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Composition of perch roe and keeping quality of roe products during cold- and frozen-storage

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Abstract. Proximate composition of whole roe bags and washed eggs of perch (**Perca fluviatilis**) was studied at different stages of maturity. Lipids and fatty acids of the roe were investigated in detail. Perch roe was processed using chemical preservatives, sugar, salt, and freezing and changes in the quality of the products were followed by chemical and sensory analyses during a one-year cold- and frozen-storage period. Mature roe as roe bags contained 13 % protein, 4 % fat and 1 % ash on wet weight basis. The amounts of protein and ash decreased somewhat when the roe was screened. The major lipids in perch roe were sterol and wax esters composing about 80 % of the total lipids. Polyenoic acids with dominant docosahexaenoic acid composed about half of the fatty acids in neutral lipids whereas saturated acids dominated in phospholipids. Frozen, washed roe was better in its quality during the one-year storage time as compared to heavy-salted, cold-stored roe containing preservatives which, in turn, was preferred to the light-salted, frozen roe or sugar-salted, cold-stored roe.

Introduction

Harvesting of fish roe for human consumption is increasing remarkably in Finland. It has been estimated (ANON. 1978) that about 100 tons of roe consisting mainly of whitefish roe is annually used as food. Potential sources for roe harvesting are provided by two species of whitefish (**Coregonus albula** and **C.lavaretus**), burbot (**Lota lota**), Baltic herring (**Clupea harengus**) and perch (**Perca fluviatilis**) (ANON. 1978). Moreover, remarkable amounts of roe is obtained during the slaughtering of cultured rainbow trout (**Salmo gairdneri**).

According to Official Statistics of Finland the roe export in 1977 was valued at over one million marks (FIM) and within three years the export had doubled in quantity.

For domestic market roe is usually salted and cold-stored whereas freezing is commonly applied for salted roe processed for export. The methods for processing fish roe are almost exclusively empirical. Therefore a systematic study on processing and quality preservation of roe was started to promote the utilization of the domestic roe potentials. The reports on preservation of Baltic herring and whitefish roe have already been published (KAITARANTA et al. 1979, LINKO et al. 1979).

This report describes our studies on the chemical composition of perch roe and on the effect of the composition on the keeping quality of roe processed in different ways.

Materials and methods

Materials and prehandling

Perch were caught during the spawning time in April—May 1978 from the coastal waters of the Archipelago Sea in Finland. Roe was removed from the fish immediately after landing. The maturity of the roe was determined using maturity index (M.I.) which expresses the gonad weight as a percentage of the total body weight. For the analyses of whole roe bags the gonads of one mature fish were used after a short rinsing with tap water. Two to three specimens of similar maturity were used to prepare pooled perch roe samples. The average M.I. of pooled samples were calculated according to the weights and M.I. of individual pairs of roe bags. The pooled roe samples were separately passed through a coarce sieve to remove membranes and the eggs were then washed using tap water, drained for about 15 minutes on a sieve and collected for the analyses.

The roe from several fish was pooled to obtain material for the processing of roe. The products were made from whole roe bags as well as from washed eggs prehandled as described above.

Processing, packaging and storage

Six different products (A—F) were made from perch roe using salt, sugar, preservatives and/or freezing:

A	Whole roe	bags frozen
B	Whole roe	bags sugar-salted (16 % NaCl, 3 % sucrose)
C	Loose eggs	 frozen
D	Loose eggs	 salted (5 % NaCl) frozen
E	Loose eggs	 salted (16 % NaCl) preservatives (0.1 % methyl ester of p-hydroxybenzoic acid)
F	Loose eggs	 sugar-salted (16 % NaCl, 3 % sucrose) preservatives (0.1 % methyl ester of p-hydroxybenzoic acid)

Products A and C were vacuum sealed in polyamide-polyethylene bags (0.09 mm, Wipak Co., Finland) and packed in waxed cartons, frozen in a plate freezer and stored at −25°C. After salting product D was stored at +2°C for one day before it was packed, frozen and stored as products A and C.

Products B, E and F, processed using salt, sugar and preservatives, were stored in wooden boxes at +2°C for one day before the boxes were immersed in brine of 50 % saturation and stored at +2°C.

