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Proximate and mineral composition of dried salted roes of hake (*Merluccius merluccius*, L.) and ling (*Molva molva*, L.)

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Proximate analyses and mineral composition of dried salted roes of hake (*Merluccius merluccius*) and ling (*Molva molva*) were determined. Both roes contained a significant amount of protein (39.1 and 43.6%, respectively) and lipid (14.13 and 14.80, respectively) because of their physiological role as reserves. Because this product is a typical food of one particular area, no specific data have been found in the literature about proximate and mineral compositions. Only trace elements (Fe, Cu and Zn) and macronutrients (crude protein and carbohydrates) varied with the type of roe. The most important minerals were Fe, Zn, K and Na. However, Na content was very high, and for this reason dried salted roe cannot be recommended for people who require dietetic control of blood pressure.

INTRODUCTION

Salting and drying are two ancient practices used by many cultures to preserve food (Clack and Goldblith, 1974). Nowadays this process is not only used to preserve food but also to give them a special flavour (Belitz and Grosch, 1988). Dried salted roe obtained from the reproductive organs of female fish is a well-known snack in the Mediterranean area. The basic steps used in its preparation are to cover the roe in salt or brine for different lengths of time (depending on roe size) and then to dry them out in the sun or in a drying oven to obtain a final product with a moisture content of around 30% (w/w). However, no nutritional information concerning such products exists. In general, the drying process should have no major negative effect on the nutritional values of foods (Pigott and Tucker, 1990), although proteins suffer denaturation (Belitz and Grosch, 1988; Cheftel *et al.*, 1989), especially in fish and fish products (Raghunath *et al.*, 1995). The mineral content of this type of food is almost certainly modified because salting involves osmotic concentration, which leads to a loss of nutrients as a consequence of leaking phenomena during the drying process.

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Epidemiological evidence suggests that excessive salt (Na) and/or K intake has a marked influence on the Na/K ratio of blood, which is one of several factors associated with the occurrence of hypertension in humans (Dahl, 1972; NRC, 1989). Because of the manufacturing process, dried salted roes have a significant amount of Na, and, for this reason, eating this product probably has a negative effect on health. However, since dried salted roe is consumed in small portions as an appetizer, except for people who are under dietetic control, Na intake is unlikely to be a problem.

The aim of this paper was to determine the proximate and mineral compositions of dried salted roes of hake (*Merluccius merluccius*) and ling (*Molva molva*).

MATERIALS AND METHODS

Materials

The roes used for the present study were the reproductive organs from female hake (*Merluccius merluccius*, L.) and ling (*Molva molva*, L.). The roes were purchased frozen and then thawed overnight. The average length of hake roe was 15 cm and of ling roe, 30 cm. Layers of salt (sodium chloride) and thawed roe were placed in a plastic container for 6 h, for hake, and 8 h in the case of ling. The roes were then washed with tap water in a

water bath to remove excess salt, and then dried in a drying chamber set at 18–25°C, with 55% humidity and an air speed of 1 m s^{-1}. The dried salted roes were taken out when a moisture of around 30% (w/w) was obtained.

Instrumental analysis

Proximate composition

Moisture content was determined using an infrared moisture balance and heating the sample at 110°C to constant weight. The crude protein content was calculated by converting the nitrogen content determined by Kjeldahl's method (6.25 X N). Fat was determined by the method described by the AOAC (1990), using the Soxhlet system. Ash content was determined by dry-ashing in a furnace oven at 525°C for 24 h. Carbohydrates were calculated by subtracting the other components from the total as recommended by FAO/WHO (1980). Energy was estimated by applying the numbers of Atwater. For fat content, the factor was 9 kcal g^{-1} and for the carbohydrate and protein contents the factor was 4 kcal g^{-1}.

