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Composition of pâtés elaborated with mackerel flesh (*Scomber scombrus*) and tuna liver (*Thunnus thynnus*): comparison with commercial fish pâtés

Yolanda Aquerreta, Iciar Astiasarán[a,*], Antonio Mohino, José Bello

[a]*Departamento de Bromatología, Tecnología de Alimentos y Toxicología, Facultad de Farmacia, Universidad de Navarra, 31080 Pamplona, Spain*

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Abstract

Three types of pâtés manufactured with different quantities of tuna liver (*Thunnus thynnus*) and mackerel flesh (*Scomber scombrus*) were developed, in order to use these low-cost raw materials. Their nutritional value was compared with commercial fish pâtés made of tuna, large-scaled scorpion fish (*Scorpaena scrofa*), salmon (*Salmo salar*) and anchovy (*Eugraulis encrasicholus*). In relation to the general composition, no relevant differences were found between experimental and commercial products, except for the fat content, which was lower in the commercial products made of tuna and large-scaled scorpion fish. Commercial pâtés in general showed higher salt contents. The fatty acid profiles of commercial pâtés showed higher unsaturated/saturated and polyunsaturated/saturated ratios. The contents of omega-3 fatty acids were as follows: eicosapentaenoic acid (EPA) ranged from 0.02 to 0.27 g/100 g in commercial products and from 0.22 to 0.36 g/100 g in experimental pâtés and docosahexaenoic acid (DHA) ranged from 0.07 to 0.50 g/100 g in the different commercial products and from 0.6 to 0.83 g/100 g in experimental fish pâtés. Commercial products showed higher omega-6/omega-3 ratios, due to the lower contents of EPA and DHA and the higher content of linoleic acid, as a result of the addition of vegetable oils in this type of product. Although a strong fishy taste was detected on sensory analysis of experimental pâtés, all of them were considered to be acceptable.

Keywords: Pâtés; Tuna liver; Mackerel flesh; Omega-3 supply

1. Introduction

Nowadays, fish is considered as a food with health advantages. Besides its nutritive value, the lipidic fraction shows an interesting fatty acid profile with a significant presence of omega-3 polyunsaturated fatty acids whose health benefits have been widely studied. Epidemiological studies carried out in the 1970s on the incidence of cardiovascular disease in the Skimo population suggested a beneficial role of these fatty acids in the prevention of cardiovascular risk (Dyerberg & Bang, 1979). As a result of this research, the importance of the omega-6/omega-3 balance has been established (Simopoulos, 1994). The ratio, omega-6/omega-3 fatty acids, in cell membrane phospholipids and plasma phospholipids, plays a pivotal role in determining membrane fluidity, gene expression, citokyne formation, lipid levels and immune responses, all of which may prevent or contribute to coronary heart disease, hypertension, diabetes, cancer, arthritis, psoriasis, ulcerative colitis, multiple sclerosis and other autoimmune disorders (Simopoulos, 1996a, 1996b). An awareness of the protective role of omega-3 polyunsaturated fatty acids against development of cardiovascular disease has prompted the promotion of fish consumption (Hearn, Sgoutas, Hearn, & Sgoutas, 1987). Today diets are high in omega-6 fatty acids because of the increased production of oils from oil seeds and other vegetable oils for cooking. The ratio omega-6/omega-3 has changed, as well, due to modern agriculture and aquaculture. The importance of omega-3 fatty acids in the diet is evident, as also is the need to return to a more physiological omega-6/omega-3 dietary ratio of about 1 to 4:1, rather than the ratio of 20 to 30:1 provided by Western diets (Simopoulos, 1996a).

* Corresponding author. Tel.: +34-948-425600; fax: +34-948-425649.

E-mail address: iastiasa@unav.es (I. Astiasarán).

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A significant proportion of total available fish is currently under-utilised (Venugopal, 1995; Venugopal & Shahidi, 1995). The fish industry generates large quantities of by-products as fish viscera and some species with low commercial value, which are currently discarded. Canned tuna is the leading seafood today (Vendruska, Otwell, & Martin, 1988). The viscera of these tunas, such as liver, have no industrial application. This implies a loss of raw material with significant nutritive value and also a possible cause of environmental pollution (Javeed & Mahendrakar, 1995). Fish viscera, especially liver, are a good source of omega-3 polyunsaturated fatty acids. Nowadays, the liver of some species, such as cod, are just used to obtain a by-product: cod liver oil.