Analytical methods

Chemical composition

Moisture, ash and crude protein were determined in triplicates. Moisture was measured as the weight loss of the sample by heating it at 105°C until constant weight. The sample was then burned in a muffle oven at 550°C to determine the ash content. Crude protein was determined using the Kjeldahl procedure and 6.25 as coefficient (the AOAC method 7.016). The fat content of roe was determined using the method of BLIGH and DYER (1959).

The lipid class determinations were performed from the total lipids using a quantitative thin-layer chromatography-flame ionization detection (TLC-FID). Lipid classes were separated on Chromarod-S quartz rods with a coating of silica gel and the quantitation was obtained using an Iatroscan TH-10 Analyzer (Iatron Laboratories Inc., Japan) as described in detail by KAITARANTA (1980).

For the fatty acid analyses the total lipids were resolved into neutral and polar lipid fractions on a silicic acid column according to the method of ROUSER et al. (1976). The eluted lipid fractions were weighed after evaporation of solvents in a vacuum rotavapor.

Fatty acids from the total lipids and the neutral and polar lipid fractions were converted into their methyl esters from the saponified samples using a slight modification of the method of van WIJNGAARDEN (1967). The methyl esters were analysed by gas-liquid chromatography (GLC) on a wall-coated open tubular FFAP-glass column as described in a previous paper (KAITARANTA and LINKO 1979).

Keeping quality

The keeping quality of the roe products (A–F) was followed during a period of one year. Samples were taken from each lot after 0, 5, 10, 20, 30, 40 and 52 weeks of storage. The analyses included the determinations of pH, the total volatile nitrogen (TVN), trimethylamine (TMA), and the acid (AV) and peroxide (POV) values.

For the quality determinations the samples of the frozen products were thawed at room temperature whereas the samples of roe products stored in brine were rinsed with water and drained on a sieve.

A water homogenate of roe was prepared from the samples with a macerator to analyse TVN and TMA. TVN was determined titrimetrically after vapor distillation according to PEARSON (1973). The TMA determination was carried out spectrophotometrically at 420 nm based on the color reaction of TMA with picric acid (HART and FISHER 1971). AV and POV were analysed from the total lipid samples. A lipid sample was dissolved in hot ethanol for titrimetric determination of AV with potassium hydroxide (the AOCS method Te 1a–64) or in a mixture of glacial acetic acid and chloroform (3:2, v/v) to determine POV by iodometric titration (the D.G.F. method E.C.–VI 6a).

Sensory evaluation

The appearance, consistence, odor and taste of the roe products made from washed loose eggs (C–F) were judged by a panel consisting of five members. Scores from 0 to 5 were given for each characteristic. Samples were also ranked according to their preference.

Results and discussion

Chemical composition

The gross composition of whole roe bags and washed loose eggs in different stages of maturity are presented in Table 1. Besides the wet weight basis the results are expressed also in terms of dry weight to eliminate the effect of a possible water gain on the composition of washed eggs.

The moisture content of washed eggs was generally about 5 % higher than that of whole roe bags. This may be due to the membranes, blood and ovarian fluid which were removed during the screening procedure of washed eggs or to an incomplete removal of water during the draining of eggs. Removing of membranes, blood and ovarian fluid from washed eggs seems to cause also a slight decrease in crude protein and minerals.

Large differences are found in the lipid content of roe from various fish species (VUORELA et al. 1979). When mature, washed perch roe contains 3.9 % of lipids on wet weight basis (Table 1), whitefish and Baltic herring roe have a lipid content of 9.9 % and 2.6 %, respectively.

The small number of samples permits only tentative conclusions about the effect of the maturity on the gross composition of perch roe. When the maturity index increased from 18.3 to 27.5 no definite changes in the proportions of ash, crude protein or lipid in the wet weight of washed loose eggs were found. At the same

Table 1. Proximate composition of whole roe bags and washed loose eggs of perch roe at different stages of maturity.

