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# Deliverable 1.2 BSR Overview of Round Goby Products and Processing Methods

TF TAK

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# Summary

This report is the second deliverable of the Interreg project RoundGoby. The study aims to give an in-depth overview of the current round goby market and therefore assist the partners who are responsible for the product development journey as well as to support the business plan development.

Current round goby products, both for human consumption and for pets, were identified on the Baltic Sea Region (BSR) market including Estonia, Latvia, Lithuania, Poland, Denmark, Sweden and Germany. Their nutritional information and ingredients were analyzed for identifying trends and the commercialization status. In addition, sensory assessment sessions with expert assessors as well as with the consumers revealed the sensory profile of the products and helped understand how the consumer interacts with and perceives those products. Moreover, the study investigated the possibilities to process round goby industrially. The information was gathered from scientific journals, market observations, consultations with experts and from leading institutions in this area.

The market analysis focuses mainly on the ready-to-eat products for humans and pets that are pre-packed. It was found that products made from round goby are extremely rare in the BSR market – no locally produced products for human consumption were found and only one local product for pets was found in total. One canned product made of round goby is sold in Estonia, Latvia and Poland but it is produced in Ukraine. Facing the low level of round goby commercialization at BSR market, the market analysis was further expanded to include also other fish products in the market. In that way, a more wholesome overview of the fish products market, that the innovative round goby products are about to enter, is given for the product and business developers. While the fish product market is quite similar in BSR countries, then still few differences in the flavor profile of the products sold in different countries were noticed. For example, while in the Baltic countries the products often contain less sugar and lack spices, then in Sweden and Denmark it seems that the consumers prefer sweeter taste profile that is rich in different spices. Opportunities for developing nutritious round goby products for BSR are given in the report.

The sensory assessment of human food products included six products in the expert session and four in the consumer study, including two products – fried and smoked – that were prepared by the project team. Round goby meat has a fragile texture, that easily loses its integrity in canned products, which is not something the consumer would expect in such a product. The consumers appreciated the most fried round goby. The sensory assessment with pet owners included four

products. The results showed that for dog owners, it is important that the treat is small and handy for trainings. The cats are very picky eaters and most of them are not trained. For companies willing to explore the valorization of round goby in pet food, it is recommended to target primarily the dogs as they seem to consume the treats more often and they are more enthusiastic to try different products.

Lastly, the report looks into the processing methods of round goby. Round goby is anatomically different from the traditional Baltic Sea fish species such as European sprat and Baltic herring, that creates challenges for processing this fish. Two companies in the local region – SEAC AB and LISNA – were consulted to highlight current possibilities. Both companies have considerable experience in testing and developing machines that can process round goby and provide great options for gutting and deheading the fish. However, more engineering is needed to achieve good quality in round goby filleting.

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# Introduction

The aim of the group of activities (GoA) 1.2 is to provide a market analysis of the round goby products on the Baltic Sea Region market including both human food and pet snacks. The Baltic Sea Region unites the countries around the Baltic Sea, including Estonia, Latvia, Lithuania, Poland, Sweden, Denmark and Germany. By identifying and characterizing the products on the market, the report gives input on the product development activities and on the Round Goby market assessment.

The report looks into the nutritional profile of the current products. Moreover, possible additional functionality options and ideas about how to improve the nutritional profile of the current products are given. The reader finds sensory assessments with expert and consumer study highlighting the profiles of the current products in human food and pet snacks categories. Additionally, an overview of the suitable technologies for round goby processing is given. Understanding those different aspects of the market is crucial for further commercialization of the round goby products for humans and pets.

Some changes from the project application have been made. Initially, only round goby products were planned to be included in the market analysis. However, only a few products were identified in the Baltic Sea Region and thus the market overview was extended to other small white fish products on the market. Moreover, to further support the product development activities in the following work packages (WPs) of this project, the round goby products were also looked up from Russian-speaking online markets, where the round goby products are more common. In this way a more holistic understanding is given about the white fish products market, where the new round goby products are about to enter.

Fortunately, for the sensory assessment of human food some round goby products were gathered and in addition, it was decided to evaluate home-made smoked round goby and fried round goby. In this way, the consumer preference for the different preparation techniques of the round goby was highlighted that could give important input for the further business case assessment.

Different sources were used for the market analysis. The human food products were looked up from the physical stores and markets, as well as from the online grocery stores. The pet food category was explored mainly through pet stores' webpages. The Russian-speaking markets were explored via online search.

The report is divided into three parts, where the first part looks into the human food market, the second pet food market and the third results from the sensory assessment.

# Part I Products for human consumption

## Country-specific market analysis

This chapter gives an overview of the existing round goby products in the participating countries. In addition, consumption trends in those countries are highlighted. Due to the absence of round goby products in several countries, an overview of the most popular fish products on those markets is given with a focus on white fish. The information was collected from the representative project partner and is based on national reports as well as local market observations. The nutritional value and recommendations for improvements are highlighted in the chapter "Processing Methods for Human Food". This information indicates what type of products people prefer and what is available on the market in specific countries and can thus help make strategic decisions.

### Estonia

According to a survey, ordered by the Estonian Ministry of Rural Affairs, the Estonians consumed approximately 17.5 kg in live weight equivalent fish products per person. Estonians prefer salmon (chosen as one of the favorites for 67% of respondents), trout (52%) and Atlantic herring (41%). The local Baltic herring is the favorite of 24% of the respondents (ranked 4$^{th}$).

The largest part of the consumed fish is fresh, chilled or frozen (41% in 2020 from the total fish products consumed). While the consumption of salted and smoked fish in 2020 decreased compared to 2019 (-26% and -14% respectively), then the consumption of canned products and other ready-to-eat fish products increased by 16% and made up to 35% of the total fish products consumed per person (1).

One national delicacy in Estonia is the fermented and spiced Baltic sprat ('vürtsikilu' in Estonian). The product has a central part on the cold buffet prepared for the celebrations of Independence Day. The fish is served on black rye bread with butter and a slice of boiled egg on top. Although beloved on that day, the product is not commonly part of the everyday diet.

Currently, two round goby products for human consumption can be found in bigger fish markets in Estonia. These are fried round goby in tomato sauce that is imported from Ukraine and a local product from southwest Estonia that is dried and salted round goby fillets with skin. However, these products are very seasonal, and their availability seems to be very limited. In addition, loose whole round goby and round goby fillets can be bought from the special fish market.

