# Eating fish in another way: Development of functional pasta by addition of fish (*D. labrax*) farmed concentrates.

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## 1.ABSTRACT

### Background and objectives

Due to its nutritional properties and a raising awareness of healthy eating, fish consumption has increased. There is a need to produce attractive foods and pasta is a good example of this, as representing an option for developing functional foods. In this sense, this research developed traditional pastas added of concentrates of flesh and skin from aquaculture seabass to improve both their sensory and nutritional properties.

### Findings

Nutritional and sensory improvements were achieved in new pastas developed with non-degreased fish concentrates. They showed higher amounts of fat and ash with an important enrichment in unsaturated fatty acids.

### Conclusions

Pastas developed were stable due to their low water activity (<0.85). They had high protein quantities (≥ 19 % in Dry Matter) and moderate fat amounts (2- 3 %) being an important source of polyunsaturated fatty acids (PUFA), especially EPA (>1%) and DHA (>2.5 %) according to fatty acid profiles.

### Significance and novelty

This work extensively suggests that incorporation of dried non-degreased fish concentrates will result in improvement of nutritional quality of pasta as well as an optimization in the use of the marine resources. This approach can be used to avail the health benefits of pasta as a functional food and provide an alternative way to consume fish.

**Keywords:**

EPA/DHA

Enriched pasta

Healthy pasta

By-product

Zero-residues

## 2. INTRODUCTION

Fish is an excellent source of high nutritional value protein and lipids rich in unsaturated fatty acids, especially those Ω-6 as eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) (Kris-Etherton, Harrys and Appel, 2000). Nutritional studies are increasingly focussing on the reduction and prevention of obesity caused by Western dietary habits. Intake of an appropriate ratio of essential fatty acids (FAs) appears to be critical for achieving these aims (Schneedorferová, Tomcala & Valterová, 2015). A balanced ratio of Ω-6/Ω-3 fatty acids is desirable in reducing the risk of many diseases, including cardiovascular disease, cancer, and inflammatory and autoimmune illness. Cereal grains are high in carbohydrates and Ω-6 fatty acids, but low in Ω-3 fatty acids and antioxidants (Simopoulos, 2003). Pasta and other cereal products serve as a food staple in the Western diet, so it could be a good opportunity to achieve the recommended daily intake of long chain n-3 PUFA. Pasta could be an excellent option to incorporate "nutraceuticals" because it is popular among consumers due to its easy handling, storage, and preparation (Iafelice, Caboni, Cubadda, Di Criscio, Trivisonno and Marconi1, 2008).

Concentrates from fish have been in focus due to its potential for human consumption and their healthy nutritional characteristics. In this sense, there are many studies devoted to increasing nutritional value in terms of the protein content of pasta products by adding of fish and seafood protein concentrates (Desai, Brenan & Brenan, 2018; Pena & Manthey, 2014; Ranya, Prabhasankar, Gowda, Modi & Bhaskar, 2014; Godoy, Franco, Souza, Stevanato, & Visentainer, 2013;). Among the most relevant studies, Iafelice et al., (2008) tried the encapsulation of fish oil for making spaghetti. Prabhasankar, Ganesan, & Bhaskar (2009) tested the incorporation of sea brown algae as an ingredient to improve the biofunctional and nutritional qualities of pasta. Ranya et al. (2014) evaluated the influence of freeze-dried shrimp (*Penaeus monodon*) meat (SM) at different levels (2.5%, 5%, & 10%; w/w) in pasta processing. Goes et al. (2016) developed sfresh noodle with tilapia (*Oreochromis niloticus*), protein concentrate. Desai, Brenan & Brenan (2018) evaluated the effect of semolina replacement with protein powder from fish (*Pseudophycis bachus*) on the physicochemical characteristics of pasta. However, the information available about pasta products with addition of fish mince is limited. Thus, the purpose of this study was to develop fresh and dried pastas enriched with non-degreased concentrates from farmed seabass (*D. labrax*), and to evaluate them in terms of physico-chemical composition, sensory analysis and microbiologic stability.

## 3. MATERIAL AND METHODS

### 3.1 Raw material

Fish used in the experience to obtain the concentrate was fresh, with less than 24 hours from sacrifice, and whole seabass (*Dicentrarchus labrax*) supplied directly from the local fish farm (Las Palmas of Grand Canaries, Spain). The degrees of freshness of fish were assessed by electrical conductivity employing a torrymeter® equipment (Distel, Scotland). Regarding cereal source, commercial semolina provided by a local industry of pasta (Innova Obrador S.L.) from Italian durum wheat was used. It had a high gluten and protein content being classified as a premium quality (protein content 13%, gluten 9% db) confirmed by Standard Methods 105/2 and 137 (ICC 2003).

