PHYSICO-CHEMICAL COMPOSITION AND SENSORY QUALITY OF ANCHOVIES (*Engraulis encrasicolus*) FROM THE NORTHERN ADRIATIC

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Abstract – The aim of this study was to research the physico-chemical and fatty acid composition, as well as the culinary usefulness of the economically important fish species European anchovy (*Engraulis encarsicolus*) in comparison to the sardine (*Sardina pilchardus*), both caught in spring in northern Adriatic. The main differences in basic chemical composition were in significantly lower fat and, consequently, higher water and protein content of anchovies in comparison with sardines. Instrumentally measured colour showed significantly brighter, redder and yellower colour (higher values) of sardines then anchovies. While the fat in anchovies contained the highest portion of docosahexaenoic acid (37.2 wt. %), fat in sardines contained a the highest portion of palmitic (21 wt. %), oleic (14.7 wt. %) and docosahexaenoic acid (21.1 wt. %). Fat in anchovies contained a higher portion of PUFA and better P/S ratio (1.56 *vs.* 1.00) then in sardines. On the contrary, the fats in sardines had higher shares of SFA and MUFA than in anchovies. There were no major differences in phospholipids' profile of sardines and anchovies. Phospholipids in anchovies contained a higher portion of *n*-3 PUFA (43.8 wt. %), followed by SFA (36.5 wt. %) and MUFA (19.6 wt. %). While sardines express better back colour, mouth feeling, juiciness, smell, and flavour, anchovies express almost optimal texture and strongly expressed bitterness. Sensory quality of marinated anchovies was comparable to the quality of sardines with better expressed flavour.

Key Words – Anchovy, Sardine. Phospholipids

I. INTRODUCTION

Research over the past few decades has shown that fish are a quality food of animal origin. For the studied fish species we selected European anchovies (increasingly economically important fish species in Slovenia), and compared their composition and quality to sardines. We have further studied lipids (fatty acid profile of lipids and fatty acid profile of phospholipids, as well as cholesterol content), which define the nutritional value of fish. However, as the anchovies are rather small fish (smaller than sardines), they are usually marinated or salted, and rarely used in the daily diet or industrial fish processing.

The aim of our study was to determine the basic chemical composition and cholesterol content in the edible part of the fish as well as the fatty acid composition of lipids and fatty acid composition of phospholipids on one hand, and to verify the culinary usefulness of European anchovies, on the other. For this purpose we determined the sensory quality of roasted and marinated anchovies and compared them with sardines. The main hypothesis was that the majority of parameters on anchovies give comparable results to parameters acquired on sardines.

II. MATERIALS AND METHODS

A total of 54 European anchovies and 54 sardines from the northern Adriatic were included in the study. Samples were collected via three consecutive catches in the spring of 2009 in the Gulf of Trieste. Twenty-four hours after the catch, one part of the catch was heat-treated and sensory assessed, another part was prepared for physico-chemical analysis (water, ash, protein and fat according to AOAC [1], cholesterol with LC modified method [2], fatty acid profile of lipids (fat) and fatty acid profile of phospholipids by GC-FID [3], colour of raw muscle with Minolta, and pH) and the third part was marinated. To evaluate the sensory qualities, a panel of four qualified and experienced panellists in the field of fish was appointed. Sensory properties of heat-treated and marinated fish were evaluated by a descriptive evaluation method with an unstructured point scale from 1 to 7 points, where a higher score indicated greater expression of a

given property. An exception here was for the texture, acidity and saltiness, which were evaluated by scoring on a structured scale of 1 to 4 to 7 (1-4-7). Here, a score of 4 points was considered optimal, with scores of 4.5 or more indicated greater (to excess) expression of a property, and those of 3.5 or less indicated lesser (insufficient) expression of a property. The colour was assessed on raw fillets, while the other parameters were assessed on the roasted fillets (T_s = 80 °C, T_{oven} = 200 °C).

Four instrumental measurements of CIE $L^*a^*b^*$ values were made on raw surface. A Minolta CR 200b colorimeter (Illuminant C, 0° viewing angle) was used to determine the CIE L^* (lightness), a^* (+/-, red to green), and b^* (+/-, yellow to blue) values.

The data were analyzed by the analysis variance (ANOVA) (SAS). The statistical model for data acquired by physico-chemical and sensory analyses of fish meat included the effects of group (anchovies, sardines), catch (1-3) and repetition within the group (1-8).