## Denmark

In 2021, the yearly average amount of fisheries and aquaculture products consumed per capita was 22-25 kg. The most popular seafood is herring, salmon and mussels (2). The fishing industry contributes about 0.4% of the Danish GDP and employs directly about 0.2% of the population (3). Interestingly, according to a study by the University of Copenhagen, the Danish kids like to cook, and they do not find fish disgusting, but they still consume fish rarely. On average 10-17 years old kids consume only 105 g of fish per week, while the recommendation is 350 g (4).

There are currently no round goby products on the Danish market. Among the ready-to-eat fish products, the Danes enjoy for example tuna in water or oil, mackerel in tomato sauce, and marinated herring. Available but less popular products are fillets of anchovies, smoked Baltic herring or sardines in vegetable oil.

## Latvia

Latvians consume approximately 24.5 kg fishery and aquaculture products per year (in live weight equivalent) (5). 97% of Latvian residents consume fish and other seafood products in their diet. The Latvian market is saturated with numerous fish products including Latvian-made seafood as well as a great number of imported fish products (tuna, anchovy, mollusks and shrimp) (6). The most preferred fish species are salmon (71%), Atlantic herring (47%), sprat (45%), mackerel (34%) and trout (29%). When purchasing fish, the focus is on price and taste characteristics, rather than the status of fish populations. 61% of Latvians eat fish products at home and prefer consuming fresh or chilled fish (preferred by 53% of consumers), semi-finished fish and seafood (50%) and frozen seafood (45%). Sterilized canned fish in the Latvian market is not so popular. The main motivation for seafood consumption for Latvians is the perception of it being a healthy food and the source of omega-3-fatty acids and essential nutrients (7).

With the growth of the fishing industry and the advancement of fish processing methods, including salting, drying, and smoking, the popularity of different fish species also expanded. The first fish canning production in Latvia began in the late 19th century, creating the famous brand "Rīgas šprotes". While many fish species faced growing concerns regarding sustainability, lampreys, in contrast, have maintained a special status in Latvia and Estonia. In most of Europe, lampreys are considered endangered and are strictly protected, but in Latvia and Estonia, lamprey holds a unique status. They are still fished and enjoyed in various dishes like grilled, fried, smoked, or marinated in vinegar and set in jelly. (8)

Some round goby products can be found on Latvian market via online search. Three ready-to-eat products made of round goby for human consumption were identified. Those were fried round goby in tomato sauce from two different brands and smoked gobies in oil. However, out of the three products only one was physically available for purchase between April-May 2024. In Latvia, it has been observed that round goby products (especially hot-smoked) have started to appear more often in the seaside fishermen’s markets during the summer season.

## Poland

Although Poland has a diverse fishing and seafood industry, its annual fish production remains at around 1.4 million tons — just one-sixth of Denmark's output. In terms of per capita consumption, fish remains one of the least popular food products in Poland. The average Polish citizen consumes only about 14 kg of fish per year, well below the global average of over 20 kg. Notably, consumption is significantly lower in rural areas compared to urban centers.

However, fish consumption in Poland has been steadily increasing in recent years. According to the Institute of Agricultural and Food Economics, the current per capita intake in 2024 was 14 kg. In 2017, the average was 12.92 kg and it rose incrementally each year—13.02 kg in 2018, 13.11 kg in 2019, and 13.33 kg in 2020. The most commonly consumed species include herring, pollock, and mackerel. (9)

In a Polish household most often, canned seafood is consumed (34%), followed by dried, smoked and salted fish (23%), fresh fish (23%) and frozen fish (17%) (10). Among prepared fish products, smoked fish spreads and frozen fish burgers are getting more recognition. Fish has also started to gain popularity in the fast-food chains (such as North Fish).

In Poland, carp fish has a symbolic part of Christmas culinary tradition. Fish products are also local specialties in the country's coastal towns.

Round goby is not very known in Polish market, but few products were still found. For human consumption those were freshwater gobies in tomato sauce, round gobies in tomato sauce and dried and salted round gobies sold loose ('beer snack'). Some of those products are available in Ukrainian food shops.

## Lithuania

In 2021, the Lithuanians ate around 17.8 kg fish per person. The most preferred saltwater species were mackerel, sprat and herring (11). Other fish products popular among Lithuanians are cod liver, mackerels in oil, in tomato sauce and in jelly, smoked sprats in oil and in tomato sauce, and also hot smoked Baltic herring.

In the Lithuanian market, the round goby is represented by one available product, fried round goby in tomato sauce. From the local fishermen, it is possible to buy fresh round goby and smoked round goby.

## Germany

In 2022 the Germans ate about 13.6 kg of fish per person, which is the second highest consumption level in the last 10 years. The most popular fish species are Alaskan Pollock (market share 19.3%), salmon (18.4%), tuna (13.5%) and herring (9.9%). Germans prefer to eat canned or

marinated fish products (28%), followed by frozen products (24%), crustaceans and mollusks (15%), fresh (13%) and smoked (10%) fish products (12). Unlike in other countries, in Germany, it is mainly the young people (from age groups 15-24 and 25-39), who are the regular consumers of fishery and aquaculture products (13).

Observations at the local grocery stores revealed that there are currently no Round Goby products on the German market. The most popular fish and seafood products on the fish aisles in Germany are shrimps, pickled herring in a cream sauce with onions, cucumber and apple, crab salad, pickled herring and fried and marinated herring.

### Sweden

In Sweden, approximately 22.7 kg of seafood was consumed per capita in 2021. The most popular species such as salmon, cod, herring and shrimps make up to 75% of the total volume. Consumer studies have identified the willingness to increase seafood consumption and increase the acceptance of more species. In 2020, Sweden made an investment of 48 million SEK to increase the seafood industry and to encourage people to eat more seafood produced in Sweden. In 2020, 74% of consumed seafood was imported (14). The Swedes enjoy eating marinated Atlantic herring, mackerel fillets in tomato sauce, marinated sprats, shrimps and anchovies' fillets in oil.

A specialty from Sweden is Surströmming, which is fermented Baltic herring. The product is prepared by salting and fermenting whole Baltic herrings in open vessels over a long time. The fish is then canned. The product has an intense odor profile and the locals recommend putting the can in the freezer before opening and opening the can under water. Traditionally, the third Thursday of August has been celebrated as the Surströmmingspremiären – from this day, it is allowed to eat this season's fermented Baltic herring. It is served together with hard bread, potatoes, sour cream and onions (15).

There are currently no round goby products sold on the Swedish market.