### 3.2 Concentrates fish powder preparation

Fresh and whole seabream was eviscerated, washed and filleted. Fillets were dried according to the scheme showed in Fig., taking care to do it subtly and slowly and after with a progressive cooling to preserve fatty acids in the best possible way. The drying was carried out in an oven (Verinox, Mod. Junior 1100, Trento, Italy) using airflow and injection of water vapour for maintaining internal conditions. Once dried, skin, bone and flesh were separated from the fish. Fish and skin were ground individuality several times until finely uniformed, packed in oxygen-impermeable plastic bags and keeping in congelation (-20 ºC) until its use.

### 3.3 Pasta formulation

Preliminary tests were developed using different raw materials (semolina, fish, eggs and additives) and formulations based on the previous researches. (Desai et al., 2016; Devi et al., 2013 & Iafelice et al., 2008). Finally, after an iterative process adapted to food development in accordance with guidelines provided by Larman (2004), two formulations were settled. The first was made with semolina durum wheat (64.5%), concentrate fish powder from flesh (10%), fresh water (25%) and monosodium glutamate -GMS- (0.5%) which was called as “Marine”; and a second denominated “Sepia” composed by semolina durum wheat (66%), pasteurized egg (10%), concentrate fish powder from skin (20%), fresh water (3%) and squid ink (1%). The incorporation of other ingredients in pastas developed (Egg, ink & GMS) intended to improve their functional properties and sensory attributes.

### 3.4 Pasta processing (fusilli)

Pasta products were manufactured with an experimental extrusion machine (Bottene, Mod. Lillodue 14057CE, Italy) in the food processing pilot plant of University of Zaragoza (Spain). The format choice was fusilli, approximately 4 cm in length. Fish powder, semolina and the rest of ingredients were mixed for 10 min, according to manufacturer´s guideline. Extrusion of fresh pasta samples were divided in two groups. The first was dried in an oven during 120 min at a temperature of 50 °C, packed in plastic bag, and maintained at room temperature. The second group was packed in plastic bags without treatment and kept frozen (-20ºC) until analysis within a period not exceeding 48 h (fresh).

### 3.5 Proximate chemical composition analysis and constituents

Determination of parameters were performed in triplicate. Total protein was determined using Kjeldahl method according to AACC method 976.05 (2000) and using a nitrogen to protein conversion factor of 6.25. Fat amount of concentrates and pastas were assessed using the Soxhlet extraction method (AACC, 2000). The quantities of ash in raw material and products were measured by gravimetry according to AACC (2000). Carbohydrate content was determined by calculating the difference among other components from 100 % and the total caloric values were obtained by using the formula described by Merrill and Watt (1973):

$$Energy\ value\ (kcal/100\ g) = 4 \times protein\ (\%) + 9 \times lipid\ (\%) + 4 \times carbohydrate\ (\%) \quad (1)$$

### 3.6 Lipids extraction and fatty acids analysis

Pastas were ground previously and like fish concentrates were finely pulverized before fat was extracted in chloroform–methanol, using a 2, 6-di-tert-butyl-4-methylphenol (BHT) as an antioxidant. One millilitre of the chloroform phase was used to assess the percentage of intramuscular fat (IMF) and subcutaneous fat (SCF) by drying at 100 °C for 20 min, the results were expressed as the weight percentage of dried muscle and skin. The methyl esters from fatty acids (FAMES) were prepared as described by Alonso et al. (2012). The FAMES were analysed in a gas chromatograph HP-6890 II (Hewlett-Packard, Waldbronn, Germany), with a capillary column SP-2380 (100m×0.25mm×0.20 μm), using nitrogen as the carrier gas. Fatty acid composition was quantified using heneicosanoic acid (C21:0) as the internal standard.

### 3.7 Quality parameters and Sensory assessment

Quality parameters were assessed in raw material and dried pastas developed. Humidity was evaluated employing an automatic thermo-balance (KERN & Sohn GmbH, DBS) and the water

activity ($a_w$) was measured by means of specific equipment (METER, AquaLab Series 4TEV) following in both cases the user manual´s equipment's protocols. The total basic volatile nitrogen (TVB-N) was measured according to the protocol described in the Regulation (EC) No 2074/200. Mesophilic viable count (MVC) was carried out according to ISO 4833-1:2013 and Yeasts and Moulds (Y&M) analysis was developed following the procedure described in ISO 7954: 1998 but in this study Saboraud Agar (Merck) was used as culture medium and the plates were incubated, without inverting, at 25ºC for 5 days.