III. RESULTS AND DISCUSSION

Table 1. Physico-chemical parameters in anchovies and sardines from the northern Adriatic

Parameter	Anchovies	Sardines
Water (g/100 g)	78.79±0.55^a	70.23±1.13^b
Protein (g/100 g)	20.35±1.00^a	18.43±2.05^b
Fat (g/100 g)	1.92±0.98^b	8.98±1.49^a
Ash (g/100 g)	1.29±0.13	1.37±0.25
L* value	36.2±3.9^b	42.2±3.5^a
a* value	1.7±1.3^b	4.3±1.8^a
b* value	2.1±1.3^b	2.4±0.8^a
pH	6.14±0.08^a	6.08±0.09^b
Cholesterol (mg/100 g)	64.6±4.0	65.2±5.4

Means with a different superscript within rows (a,b) differ significantly ($P \leq 0.05$)

On average, the edible part of anchovies contained 78.79 g of water, 20.35 g of protein, 1.92 g of fat, 1.29 g of ash and 64.67 mg of cholesterol per 100 g (Table 1). The results are in agreement with findings in literature [4]. Meat of sardines used in our study contained 70.23 g of water, 18.43 g of protein, 8.98 g of fat, 1.37 g of ash and 65.2 mg of cholesterol. Our results have been confirmed by some studies [5, 6, 7, 8]. Both anchovies and sardines are highly perishable products, with pH values quite high (6.14-6.08).

Table 2. Fatty acids composition and calculated nutritional information of anchovies and sardines fat

Fatty acid (wt. %/total FA)	Anchovies	Sardines
C8:0	0.16±0.1^a	0.02±0.0^b
C12:0	0.00±0.0^b	0.05±0.0^a
C12:1*c*-7	0.00±0.0^b	0.03±0.0^a
C14:0	4.92±1.4^b	6.15±0.1^a
C14:1*t*-9	0.09±0.1^b	0.20±0.0^a
C14:1*c*-9	0.00±0.0^b	0.10±0.0^a
C15:0	0.60±0.3	0.65±0.0
C15:1*c*-5	0.00±0.0^b	0.06±0.0^a
C16:0	20.5±1.0	21.0±0.3
C16:1*t*-9	0.18±0.2^b	0.59±0.0^a
C16:1*c*-9	3.17±1.2^b	4.54±1.0^a
C17:0	1.28±0.2	1.31±0.1
C17:1*t*-10	0.00±0.0^b	0.08±0.0^a
C17:1*c*-10	0.18±0.3^b	0.59±0.0^a
C18:0	4.78±0.3	4.73±0.2
C18:1*c*-11	2.95±0.3^a	0.05±0.0^b
C18:1*c*-9	4.26±0.2^b	14.7±0.7^a
C18:2*c*-9,12	1.51±0.3	1.60±0.1
C18:3*c*-6,9,12	0.00±0.0^b	0.13±0.0^a
C20:0	0.46±0.2^b	0.70±0.2^a
C18:3*c*-9,12,15	1.13±0.5^b	1.53±0.0^a
C20:1*c*-5+*c*-8+*c*-11	0.62±0.4^b	1.94±0.1^a
C21:0	1.68±0.5^b	2.99±0.1^a
C20:2*c*-11,14	0.35±0.1^b	0.46±0.1^a
C22:0	0.05±0.1^b	0.20±0.0^a
C20:4*c*-5,8,11,14	1.80±0.2^b	1.04±0.3^a
C22:1*c*-13	0.28±0.2^b	0.69±0.3^a
C20:5*c*-5,8,11,14,17	9.06±1.0	8.71±0.3
C24:0	0.01±0.0^b	0.07±0.0^a
C24:1*c*-9	0.17±0.3^b	0.64±0.1^a
C22:4*c*-7,10,13,16	0.36±0.2^b	0.46±0.0^a
C22:5*c*-7,10,13,16,19	1.04±0.0^b	1.11±0.0^a
C22:6*c*-4,7,10,13,16,19	37.2±6.2^a	20.1±0.5^b
SFA	34.4±1.3^b	37.8±0.5^a
MUFA	11.2±2.9^b	24.2±1.2^a
PUFA	53.6±4.0^a	37.8±1.0^b
n-6	3.67±0.6^a	3.24±0.3^b
n-3	48.4±4.8^a	31.4±0.8^b
P/S	1.56±0.2^a	1.00±0.0^b

Means with a different superscript within rows (a,b) differ significantly ($P \leq 0.05$)

While the most commonly represented fatty acids (FA) in anchovies fat are docosahexaenoic (DHA,

C22:6n-3) and palmitic (C16:0) acids, the most common FAs in sardines fat are palmitic, DHA and oleic (C18:1c-9) acids (Table 2). Combined, eicosapentaenoic (EPA, C20:5*n*-3) and DHA, the nutritionally most important FAs, in anchovies and sardines presented the highest shares [9]. DHA and EPA contents exceeded 1.5 g per 100 g of fish meat, which exceeds the value necessary to protect against cardiovascular disease [10,11,12]. If we observe the *n*-3 long chain polyunsaturated fatty acids (*n*-3 LC PUFA) the anchovies contained 1.5-fold as many *n*-3 LC PUFA than sardines.

Both species have highly favourable P/S index (1.56 *vs.* 1.00), however this index is higher (better) in anchovies. Anchovies fat has a slightly better ratio of *n*-6 and *n*-3 PUFA (0.08 *vs.* 1.00), which reduces the risk of thrombosis and atherosclerosis in human.