### Round goby products from the rest of the world

The round goby products for human consumption from the rest of the world are mainly from Ukraine and Russia. The Ponto-Caspian region is the historical origin of the round goby and thus it has been a natural part of the diet for the people from this region. Through internet research different kinds of canned products were identified. From the Ukrainian market eight products were found – two of them packaged in glass jars and 6 in metal cans. Most of the products are fried (4 products) or blanched (2) fish in tomato sauce, two of them are smoked fish in oil. From Russian market 4 different products were identified. Two of them are the traditional ones – in tomato sauce and blanched in oil, while the other two are more unique. These were round gobies in tomato sauce with vegetables and another similar product that includes beans and spices. In general, more spices (such as coriander, clove, bay leaf) can be noted on the round goby product labels from Ukrainian and Russian markets. Some of the products can be found in Table 1.

Finland is also part of the BSR, however not participating in this project. A look into Finnish market revealed that currently no round goby products are available there. During the Baltic Sea Challenge project in 2019-2023 a wine bar Vestämö Wine Bar in Turku developed 8 tapas recipes from different 'junk fish' including round goby and served them to customers. However, when checking the menu in 2025 no dishes from round goby could be found.

*Table 1 Examples of round goby products from Black Sea region*

| Product photo | Product description, Country of origin | Ingredients |
|---|---|---|
|   | Smoked round goby in oil, Ukraine | Round goby, refined sunflower oil, salt |
|   | Fried round goby with vegetables, Russia | Round goby, water, vegetables, wheat flour, sunflower oil, tomato paste, sugar, salt, acetic acid, spices |
|   | Fried round goby in spicy tomato sauce, Russia | Fried round goby, beans, water, tomato paste, sugar, onion, garlic, ground red pepper, black pepper, cilantro, clove, bay leaf, wheat flour, acetic acid |
|   | Blanched round goby in oil, Ukraine | Round goby, refined sunflower oil, salt, pepper, bay leaf |

## Processing methods for human food

A gutting machine is used to remove the internal organs of the fish. Usually, the fish belly is cut using blades following a gut removal by vacuum suction.

*Figure 1 SEAC AB Nobbing machine FPM-200*

A Swedish company SEAC AB, specialized in small-size fish, offers a Nobbing machine FPM-200, that incorporates an individual head measuring device and mechanical gutting. TFTAK consulted SEAC AB to gain further insight into round goby processing. The company said that they have developed a machine specially for round goby processing already in 2013 with successful results. Here you can also see a video of the machine. While the tests of the male fish are removed easily with the vacuum succession, then the female ovaries are more tightly bound, and thus, often not removed by the succession as seen on the video as well. The roe won't impair the taste and the high-end chefs who have tested it during GoA 2.2 activities have found a great use for the roe and are interested in incorporating it into recipes. The machine was developed as per request from the Crimea region, but due to geopolitical instabilities in the region, the project was dropped. The company is now actively looking for a partner who would be interested in either buying or renting the developed nobbing machine for round goby (16).

In addition to SEAC, a Latvian company LISNA is also offering a machine specially designed for round goby processing and they have also conducted tests for automated round goby filleting. Alternatively, a Spanish company Gaictech offers a gutting machine for small pelagic fish with a capacity to cut up to 350 fish/min.

During a research study by TFTAK different processing methods of round goby and its impact on the final product quality were tested. It was concluded that it is most efficient to first gut and dehead the fish and then debone and mince it with a separator. In these experiments, the fish were manually deheaded and gutted, followed by separation of fish meat by using a small commercial separator. When the whole fish was processed in the separator, then the resulting minced fish meat contained unpleasant pieces of bones and clams from round goby's gut. From the minced fish meat produced from the gutted fish, it is possible to produce tasty fish balls for example. The byproducts from the process could be used for producing pet food or fish broth (17). It was also mentioned by SEAC, that fish burgers in general have recently gained popularity in Swedish market that could be a good application for round goby minced meat (16).

As mentioned, the mechanical method is one option to remove the bones. Then the bones are pulled out manually with a tool. It is a rather time-consuming, unhygienic and laborious method. Other different methods can theoretically be applied to the whole fish to remove or soften the bones.

- Chemical treatment – the fish is treated with acid, alkali and enzymes to soften the bones. Although efficient, it also evokes the degradation of fish proteins, impairing the taste and textures.
- Enzyme treatment – also efficient, but wrong inactivation can hydrolyze the fish meat.
- Thermal separation – it is easier to remove the bones after the fish has been cooked. It will lead to changes in textural properties of the meat (18).

Industrial separators are most commonly used for removing bones, together with fins and skin. The machine consists of a perforated rotating stainless-steel drum and a rubber belt. The rubber belt presses the fish against the drum. The fish meat is then pushed through the holes in the drum. The outcome is minced fish meat that can be used in different products. Some separators can process the whole fish, while others are for a specific part (such as fillets). Researchers who developed a special fish bone separator for carp (*Cyprinus carpio*) reported few drawbacks of the available machines such as (1) the low hygiene level of the rubber belt, (2) hard bones can damage the belt surface, (3) the machines are commonly designed for processing several tons per day and (4) they tend to cost too much to be affordable for small-scale production (19).

During the study by TFTAK, it was found that manual filleting of round goby is troublesome due to the fragile nature of the fish meat and the small size of the fish coupled with very slimy surface. In industry, a filleting machine is used to automate the fish filleting (17). SEAC AB has also tested filleting round goby together with Danish scientists about 10 years ago. It was pointed out by the company, that currently, it is complex to transfer solutions suitable for herring or other fish filleting to processing round goby because of their anatomical differences (16).

All in all, it can be said that because of the strong bones more processing is recommended after deheading and gutting the fish. Currently, it is possible to produce the fish minced meat, but producing round goby fish fillets at industrial scale is troublesome.