Roe sample	Maturity Index	Percentages on wet weight basis				Percentages on dry weight basis		
		Moisture	Ash	Protein	Lipid	Ash	Protein	Lipid
Washed eggs	18.3	84.1	0.6	8.2	3.9	3.7	51.4	24.6
Washed eggs	21.3	84.1	0.6	8.3	4.1	3.9	52.3	25.9
Washed eggs	27.5	84.9	0.7	8.2	3.9	4.9	54.5	25.6
Whole roe bags	19.1	78.0	1.0	13.4	4.2	4.8	60.8	19.2
Whole roe bags	23.2	79.3	1.0	12.4	4.2	4.8	59.6	20.5

time, the solids which were not determined as crude protein, lipid or ash decreased distinctly. The same feature was earlier found during the maturation of Baltic herring roe (VUORELA et al. 1979). However, the amount of these undetermined solids in washed mature perch roe remained on a relatively high level, about 15 % of dry weight, as compared to 0.7–7.4 % in mature Baltic herring, rainbow trout, whitefish and burbot roe.

Rancidity of lipids was found to be one of the most important factors limiting the keeping quality of roe products (KAITARANTA et al. 1978, 1979, LINKO et al. 1979). Besides the external factors (storage circumstances, available oxygen etc) the development of rancidity depends especially on the lipid composition.

Lipid class composition of mature perch roe is shown in Table 2. The major part of lipids in washed eggs, about 82 %, consists of neutral lipids. In this respect perch roe resembles whitefish roe where neutral lipids comprise about 70 % of the total lipids (KAITARANTA 1980). However, when calculated on wet weight basis the polar lipids in perch roe are found to be about 0.7 % while the corresponding values for Baltic herring and whitefish roe are about 1.8 and 2.5 %, respectively.

The Iatroscan analysis revealed that sterol and wax esters in perch roe form the major part of the neutral lipids (97 %) and also of the total lipids (80–83 %). A comparison of the lipid composition of perch roe with the data reported for whitefish (KAITARANTA 1980) and Baltic herring (KAITARANTA et al. 1978) roe shows remarkable differences. Although the neutral lipids dominated also in whitefish roe, instead of sterol and wax esters, triglycerides were the major lipid fraction, 65 % of the total lipids. In Baltic herring roe, phospholipids comprised 86 % of the total lipids.

In order to understand the differences in the oxidation rate of roe lipids of various fish species a general view on the fatty acid composition of perch and whitefish roe is presented in Table 3. The results show that large proportions (85 %) of unsaturated acids with dominant monoenoic components are found in the total lipids of perch roe. This is due to the remarkably low proportion of saturated acids in neutral lipids and to the high amounts of monoenoic acids in both neutral and polar lipids. In whitefish roe, unsaturated fatty acids form about 74 % of the total fatty acids. Further, about 50 % of the whitefish roe fatty acids have polyunsaturated structures.

Table 2. Lipid class composition of whole roe bags and washed loose eggs of perch roe.

Lipid group	Washed eggs		Roe bags	
	SiO_2-chromatog.	Iatroscan	SiO_2-chromatog.	Iatroscan
Polar lipids	17.8	15.5	20.2	17.3
Neutral lipids	82.2	84.6[a]	79.8	82.8[a]
Sterol and wax esters		82.6		80.3
Triglyserides		1.0		1.1
Others		1.0		1.4

[a] Calculated as the sum of the neutral lipid subfractions.

Table 3. General fatty acid composition of the total lipids (TL), and the neutral (NL) and polar (PL) lipid fractions of washed eggs of perch and whitefish roe.

Fatty acid group	Proportions in the total fatty acids					
	Perch			Whitefish [a]		
	TL	NL	PL	TL	NL	PL
Saturated	15.1	4.5	46.1	26.1	25.6	33.9
Monoenoic	48.3	43.9	31.1	21.0	23.7	12.9
Polyenoic	36.6	51.7	22.9	53.4	51.5	53.7
ω 3 series	27.3	41.5 [b]	18.6	40.9	38.7 [b]	42.0
ω 6 series	8.7	10.2	4.3	11.8	11.9	11.2

[a] Kaitaranta 1980

[b] includes 29 % and 12 % 22:6 ω 3 in perch and whitefish roe lipids, respectively.

Table 4. Changes in the pH values of different perch roe products during the storage of one year.

