DOI: 10.7251/QOL1901047G **UDC:** 597.556.31:664

Original scientific paper

Impact of Vacuum Packaging and Modified Atmosphere Packaging of Marinated Mackerel on Aerobic Bacteria Growth

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Abstract: Fish as a food is very acceptable for consumers. Various species of fishes nowdays are everyday on our tables. Fish from north seas are also in high demand from consumers, but it is challeng to keep and transport fish to consumers. Thats why as prevention of spoiling fish before consumation is to keep it on special regime. In our challeng we packaged fish in vaccum and modified atmosphere, and than followed the growth of aerobic bacterias mainly cause of spoilage.

Key words: Fish, Mackerel, Vacuum package, Modified atmosphere, aerobic bacteria.

INTRODUCTION

Fish is very significant source of the animal proteins in a whole world. Annual fishing is approximately 100 mil tonnes, where approximately 70 Mill tonnes use for human consumption. Beside of wild fish, for human consumption every year globbaly demmand is approximatelly 40 Mil tonnes of aquacultured fish. About ¼ of total quantity is using as fresh fish, and the rest is processing in different ways (freezing, salting, drying, smoking, canning). Mackerel is on top ten list of fishies cached with net in seas, with annual quantity of catched fish from more than 1 Mill tonnes. Mackerel belongs to a scombroid type fish, containing more fats in its body. Mackerel is significant source of proteins, also rich in unsaturated fatty acids, esspecialy omega-3 fatty acids. Containing omega 3 fatty acids makes this fish as a good choice for human consumption as prevention of cardiovacular diseases and diabetes (Sidhu, 2003; Duyar i Eke, 2009).

Fish as food is easy spoiling food, and spoilage is result of complex chemical, microbiological and physical mechanismus. Enzymatic and chemical reactions are most important for spoilage beguining. For qualuty characterisation of the fish during processing and keeping, methods used for microbiological, chemical, physical and sensoric analysis are internationaly standardised. стандардизоване (Stohr и cap., 2001).

Microbiology testing are wide range of methods and one of the most important is total plate count of aerobic mesophilic bacteria.

Fish spoilage can be prevented by processing, canning and packaging. These fish processing enable fish preservation for longer time than fresh fish.

Marinating is one of the oldest type of fish processing, widely used in Europa. This proces of marinating mainly use for fishes with higher percent of fat, such as assoc.dine, mackerel, herring, and often for crabs and shells to (Duyar i assoc.., 2000).

The most suitable way to put fish on the market is as packaged fish. Packaged fish can be provide to consumers as fish packaged in vacuum or modified atmosphere. If packaged in vaccum, removing air from package, we create anaerobic/microaerophilic environment, increasing CO_2 and reduction of pH. Residual oxyigen, are used by tissue and bacteria, transforming to CO_2 which enables growth of anaerobic bacteria and facultative aerobes. By simple vaccuming process we extend the usage of fish but also enable drying of the product. For that reasons packaging of fish (food in general) in mixture of gases, or MAP (*Modified Atmosphere Packaging)* leading technology for packaging in 21 st century. Diference betwen 2 procedures, is that for the vacuum inside we have process of creating mixture of gases while where used MAP we inject gases to create same environment (Günsen и assoc.., 2010; Günsen и assoc.., 2011).

It is reccomendation for fat type of fishes to use MAP as 60% CO_2 и 40% N_2 mixture of gases. Data for marinated fish packaging, are not easily available, so the reccomendation for the mixture of gases for this food is not available (Ruis-Capillas i Moral, 2001; Günsen и assoc.., 2011; Gökoğlu i assoc.., 2004).