A panel of nine expert sensory assessors was formed from the managers of local pasta industry, one chef specialist in pasta and researchers of the Agri-food Institue of Aragón (IA2). All the judge had demonstrated particular accuracy and reproducibility in panel work, and had developed a good long-term sensory memory, allowing reliable comparative judgements, even without the presence of control samples (ISO 8586-2:2008). The task of this expert panel consisted in the choice of the best from a total pasta formulation tested. For this purpose, two work sessions were held to taste, discuss and finally select two recipes based on the panel's agreement. Besides this, a panel of twelve selected assessors with previous experience in sensory analysis of fish freshness and pasta products was chosen from the staff of University of Zaragoza to carry a quality descriptive analysis -QDA- (Lawless & Heymann, 2010) in the fresh and dried pastas developed. The assessors had demonstrated sensory sensitivity in preliminary tests, and were able to make c

onsistent and repeatable sensory assessments of various samples. The panel received a prior training with respect to the use of assessment scoresheets and intensity scales to evaluate different attributes according to requirements of ISO standards (ISO 8586: 2012). The attribute intensities were rated on structured graphical intensity scales. The scales had 11 point with a mid-point and verbally anchored at each end, the left side of the scale corresponding to the lowest intensity (value 0) and the right side to the highest intensity (value 10) of each attribute.

### 3.8 Statistical analysis

Results were analysed using a XLSTAT Version 2016 (Addinsoft©). Normally and homogeneity of variance were tested. (*Kolmogorov-Smirnoff and Levene* test respectively) and statistical analysis of data was done by ANOVA ($p < 0.05$) and Fisher like a posteriori test was used to assess significant differences among means. Principal Component Analysis (PCA) was used to draw a plot with ellipses for sensory profile for each pasta made following the method described by Lê & Husson et al (2008). It allows to visualize on the same graph sensory attributes (descriptors), as well as the products with a confidence ellipse whose orientation and

surface depend on square cosines determinate by ratings given by different assessors. These ellipses are a graphical confidence test and it were calculated using a resampling method (*Hotteling test*).

## 4. RESULTS AND DISCUSSION

### 4.1 Characterization of the developed concentrates and pastas.

A complet sampling of the whole seabass demonstrated that fish had an optimum freshness degree with a mean value of 12.46+/-0.51 in the Torry Std. Scale that corresponding an Extra (E) category according to Council Regulation 2074/2005. Proximate composition parameters of concentrates from skin and meat fish show in Table 1. Significant differences ($p \leq 0.01$) were found among original concentrates in humidity, protein and ash composition. Meat concentrate had amounts of water and protein bigger than skin. However, this last one had the higher ash quantity due to a big amount of minerals such as calcium and magnesium, which are contained in hydroxyapatite, a main component of fish scales presents in the skin. Energy values did not show significant differences between concentrates and both had a contribution of 400 to 450 Kcal/ 100g. An adjustment of humidity was made at 10%, which represents an adequate value for a dry food as pasta (BEDCA, 2018), and values obtained confirmed the previous findings.

Table 1 exhibit a proximate composition (%) and energy values (Kcal/100g) for dried pastas selected and their references values. Very high significant differences ($p \leq 0.001$) were found among pastas with respect to lipid composition. Sepia was the food with the largest amount (> 6%) while pasta durum was the lowest (‹ 2%). The rest of pasta were different ($p \leq 0.001$) among them and bigger than durum. Marine had a 1% less than durum with egg coinciding with previous finding reported by Kadam y Prabhasankar (2010). However, it must be taken into account that the fat from fish concentrated showed a higher amount of fatty acids than those from egg and cereals. Total lipids content in both pastas developed in this study increased due to the incorporation of fish concentrate as in previous experiences where fish was used as raw material (Desai, Brenan & Brenan, 2018; Goes et al, 2015; Iafelice et al, 2008). In this research ash composition demonstrated, a linear increase related to the addition of fish concentrates (Table 1). Sepia showed a bigger quantity that the rest (> 2 %), which can be associated with the ash content in the standardized concentrates composition (Table 1). However, despite not being statistically different, it could be observed that the Marine had a greater proportion (≥ 0.8 %) than the references (≤ 0.6 %).

Ash amounts increased in pastas developed. The fabrication process of fish protein concentrate aggregates nutrients and minerals found naturally in fish (Goes et al, 2015). Devi, Aparna, & Kalpana (2013) found that calcium, phosphorus content was higher in fish incorporated pastas than control without fish mince; therefore, the greater ash compositions detected in the pastas of this study is important because these foods could be a source of several essential minerals. About crude protein in pastas, there were not differences among treatments. Marina and sepia dried pastas showed amounts bigger than the mean of 11.5 % indicated for Belitz, Grosch & Schieberle (2009) for pasta dried. Significant difference ($p \leq 0.05$) was detected in carbohydrates content among Sepia and the rest of pastas include references. It showed values ≥ 65 %, which is considerably less than 70 to 75 % for carbohydrates usually present in pastas from durum semolina (BEDCA, 2018 & Belitz, Grosch & Schieberle, 2009). The energy value of the products ranged from 372 to 383.6 Kcal/100g. The energy content in both pastas studied was higher than references (≤ 369 Kcal/100g) and in addition, these values were higher than those reported in previous studies Desay et al (2018) & Devi, N; Aparna, K. & Kalpana (2013). The rise of energy value in pastas with fish concentrates added could be due to the inclusion of nutrients such as polyunsaturated fatty acids (PUFA) and essential amino acids present in the fish powder (Oliveira, Lourengo, Sousa, Joele & Ribeiro, 2015) but absent from the durum wheat semolina (Zhang, Li, Wang, Xue & Xue, 2016).

