlantic mackerel, which is a raw material of çiroz, has polyunsaturated fatty acids and are sensitive to peroxidation. Free radicals react with oxygen to produce fatty acid peroxides. The fatty acid peroxides are free radicals which can attack another lipid molecule, resulting in peroxide and a new free radical. The primary product of lipid oxidation is the fatty acid hydroperoxide, measured with peroxide value (PV) (Hamre et al., 2003). As seen in table 1, initial PV values were 5.69 ±2.14 meq O_2/kg for çiroz packaged in oxygen absorber and 5.83 ±2.30 meq O_2/kg for çiroz packaged in vacuum. The maximum values of PV were found 39.66 ±1.04 meq O_2/kg for çiroz packaged in oxygen absorber in the sixth month of storage and 41.94 ±1.33 O_2/kg for çiroz packaged in vacuum in the five month of storage. Similar results were reported by Selmi et al. (2010) for dried fish products.

As a consequence of oxidative spoilage, lipid hydroperoxides are formed, which, in turn, are unstable and decompose to aldehydes, ketones, alcohols, acids or hydrocarbons. These so-called secondary oxidation products can change food quality parameter, namely, colour, texture, flavour and odour (Andersen et al., 2007; Azad Shah et al., 2009; Christensen et al., 2011). One of the most important products of seconder oxidation is malondialdehyde (MDA), MDA has often been used as marker of oxidative damage in fatty foods. The most widely used method for determination of MDA is the spectrophotometric determination of the pink fluorescent MDA-thiobarbituric acid (MDA-TBA) complex produced after reaction with 2-thiobarbituric acid (TBA) at low pH and high temperature (Hamre et al., 2003). The TBA

value is an important parameter in determining lipid oxidation (Insausti et al., 2001). At the beginning of the storage, TBA values were found as 9.39 ±0.63 and 9.47 ±0.73 mg malonaldehyde/kg fish flesh, for the first 5 months of storage in all samples showed a continuous increase, after 5 months the value of TBA showed declines were observed (Table 1). It has been reported that in many literatures the negative changes in taste and smell become apparent when the TBA value reaches its maximum value (Guilluén-Sans and Guzmán-Chozas, 1998). Similar results were found in this study. The significant decrease in sensory values (acceptable limit) and the maximum value of TBA were measured at the fifth month of storage.

Glycerides, glycolipids and phospholipids in fatty fish muscle are hydrolysed by lipases to free fatty acids, which then undergo further oxidation to produce low molecular weight compounds, such as aldehydes and ketones. These compounds are responsible for off-flavour and off-odour and taste of fish and fish products (Hamilton et al., 1997). Initial values ranged from 2.10 to 2.50 (% of oleic acid) while final values ranged from 4.08 to 3.35 for çiroz packed in oxygen absorber and vacuum, respectively. These results indicate that there is a relationship between FFA release and loss of freshness. In the present study, the production of peroxide and free fatty acid was also slower in çiroz samples packaged in oxygen absorber than çiroz samples packaged in vacuum.

Table 1. Changes in sensory and chemical properties of Turkish traditional salted dried fish "çiroz"