Tabela 1. Efect on expiration date of fish and fish products in mixture of gasest (Siverstvik i assoc.., 2002)

Fish/product	T (ºC)	Atmospher $CO_2 : N_2 : O_2$	Days	Refernce
Filets catfish (*Icatalurus punctatus*)	2	80 : 20	28	***Silva and White (1994)***
Filet african catfish	16	Vazduh	3	***Reddy and assoc.. (1997a)***
	16	75 : 25 : 0	4	
	16	Vakuum	3	
	8	Vazduh	6	
	8	75 : 25 : 0	13	
	8	Vakuum	6	
	4	Vazduh	13	
	4	75 : 25 : 0	38-40	
	4	Vakuum	20-24	
Filet cod (*Gadus morhua*)	1	CA 60 : 40 : 0	12	***Woyewoda and assoc.. (1984)***
	1	60 : 40 : 0	12	
	1	Vazduh	9	
Filet Cod (*Gadus morhua*)	2	40 : 60 : 0	11	***Guldager and assoc.. (1998)***
	2	40 : 60 : 0	20	
	2	40: 40 : 20	13	
Filet Cod	16	Vazduh	3-4	***Reddy and assoc.. (1999)***
	16	75 : 25: 0	6	
	16	Vakuum	3-4	
	8	Vazduh	13-17	
	8	75 : 25: 0	24-27	
	8	Vakuum	13	
	4	Vazduh	20-24	
	4	75 : 25 : 0	55-60	
	4	Vakuum	24-27	
Filet Cod	0	40 : 30 : 30	12,5	***Cann and assoc.. (1983)***
	5	40 : 30 : 30	<7	
	10	40 : 30 : 30	3	
	0	Vakuum	9	
	5	Vakuum	<4	
	10	Vakuum	2	
Cod (*G. morhua*)	2	100 : 0 : 0	10	***Jensen and i assoc.. (1980)***
	2	60 : 40 : 0	10	
	2	40 : 60 : 0	9-10	
	2	Vakuum	8-9	
	2	Vazduh	7	
Cod (*G. morhua*) fish/Filet	0	Vazduh	12-13	***Villemure and assoc.. (1986)***
	0	25 : 75	20	
Filet Cod (*G. morhua*)	0	2 : 98 : 0	14	***Dalgaard and assoc.. (1993)***
	0	3: 97 : 0	13	
	0	29 : 71 : 0	16	
	0	48 : 52 : 0	20	
	0	97 : 3 : 0	15-16	

Filet Cod (*G. morhua*)	26	100 : 0 : 0	2-3	***Post and assoc.. (1985)***
	26	Drugi gasovi	2	
	12	Vazduh	6	
	12	Vakuum	10	
	12	0 : 100 : 0	13	
	12	100 : 0 : 0	11	
	8	Vazduh	6	
	8	Vakuum	16	
	8	0 : 100 : 0	17	
	8	100 : 0 : 0	23	
	8	90 : 8 : 2	17	
	8	65 : 31 : 4	16	
	4	100 : 0 : 0	40-53	
Blue Cod (*Arapercis colias*) smoked Filet	3	100 : 0 : 0	49	***Penney et al. (1994)***
	3	Vakuum	14	
	3	Vazduh	14	
	-1.5	100 : 0 : 0	113	
	-1.5	Vakuum	35	
	-1.5	Vazduh	28	
Crab (*Pacifastacus leniusxulus*)	4	80 : 20 vazduha	21	***Wang and Brown (1983)***
	4	Vazduh	14	
Romb fish (*Limanda ferrugina*)	26	Vazduh	2	***Post and assoc.. (1985)***
	26	Vakuum	2	
	26	0 : 100 : 0	4	
	26	100 : 0 : 0	1	
	12	Vazduh	5	
	12	Vakuum	8	
	12	0 : 100 : 0	7	
	12	100 : 0 : 0	8	
	8	Vazduh	5	
	8	Vakuum	7	
	8	0 : 100 : 0	4	
	8	100 : 0 : 0	10	
Cod, (*Melanogrammus aeglefinus*)	0	40 : 30 : 30	10	***Dhananjaya and Stroud (1994)***
	0	Vazduh	8	
	5	40 : 30 : 30	7	
	5	Vazduh	7	
	10	40 : 30 : 30	4	
	10	Vazduh	4	
Cod, Filet (*Melanogrammus aeglefinus*)	0	60 : 20 : 20	14	***Dhananjaya & Stroud (1994)***
	0	Vazduh	10	
Hake (*Merluccius merluccius)* slajs-ovani Filet	2	50 : 45 : 5	14	***Pastoriza and assoc.. (1998)***
	2	50 : 45 : 5	16	
	2	Vazduh	7-8	
Herring, Filet	2	20 : 80 : 0	3	***Randell and i assoc.. (1995)***
	2	20 : 80 : 0	3	
	2	40 : 60 : 0	6	
	2	40 : 60 : 0	8	
	2	Vakuum	3	
Herring (*Clupea harengus*) fillets	0	60 : 40 :0	14	***Dhananjaya and Stroud (1994)***
	0	Vazduh	12	
Herring, cela (*C. harengus*)	0	60.40:0	14	***Dhananjaya and Stroud (1994)***
	0	Vazduh	12	
BAss *(Morone saxatilis, M. chrysops)*	2	60 : 34 : 6	13	***Handumrongkul and Silva (1994)***
	2	Vazduh	7	