Product	Storage time (week)						
	0	5	10	20	30	40	52
A	6.10	5.95	5.80	5.90	5.85	5.85	5.80
B	5.65	5.50	5.45	5.25	5.20	5.15	5.10
C	6.00	5.90	5.90	5.90	5.90	5.85	5.85
D	5.75	5.70	5.70	5.55	5.75	5.55	5.55
E	5.95	5.70	5.65	5.65	5.70	5.15	5.25
F	5.80	5.75	5.65	6.00	5.50	5.35	5.20

Table 5. Changes in the amounts of total volatile nitrogen (TVN, mg N/100 g) in different perch roe products during the storage of one year.

Product	Storage time (week)						
	0	5	10	20	30	40	52
A	11.9	16.8	20.5	37.1	35.5	23.8	16.8
B	15.4	11.2	13.4	18.9	18.5	13.4	12.9
C	9.1	16.1	16.0	18.2	28.4	23.0	14.6
D	18.2	21.0	23.4	26.6	36.9	26.3	25.2
E	12.6	5.6	9.7	9.1	9.9	9.2	7.8
F	11.2	4.2	10.0	8.4	12.8	5.9	7.8

Table 6. Changes in the content of trimethylamine (TMA, mg N/100 g) in different perch roe products during the storage of one year.

Product	Storage time (week)						
	0	5	10	20	30	40	52
A	0.5	0.8	0.9	0.6	0.5	1.8	1.1
B	0.6	0.7	0.5	0.4	0.4	0.8	0.4
C	0.5	0.5	0.5	0.5	0.5	0.8	0.7
D	0.5	0.5	1.1	0.5	0.7	1.0	0.2
E	0.2	0.2	0.2	0.6	0.1	1.4	0.2
F	0.2	0.2	0.5	0.1	0.1	0.1	0.1

In the amounts of individual fatty acids a characteristic feature for the neutral lipids of perch roe is the high proportion of docosahexaenoic acid (22:6 ω 3), 29 %, as compared to 12 % in the neutral lipids of whitefish roe (KAITARANTA 1980).

Keeping quality of roe products

The initial pH values in different roe products (Table 4) varied from 5.65 to 6.10 depending on the processing methods. All frozen products (A, C, D) retained their pH values almost unchanged during the whole storage period. All salted and sugar-salted, cold-stored products (B, E, F) had a tendency of slowly decreasing pH-values. At the end of the storage their pH varied from 5.10 to 5.25 ranging about 0.5—0.7 pH-unit lower than the initial values.

The total volatile nitrogen in different roe products varied from 9 to 18 mg N/100g at the beginning of the storage (Table 5). The amount of volatile nitrogen compounds in salted and sugar-salted, cold-stored products (B, E, F) remained nearly unchanged whereas in frozen products (A, C, D) a slow increase was found during the first 30 weeks of storage, with the maximum value of 37 mg N/100g. Later on the total volatile nitrogen turned to a slight decrease. In this respect frozen perch roe products behaved unexpectedly as in the low storage temperature the bacterial growth, which usually gives rise to volatile nitrogen compounds, is retarded. In earlier studies it was found that the total volatile nitrogen in frozen Baltic herring (LINKO et al. 1979) and whitefish (KAITARANTA et al. 1979) roe products remained unchanged or even decreased during the frozen storage.

A good correlation of the total volatile nitrogen to the sensory analysis has been reported for various fish species (FIELDS et al. 1968). PEARSON (1973) showed that the acceptable quality of whitefish fillet was lost when the TVN content exceeded 30 mg/100g. This level was also suggested by LINKO et al. (1979) as the acceptable limit for Baltic herring roe products. On the other hand, for canned sturgeon caviar the upper limit of 15 mg N/100g has been established as a quality standard in USSR (ANON. 1970). In perch roe products an unpleasent flavor even at the beginning of the experiments interfered with any attempts to correlate the TVN determinations to sensory analyses.

The trimethylamine content is used as a quality index for fresh marine fish and 2 mg TMA-N/100g has been proposed as the upper limit of acceptability (TARR and NEY 1949). In perch roe products (Table 6) the TMA values remained very low during the storage period. Similar results with TMA showing no appropriate criteria for the quality of roe were earlier obtained for whitefish roe (KAITARANTA et al. 1979) and Baltic herring roe (LINKO et al. 1979).