### 4.2 Fatty acids profile in pastas developed

As said before the incorporation of fish concentrates was able to increase the fat composition in a different way in each pasta developed. These rises suggest major changes in the fat composition of products made. About, Table 2 show fatty acid profiles determinate in raw material (concentrates) and pastas both dried and fresh. Saturates fatty acids in Pastas Marine showed significant differences *($p \leq 0.05$)* were bigger than raw pasta (durum). For its part, there were not differences among Sepia products and their reference pasta durum with egg. Cereal grains are high in carbohydrates and u-6 fatty acids, but low in u-3 fatty acids and antioxidants (Simopoulos, 2003). The supplementation of pasta with the addition of concentrates from sea bass improved its nutritional value significantly *($p \leq 0.05$)* because increased total unsaturated fatty acids (% total UFA). In the case of Marine pasta, a rise of 21% was established with respect to the reference (raw pasta). For its part, Sepia too showed the increase of 27% compared to raw pasta with egg. In this sense, highlighting the enrichment with eicosapentaenoic (EPA) and docosahexaenoic acids (DHA) in all products manufactured,

where Marine showed a bigger amount than Sepia with significance ($p \leq 0.05$) differences. The average for the same types of pasta, without considering to their water contents, was 1.56% and 4.42% for EPA and DHA respectively in Marine pasta, and 0.96% and 2.49% in Sepia, demonstrating that there was an important nutritional contribution.

Fatty acid ratios related to human health are shown in Table 2. A nutritional specification established that *P/S ratio,* a proportion between PUFA and saturated fatty acids –SFA- (DFN, 2014). According to Department of Health & Social Care -DFN- (1994), an amount of 0.4 or more is suitable for a human health. All the values determined in pastas made in this study exceeded that recommendation showed results from 1.25 to 1.68, without significant differences among them. In western diets, p/s ratio should be about 0.6; it is suggested that increasing it to near 1.0 would reduce the risk of atherosclerosis and coronary heart disease. (DFN, 2014). Ideal value for Ω6/Ω3 ratio is around 2:1 (Simopoulos, Leaf & Salem, 1999). Finding of this study demonstrate that in pastas with seabass concentrates values from 2.98 to 4.56 and more than 2.0 were estimated. The above it is an agreement with results reported by previous studies (Filipovic et al, 2015; Devi, Aparna, & Kalpana, 2013; Iafelice et al, 2008). The Ω6/Ω3 ratio, from a nutritional perspective, could be reduced as a consequence of increased EPA and DHA according to recent modifications in the nutritional guidelines for human diets that suggest decrease from inadequate values ≥10/1 to optimal values ≤ 5/1(EFSA,2010 & Simopoulos, 2003). This last requirement was adequately achieved in the pastas developed.

A considerable increase of Ω-3 fatty acids in pastas with fish concentrates incorporated were detected. In marine pasta, a quantity of Ω-3 UFA showed a mean of 278.43 mg/100g fat meanwhile in Sepia was 371.80mg / 100g fat. The addition of Ω-3 fatty acids affects the increase in lipid content in pasta particularly positively contributes to a better ratio of Ω-6/Ω-3 fatty acids regardless added quantity (Filipovic et al, 2015; Ramya et al, 2014, Iafelice et al, 2008, Simopoulos, 2003). The intake of 100g of any pasta made with seabass non-degreased concentrates contributes in average with 0.32g/100g Ω-3 fatty acids level that is higher than 7.25 mg/g suggested by ISSFAL (2004) and is in accordance with the value of 90 mg/ 100g in adult proposed NHI (2015). Fortified pastas (100 g) provided from 272.58 to 371.80 of Ω-3 PUFA, corresponding to 56 - 74 % of the Recommended Intake of 500 mg/day proposed by ISSFAL (2004) and exceeding notoriously the range of 250 mg recognized by EFFSA (2010) as a dietary guideline for adult population. Findings of this research demonstrated that Pasta, popular food in the Western diet could be a good opportunity to achieve the recommended daily intake of Ω-3 PUFA and to decrease dietary n-6/n-3 ratio, it being a good opportunity to achieve a healthy diet.

### 4.3 Quality parameters and sensory profiles

Quality parameters measured in raw material and products are shown in the Table 3. As can be see, $a_w$ in concentrates both meat and skin were satisfactory for this type of product with values near from 0.35 (Badui, 2006). For its part, pastas enriched with concentrates showed values less than optimal range for growth of the most of bacteria (≤0.85) and could be keeping stable for an extended time (long shelf life), as microbiological count in samples showed. About TVB-N, a low values (< 57 mg/ 100g on dried basis) were detected in concentrates freshly made that met the limits established in the Regulation 1022/2008 of 60 mg/100g for fishery products directly used for get oil and other by-products. In this sense, low values (≤ 27 mg/100g db) of TBV-N were detected in all pastas elaborated with fish concentrate.