Mineral composition

Fat was extracted from the sample by repeatedly washing with warm chloroform/methanol (2:1, v/v), following the method described by Bligh and Dyer (1959). Samples were dried overnight in a forced-draught oven at 90°C. Mineral composition was analysed after destroying the organic matter of the samples by dry ashing in a Nabertherm furnace oven, model L3/P (Liliental, Bremen, Germany) for 24 h with a final temperature of 525°C. The ash was dissolved with 2 ml of concentrated HNO_3 acid on an electrical hot plate, and collected from the crucibles by washing with distilled dionized water into volumetric flasks of 50 ml. Minerals were measured by flame atomic absorption spectrophotometry, using a Perkin–Elmer AA spectrophotometer model 3100 (Norwalk, CT, USA) with air-acetylene flame, flow spoiler and corrosion resistant nebulizer. A monoelemental hollow cathode lamp was used for each element. The instrumental conditions recommended by the manufacturer (wavelength, slit and lamp intensity) were applied (Anonymous, 1978).

Mineral assay quality control

To minimize the risk of adventitious contamination, all glassware and crucibles were acid-washed overnight in a 6 N solution of analytical grade HCl. Distilled, deionized water was used to rinse all glassware. The Community Bureau of Reference material CRM-422 (cod muscle) was used as a control to test the method for accuracy.

Statistical analyses

A one-way analysis of variance was used to evaluate the differences in mineral content using SYSTAT software (Wilkinson and Howe, 1992). Significance between means was determined by means separation (Tukey's test). A level of $p < 0.05$ was used to establish significant differences among means.

RESULTS AND DISCUSSION

Table 1 shows the F ratios and the probability from the ANOVA analysis of the salted roe depending on the type or species. According to the criteria described in the statistical analyses section, only trace elements (Fe, Cu and Zn) and macronutrients (crude protein and carbohydrates) were significantly affected by the type of roe.

Table 2 gives the proximate composition (moisture, crude protein, fat, carbohydrates and ash) and energy value of the two commercial roes studied. The moisture content of the hake and ling salted roes studied varied from 28.66 to 31.34% placing the technological classification of this product as 'an intermediate moisture product', with values between 30 and 50% moisture. The protein content in the dried salted roes ranged between 39.1 and 43.6% (in hake and ling, respectively) with a significant difference between types. These values are higher than the protein content of other roes such as different caviar (from 10.1 to 28.6%; Rehbein, 1985), mainly due to the higher moisture content (from 44.8 to

Table 1. ANOVA analysis of proximate and mineral composition between hake and ling dried salted roes

Nutrients	F ratio	P
Fe	17.24	0.014
Cu	32.12	0.005
Mn	0.055	0.82
Zn	78.53	0.001
Ca	1.98	0.23
Mg	0.66	0.46
K	0.95	0.39
Na	0.46	0.54
Moisture	3.83	0.12
Crude protein	7.35	0.050
Fat	0.12	0.75
Carbohydrate	145	0.000
Ash	0.36	0.58

Table 2. Proximal composition of dried salted roes[1]

Parameters	Hake	Ling
Moisture	28.66 ± 1.29^a	31.34 ± 2.09^a
Crude Protein	39.1 ± 1.4^b	43.6 ± 1.41^a
Fat	14.13 ± 1.20^a	14.80 ± 1.79^a
Carbohydrates	11.2 ± 1.21^a	3.13 ± 0.43^b
Ash	6.69 ± 1^a	7.14 ± 0.64^a
Energy[2]	328	320

[1]Mean and standard deviation of three samples, expressed as percentage of wet matter.
[2]Data expressed in kcal/100 g.
[a–b]Different letters within the same row indicate significant difference at $p < 0.05$.

78.3%) of these samples, in comparison with hake and ling salted and dried roes. There was an agreement in protein content between our samples and other similar roes such as cured mullet roe (40.0%) which showed a moisture content of 26.5%. Iwasaki and Harada (1985) described the proximate composition of different species of raw roes with a wide range in protein content (11.5% in anglerfish to 30.2% in crab), as result of such different moisture levels. According to published data, the fat content in raw and processed roes from fish and fish products ranged from 3.0% in Pacific herring (*Clupea pallasi*) roe to 23.6% in sturgeon (*Arcipenser stellatus*) roe (Iwasaki and Harada, 1985; Rehbein, 1985). In our samples, the fat content was 14.13% in hake and 14.80% in ling salted and dry roes, with no significant differences appearing between the species studied. These values were lower than data reported by Hsu and Deng (1980) who obtained an average value of 23.05% in salted mullet roe. With reference to the composition of the fat, it is noteworthy that roe lipids could have a preventative effect on heart diseases, because of their high content of polyunsaturated fatty acids (Yang *et al.*, 1993).