Hydrolysis of lipids in perch roe products during the storage was followed by successive determinations of the acid value (Fig. 1). The initial AV values varied from 3 to 10 mg KOH/g of oil. However, during the storage only small changes in different products were found. Slight increases occurred in salted and sugar-salted, cold-stored products (B, E, F) with the maximum value of about 20 mg KOH/g of oil which was measured for sugar-salted roe (B) after 30 weeks of storage. In heavy salted Baltic herring roe studied by LINKO et al. (1979) the acid value increased to about 50 mg KOH/g of oil during a half year cold-storage and exceeded 80 mg KOH/g of oil during the continued storage.

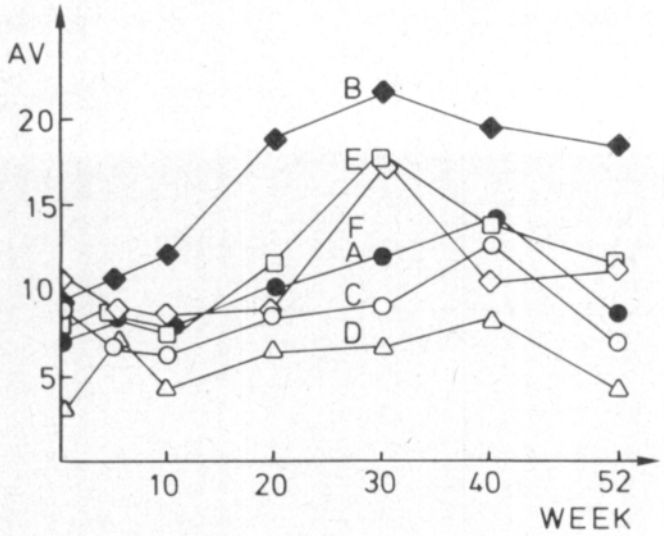

Fig. 1. Changes in the acid value (AV, mg KOH/g oil) of different perch roe products during the storage of one year.

Lipid hydrolysis in fish tissues is an enzymatic reaction catalyzed by the tissue enzymes only (OLLEY and LOVERN 1960). Thus differences in the development of lipid hydrolysis in various roe may result from different activity levels of lipolytic enzymes and/or from variations in the stability of individual lipid classes against the attack of tissue enzymes.

The development of oxidative rancidity in different perch roe products measured as an increase in the peroxide value is shown in Fig. 2. The initial values were found to be exceptionally high ranging from 11 to 26 meq 0_2/kg of oil. For fresh Baltic herring and whitefish roe products the peroxide values of about 4 and less than 0.5 meq 0_2/kg of oil, respectively, were measured (LINKO et al. 1979, KAITARANTA et al. 1979). No standards for the roe quality assessment concerning rancidity have been established whereas a proposal of 2 meq 0_2/kg of oil has been presented by KE et al. (1975) to classify mackerel fillet acceptable. This limit, how-

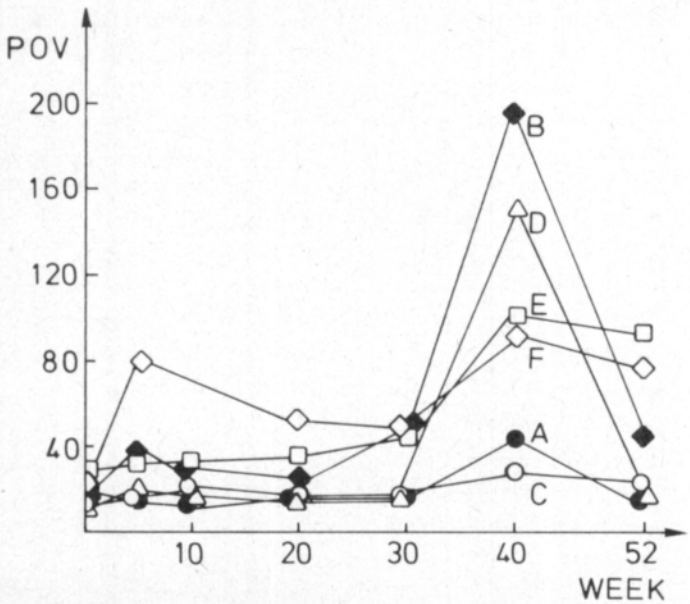

Fig. 2. Changes in the peroxide value (POV, meq 0_2/kg oil) of different perch roe products during the storage of one year.

ever, cannot be generally applied as the rancidity index for roe products because of the high initial values in some fish roe.