## Overview of the nutritional value of round goby and other small white fish products by processing method

The fish products on the market can be categorized by processing methods. The traditional fish processing methods are smoking, salting, drying and marinating, which can be applied in different combinations and that can use the whole fish or filleted fish as raw material. In modern times, processes such as canning, sous-vide cooking, surimi preparation and ready-to-eat products have expanded opportunities for fish processing (20). There are only very few round goby products available on the market, thus the market overview covers also other fish products of mainly white fish, that could give inspiration to the product developers. On Figure 2 the most common preparation methods for ready-to-eat white fish products are summarized. The scheme was prepared as per market observation by partners from different BSR countries. In this chapter,

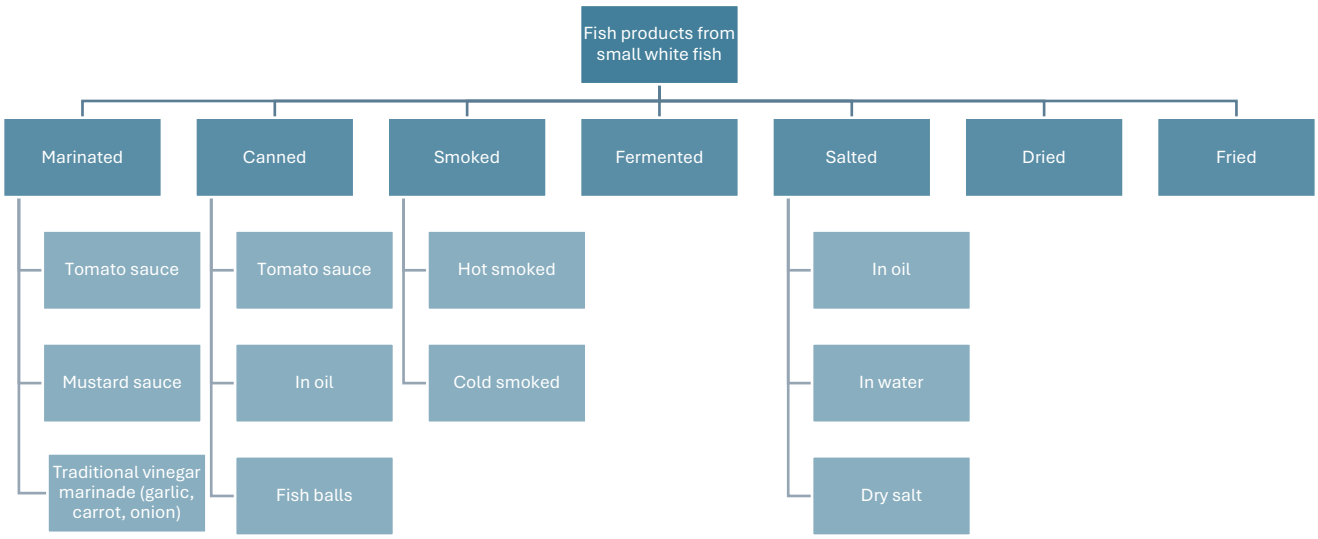


*Figure 2 Overview of the most common processing methods of small white fish. Based on market observations in BSR.*

only products that were physically available in the stores in April-May 2024 are concluded.

### Marinating

Marinated fish is a whole fish or portions of fish treated with a solution including sugar, spices, oil, plant extracts and acids like vinegar, fruit juice or wine. The aim of marinating is to extend the shelf life and to improve the flavor profile. Most common is to use acetic acid and salt for the marinade, which will create an unsuitable environment for bacterial growth and enzyme activity. Different additives such as spice, sauce, cream, oil, mayonnaise and dill enhance the flavor further. In addition, plant extracts from tomato, garlic and dill have antioxidative effect, which slows down the lipid oxidation (21).

A rich choice of different types of marinated fish products is available in BSR and a choice of them is summarized in Table 2. The products are most often made of fish fillets in the case of herring, but the products of smaller fishes incorporate deheaded and tail-cut fish with guts In Estonian market, it is most common to marinate the fish in tomato or mustard sauce or simply in vinegar with some vegetables such as onion and carrot. The product profiles seems to be similar in Poland, Germany, Latvia and Lithuania. On the other hand, in Denmark and Sweden, it seems that the consumer prefers sweeter marinated fish products as the most marinated fish products in these markets are higher in sugar. While in the Baltics the sugar content is mostly <10 %, then in Sweden and Denmark it is often >15 %. Also, in Sweden and in Denmark the fish products often have a richer profile of spices. For example, marinated fish products on these markets could contain cinnamon and nutmeg.

Only one marinated round goby product was available during summer 2024 in BSR. The fried goby in tomato sauce that is produced in Ukraine, can be bought from Estonia and Latvia. The round goby product has less fat compared to the popular herring products. This is due to the low-fat body composition of this fish.

*Table 2 Marinated white fish products on BSR market.*

| | Product (Photo, name, country of origin) | Ingredients | Nutritional value |
|---|---|---|---|
| MARINATED |  Fried European sprat in tomato sauce, Läätsa Kalatööstus AS, Estonia | Fried European sprat, water, tomato paste, sugar, wheat flour, salt, onion, carrot, rapeseed oil, acidity regulator: acetic acid, citric acid, flavors & aromas, preservative E211 | Energy: 236 Kcal<br>Total fat: 18.2 g Saturated: 2.8 g<br>Total carbohydrates: 11.2g<br>Sugars: 7.2 g<br>Protein: 8.1 g<br>Salt: 2.5 g |
| |  Fried round goby in tomato sauce, Riga Gold, from Ukraine, sold in the Baltics | Fried Goby, tomato sauce (tomato paste, sugar, wheat meal, sunflower oil, salt, onion, spices, acetic acid). | Energy: 94.1Kcal<br>Total fat: 0.7 g<br>Saturated: 0.1 g<br>Cholesterol: 52.9 mg<br>Sodium: 494.1 mg<br>Total carbohydrates: 9.4 g<br>Fiber: 0g<br>Added sugar:7.1 g<br>Protein: 9.4 g |
| |  Atlantic herring fillet in mustard sauce, Well Done, Lithuania | **Marinated Atlantic herring 35%** (filet, sugar, salt, acidity regulators: E260, E330, E331, E575, E334, E262; flavor enhancer E621, dextrose, glycose syrup, preservatives: E211, E202), **Mustard sauce 35%** (water, refined oil (1:rapeseed; 2: sunflower), sugar, thickeners: E1414, E1442, E1412, E401, E412, E415, E10; cream powder, salt, milk protein, yogurt powder, yolk powder, egg powder, sugar, salt, spices, flavors), **Mustard 15%** (water, mustard seeds, vinegar, sugar, salt, spices, natural flavors), **Marinated cucumber 11.5%** (cucumber, water, brandy vinegar, salt, sugar, spice extracts), **Marinated onion** (onion, sugar, salt, acidity regulator E260, preservative E211) | Energy: 210 Kcal<br>Total fat: 16 g<br>Saturated: 2.3 g<br>Total carbohydrates: 7.9 g<br>Sugars: 4.9 g<br>Protein: 7.6 g<br>Salt: 2.5 g |
| |  Baltic herring rolls in garlic sauce, Viru Rand OÜ, Estonia | Baltic herring filet, water, sugar (max 9%), salt (max 4.5%), garlic 2%, acidity regulator E260, apices, preservative E211 | Energy: 139 Kcal<br>Total fat: 5 g<br>Total carbohydrates: 9.5 g<br>Sugars: 9 g<br>Protein: 14 g<br>Salt: 4.5 g |