The fraction of carbohydrates was 3.13% for ling and 11.2% for hake, with clear significant differences. These values show a wide range since the carbohydrates are second reserve substances and their percentage is species dependent. Carbohydrates reported in salted mullet roe (8.7%; Hsu and Deng, 1980) were within the range obtained in the present study for salted dried hake and ling roes. The average mean ash content observed in salted and dried hake and ling roes was 6.92%. This value is mainly affected by the salting process, which provided a high amount of minerals to the roes. The ash content detected in the samples studied was also higher than the value obtained in other salted dried roes (mullet roe with 2.63% ash content; Hsu and Deng, 1980). The differences in ash contents in salted dried roes depend on processing, because an osmotic dehydration process was used for cured mullet (brine with 15% salt for 28 h) whereas our samples were covered with sea salt for several hours (4 or 8 h, depending on roe size) during which the raw roe loses water and incorporates many solutes. The final moisture content of cured mullet roe was higher than that of our salted and dried roes. In addition, (because of the different permeabilities of skin to salt) (Hsu and Deng, 1980), the effect of osmotic dehydration could also be considered species dependent.

The mineral composition of dried and salted roes is shown in Table 3. We consider that it is important to know the exact mineral composition of this food, but there are no references to compare our data with other similar products. All the references found in the literature concern the mineral content of fish muscle (Belinsky *et al.*, 1996), fish protein (Hoskins and Loustaunau, 1974) and other fish products (Chiou *et al.*, 1989), and there is no reference to salted and dried roe, probably because its production and consumption is geographically limited.

Table 3. Mineral composition of dried salted roes[1]

Minerals	Hake	Ling
Fe	4.46 ± 0.73^a	2.13 ± 0.30^b
Cu	0.25 ± 0.11^b	0.66 ± 0.006^a
Mn	0.23 ± 0.13^a	0.25 ± 0.07^a
Zn	4.10 ± 0.84^b	10.94 ± 1.04^a
Ca	16.7 ± 4.81^a	21.6 ± 3.42^a
Mg	36.8 ± 5.34^a	34.0 ± 2.58^a
K	491 ± 93.85^a	605 ± 52.69^a
Na	2473 ± 104.94^a	2348 ± 302.77^a

[1]Mean and standard deviation of three samples, expressed in mg/100 g of wet matter.
[a–b] Different letters within the same row indicate significant differences at $p < 0.05$.

The Fe content of foods varies widely, higher values existing in meat and meat products than in fish. In edible muscle, the Fe content depends on the species. In different samples of Mediterranean fish, the Fe contents ranged from 0.3 mg 100 g^{-1} w/w in young hake (*Merluccius merluccius*) to 0.8 mg/100 g in sole (*Solea solea*) (Martínez, 1995). Other information on Fe content in fish muscle indicate higher contents ranging from 0.8 to 1.9 mg/100 g, in the edible muscle of Peruvian jack mackerel (*Trachurus murphyi*) (Vlieg and Baley, 1989), or in 20 different species from India (Chandrashekar and Deosthale, 1993). Fe concentrations in the salted and dried roes studied were 2.13 mg/100 g w/w in ling and 4.46 mg/100 g in hake, higher than any Fe content described in the literature for fish products. The significant differences between hake and ling salted dried roe Fe contents could be due to anatomical differences in the blood circulatory system. In fact, the values reported in this study are higher than those reported by Belinsky *et al.* (1996), whose found that Fe contents ranged between 0.2 and 0.4 mg/100 g in whitefish (*Coregonus clupeaformis*), cisco (*Coregonus artedii*) and leak trout (*Salvelinus namaycush*) raw roe.

Cu content in fish products generally shows the same behaviour as Fe, with a significant dependence on the species, as contested by different authors (Martínez, 1995; Vlieg and Baley, 1989; Chandrashekar and Deosthale, 1993). Cu contents in different samples of Mediterranean fish are of 0.04 mg/100 g in young hake to 0.3 mg/100 g in blue whiting, and 0.07 mg/100 g in hake, place and sole (Martínez, 1995). Wider results for Cu content have been observed by other authors (Vlieg and Baley, 1989; Chandrashekar and Deosthale, 1993) but with similar magnitude (0.02 to 0.11 mg/100 g w/w). Wet weight Cu contents of hake and ling roes were significantly different (Table 1) and higher than those reported in the literature (0.25 and 0.66 mg/100 g, respectively). Both were higher than the concentrations recorded in edible fish muscle in the scientific literature, but are similar to the Cu contents of raw roe described by Belinsky *et al.* (1996) (0.1 and 0.5 mg/100 g in raw roe for whitefish, cisco and leak trout).