During the storage of perch roe products the peroxide value retained its initial level only in unsalted, frozen products (A and C). In all the other products the peroxide value started to increase rapidly after the lag of 30 weeks and reached exceptionally high values, 150—200 meq 0_2/kg of oil, in products B and D after 40 weeks of storage. The prooxidative effect of sodium chloride on the deterioration of fats in frozen roe is distinctly seen in Fig. 2 if the changes in the peroxide value of product C (with no added salt) are compared with those of product D (5 % added salt).

Susceptibility of roe lipids to oxidative rancidity seems to vary greatly in various fish species. For instance, after one year of cold- or frozen-storage the peroxide value in certain whitefish roe products (KAITARANTA et al. 1979) did not reach even the initial level of the peroxide value in the respective perch roe products. This is apparently due to the different lipid composition of the roe. Highly unsaturated fatty acids, especially docosahexaenoic acid (22:6 ω 3), form a higher proportion in perch roe fatty acids than they do in whitefish roe (Table 3). Moreover, sterol and wax esters form the major fraction in perch roe lipids. The unsaturated alcohol components of wax esters may as well undergo oxidation to form lipid peroxides which are measured as an increase in the peroxide value. In whitefish roe, wax esters are a very minor component (KAITARANTA 1980) and hence the significance of peroxides derived from fatty alcohols in whitefish roe is negligible.

Sensory evaluation of the washed perch roe products (C, D, E, F) was made after 5, 10 and 30 weeks of storage. In addition to the scoring of the quality characteristics the panel members also ranked the products in the order of preference (Table 7).

A varnish-like flavor was recognized in all perch roe products from the very beginning of the storage. This unattractive flavor made the panel members to describe the perch roe products inferior to the roe products of other fish species evaluated earlier. The flavor is possibly associated with the high sterol and wax ester content, which may be the origin of these flavor components. In an earlier report on the utilization of fish roe (ANON. 1978) the taste of perch roe was described capricious.

The frozen roe product C was ranked as the topmost and it best retained its quality during the 30 weeks of storage. It was followed by the cold-stored, heavy-salted product E, which after 10 weeks of storage was preferred to the frozen product. The sugar-salted roe product F which was cold-stored in the same conditions as the salted product E was, however, graded distinctly lower in quality. The salted product D, kept in frozen-storage was ranked as the last mainly because of its watery consistency after thawing and its inferior taste. All the products excluding the frozen roe C were classified nonedible after 30 weeks of storage.

Conclusions

The relatively high lipid content (4 % wet weight) is one characteristic for the proximate composition of perch roe. Another feature is the high amount of solids not determined as protein, lipid or ash. The lipids are mainly composed of wax and sterol esters which usually do not dominate in fish lipids. Moreover, the fatty acids in

Table 7. Sensory evaluation of different perch roe products after 5, 10 and 30 weeks of storage. Scores from 0 to 5 were given for the quality characteristics. The table shows the average scores and the ranking by a five-member panel.

Characteristic	Product	Storage time (week) 5	10	30
Appearance	C	2.8	2.6	3.3
	D	1.6	1.2	3.0
	E	3.6	3.0	2.8
	F	3.4	2.6	3.3
Consistence	C	3.0	2.0	3.5
	D	1.8	0.8	2.5
	E	4.0	2.8	2.3
	F	4.0	2.6	2.0
Odor	C	4.0	2.2	3.5
	D	3.0	1.8	2.0
	E	2.4	2.4	1.8
	F	2.2	2.2	1.8
Taste	C	2.6	2.2	2.8
	D	1.8	1.0	1.5
	E	2.0	2.0	1.8
	F	2.2	1.6	1.5
Sum of the scores	C	12.4	9.0	13.0
	D	8.2	4.8	9.0
	E	12.0	10.2	8.5
	F	11.8	9.0	8.5
Ranking	C	I	II	I
	D	IV	IV	III–IV
	E	II	I	II
	F	III	III	III–IV

perch roe lipids contain very high proportions of docosahexaenoic acid.