Mackerel, Filet (*Scombrus scombrus L.)*	-2	100 : 0 : 0	>21	***Hong and assoc.. (1996)***
Cod, Filet (*Sebastes spp.*)	1.7	CA 80 : 20 vazduha	13	***Parkin and assoc.. (1981)***
	1.7	Vazduh	6	
Salmon, Filet (*Salmo salar*)	2	100:0:0	18	***Pastoriza and assoc.l. (1996)***
	2	Vazduh	8	
Salmon, Filet (*Oncorhynchus tahawytsacha*)	4.4	60 : 15 : 25	12	***Stier and i assoc.. (1981)***
	4.4	Vazduh	6	
	22.2	60 : 15 : 25	2	
	22.2	Vazduh	1	
Salmon, Filet	16	Vazduh	4	***Reddy and assoc.. (1997b)***
	16	75 : 25 : 0	5-6	
	16	Vakuum	3	
	8	Vazduh	13-17	
	8	75 : 25 : 0	20-24	
	8	Vakuum	>6; >10	
	4	Vazduh	24-27	
	4	75 : 25 : 0	55-62	
	4	Vakuum	34-38	
Salmon,	0	60 : 40 : 0	12,9	***Cann and assoc.. (1984)***
	5	60 : 40 : 0	7.1	
	10	60 : 40 : 0	3.4	
	0	Vakuum	11.8	
	5	Vakuum	8	
	10	Vakuum	3	
Salmon, Filet (*S. salar*) fillets	2	60 : 40 : 0	17	***Randell and assoc.. (1999)***
	2	40 : 60 : 0	17	
	2	Vakuum	17	
	2	Vazduh	11	
Assoc.dine (*Assoc.dinops melanostictus*)	5	80 : 20 : 0	4	***Fujii and i assoc. (1989)***
	5	20 : 80 : 0	4	
	5	Vazduh	2	
Shrimp, sa glavom ili bez nje (*Pandalus platyceros*)	0	CA 100 : 0 : 0	>14	***Matches and Layrisse (1985)***
	0	Vazduh	7	
	0	Vazduh	7	
Snaper, Filet (*Chrysophrys auratus*)	3	100 : 0 : 0	6-8	***Scott and assoc.. (1984)***
	3	Vakuum	3	
	3	Vakuum	6	
	3	Vazduh	3	
Snaper, Filet (*Chrysophrys auratus*)	-1	40 : 60 : 0	9	***Scott and assoc.l. (1986)***
	-1	Vazduh	9	
	-1	100 : 0 : 0	18	
Swordfish, (*Xiphias gladius*)	2	Vazduh	6	***Oberlender and assoc.. (1983)***
	2	CA 100 : 0 : 0	>22	
	2	CA 70 : 0 : 30	>22	
	2	CA 40 : 0 : 60	14	
	2	CA 70 : 30 : 0	>22	
	2	CA 40 : 60 : 0	20	
Tilapia, Filet (*Tilapia spp.)*	4	75 : 25 : 0	>25	***Reddy and assoc.. (1995)***
	8	75 : 25 : 0	13-16	
	16	75 : 25 : 0	9-13	
	4	Vazduh	9-13	
	8	Vazduh	6-9	
	16	Vazduh	3-6	