A sensory profile for pastas designed based on sensory attributes assessment by QDA are shown in Fig.2. A group formed by 14 sensory attributes was generated by sensory profiling technique. An ANOVA ($p \leq 0.05$) demonstrated that only 9 of them showed a significance discriminatory power and only 11 were used for drawn plot. Both formulations and the control (pasta durum) were well discriminated in the analysis, clearly forming three groups (Durum, Marine and Sepia). However, inside of each group an overlapped was observed indicating that similarity between the pastas (dried and fresh). The above clearly demonstrated that the panel discriminated adequately by type of pasta but was not able to differentiate between the distinct types of preservation treatment in the same pasta (fresh maintained at low temperature or dried at room temperature) (Table 4). The pasta durum (reference) showed typical characteristics like a yellow colour, farinaceous odour and typical semolina flavour. In other hand, Marine fresh pasta had a fishy odour with a medium intensity and a typical colour less intense. Once dried, this pasta had some note of fish odour in a medium intensity. For its part, Sepia fresh pasta exhibited a typical colour of ink squid (black), without flour odour but with some notes of fish flavour. After drying, Sepia resulted with a mild fish odour but with texture less hard than fresh pasta. Highlighting that both fresh and dried sepia pasta were more chewable than all the rest. Finally, flour odour and pastiness did not show any outstanding behaviour in products developed.

The half of sensory attributes no showed significance difference with respect the control (pasta durum) and pastas developed had structural characteristics similar in terms of elasticity, hardness and pastiness. Also all pastas evaluated by panel showed a low valuation in negative

attributes as such oil or rancidity flavours and all of them keeping moderate farinaceous flavour and odour. The above agrees with the finding reported by Iafelice et al. (2008) who established that the perception of an uncommon flavour was reported but it did not refer to fish oil flavour in spaghetti enriched with Long Chain Ω-3 Fatty Acids. Main differences detected between pastas enrichment with seabass non-degrease concentrates and control (pasta durum) were located in colours, fishy flavour and odour, especially in chewiness a secondary property of the texture.

## 5. CONCLUSION

This research demonstrates that the inclusion of up to 10% of non-degreased, dried and ground of concentrates from seabass both of meat and skin are able to increase total lipids contents as well as mineral elements composition due to the rise of ash portions. The enrichment of pasta with fish concentrates improved the quantities of unsaturated fatty acids, especially EPA and DHA, causing a positive increase in the Ω6/Ω3 ratio that greatly exceeds current nutritional guidelines. Concentrates and pastas made showed adequate quality control parameters. They resulted with low values of water activity and satisfactory microbiological count which makes them very stable foods**.** Development of pastas using cereals and seabass concentrates, without compromising on the quality of the final product, can improve the nutritional quality also adding a particular sensory attributes (odour and flavour). Thus, products developed in this study can be scaled up for potential commercialization and marketing.

## 6. KNOWLEDGEMENTS

The authors would like to thank the support for this research by *La Cátedra AgroBank* of the University of Lerida and *La Caixa Obra Social* Foundation through the Project 18-01-2018 on 1th. Call for Aid to the transfer of knowledge to the agri-food sector.

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Table1. Proximate composition (%) and energy values (Kcal/100g) for non-degrease seabass (*D. Labrax*) concentrates, dried pastas developed and their references values.

| | RAW MATERIAL (FIS CONCENTRATES) | | | |
|---|---|---|---|---|
| | ORIGINAL | | STANDARDIZED | |
| | **Meat concentrate** | **Skin concentrate** | **Meat concentrate** | **Skin concentrate** |
| ***Humidity*** | 18.5 | 3.5 | 10.0 | 10.0 |
| ***Protein*** | 48.9 | 43.5 | 54.0 | 40.6 |
| ***Lipids*** | 18.4 | 26.8 | 20.3 | 25.0 |
| ***Ash*** | 1.7 | 16.8 | 1.9 | 15.7 |
| ***Carbohydrates*** | 12.6 | 9.4 | 13.9 | 8.7 |
| *Energy value (kcal)* | *411.3* | *452.7* | - | - |

| | PRODUCT (PASTAS) | | | |
|---|---|---|---|---|
| | Sepia | Marine | Durum & Egg[1] | Durum[1] |
| ***Humidity*** | 10.0 | 10.0 | 9.7 | 9.5 |
| ***Protein*** | 16.1 | 15.3 | 13.5 | 12.5 |
| ***Lipids ****** | 6.5 *D* | 3.0 *B* | 4.2 *C* | 1.5 *A* |
| ***Ash ****** | 2.2 *B* | 0.8 *A* | 0.4 *A* | 0.6 *A* |
| ***Carbohydrates **** | 65.2 *A* | 70.8 *B* | 69.2 *AB* | 75.9 *B* |
| ***Energy value (kcal)*** | *383.6* | *372.0* | *368.4* | *367.0* |