The exceptional lipid composition determines also the storage quality of perch roe. Although the lipid hydrolysis seems to be a rather slow process, the initial levels of the acid value and especially the peroxide value are high. During the storage of roe the peroxide value increased in all the products except in the unsalted frozen roe and reached a very high level in some products. This may be due to the unsaturated fatty alcohols, which in addition to unsaturated fatty acids, form peroxides. The decomposition of proteins and other nitrogenous compounds measured as an increase in the total volatile nitrogen value was slow and did not cause quality problems.

The most applicable method for a long-term storage of perch roe as evaluated by the chemical and sensory analyses was freezing in an air-proof vacuum package. Heavy-salted, cold-stored roe with preservatives had an acceptable quality during the first 20 weeks of storage but was classified non-edible 10 weeks later. On the other hand, heavy salting with simultaneous addition of sugar and preservatives was found to decrease the keeping quality. Salting of roe followed by frozen storage accelerated the oxidation of lipids and impaired the consistency of the product after thawing thus shortening the storage life of the product. All perch roe products were characterized by a varnish-like flavor.

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References

ANON. 1970. Canned sturgeon caviar, quality requirements for certified products. USSR KOMITET STANDARDTOV. Soviet Standard, Gost 5. 627-670.

ANON. 1978. Mädin hyödyntäminen. Sitra Ser. A. 53. 44 p. Helsinki.

BLIGH, E.G. & DYER, W.J. 1959. A rapid method of total lipid extraction and purification. Can. J. Biochem. Physiol. 37:911–917.

FIELDS, M.L., RICHMOND, B.S. & BALDWIN, R.E. 1968. Food quality as determined by metabolic by-products of microorganisms, Adv. Food Res. 16:161–229.

HART, F.L. & FISHER, H.J. 1971. Modern food analysis. 519 p. New York.

KAITARANTA, J. 1980. Lipids and fatty acids of a whitefish (**Coregonus albula**) flesh and roe. J. Sci. Food Agric. In press.

– & LINKO, R. 1979. Fatty acids of whitefish (**Coregonus albula**) flesh lipids. J. Sci. Food Agric. 30:921–926.

– , VUORELA, R. & LINKO, R. 1978. Lipid composition of fish roe and the spoilage of roe products during storage. 14th World Congr. Intern. Soc. Fat Res. Brighton. Commun. 0102.

– , VUORELA, R. & LINKO, R. 1979. Muikun mädin säilyvyydestä. Suom. Kalatal. 49:9–16.

KE, P.J., ACKMAN, R.G. & NASH, D.M. 1975. Proposed rancidity indexes for accessing the storage-life of frozen mackerel. Environment Canada, Fisheries & Marine Service, Halifax Lab. New Ser. Circ. 52.

LINKO, R., VUORELA, R. & KAITARANTA, J. 1979. Changes in the quality of Baltic herring roe products during cold and frozen storage. XV Intern. Congr. Refrig. Venice. Pap. C 2 121.

OLLEY, J. & LOVERN, J.A. 1960. Phospholipid hydrolysis in cod flesh stored at various temperatures. J. Sci. Food Agric. 11:644–652.

PEARSON, D. 1973. Laboratory techniques in food analysis. 315 p. London.

ROUSER, G., KRITCHEVSKY, G. & YAMAMOTO, A. 1976. Column chromatographic and associated procedures for separation and determination of phosphatides and glycolipids. In Lipid chromatographic analysis. p. 713–776. Ed. G.V. Marinetti. Marcel Deccer Inc. New York.

TARR, H.L.A. & NEY, P.W. 1949. Effect of flesh acidity on bacterial number and trimethylamine in spoiling fish. Prog. Rept. Pacific Coast Sta. Fish. Res. Board Can. 78:11–13.