| | | | |
|---|---|---|---|
| |  Marinated herring filet with a round taste, ABBA, Sweden | Herring fillets, sugar, salt, vinegar, spices (including cinnamon, nutmeg, padouk wood, paprika), onion, dill, natural aroma, red padouk extract, preservatives (sodium benzoate, potassium sorbate). | Energy: 229 kcal<br>Total fat: 13 g<br>Saturated: 3.3 g<br>Total carbohydrates: 18 g<br>Sugars: 17 g<br>Protein: 11 g<br>Salt: 6.7 g |
| |  Marinated herring filets, Glyngøre, Denmark | Herring, sugar, water, 6% onion, vinegar, salt spices (including allspice), red peppers, acidity regulators (E296, E330) | Energy: 1100 kj/ 270 kcal<br>Fat: 15 g<br>Saturated: 4 g<br>Carbohydrates: 22g<br>Sugars: 21 g<br>Fibers: 0 g<br>Protein: 11 g<br>Salt: 2.4 g |

## Salting

In high salt concentrations, a living cell dehydrates through osmosis, which limits the bacterial count in fish product prepared that way. In addition, the decreased water activity deactivates enzymatic degradation. Different types of salting techniques exist:

- Brining – used as a pre-treatment where fish is left in a salt solution for a short time before further processing;
- Pickling – fish is stored in the brine for a longer time;
- Kench curing (also Dry salting) – fish are split opened and salted, the brine is allowed to drip off;
- Gaspe cure – dry salted product is left to develop in the developing brine for several days, followed by drying in the sun;
- Wet salting – dry salted fish is left to mature in the developing brine.

The salt uptake is impacted by the fat content of a fish. A study, where it was compared between cod and salmon, cod showed higher salt uptake than salmon. Salting can also impact the texture of the fish product. A study about salted herring showed that heavy salted herring remains firmer than the lightly salted herring (20).

Among small white fish no commercialized salted round goby products were found at BSR. Other than that, salted salmon and herring are very popular products in all countries and the products are similar to what has been summarized in Table 3. Dry salted products are presented under 'Drying'.

*Table 3 Salted white fish products on BSR market*

| | Product (Photo, name, country of origin) | Ingredients | Nutritional value |
|---|---|---|---|
| SALTED |  Salted herring fillet, Abba, Sweden | Herring fillet with skin, salt, vinegar, preservatives (natrium benzoate) | Energy: 193 Kcal<br>Total fat: 14 g<br>Saturated: 3.8 g<br>Total carbohydrates: 0.7 g<br>Sugars: 0 g<br>Protein: 15 g<br>Salt: 7.2 g<br>EPA + DHA: 2.7 g<br>Omega 3: 3.2 g |

| | | | |
|---|---|---|---|
| |  Lightly salted herring in oil, Vici, Lithuania, sold in Baltics | Herring fillet without skin 80%, salt, acidity regulator: natrium acetate, citric acid: dextrose, glucose, preservatives: natrium benzoate, potassium benzoate, rapeseed oil 20% | Energy: 158 Kcal<br>Total fat: 12,5 g<br>Saturated: 1,7 g<br>Total carbohydrates: 0,3 g<br>Sugar: 0,1 g<br>Protein: 11,1 g<br>Salt: 5 g |

## Drying

Drying reduces the water activity and thus prolongs the shelf-life of the fish. In addition, drying evokes protein and lipid oxidation and Maillard-reactions, that produces flavor and aroma enhancing compounds. However, excessive drying results in off-flavors and rancid taste. In general, 45 to 60% relative humidity is recommended for drying fish. However, the fish thickness, salt and fat content as well as drying temperature and air velocity has an impact on the quality of the dried fish. Traditionally, sun or air drying has been used, but nowadays technologies such as solar tunnel dryers, convective air dryers and microwaves have been used (20).

Dried fish products seem to be not as popular on the BSR market as marinating and salting. During the market observations only a few dried products were noted and some examples can be found in Table 4. However, in Estonia this category provides great variety of different small fish from around the world, such as the *Selaroides leptolepis* (yellowstripe scad), *Saurida undosquamis* (brushtooth lizardfish) and *Stolephorus spp* (Indian anchovy). In Poland, the dried round goby can be bought from Ukrainian store. In Sweden, Denmark and Germany this type of fish products are not widely sold.

*Table 4 Dried fish products from the BSR market*

| | **Product (Photo, name, country of origin)** | **Ingredients** | **Nutritional value** |
|---|---|---|---|
| **DRIED** |  Dried salted round goby 'beer snack', Poland | Whole salted and dried round goby | *no data available* |

| | | | |
|---|---|---|---|
| |  Salted and dried *Saurida undosquamis,* Thailand, sold in Estonia | Fish (*Saurida undosquamis)* 97%, salt, moisturizing agent: sorbitol | Energy: 1176 kJ/ 281 Kcal<br>Total fat: 3.1 g<br>Saturated: 1.06 g<br>Total carbohydrates: 1.06 g<br>Sugar: 1 g<br>Fibers: 0g<br>Protein: 54.4 g<br>Salt: 7.3 g |
| |  Dried round goby fillets with skin, Estonia | Round goby, salt 6%. | Energy: 926 kJ/ 246 Kcal<br>Total fat: 1.1 g<br>Saturated: 0.2 g<br>Total carbohydrates: 0 g<br>Sugar: 0 g<br>Protein: 52 g<br>Salt: 6 g |

## Smoking

The smoke serves two purposes – it gives the fish a certain organoleptic character and has also an antimicrobial effect. The smoke develops traditionally when burning wood such as maple, oat, alder, birch and fruitwoods, each one of them contributing with unique flavor nuance. The smoke can also be produced electrostatically. During hot smoking, the temperature is around 80-100°C, while cold smoking occurs at 30-33°C. Cold smoking will not protect against bacterial growth (20). In food industry, liquid smoke is often added to the products traditionally prepared by smoking. However, due to concerns about genotoxicity, all eight smoke flavorings previously allowed in EU are banned from 1st January 2025 based on EFSAs most recent scientific assessment (22).