Trout, cela	0	60 : 40 : 0	8	***Cann and assoc.. (1984)***
	5	60 : 40 : 0	8	
	10	60 : 40 : 0	3.8	
	0	Vakuum	9	
	5	Vakuum	6.5	
	10	Vakuum	3.7	
Trout, Filet (*Salmo gairdneri*)	1.7	80 : 20 : 0	20	***Barnett and assoc.. (1987)***
	1.7	80 : 20 : 0	20	
	1.7	Vazduh	10	
Trout, Filet (*Oncorhynchus mykiss*)	2	20 : 80 : 0	6	***Randell and assoc.. (1995)***
	2	20 : 80 : 0	9	
	2	40 : 60 : 0	6	
	2	40 : 60 : 0	9	
	2	Vakuum	6	
Hake (*Merluccius bilinearis*)	26	sve vrste pakovanja	2	***Post and assoc.. (1985)***
	12	Vazduh	5	
	12	Vakuum	9	
	12	0 : 100 : 0	9	
	12	100 : 0 : 0	12	
	3	Vazduh	4	
	8	Vakuum	10	
	8	0 : 100 : 0	10	
	8	100 : 0 : 0	15	
	8	90 : 8 : 2	13	
	8	65 : 31 : 4	7	
	4	100 : 0 : 0	15	

MATERIALS AND METHODS

For the experiment we used mackerel consume size (350-400 gramms), from fish processing plant. For the packaging from selected fished we used fish carcasses. After that fish is divided in to 2 groups, one treated just with salt solution 10% NaCl,, and second group was marinated in marinade (10% NaCl + 1% vinegar. Both groups was packaged in to vacuum and in to MAP. After packaging fish was keeped under same conditions in cold chamber +4 Cº. Results were statisticaly processed as mean average, variation, variance, corelation.

Aim of this experiment was to evaluate influence of package of the marinated fish Mackerel, in the vacuum package and the modified atmosphere, and to evaluate the growth of the aerobic mesophilic bacteria on fish. We used MAP as 60% CO_2 и 40% N_2 mixture of gases.

For that reasons we checked for 2 months (every 10 days) Total bacterial count for aerobic mesophilic bacteria. Results we expected should be in favoure of packaging fish in non aerobic atmosphere.

We used ISO 4833-1 method for total plate count for aerobic mesophilic bacteria.

RESULTS AND DISCUSSION

Results for 2 groups respectively packaged in vaccum and modified atmosphere.

Table 2. Total count 0. day

Group	$\overline{X}$	Variation				
		Sd	Se	Iv		Cv %
				Xmax	Xmin	
VKS	$3,17^{AB}$	0,37	0,15	3,80	2,80	11,42
MAPS	$3,00^{CD}$	0,14	0,06	3,20	2,80	4,71
VKK	$2,45^{AC}$	0,10	0,04	2,60	2,30	4,28
MAPK	$2,45^{BD}$	0,10	0,04	2,60	2,30	4,28

Table 3. Total count 10. day

Group	$\overline{X}$	Variation				
		Sd	Se	Iv		Cv %
				Xmax	Xmin	
VKS	$3,98^{ABC}$	0,19	0,08	4,20	3,70	4,87
MAPS	$3,50^{ADE}$	0,09	0,04	3,60	3,40	2,56
VKK	$3,02^{BDa}$	0,15	0,06	3,20	2,80	4,88
MAPK	$2,73^{CEa}$	0,12	0,05	2,90	2,60	4,43

Table 4. Total count 20. day

Group	$\overline{X}$	Variation				
		Sd	Se	Iv		Cv %
				Xmax	Xmin	
VKS	$5,92^{ABC}$	0,15	0,60	6,10	5,70	2,49
MAPS	$5,50^{ADE}$	0,10	0,43	5,70	5,40	1,89
VKK	$3,92^{BDF}$	0,19	0,08	4,20	3,70	4,96
MAPK	$3,02^{CEF}$	0,15	0,06	3,20	2,80	4,88