Pâté, a product with an important gastronomic tradition, is a value-added food which has interesting sensory properties and which can be made from different ingredients (Le Ba & Zuber, 1996). Pâtés made with liver from goose or pig are traditional products in the meat industry that have been taken as a reference by the fish industry for the development of similar products elaborated with different fish species, such as salmon, tuna or anchovy. These products widen the variety of pâtés, allowing different sensory properties and the nutritional benefits derived from the use of fish as a raw material. However, the fish species that are used for these pâtés are available fish with significant commercial value.

Growth in demand, worldwide, in recent years and resource limitations require the industry to make good use of fish production. The aim of this work was to elaborate fish pâtés with viscera (tuna liver, *Thunnus thynnus*) and mackerel (*Scomber scombrus*, a species of low commercial value), analysing their composition and their potential nutritional advantages compared with commercial fish pâtés currently available.

2. Material and methods

2.1. Elaboration of pâtés

Three experimental pâtés were elaborated in a pilot plat. Table 1 shows the different percentages of raw materials used in the three formulations. In the three cases, other ingredients were added as follows (g per kg of raw material): sodium chloride (15), powdered milk (20), sodium caseinate (10), dextrose (7), polyphosphates (2), monosodium glutamate (2), powdered white pepper (3), powdered nutmeg (1), powdered ginger (1) and powdered onion (1). Mackerel pieces were eviscerated and the head and skin were removed, yielding the mackerel flesh. Tuna liver and mackerel flesh were cut before being added to the mixture.

Table 1
Raw material used in the three formulations of the experimental pâtés (%)

	Product A	Product B	Product C
Tuna liver	10	10	20
Mackerel flesh	30	35	30
Pork back fat	40	30	20
Water	20	25	30

The manufacturing process was, for all products, as follows: pork back fat was scalded for 15 min at 80 °C and then minced in a cutter. Subsequently, sodium caseinate, powdered milk, dextrose and polyphosphates were added and mixed. Hot water was then added slowly, followed by the tuna liver, the mackerel flesh and the remainder of the ingredients. The whole mixture was completely minced. Finally, the mixture was packed in a glass container and sterilised.

2.2. Commercial fish pâtés

Four commercial fish pâtés were purchased from local markets

According to their type labelling, the different commercial pâtés were elaborated with the following ingredients: tuna pâté: tuna, skimmed milk, vegetable oils and proteins, mashed potatoes, salt, spices and flavourings; large-scaled scorpion fish pâté: large scaled scorpion fish, hake, tomato, vegetable margarine, milk, eggs, wine, spices and salt; salmon pâté: salmon, skimmed milk, vegetable oils and proteins, dewlap, salt, spices and stabilizers (E-407) and anchovy pâté: anchovy, skimmed milk, vegetable oils and proteins, mashed potatoes, salt, spices and flavourings.

2.3. Analytical procedures

Moisture was determined by drying, using the method of ISO 1442–1973 (ISO, 1973). Total protein was analysed using the Kjeldahl method for nitrogen determination (AOAC, 2000a). Total fat was determined using the method of AOAC (AOAC, 2000b) with a Tecator apparatus (Rafatec II 1050 Extractor), using petroleum ether. Ash was determined by incineration, using the method of AOAC (AOAC, 2000c). Sodium chloride was determined according to the Carpentier Volhard method (AOAC, 2000d). The carbohydrate content was analysed according to Osborne and Vooght (1978). The calorific value was determined by applying the appropriate conversion factors: 4 kcal/g protein and carbohydrates, 9 kcal/g fat.

The method of Folch, Lees, and Slone-Stanley (1957) was used for the extraction of fat. Fatty acid composition was determined by gas chromatography. BF_3/methanol was used for the preparation of fatty acid methyl esters (AOAC, 2000e). An automatic Perkin-Elmer

Autosystem model gas chromatograph fitted with an SP-2380 capillary column, 60 m×0.25 mm, of fused silica (Supelco, Inc. Bellefonte, PA) and FID, was used. The temperature of the injection port and detector was 250 °C, and the oven was programmed to increase from 170 to 200 °C at a rate of 2 °C/min. The carrier gas was hydrogen (13 psig). The sample size was 0.5 μl. Peaks were identified by comparison of their retention times with those of standard mixtures (Sigma, St. Louis, MO, 99% purity specific for GC), and their areas were automatically integrated using heptadecanoic acid methyl ester (Sigma) as internal standard.