While hot and cold smoked salmon and trout are popular in all countries, similar products from other fish species, especially from small fish, are not that common with the only exception being smoked sprats in oil common in the Baltics, the product example can be seen on Table 5. In Latvia and Lithuania, it is possible to buy hot smoked round goby from the local fishermen markets in loose. However, no packaged smoked round goby in BSR supermarkets was found.

*Table 5 Smoked fish products from the BSR market*

| | Product (Photo, name, country of origin) | Ingredients | Nutritional value |
|---|---|---|---|
| SMOKED |  Smoked *Sprattus sprattus*, Brivais vilnis, Latvia | Smoked sprat 70%, rapeseed oil (29%), salt (1%) | Energy: 1473 kJ/ 356 Kcal<br>Total fat: 32 g<br>Saturated: 6 g<br>Total carbohydrates: 0 g<br>Sugar: 0 g<br>Fibers: 0 g<br>Protein: 17 g<br>Salt: 1.5 g |

## Canning

Canning is used for preservation, but as there is heat treatment involved, then it also cooks the food. Canned products have a long shelf-life and they can be stored at room temperature when sealed. The canning process includes food preparation, filling the cans, sealing, heat sterilization and cooling. During the heat treatment, the spoilage microorganisms must be destroyed to prevent poisoning or spoilage. It is important to choose heat treatment that also kills the spore forming microorganism such as *Clostridium botulinum*. The typical sterilization temperature is 121.1°C. It has been proven that microorganisms die in a logarithmic manner when being exposed to lethal degrees of heat. That makes possible to mathematically calculate the heating time (the D value) needed for a desired level of microorganism reduction at a certain temperature. The most common fish for canning are tuna, sardines/pilchards, herring/mackerel/anchovies and salmon. Vegetables oils and tomato paste are traditionally used as covering liquids for canned fish products. Different packages such as metal and glass containers or retort pouches are used for packaging heat sterilized fish products. Retort pouches provide some advantages such as less storage space required and shorter sterilization time and easy opening for the consumer, however, more attention is needed to prevent pouches from expanding and bursting during sterilization. It is also important to guarantee safe sealing. For packaging human food, most often metal or glass is used (23).

The heat treatment will not only inactivate the spoilage microorganisms, but it will also have an impact on the food product's organoleptic qualities as well as on the nutrient content as the food cooks during the process.

The consumer can find different canned products on the market that have been highlighted in the previous sections and a few examples are also given in Table 6.

*Table 6 Canned fish products from the BSR market*

| | Product (Photo, name, country of origin) | Ingredients | Nutritional value |
|---|---|---|---|
| CANNED |  Fish balls in tomato sauce, Latvia, sold in Baltics | Fish 65% (fresh and smoked fish), barley groat, rapseed oil, wheat flour, salt, spices, tomato sauce 30% (water, tomato paste, rapeseed oil, sugar, salt, dried onion, acidity regulator – acetic acid, spices), vegetables 5% (dried carrot) | Energy: 611 kJ/ 146 Kcal<br>Total fat: 5.8 g<br>Saturated: 1.2 g<br>Total carbohydrates: 14.2 g<br>Sugar: 4 g<br>Protein: 10 g<br>Salt: 1.8 g |
| |  Herring in rapeseed oil, Coop, Denmark | Smoked herring fillets (Clupea harengus) 63%, rapeseed oil 36%, salt | Energy: 1211 kJ/ 292 kcal<br>Total fat: 24 g<br>Saturated: 4.2 g<br>Total carbohydrates: 0 g<br>Sugar: 0 g<br>Protein: 19 g<br>Salt: 1.9 g |

## Fermenting

The fermentation of fish depends on the enzymes and microorganisms present in the fish muscle tissues and in the digestive tract. While the enzymes influence mainly the texture and have a minimal effect on the taste, then the microorganisms are responsible for the final on the aroma and taste development in the product (24). Fermented fish products are rare in the BSR market. Only exceptions are spiced European sprat or 'vürtsikilu' from Estonia and fermented Baltic herring or 'surströmming' from Sweden, that can also be found in Table 7. While the Swedish version of the fermented fish includes fermentation with only added salt, then in the Estonian version different spices such as black pepper, clove, nutmeg, cinnamon, ginger powder, coriander seeds, bay leaf are used in addition to salt and sugar. The fermentation process itself is similar – the salt and the mix of spices is added to the layer of fish and left fermenting in open vessels for a few days.

No fermented round goby products are available on the BSR market.

*Table 7 Fermented fish products on the BSR market*

| | Product (Photo, name, country of origin) | Ingredients | Nutritional value |
|---|---|---|---|
| FERMENTED |   Surströmming, Sweden | Fermented Baltic herring, salt | Energy: 389 kJ/ 93 kcal<br>Total fat: 4.5 g<br>Saturated: 1.1 g<br>Total carbohydrates: 0.73 g<br>Sugar: 0.73 g<br>Protein: 12.6 g<br>Salt: 7 g |
| |   Vürtsikilu, Estonia | Fermented European sprat, salt, spices, sugar, preservatiive E211 | Energy: 611 kJ/ 146 kcal<br>Total fat: 11.02 g<br>Saturated: 2.77 g<br>Total carbohydrates: 0.17 g<br>Protein: 11.71 g<br>Salt: 8.5 g |

## Frying

Frying is popular among home cooks and restaurant chefs and many fried products can be found among frozen food products. However, not many ready-to-eat fried fish products can be found from the supermarket. One example of such a product can be found in Table 8.

This preparation method is rather fast and cheap that causes great changes in the nutritional profile and sensory characteristics of the food. Frying involves immersing food at high temperature, which leads to physical and chemical changes. The starch undergoes gelatinization, protein denaturation and browning, which ultimately results in the formation of a crust. Understanding the mechanisms involved in the process can help reduce the oil absorption into the food product. Innovative frying techniques such as vacuum frying, microwave cooking and hot-air frying can have an advantage over traditional deep-fat frying (25).

Frying can also be used as a pre-treatment for marinating, for example in the case of the fried round goby in tomato sauce from Ukraine (Table 2).