****High significant differences between original samples (*p ≤ 0.01)***

**[1] Values from BEDCA data base (2018)**

Capital letter showing significance differences among type of pasta (raws)

* (*p ≤ 0.05)*

**(*p ≤ 0.01)*

***(*p ≤ 0.001)*

Table 2. Fatty acids profile (% based on fat compound) in concentrates of fish and pastas developed

| | FLESH CONC. | SKIN CONC. | MARINE FRESH | MARINE FROZEN | SEPIA FRESH | SEPIA FROZEN | RAW pasta[1] | Raw Pasta & Egg[1] |
|---|---|---|---|---|---|---|---|---|
| *C14* | 1.5 | 1.42 | 1.15 | 1.16 | 1.05 | 1.02 | - | - |
| *C15* | 0.22 | 0.22 | 0.2 | 0.2 | 0.15 | 0.15 | - | - |
| *C16* | 14.99 | 15.32 | 15.95 | 16.02 | 17.8 | 17.88 | - | - |
| *C17* | 0.27 | 0.27 | 0.25 | 0.26 | 0.23 | 0.24 | - | - |
| *C18* | 3.53 | 3.71 | 3.43 | 3.44 | 5.65 | 5.44 | - | - |
| *C20* | 0.22 | 0.21 | 0.19 | 0.19 | 0.16 | 0.16 | - | - |
| *C22* | 0.12 | 0.12 | 0.12 | 0.12 | 0.13 | 0.14 | - | - |
| *C24* | 0 | 0 | 0.06 | 0.06 | 0.06 | 0 | - | - |
| ***% SFA*** | **20.85** | **21.27** | **21.35 B** | **21.45 B** | **25.23** | **25.03** | **13.12 A** | **22.01** |
| *C14:1* | 0.05 | 0.05 | 0.04 | 0.06 | 0.08 | 0.06 | - | - |
| *C16:1* | 3.34 | 3.19 | 2.73 | 2.78 | 2.66 | 2.7 | - | - |
| *C17:1* | 0.22 | 0.22 | 0.18 | 0.18 | 0.16 | 0.16 | - | - |
| *tC18:1 n-9* | 0.25 | 0.27 | 0.22 | 0.23 | 0.19 | 0.18 | - | - |
| ***C18:1 n-9 (OLEIC)*** | **2.74** | **2.74** | **2.34** | **2.34** | **2.13** | **2.11** | - | - |
| *C18:1 n-11* | 37.86 | 36.97 | 31.56 | 31.78 | 34.16 | 33.82 | - | - |
| *tC18:1 n-7* | 0.09 | 0.11 | 0.08 | 0.08 | 0.07 | 0.07 | - | - |
| *C20:1* | 2.05 | 1.99 | 1.66 | 1.67 | 1.26 | 1.24 | - | - |
| *C22:1 n-9* | 0.23 | 0.21 | 0.18 | 0.18 | 0.13 | 0.13 | - | - |
| ***% MUFA*** | **46.83 C** | **45.75 C** | **u38.99 B** | **39.3 B** | **40.84 B** | **40.47B** | **10.36 A** | **35.89 B** |
| *tC18:2 n-6* | 0.3 | 0.28 | 0.23 | 0.23 | 0.18 | 0.18 | - | - |
| *C18:2 n-6* | 17.04 | 15.98 | 25.18 | 24.92 | 24.01 | 24.25 | - | - |
| *C18:3 n-3* | 3.05 | 2.84 | 2.97 | 2.96 | 2.27 | 2.26 | - | - |
| *C18:3 n-6* | 1.18 | 0.22 | 0.18 | 0.18 | 0.16 | 0.16 | - | - |
| *C20:2 n-6* | 0.67 | 0.63 | 0.52 | 0.52 | 0.43 | 0.43 | - | - |
| *C20:3 n-6* | 0.16 | 0.15 | 0.1 | 0.12 | 0.09 | 0.09 | - | - |
| *C20:3 n-6* | 0.63 | 0.59 | 0.1 | 0.1 | 0.12 | 0.13 | - | - |
| *C20:4 n-6* | 0.54 | 0.72 | 0.59 | 0.58 | 0.79 | 0.86 | - | - |
| *C20:5 n-3 (EPA)* | 1.79 B | 1.98 C | 1.58 B | 1.55 B | 0.96 A | 0.96 A | - | - |
| *C22:6 n-3 (DHA)* | 4.34 B | 5.58 C | 4.49 B | 4.34 B | 2.49 A | 2.5 A | - | - |
| ***% PUFA.*** | **29.7 B** | **28.97 B** | **35.94 B** | **35.5 B** | **31.5 B** | **31.82 B** | **43.51 C** | **9.09 A** |
| ***% total UFA.*** | **76.53 B** | **74.72 B** | **74.93 B** | **74.8 B** | **72.34 B** | **72.29 B** | **53.87 A** | **44.98 A** |
| ***% UFA + SFA*** | **97.38 B** | **95.99 B** | **96.28 B** | **96.25 B** | **97.57 B** | **97.32 B** | **66.99 A** | **72.97 A** |
| ***P/S ratio*** | **1.42** | **1.36** | **1.68** | **1.66** | **1.25** | **1.27** | **3.32** | **0.41** |
| ***Ω-6 /Ω-3 RATIO*** | **2.24** | **1.79** | **2.98** | **3.01** | **4.51** | **4.56** | - | - |
| ***mg Ω -3/100g*** | - | - | **278.43** | **272.58** | **371.80** | **371.80** | - | - |
| ***% DRI (ISSFAL)[2]*** | - | - | **56** | **55** | **74** | **74** | - | - |
| ***%DRI (EFSA)[3]*** | | | **111** | **109** | **149** | **149** | | |