Table 3. Fatty acids composition and calculated nutritional information of anchovies and sardines phospholipids

Fatty acid (wt. % of FA)	Anchovies	Sardines
C14:0	2.87±1.9[a]	2.45±1.3[b]
C16:0	26.3±3.4[a]	23.0±2.3[b]
C16:1*c*-9	0.00±0.0	0.27±0.6
C18:0	10.2±3.2[a]	7.8±1.9[b]
C18:1*c*-11	12.8±9.5	8.6±4.3
C18:1*c*-9	7.6±11.8	11.8±5.7
C22:1*c*-13	1.28±2.4[a]	0.00±0.0[b]
C20:5*c*-5,8,11,14,17	6.29±1.6[b]	8.21±1.5[a]
C22:6*c*-4,7,10,13,16,19	28.6±5.7[b]	35.4±2.9[a]
SFA	36.5±5.1	36.1±5.9
MUFA	19.6±6.1	22.7±5.3
PUFA	43.8±4.9	41.0±7.9
n-6	0±0	0±0
n-3	43.8±4.9	41.0±7.9
P/S	1.23±0.3	1.19±0.4

Means with a different superscript within rows (a,b) differ significantly ($P \leq 0.05$)

The fundamental building blocks of all cell membranes are phospholipids. From the results of phospholipids' profiles of both species (Table 3) it can be concluded that sardines contain substantially higher shares of DHA and EPA, slightly more PUFA, *n*-6 fatty acids below the detection limit and virtually equal portions of SFA and MUFA in comparison with fat. Findings are in agreement with Bandarra *et al.* [14] which found that the structural lipids, such as phospholipids are often more unsaturated than neutral lipids. Phospholipids in anchovies contained less PUFA, no *n*-6 fatty acids, and almost equal shares of SFA, MUFA and *n*-3 fatty acids compared with fats. The conclusion of the research is that there is substantially less distinction in the proportion of fatty acids in phospholipids between the species of anchovies and sardines than between lipids (fat).

The evaluated sensory quality of roasted anchovies is slightly worse than in sardines. The colour of back and abdomen and the texture were evaluated better. The juiciness, mouth feel, smell and flavour were less expressed, with more noticeable bitterness (Table 4).

Table 4. Sensory traits in roasted and marinated anchovies and sardines

Trait (scores)	Anchovies	Sardines
Roasting		
Colour of back (1-4-7)	4.1±0.2[b]	4.5±0.4[a]
Colour of abdomen(1-4-7)	4.8±0.3	4.9±0.4
Texture (1-4-7)	3.6±0.3[a]	3.3±0.5[b]
Juiciness (1-7)	5.1±0.5[b]	5.6±0.4[a]
Fattiness (1-7)	1.3±0.4[b]	1.9±0.8[a]
Mouth feeling (1-7)	5.3±0.3[b]	5.4±0.3[a]
Smell (1-7)	5.7±0.4[b]	6.0±0.2[a]
Flavour (1-7)	5.5±0.4[b]	5.8±0.3[a]
Bitterness (1-7)	1.6±0.7[a]	1.3±0.5[b]
Marinating		
Appearance(1-7)	6.7±0.5[a]	5.4±0.3[b]
Colour (1-7)	2.2±0.3[b]	4.7±0.4[a]
Smell (1-7)	5.8±0.3	5.6±0.3
Stiffness (1-7)	5.5±1.0[a]	3.9±0.6[b]
Texture (1-4-7)	4.1±0.2[a]	3.2±0.5[b]
Juiciness (1-7)	5.8±0.4[a]	5.2±0.3[b]
Rancidity (1-7)	1.0±0.0	1.0±0.0
Acidity (1-4-7)	5.5±0.4[a]	4.5±0.4[b]
Saltiness (1-4-7)	4.0±0.0	4.0±0.0
Bitterness (1-7)	1.1±0.2[b]	2.2±0.8[a]
Flavour (1-7)	6.0±0.0[a]	5.1±0.2[b]

Means with a different superscript within rows (a,b) differ significantly ($P \leq 0.05$)

Marinating is an old chemical method of fish preservation in which the complementary effect of acetic acid and salt achieves the digestibility of fish fillets [14], thus limiting the microbial and enzymatic activity and changing the taste and texture of the fish. Sensory quality of marinated

anchovies is comparable to the quality of sardines: appearance of anchovies is better than in sardines, but anchovies became gray in colour. Smell is similar than in sardines, expressed almost optimal texture and greater rigidity, better juiciness and flavour, more intense acidity, and almost imperceptible bitterness and appropriate saltiness (Table 4).

IV. CONCLUSION

High content of easily digestible protein and *n*-3 fatty acids ranks anchovies and sardines meat among excellent substitutes for meat of slaughter animals in human diet. Sardines in Slovenia are sold and consumed much more than anchovies, perhaps due to its poor recognition among the people. However, anchovies earn a prominent place in the fish supply and human consumption; nutritional aspect of anchovies is comparable to sardines: contain more *n*-3 fatty acids than sardines and consequently has a lower ratio of *n*-3/*n*-6, which had a positive impact on human health. Consumption of fish in Slovenia's population had decreased between years 1997-2009, from once a week to once or three times a month [15]. Therefore, the various institutions in the country have to provide a better awareness of the importance of fish in a balanced diet and the impact of these on health.

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