*Table 8 An example of the fried fish product in BSR market.*

| | Product (Photo, name, country of origin) | Ingredients | Nutritional value |
|---|---|---|---|
| FRIED |  Fried European sprats, Estonia | European sprat, salt, breadcrumbs (wheat flour, water), spices. Fried in rapeseed oil without preservatives. | Energy: 761.5 kJ/ 182 kcal<br>Total fat: 9.1 g<br>Saturated: 1.9 g<br>Total carbohydrates: 9.1 g<br>Sugar: 2 g<br>Protein: 16.1 g<br>Salt: 1 g |

## Opportunities for round goby

Currently, round goby products are rare in the BSR market. Moreover, the few that are available seem to be seasonal. That gives many possibilities for filling the gap in the market with innovative fish products of round goby. Combining the findings from the market analysis and the sensory assessments, some opportunities for developing round goby products for human food are suggested.

Producing minced meat from round goby has been previously suggested to be the most efficient processing method for this fish in an earlier study by TFTAK where different processing methods were tested (described in greater detail under 'Processing methods for human food'). Minced fish meat is a great starting point for many products such as fish burgers/patties, fish fingers and fish balls that are fried products by nature and often frozen for longer storage. The same study also included product development for round goby products by TFTAK and round goby fish patties with spinach and beetroot fillings, as well as round goby fish balls with Cheddar were developed. Moreover, fish balls can be used to fill fish dumplings, called *eo-mandu* in Korean, capitalizing on the increasing infusion of Asian cuisine to the Western world (for example, import of Korean instant noodles to Europe increased 52.1% and kimchi 40.3% in first half of 2024 compared to the same period earlier (26)).

The sensory evaluation (described in Part III) revealed that the fried round goby in tomato sauce by Riga Gold appeared very mushy and did not hold its integrity. For the consumer it was not very pleasant to experience it in a fish product. The reason why the fish loses its integrity in such a product could be in the preparation method (marinating) and/or in the packaging method (canning). More research is needed to find out if it is possible to develop a similar product without losing fish integrity. Marinating itself is a versatile preparation method that allows experimenting with various flavor nuances that could also provide an opportunity for the round goby. In addition to tomato marinade, other popular marinades as mustard and marinades with vegetables could be explored.

Salt has a strengthening effect on protein gels, suggesting that it could also help making the flaky round goby firmer. Thus, salting could be used as a pre-treatment for marinating or frying to improve the texture.

Due to the increasing evidence between intake of NaCl and the incidence of cardiovascular diseases, hypertension and diabetes, a non-sodium salt such as KCl could be considered as an alternative (27).

Round goby is a lean fish. Its body fat content is around 0.5%, while at the same time it is rich in protein (18% wet basis) (28). This gives an opportunity for developing low fat high protein products that are still in high demand on the market (29). For example, a company from Iceland markets its freeze-dried cod bites as 'Icelandic superfood' targeting bodybuilders and beauty/health enthusiasts (see crunchyfish.com). The macronutrient composition of cod is similar to round goby, meaning freeze-dried snacks could be one opportunity for using round goby for human consumption. Moreover, it is most likely to be possible to produce the snacks from the round goby minced meat, thus overcoming the challenges in filleting round goby.

Round goby could also be a good choice for breakfast or snack-time/aperitif spread. An example could be taken from the French *rillettes*, which is traditionally made from meat or fatty fish. In this product, the fish minced meat is mixed with cream cheese or crème fraiche to produce a spreadable texture. Lemon juice, chives, parsley, dill, shallots or/and capers could be added for some extra flavor and/or even Dijon mustard for mild spice. Addition of vitamins and omega-3 fatty acids could further increase the nutritional profile of the product.

Considering the nutritional profile of the current fish products, then it can be seen that in most cases, those products are good sources of protein and fat. When developing similar products from the round goby, then the addition of fat might be needed for better mouthfeel as the fish itself is lean. Canola (rapeseed) oil has low level (7%) of saturated fatty acids (SFAs) and a good amount of monounsaturated (MUFAs) and polyunsaturated fatty acids, among others oleic acid, linoleic and alpha-linolenic acid that have been shown to have cardioprotective effect (30).

Round goby has great potential to provide nutritious and tasty products for all the countries in the BSR market. However, it could be beneficial to modify the recipes according to the country-specific consumer preferences. In the scope of this study, it was found that the fish products in Sweden and Denmark often contain more sugar and spices, then in the Baltics. At the same time, the product developer should keep in mind that from the nutritional aspect, it is recommended to avoid adding excessive sugar to the products (31).

## Highlights from Part I

- No round goby products found on Swedish, Danish, German, Finnish market.
- Few round goby products sold on Estonian, Latvian, Lithuanian and Polish markets.
- Compared to the few round goby products found on the BSR market, the products in Ukrainian and Russian markets have some more variety and more various selection of spices. The products from those markets could give inspiration to the BSR product developers, however, it is important to keep in mind the regional differences in taste preferences.
- Majority of fish products are marinated canned products that seem to be most numerable in all countries in BSR. Most popular marinades are tomato, mustard and a traditional vinegar based marinade with onions and vegetables.
- Marinated fish products in Denmark and Sweden contain more sugar than in the Baltics and Poland, Germany.
- Dried fish products are more numerous in the Baltics than in Germany, Sweden and Denmark.
- Smoked and fried fish pre-packaged ready-to-eat products are rather rare in the BSR market.
- Round goby is a lean fish, that provides opportunities for low fat high protein snacks. Other fish products where round goby could be one or the main ingredient include fish burgers, fish balls, breakfast spreads and dumplings. Considering the current technological readiness, it is possible to produce minced fish meat, that can be a good starting point for the products mentioned. The products could either be packaged in modified atmosphere or frozen to extend the shelf life.

# Part II Products for pets

Part two gives an in-depth overview about the pet food market and trends with the aim to position round goby in this market. There is no country-specific information available about consumption trends in pet food category on a national level as it was available to some extent for human food products. Therefore, the limited country-specific information from market observations is complemented with the global market analysis.

## Global financial indicators and BSR overview of the pet food market

The global pet food market is experiencing robust growth, driven by increasing pet adoption and the humanization of pets, particularly dogs and cats. In 2022, dogs represented the largest segment of the market, valued at $80 billion, while cats accounted for significant growth as well, with a market share of 32% attributed to their rising popularity as companions. North America leads the market due to high pet ownership rates and disposable income, with a market value of $77 billion in 2022. Meanwhile, Europe and the Asia-Pacific region are also witnessing substantial growth driven by trends toward premiumization and the increasing preference for commercial pet food (32).

In 2022, dog and cat food was the 145$^{th}$ most traded product. The export of pet food is led by Germany ($2.9 billion), followed by Thailand ($2.6 billion), USA ($2.5 billion), France ($2 billion) and Poland ($1.6 billion) (33). The global shift from home-cooked meals to commercial pet foods, coupled with the growing awareness of pet health and nutrition, is anticipated to drive the market at a compound annual growth rate (CAGR) of 7.4% through 2029. This evolving landscape indicates that the pet food industry will continue to flourish, adapting to changing consumer behavior and preferences (32).