**[1]References values from BEDCA database (2018)**
**[2] International Society for the Study of Fatty acids and Lipid's (2004)**
**[3] European Food Safety Authority (2010)**

Conc.: fish concentrate. SFA: Saturated Fatty Acids. MUFA: Monounsaturated Fatty Acids. PUFA: Poly Unsaturated Fatty Acids. UFA: Unsaturated Fatty Acids. P/S ratio: PUFA/SFA ratio.

Different capital letters in the same rows indicate significant differences among mean values *($p \leq 0.05$)*

Table 3. Quality parameters for pastas developed with fish concentrates

| | $a_w$ | Humidity (%) | TVB-N (mg/100g db) | MVC (cfu/g) | Y&M (cfu/g) |
|---|---|---|---|---|---|
| Meat concentrate | 0,82 | 18,44 | 50,49 | ND | ND |
| Skin concentrate | 0,44 | 3,5 | 56,78 | ND | ND |
| Marine dried | 0,38 | 1,68 | 25.88 | ND | 2,5 |
| Sepia dried | 0,39 | 2,17 | 26.23 | ND | 3,1 |

TVB-N: Basic volatile nitrogen, MVC: Mesophilic viable count, Y&M: Yeasts and Moulds, db: dry base, cfu: colony forming units and ND: Growing not detected with a sensitivity of $10^2$ cfu/g

Table 4. Sensory attributes obtained by QDA for pastas enriched with fish concentrates and reference (pasta durum).

| | PASTAS | | | | |
|---|---|---|---|---|---|
| | **Durum** | **Marine fresh** | **Marine dried** | **Sepia fresh** | **Sepia dried** |
| *Typical aroma* *** | 7,5 b | 1,7 a | 0,9 a | 2,4 a | 2,6 a |
| *Flour odour* | 5,5 | 5,8 | 5,7 | 4,7 | 4,3 |
| *Fish odour* *** | 0,1 a | 5,6 cd | 6,4 d | 3,8 bc | 3,6 b |
| *Characteristic colour (Yellow)* *** | 8,2 b | 1,9 a | 1,9 a | 8,1 b | 7,1 b |
| *Homogeneity in colour* ** | 9,2 b | 7,7 a | 7,8 a | 8,2 a | 7,7 a |
| *Elasticity* | 7,8 | 6,8 | 7,6 | 7,3 | 7,6 |
| *Hardness* | 6,7 | 5,8 | 5,2 | 5,5 | 4,7 |
| *Chewiness* ** | 8,0 b | 5,6 a | 6,3 a | 8,0 b | 7,8 b |
| *Pastiness* | 4,1 | 4,9 | 5,0 | 3,8 | 3,7 |
| *Characteristic flavour* *** | 4,6 b | 1,2 a | 1,2 a | 2,2 a | 1,2 a |
| *Flour flavour* | 6,6 | 7,0 | 6,1 | 6,7 | 5,9 |
| *Fish flavour* *** | 0,1 a | 3,9 bc | 5,0 c | 4,5 bc | 3,7 b |
| *Oil flavour* | 0,1 | 0,5 | 0,0 | 0,1 | 0,3 |
| *Rancidity flavour* | 0,1 | 0,3 | 0,1 | 0,2 | 0,3 |

Capital letter showing significance differences among type of pasta (columns)

* ($p \leq 0.05$)