VUORELA, R., KAITARANTA, J. & LINKO, R. 1979. Proximate composition of fish roe in relation to maturity. Can. Inst. Food Sci. Technol. J. 12:186–188.

van WIJNGAARDEN, D. 1967. Modified rapid preparation of fatty acid esters from lipids for gas chromatographic analysis. Anal. Chem. 39:848–849.

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SELOSTUS

Ahvenen mädin koostumus ja mätivalmisteiden säilyvyys kylmä- ja pakkasvarastoinnin aikana

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Tutkimuksessa selvitettiin kokonaisina mätipusseina olevan sekä pestyn, kalvoista puhdistetun ahvenen mädin kemiallista koostumusta sekä erilaisten mätivalmisteiden säilyvyysominaisuuksia.

Kokonaisten mätipussien tuorepainosta keskimäärin 79 % oli vettä, 13 % proteiinia, 4 % rasvaa ja 1 % tuhkaa. Kuivapainoa kohden lasketut tulokset osoittivat mädin pesu- ja puhdistusvaiheessa tapahtuvan osittaista proteiini- ja tuhkapitoisuuden vähenemistä. Muutokset johtunevat mätipussin sisällä olevan veren ja välinesteen sekä kalvojen poistamisesta pesun ja puhdistuksen aikana.

Tavanomaisesta kalan mädin koostumuksesta poikkeavasti ahvenen mäti sisältää runsaasti vaha- ja steroliestereitä, joiden yhteenlaskettu osuus kokonaislipideistä oli noin 80 %. Fosfolipidit muodostivat keskimäärin 18 % ja triglyseridit vain noin 1 % lipidien kokonaismäärästä. Kokonaislipidien rasvahapoista lähes puolet oli monoeenisia, tyydyttymättömien rasvahappojen kokonaismäärän ollessa noin 85 %. Neutraalilipidien rasvahappokoostumuksessa oli merkillepantavaa monityydyttämättömän dokosaheksaeenihapon, 22:6ω3, suuri osuus, noin 30 % rasvahappojen kokonaismäärästä tässä lipidifraktiossa. Fosfolipideissä tyydyttyneet hapot muodostivat lähes 50 % rasvahappojen kokonaismäärästä.

Suolaamalla ja/tai pakastamalla sekä sokeria ja säilöntäaineita käyttämällä tuotettiin ahvenen mädistä valmisteita, joiden laadussa tapahtuvia muutoksia tutkittiin yhden vuoden kestäneen kylmä- ja pakkasvarastoinnin aikana.

Mätivalmisteiden pH-arvoissa oli varastoinnin aikana havaittavissa lievää laskua, joka kylmäsäilytetyissä valmisteissa oli huomattavinta. Haihtuvien typpiemästen ja trimetyyliamiinin määrissä, jotka kuvaavat mikrobiologista alkuperää olevia muutoksia, ei todettu merkittävää kasvua. Rasvojen hydrolyyttinen eltaantuminen oli hidasta, kun taas oksidatiivista eltaantumista ilmaiseva peroksidiluku, jonka lähtötaso kaikissa mätivalmisteissa oli verraten suuri, kasvoi kylmäsäilytetyissä valmisteissa ja myös suolatussa, pakastetussa mädissä poikkeuksellisen korkeaksi.

Kemiallisten määritysten ja aistinarvostelun perusteella pakastus ja sitä seuraava pakkasvarastointi soveltui parhaiten pestyn ahvenen mädin käsittelyyn ja säilytykseen. Kovasuolattu (16 % NaCl), kylmäsäilytetty mäti, johon säilöntäaineeksi oli lisätty p-hydroksibentsoehapon metyyliesteriä (0,1 %), säilytti laatunsa hyväksyttävänä noin puolen vuoden ajan. Kevytsuolausta ja pakastusta sekä sokerisuolausta ja kylmävarastointia käyttämällä saatujen valmisteiden laatu ja säilyvyys oli selvästi heikompi kuin edellä mainituilla valmisteilla. Kaikissa ahvenen mätivalmisteissa tunnistettiin epämiellyttävä "vernissamainen" sivumaku.