The cholesterol content was calculated by gas chromatography, according to the method of Kovacs, Anderson, and Ackman (1979). A Perkin-Elmer Sigma 300 + HS 6 with an SP2250 column, 2 m×6 mm, packed with Supelcoport (Supelco, Inc. Bellefonte, PA) was used. The oven temperature was 260 °C. The temperature of the injection port and detector was 285 °C. Nitrogen was used as carrier gas. The sample size was 0.5 μl. Cholesterol standards (Sigma), with concentrations ranging from 0 to 2 mg/ml in chloroform were used, and to each was added 1 ml of a cholestane (Sigma) solution (2 mg/ml) as internal standard. After analysis, the cholesterol/cholestane area ratio versus cholesterol/cholestane weight ratio was obtained. By referring to this standard curve, the amount of cholesterol of the unknown sample was calculated. A Perkin-Elmer Turbochrom program was used for quantification.

2.4. Sensory analysis

Sensory evaluation was carried out according to UNE 87-020-93 (1993). Quantitative descriptive analysis (QDA) was carried out to evaluate the sensory quality of the different products. Samples were examined by 10 selected and trained panellists for: fishy odour, fishy taste, fatness and granularity. A continuous scale between 1 and 6 was used. A value of 1 corresponded to the lowest intensity for each parameter and a value of 6 to the highest. The general acceptability was also evaluated, using a six-point scale, from very disagreeable (1) to very agreeable (6).

2.5. Data analysis

Every parameter was measured in triplicate for each sample. For the experimental pâtés, three batches were elaborated for every type of product, analysing two samples of each batch. For commercial fish pâtés, four samples of each type were analysed. Data analysis was carried out with a SPSS 9.0 for Windows program. Analysis of variance (ANOVA) and a posteriori Tukey-b test were used to determine significant differences ($P < 0.05$) for each parameter.

3. Results and discussion

3.1. General

Although there are several publications that study different aspects of pâtés, such as stability, sensory properties or microbiology (Bonneau, 1995; Curt, 1995; Fromentier, 1998; Le Ba & Zuber, 1996; Siret & Issanchou, 1997), bibliographic references about fish pâtés have not been found.

3.2. General composition

Pâtés are considered, in general, as high energy foods, supplying, in the traditional formulations (pâtés made with goose/pork liver), around 450 kcal/100 g (Moreiras, Carbajal, & Cabrera, 1992). The calorific value of experimental fish pâtés elaborated in this work was in the range 294–336 kcal/100 g, which implies 20–33% less calories than in the traditional formulations (Table 2). The main energy nutrient was fat (25–33%), followed by protein (12–14%) and carbohydrates (4–5%).

Commercial fish pâtés showed a great variability in their calorific values which ranged between 164 and 284 kcal/100 g (Table 3). This diversity was due to the differences in the moisture/fat ratio. Salmon and anchovy pâtés had the lowest moisture percentages and the highest fat contents (26–29%), whereas pâtés made with tuna and large-scaled scorpion fish had the highest moisture contents and the lowest fat contents (10–15%). Moreover, carbohydrates were at lower concentrations in the products with low water content. Tuna pâté had the highest percentage of carbohydrates and anchovy had the smallest, despite both pâtés including mashed potatoes in their ingredients. The protein content was lower than in the experimental pâtés, especially in salmon pâtés, which only supplied 7% of protein.

In relation to the general composition, it can be affirmed that no relevant differences were found between the assayed products and the commercially available fish pâtés, except for the fat content. The sodium chloride content was lower in the experimental fish pâtés than in most of the commercial ones. Only commercial pâtés made of large-scaled scorpion fish had contents of sodium chloride similar to experimental products. This can be considered as a nutritional advantage.