Hake and ling salted and dried roes have a higher Mn concentration (0.23 and 0.25 mg/100 g w/w, respectively) than edible muscle, where it ranged from 0.009 to 0.07 mg/100 g (Vlieg and Baley, 1989; Chandrashekar and Deosthale, 1993). For Zn contents, the same trend was observed with values that were 3 to 4 times higher than muscle (4.10 and 10.9 mg/100 g w/w for hake and ling salted and dried roes, vs 0.4 to 1.1 mg/100 g w/w for different edible portions of Mediterranean, Indian and Canadian or Peruvian fishes). Only raw roe of white fish, or cisco were similar in Zn contents (2.3 to 5.4 mg/100 g w/w) (Belinsky *et al.*, 1996). Zn contents in hake and ling salted and dried roes also showed significant differences (Table 1) that might be due to enzymic differences.

The Ca content of the flesh of some Mediterranean fish ranged from 15.4 mg/100 g in plaice and 80.1 mg/100 g in sole (Martínez, 1995). The values reported by this author are higher than those reported in Indian fish (4.7–51.4 mg/100 g, Chandrashekar and Deosthale, 1993) and in Canadian fish (3.0–12.7 mg/100 g, Belinsky *et al.*, 1996). The Ca content of salted and dried roe of hake and ling fell within the range found in the scientific literature for fish flesh, with values of 16.7 and 21.6 mg/100 g, respectively. However, these values are lower than those reported by Belinsky *et al.* (1996) for eggs of whitefish, cisco and lake trout, with a mean value of 35 mg of Ca $100\,g^{-1}$ wet weight. In salted and dried roes, the Mg ranged from 34.0 mg/100 g in ling roe to 36.8 mg/100 g in hake roe, without significant differences between the two species. These values are very similar to those reported in fish flesh by other authors (Chandrashekar and Deosthale, 1993).

In Peruvian mackerel flesh, the levels of K varied from 228–294 mg/100 g (Vlieg and Baley, 1989) whereas, in six oceanic pelagic species from New Zealand, the K content ranged from 282 mg/100 g in moonfish (*Mola mola*) to 424 mg/100 g in swordfish (*Xiphias gladius*) (Vlieg *et al.*, 1993). K values in salted and dried hake roe were similar to the data reported for flesh, with a value of 490.1 mg/100 g wet weight. Although, in ling roe, the mean K content was higher than in hake roe and edible muscle, with a value of 605 mg/100 g, they did not show significant differences (Table 3).

The values of Na in roe were higher than those in edible fresh muscle as reported by Vlieg *et al.* (1993) in six oceanic pelagic species, and by Vlieg and Baley (1989) in Peruvian mackerel. Na levels in dried salted roe ranged from 2348 mg/100 g in ling to 2473 mg/100 g in hake. This high Na content is clearly due to the salting process used to obtain the commercial product. For this type of product it is especially important to study the Na content, since chronic excessive Na intake has been associated with blood pressure. However, it must be borne in mind that dried salted fish roes are consumed as a snack, not as a basic food, and snacks of 20 g of both types of salted and dried roes provide around 20% of the recommended dietary allowances of Na (NRC, 1989). This fact, added to the high commercial price of this product, determines the low frequency of their consumption. Only if this food is consumed daily, would there be a problem related to hypertension.

CONCLUSIONS

Roe has an important amount of protein and lipid because of its physiological role as a reserve. Dried salted roes of hake and ling provide higher values of Fe and Cu than the edible muscle of fish. However, because of the very high Na content, roe cannot be recommended for people who require dietetic control of blood pressure. The above data are very important bearing in mind the new labelling regulations of the USA concerning the nutritional information to be provided to the consumer. It is very likely that European labelling regulations will also require this information in the near future.

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