***($p \leq 0.01$)

***($p \leq 0.001$)

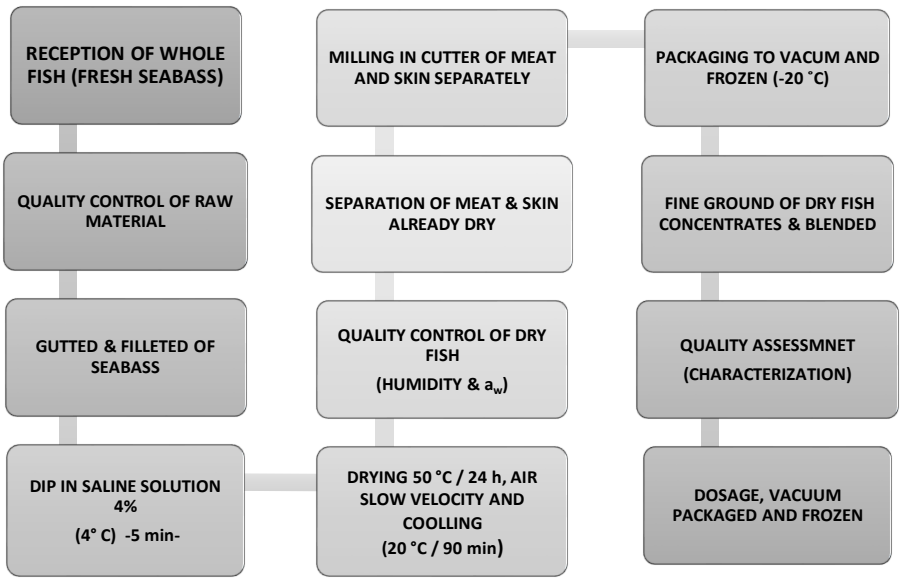
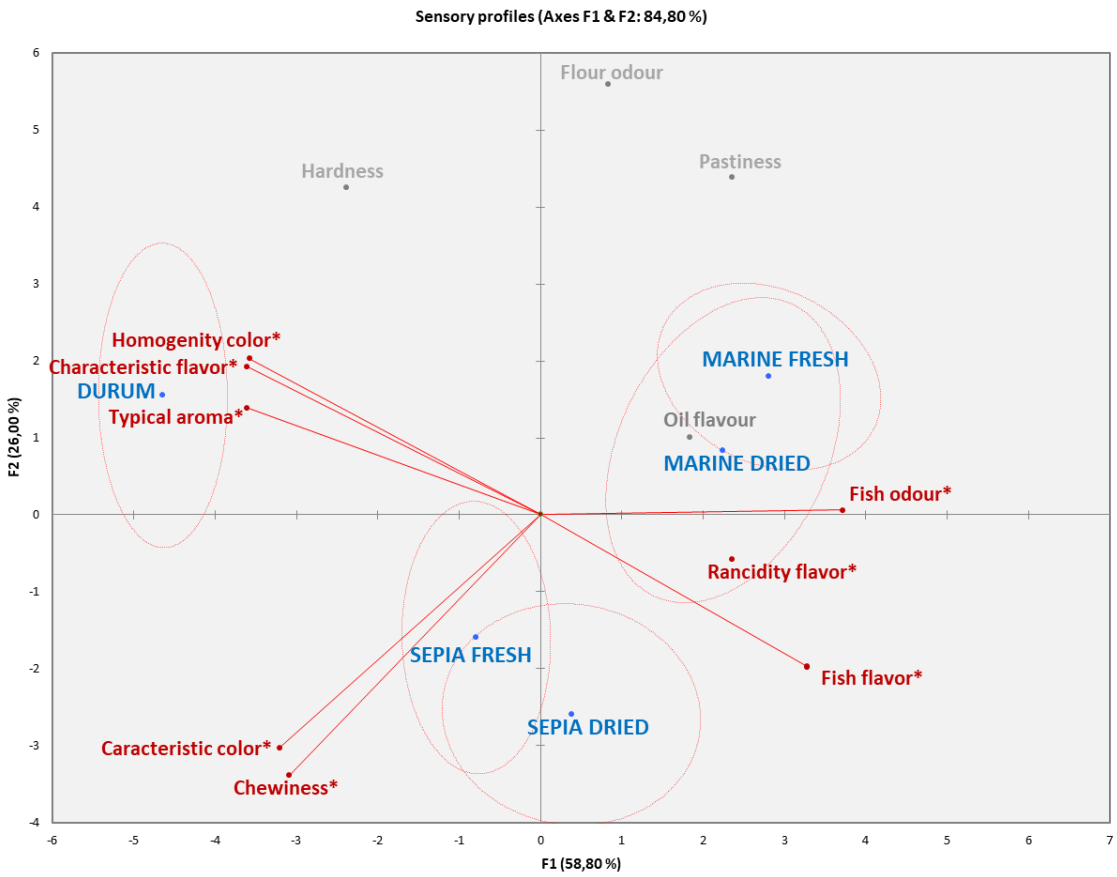



Fig.1 Technological scheme for elaborate non-degreased seabass concentrates powder.




**sensory attributes with significates discrimination power (p<0.05)*

Fig.2 Sensory profile (bi-plot) for pastas enrichment with fish concentrates and the reference food (pastas durum) obtained by QDA.