Table 5. Total count 30. day

Group	$\overline{X}$	Variation				
		Sd	Se	Iv		Cv %
				Xmax	Xmin	
VKS	$6,55^{ABC}$	0,22	0,09	6,90	6,30	3,31
MAPS	$6,05^{ADE}$	0,15	0,06	6,20	5,80	2,51
VKK	$4,62^{BDF}$	0,12	0,05	4,80	4,50	2,53
MAPK	$3,72^{CEF}$	0,15	0,06	3,90	3,50	3,96

Table 6. Total count 40. day

Group	$\overline{X}$	Variation				
		Sd	Se	Iv		Cv %
				Xmax	Xmin	
VKS	$7,07^{ABC}$	0,12	0,05	7,20	6,90	1,71
MAPS	$6,60^{ADE}$	0,14	0,06	6,80	6,40	2,14
VKK	$5,13^{BDa}$	0,18	0,07	5,40	4,90	3,41
MAPK	$4,75^{CEa}$	0,27	0,11	5,10	4,40	5,77

Table 6. Total count 50. day

Group	$\overline{X}$	Variation				
		Sd	Se	Iv		Cv %
				Xmax	Xmin	
VKS	$7,30^{ABC}$	0,14	0,06	7,50	7,10	1,94
MAPS	$6,68^{ADE}$	0,15	0,06	6,90	6,50	2,20
VKK	$5,25^{BDF}$	0,10	0,04	5,40	5,10	2,00
MAPK	$4,78^{CEF}$	0,21	0,09	5,00	4,50	4,47

Table 2. Results for total count in mackerel packaged in vacuum and MAP. Average bacterial count for the first and second group of mackerel (3,17±0,37 log CFU/g 1 group i 3,00±0,14 II group) was statistically significantly higher ($p<0,01$) of the average total count in 3 and 4 group (2,45±0,10 log CFU/g III group i 2,45±0,11 log CFU/g IV group). Average number of total count between first and secind group of marinated mackerel, as between average total count of the 3 rd group wasnt statisticaly significant difference.

After 10 days keepin under 3 ºC temperature total count in marinated mackerel was 2,73±0,12 log CFU/g (IV group) and 3,98±0,19 log CFU/g (I group). Average number of total count statisticaly was significantly lower against 1st and second group ($p<0,01$) as against 3rd group but with statisthic ignificance of $p<0,05$. It was confirmed, between total count of 1st, 2nd and 3rd statisticaly significant difference ($p<0,01$) (tabela 3).

Average total count after 20 days was 3,02±0,15 log CFU/g (IV group) to 5,92±0,15 log CFU/g (I group). Between al groups we have confirmed statisticaly significant difference ($p<0,01$) (tabela 4). Identical results statisticaly significant difference was ($p<0,01$) between average values of total count on 30. and 50. days of testing (tables 5 i 6). Average total count on 30. day was 3,72±0,15 log CFU/g (IV group) up to 6,55±0,22 log CFU/g (I group) and 50. day 4,78±0,21 log CFU/g up to 7,30±0,14 log CFU/g (I group). Similar results were obtained 40.days where we had statisticaly significance as III group (5,13±0,18 log CFU/g) and IV group (4,75±0,27 log CFU/g) of $p<0,05$ (Table 6).

Total count of aerobic mesophilic bacterias in all samples of marinated mackerel was growing from day 0 to 50 day. Growth was from I group 3,17±0,37 log CFU/g up to 7,30±0,14 log CFU/g, II group from 3,00±0,14 log CFU/g up to 6,68±0,15 log CFU/g, III group from 2,45±0,15 log CFU/g up to 5,25±0,10 log CFU/g and IV group from 2,45±0,11 log CFU/g up to 4,78±0,21 log CFU/g.

CONCLUSIONS

During torage period of marinated mackerel total count of bacteria (Aerobic mesophilic bacteria) between compared groups in most cases were statisticaly significantly different. In all cases comparison between total counts was lower in groups (samples) previouslz treated – marinated with add od 1% vinegar. Total count showed continual growth up to 50 days od storage.

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Recived: May 6, 2019

Accepted: June 20, 2019