Storage time (Monthly)		**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Sensory score	AP	8.75 ±0.15^{A}	7.43 ±0.12^{A}	6.85 ±0.13^{A}	6.58 ±0.15^{A}	5.80 ±0.12^{A}	**5.20 ±0.08**^{A}	4.95 ±0.11^{A}	4.35 ±0.13^{A}
	VP	8.45 ±0.25^{A}	7.30 ±0.08^{A}	6.65 ±0.10^{A}	6.38 ±0.19^{A}	5.75 ±0.05^{A}	**5.10 ±0.05**^{A}	4.85 ±0.08^{A}	4.13 ±0.10^{A}
TVB-N (mg/100g fish flesh)	AP	2.64 ±0.51^{A}	4.93 ±0.92^{A}	8.71 ±2.02^{A}	11.75 ±3.53^{A}	13.60 ±2.64^{A}	17.08 ± 3.48^{A}	**21.30** ±3.50^{A}	22.43 ±3.48^{A}
	VP	2.95 ±0.37^{A}	10.01 ±0.09^{B}	12.36 ±2.11^{B}	14.90 ±0.29^{B}	18.74 ±0.24^{B}	**21.20 ±3.40**^{A}	22.43 ±3.92^{A}	23.92 ±2.06^{A}
TMA-N (mg/100g fish flesh)	AP	1.64 ±0.16^{A}	2.03 ±0.15^{A}	2.44 ±0.01^{A}	2.72 ±0.04^{A}	3.09 ±0.47^{A}	3.20 ±0.64^{A}	3.39 ±0.76^{A}	3.64 ±1.04^{A}
	VP	1.73 ±0.07^{A}	2.16 ±0.28^{A}	2.61 ±0.10^{B}	3.00 ±0.37^{A}	3.19 ±0.52^{A}	3.28 ±0.61^{A}	3.61 ±0.81^{A}	4.16 ±1.30^{A}
PV (meq O_2/kg fish flesh)	AP	5.69 ±2.14^{A}	15.25 ±2.94^{A}	23.45 ±1.39^{A}	26.66 ±2.89^{A}	28.31 ±2.96^{A}	32.59 ±2.92^{A}	**39.66** ±1.04^{A}	12.30 ±2.50^{A}
	VP	5.83 ±2.30^{A}	17.37 ±3.97^{A}	24.95 ±0.37^{A}	31.17 ±0.56^{B}	34.42 ±0.26^{B}	**41.94** ±1.33^{B}	15.64 ±1.30^{B}	8.37 ±2.17^{B}
TBA-i (mg malonaldehyde/kg fish flesh)	AP	9.39 ±0.63^{A}	11.30 ±0.98^{A}	11.82 ±0.66^{A}	12.77 ±0.28^{A}	13.20 ±0.23^{A}	**15.84** ±0.34^{A}	8.96 ±1.19^{A}	7.93 ±2.00^{A}
	VP	9.47 ± 0.73^{A}	11.67 ±0.85^{A}	13.27 ±0.04^{B}	13.58 ±0.17^{B}	14.18 ±0.36^{B}	**17.32** ±0.08^{B}	9.45 ±0.12^{A}	6.85 ±0.80^{A}
FFA (g oleic acid/100g fish flesh)	AP	2.10 ±0.64^{A}	2.32 ±0.46^{A}	2.58 ±0.28^{A}	2.80 ±0.22^{A}	3.34 ±0.08^{A}	4.03 ±0.22^{A}	**4.51** ±0.22^{A}	4.08 ±0.32^{A}
	VP	2.50 ±0.10^{A}	2.59 ±0.14^{A}	2.70 ±0.26^{A}	3.13 ±0.04^{B}	3.75 ±0.06^{B}	**4.27** ±0.15^{A}	3.93 ±0.03^{B}	3.35 ±0.15^{B}

In these hard salted products, halophilic bacterial growth is possible and extremely halophilic bacteria should be analysed on these products (Tülsner, 1994). In this study, the psychrotrophic, anaerobic and extremely halophilic bacteria count all during storage was not exceeded over 4 log cfu/g in both groups. Anaerobic sulphite-reducing *Clostridium* count was determined <1 log cfu/g in packaged vacuum and oxygen absorber çiroz samples during the storage. Hernández-Herrero et al., (1999) reported a similar microorganism load for extremely salted anchovy products.

Conclusion

As a result, it can be said that the active packaging systems using oxygen absorber in the packaging of çiroz products may be an alternative to vacuum packaging. Quality losses due to fatty oxidation are important for a traditional salted dried fish product "çiroz". While the preferred vacuum packaging system for fatty oxidation requires equipment, active packaging systems by oxygen absorbers, an alternative packaging approach, appear to be an alternative to packaging of fish products sensitive to fatty oxidation.

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