3.3. Lipid fraction

Nowadays, it is recognised that the amount and nature of fat intake in the human diet are related to the incidence of atherosclerosis and other diseases. Unsaturated/saturated (U/S), polyunsaturated/saturated (P/S) and omega-6/omega-3 are ratios that typify the lipidic fraction of foods. Tables 4 and 5 show the composition

Table 2
General composition, calorific value and salt concentration of experimental fish pâtés[a]

	A	B	C
Moisture (%)	47.54±0.37a	50.82±0.28b	56.29±0.06c
Protein (%)	12.78±0.65a	14.13±0.24b	12.0±0.60a
Fat (%)	33.08±0.14a	28.88±1.10b	25.07±0.12c
Ash (%)	2.35±0.05a	1.25±0.12b	1.57±0.16b
Carbohydrates (%)	4.25±0.03a	4.92±0.02b	5.08±0.04b
Calorific value (kcal/100 g)	326	336	294
Sodium chloride (%)	1.04±0.04a	1.04±0.04a	0.72±0.04b

[a] Mean±standard deviation. Values in the same row bearing different letters are significantly different ($P<0.05$).

Table 3
General composition, calorific value and salt concentration of commercial fish pâtés[a]

	Tuna	Large-scaled scorpion fish	Salmon	Anchovy
Moisture (%)	69.05±0.24b	67.87±0.14b	60.26±0.57a	58.25±0.91a
Protein (%)	11.48±0.72a	10.52±0.14a	7.14±0.31b	10.1±0.35a
Fat (%)	10.01±0.28a	14.68±1.48b	28.90±0.85c	26.16±0.88c
Ash (%)	2.37±0.03a	2.11±0.08b	2.05±0.08b	3.40±0.03c
Carbohydrates (%)	7.09±0.20a	4.82±0.18b	1.65±0.05d	2.07±0.09c
Calorific value (kcal/100 g)	164	194	301	284
Sodium chloride (%)	1.37±0.10a	1.00±0.04b	1.30±0.03a	2.53±0.01c

[a] Mean±standard deviation.

Table 4
Fatty acid profiles (g/100 g) and cholesterol contents (mg/100 g) of experimental fish pâtés[a]

	A	B	C
Lauric 12:0	0.03±0.01a	0.05±0.01b	0.04±0.01b
Myristic 14:0	0.43±0.03a	0.44±0.05a	0.39±0.01b
Palmitic 16:0	5.99±0.21a	5.64±0.06b	5.44±0.51b
Palmitelaidic *trans* 16:1 ω-7	0.1±0.01a	0.07±0.02b	0.08±0.01b
Palmitoleic *cis* 16:1 ω-7	0.64±0.06a	0.55±0.15b	0.51±0.01b
Stearic 18:0c	2.75±0.31a	3.25±0.53a	2.92±0.32a
Elaídic *trans* 18:1 ω-9	0.71±0.17a	–	0.08±0.01b
Oleic *cis* 18:1 ω-9	10.21±1.08a	8.19±1.27b	7.38±0.71b
Linolelaidic *trans* 18:2 ω-6	0.11±0.02	–	–
Linoleic *cis* 18:2 ω-6	3.31±0.13a	2.87±0.21b	3.08±0.29ab
Arachidonic 20:0	0.07±0.01a	0.12±0.01b	0.11±0.01b
Linolenic *cis* 18:3 ω-3	0.35±0.05a	0.29±0.03a	0.45±0.04b
Erucic *cis* 22:1 ω-9	0.43±0.01a	0.22±0.02b	0.19±0.04b
Eicosapentaenoic *cis* 20:5 ω-3	0.22±0.01a	0.36±0.06b	0.36±0.04b
Docosahexaenoic *cis* 22:6 ω-3	0.60±0.02a	0.83±0.17c	0.74±0.06b
Σ SFA (g /100 g)	9.27	9.5	8.79
Σ *cis*-MUFA (g /100 g)	11.28	8.69	8.08
Σ *cis*-PUFA (g /100 g)	4.48	4.35	4.36
UFA/SFA	1.8	1.4	1.4
PUFA/SFA	0.5	0.45	0.5
Omega-6/omega-3	3	1.9	2
Cholesterol (mg/100 g)	71.90±5.32a	59.53±2.69b	67.37±5.33a

[a] Mean±standard deviation. SFA, saturated fatty acids; UFA, unsaturated fatty acids; MUFA, monounsaturated fatty acids; PUFA, polyunsaturated fatty acids. Mean±standard deviation. Values in the same row bearing different letters are significantly different ($P<0.05$).

Table 5
Fatty acid profiles (g/100 g) and cholesterol contents (mg/100g) of commercial fish pâtés[a]

	Tuna	Large-scaled scorpion fish	Salmon	Anchovy
Caprilic 8:0		0.11±0.02		
Capric 10:0		0.12±0.01		
Láuric 12:0		0.69±0.01a	0.05±0.01b	
Myristic 14:0	0.03±0.01a	0.35±0.01c	0.38±0.01c	0.13±0.01b
Palmitic 16:0	0.6±0.01a	2.23±0.06c	3.46±0.02d	1.36±0.02b
Palmitoleic *cis* 16:1 ω-7	0.03±0.01a	0.08±0.01b	0.46±0.01d	0.13±0.01c
Stearic 18:0c	0.35±0.04a	0.71±0.03b	1.68±0.02c	0.73±0.01b
Elaídic *trans* 18:1 ω-9		0.51±0.42a	0.09±0.01b	
Oleic *cis* 18:1 ω-9	1.97±0.06a	3.58±0.07b	7.13±0.05d	4.03±0.04c
Linolelaidic *trans* 18:2 ω-6	0.06±0.02a	0.06±0.01a	0.14±0.01b	0.14±0.01b
Linoleic *cis* 18:2 ω-6	5.13±0.21a	3.55±0.09b	10.1±0.08c	16.62±0.07d
Arachidonic 20:0	0.04±0.02a	0.08±0.01b	0.13±0.01c	0.11±0.01bc
Linolenic *cis* 18:3 ω-3	0.05±0.01a	0.39±0.02b	0.33±0.04b	1.83±0.01c
Erucic *cis* 22:1 ω-9	0.04±0.01a	0.06±0.01a	0.41±0.01c	0.19±0.02b
Eicosapentaenoic *cis* 20:5 ω-3	0.02±0.02a	0.07±0.01b	0.27±0.01d	0.10±0.01c
Docosahexaenoic *cis* 22:6 ω-3	0.07±0.04a	0.12±0.01a	0.50±0.01c	0.21±0.02b
Σ SFA (g /100 g)	1.02	4.29	5.7	2.33
Σ *cis*-MUFA (g /100 g)	2.04	3.72	8	4.35
Σ *cis*-PUFA (g /100 g)	5.27	4.13	11.2	18.8
UFA/SFA	7.2	2	3.4	10
PUFA/SFA	2.3	1	2	8.1
Omega-6/omega-3	38.2	6.2	9.3	7.8
Cholesterol (mg/100g)	77.35±4.52a	66.79±6.97a	110.65±3.58b	103.85±10.43b

[a] Mean±standard deviation. SFA, saturated fatty acids; UFA, unsaturated fatty acids; MUFA, monounsaturated fatty acids; PUFA, polyunsaturated fatty acids.

of the lipid fraction, fatty acid profile and cholesterol content, and the values obtained for the mentioned ratios of both types of products.

Although some significant differences were found in the individual fatty acids between the three assayed formulations, the total amounts of saturated, monounsaturated and polyunsaturated fractions appeared quite similar. On the other hand, a great variation was observed in the commercial products due to the different amounts and types of fats used as ingredients. The level of SFA and MFA were higher in the experimental fish pâtés than in the commercial ones. Only salmon pâtés had a content of oleic acid similar to that of the assayed products. Salmon and anchovy showed the highest content of PUFAs. Also, these pâtés had the highest fat contents. As alfa-linoleic acid was the main fatty acid which contributed to the PUFA fraction in these products, it seems that these pâtés were made with the highest vegetable oil amounts.

As a consequence of the analyzed fatty acid profile, U/S and P/S were higher in the commercial products than in the experimental pâtés. U/S and P/S ratios were similar in all the fish liver pâtés manufactured in this work. U/S ratio ranged from 1.4 to 1.8 and P/S ratio was, in all the cases, around 0.5. In commercial fish pâtés, these ratios showed more variability, the index U/S ranging from 2 to 10 and P/S from 1 to 8.

The omega-6/omega-3 ratio has acquired great significance from a health viewpoint. The usefulness of this index is due to the competition of both series of fatty acids for the enzymes involved in metabolic routes which take part in the development of some diseases (Simopoulos, 1996b).

In experimental fish pâtés, the level of eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) were high, implying that these products were a good source of omega-3 fatty acids. In the analyzed commercial product, EPA content ranged from 0.02 to 0.27 g/100 g and DHA content ranged from 0.07 to 0.50 g/100 g. In assayed formulations, EPA content was 0.22 in product A and 0.36 in products B and C; DHA content ranged from 0.60 to 0.83 g/100 g. These concentrations can be considered as very significant, taking into account that 100 g of sardine, a fatty fish considered as a good source of omega-3 fatty acids, supplies around 0.47 g of EPA per 100 g and 100 g of salmon or sardine supply around 1.2 g of DHA (Moreiras, Carbajal, & Cabrera, 1992).

In commercial products, the omega-6/omega-3 ratio ranged from 6 to 9, except for tuna pâtés (omega-6/omega-3 = 38). These high values were due to the high content of omega-6 PUFA, especially linoleic acid. This fatty acid reached 50% of total fatty acids in tuna pâtés and between 24 and 40% in the other commercial products. The addition of vegetable oils in the formulation

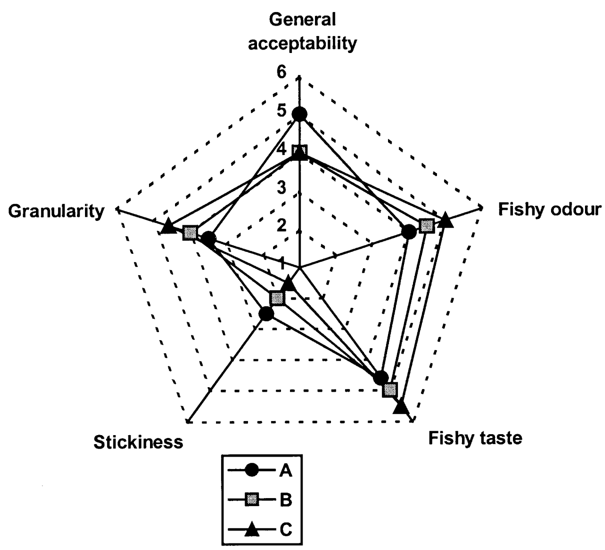

Fig. 1. Sensory analysis of experimental fish pâtés.

of these commercial fish pâtés was probably the reason for the high omega-6 polyunsaturated fatty acids levels. In assayed fish pâtés, values of omega-6/omega-3 ratio ranged from 2 to 3. These low values constitute a nutritional advantage compared to commercial fish pâtés.

Cholesterol content of pâtés, ranged from 59.5 to 71.9 mg/100 g in assayed formulations. Tuna and large scaled scorpion fish pâtés supplied similar amounts of cholesterol, whereas in commercial pâtés whose fat content was higher (salmon and anchovy) the cholesterol concentrations were higher (111 and 107 mg/100 g, respectively). In all cases, these values were appreciably lower than those of traditional liver pâtés, as shown in food composition tables: 156 mg/100 g (Pennington, 1994) and 255 mg/100 g (Moreiras, Carbajal, & Cabrera, 1992).

3.4. Sensory analysis

Although this was not an aim of the work, it seemed interesting to evaluate the potential acceptability of the developed products. A sensory analysis with personnel from the laboratory was carried out. The most problematic properties, such as fishy odour, fishy taste, fatness and granularity were evaluated by the panel members, who were trained previously with traditional pâtés. Fig. 1 displays the results obtained. In general, the fishy odour and taste were considered as "strong", especially in product C, which had the highest percentage of fish liver. In relation to texture properties, product A, which had a larger amount of pork back fat, was most suitable for being spread, and therefore the sensory panel qualified its fatness with higher values. This product (A) showed, at the same time the lowest values for granularity, a parameter which reflects the particle size. As a consequence of the evaluation of these properties, product A showed the highest acceptability, although all of them were considered to be acceptable. These results show that, probably, these types of products could be accepted by the consumer, although studies with a larger number of subjects should be carried out.

In summary, pâtés made with tuna liver and mackerel are products with an interesting chemical composition, having nutritional advantages compared with traditional meat pâtés and also compared with commercially available fish pâtés, especially because of their omega-3 fatty acid contents. From the sensory point of view, they could be acceptable to the consumer.

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