## Market observation on BSR market

In **Estonia**, the pet snack market is rather diverse. Many different combinations of various vegetables and fish could be found. The most common fish species that could be found in pet snacks are white oceanic fish, salmon, tuna and herring. Also, the type of snack varies. The consumer can choose from dental sticks, raw snacks, cooked, dried and extruded snacks for example. While the main supermarkets sell imported brands such as Pedigree, Whiskas, Purina, Prima Dog and Prima Cat, then a few rather small innovative local brands that sell premium snacks can be found online or in selected stores. These brands are for example Farm, Pala Petfoods, Island of Pets, Brux, Free Spirit Paws and Petbit. There is only one pet snack made of round goby available on Estonian market. It is a raw fish snack made for dogs, consisting of different fish species including round goby.

In **Denmark**, the consumer can also choose from different product types and there are local pet food brands represented, such as Aller Petfood, MÆT, Faunakram, Henne Pet Food. Danes do not sell any round goby products for pets.

In **Latvia**, a study (34) has identified a decrease in the consumption of factory-produced dry food for pets and an increased interest in raw food. Most common fish species in pet snacks are cod, herring, salmon, sprat and sardines. There seems to be not many local pet food brands on the market, one that was identified was Zorro. Two products made from round goby were found for pets. Those were dried whole fish products from two brands sold by PetPlanet.lv and 1a.lv. However, they seem to be very seasonal, as they were not available for purchase during spring-summer 2024.

**Poland** has a well-established pet food market, with many local big brands such as PUPIL Foods, Dolina Noteci, Pet Republic, Dogs Plate and many more available. In fact, Poland is the 5$^{th}$ largest exporter of pet food in the world, which makes this commodity group as one of the most important ones in Polish export. In 2022, export of dog and cat food from Poland amounted to $1.6 billion (33). In 2022, the pet food export represented 0.5% of the total export and Poland holds 7.6% share in the global pet food exports. The export values have been increasing in the last years (35). Fish in pet food is increasing its popularity and gobies are appearing more often as one ingredient in pet food. One dried goby product was identified for pets, but at the moment its production has been discontinued.

**In Lithuania**, there are some local pet food producers in the market, such as Rafus Menu and Top Dog Bistro both offering natural frozen pet food. Lithuania hosts one of the most modern pet food companies in Northern Europe – Aquatera LT, where for example dog food sold under brand Nature's Protection is produced. No products made of round goby were identified for pets.

**Germany** stands as one of the top exporters of dog and cat food worldwide. In 2022, the country exported approximately $2.8 billion worth of these products, positioning it among the leading exporters globally (33). In Germany, there are several large German pet food brands on the market. The list includes Heriso AG, Deuerer, Rondo Food, Bewital Petfood GmbH & Co. KG and Vitakraft Pet Care GmbH & Co.

**Swedish** consumer can choose between many pet food brands with diversified products portfolios. In both dry and wet pet food, salmon is the most common fish. The Swedish consumer used to prefer MSC-licensed petfood, however, since the beginning of 2023 the consumption has decreased. One reason for that is the increased price-sensitivity among Swedish consumers. In the premium segment the consumer tends to value Swedish ingredients and a low climate footprint. Some local brands on the market are for example Magnussons pet food, Furry family, Halla Pet Food, Husse and Doggy AB.

In table 9 some examples of the pet food products found in the BSR countries can be seen. All in all, it can be said that similar trends in the pet snacks market in BSR countries can be seen. In terms of the ingredients and nutritional value of the products, no significant difference between countries could be identified.

*Table 9 Examples of pet snacks on BSR market*

| | Product (Photo, name, country of origin) | Ingredients | Nutritional value |
|---|---|---|---|
| PET SNACKS |  Chicken twist, Prima Pet Premium Oy, Finland | Chicken 48,8%, cod 20%, glycerol, starch, sorbitol, plant protein, salt 0,2% | Crude fat 4.5%<br>Crude protein 21%<br>Salt 0.2% |
| |  Duck-herring treat for dogs, Prima Pet Premium Oy, Finland | Poultry 84% (duck 26%), vegetable glycerine, herring (4%), dried cranberries (4%), dried eggshells (1%), lignocellulose, salt. Contains natural antioxidants. | Crude protein 32%<br>Crude fat 20%<br>Moisture 18%<br>Crude ash 15%<br>Crude fibres 8%<br>Energy 4130 kcal/kg |
| |  Raw treats for dogs, Pala Petfoods, Estonia | Rabbit (37%), Atlantic herring (30%), salmon (15%), carrots, cabbage, beets, wheatgrass, egg yolk, Icelandic kelp, sea buckthorn, cranberries, blueberries, oregano, natural tocopherols with rosemary extract, crabshell, sea salt, turmeric, thyme, bamboo fibre, citrus bioflavonoids, black pepper. | Crude Protein: 52%<br>Crude Fat: 22%<br>Crude Fibre: 3%<br>Moisture: 10%<br>Ash: 8%<br>Carbohydrates: 5%<br>Calcium (Ca): 1.6%<br>Phosphorus (P): 1.1%<br>CA : P: 1.39 : 1<br>Omega 3 Fatty Acids: 2.9%<br>Omega 6 Fatty Acids: 2.3%<br>Energy: 4302 kcal/kg |
| |  Dried fish treat for cats, Nature's Protection, Germany | Sunfish | Crude protein 60%<br>Crude fibres 1%<br>Crude fat 6%<br>Crude ash 4%<br>Moisture 16% |

## Functionalities and trends on the BSR market

On the pet food market, the consumer can choose from many products targeting a specific characteristic (such as the color of the fur, weight and age class) or products aiming to support different health problems. Regulation (EC) 767/2009 sets a framework for using the claims on feed in Article 13. While it is not allowed to claim that the feed will prevent, treat or cure a disease, then claims about optimization of the nutrition and support or protection of the physiological conditions are allowed, which leaves the brands good opportunities for targeting different problems of the pet owners'. It is also mentioned in the regulation that the person responsible for the labelling must provide scientific proof of the claim in the form of publicly available or company research. Some of the most prevalent added value products include:

- Products targeting **oral health** – periodontal disease is the most common health problem in small animals. It has been evaluated that 70% of cats and 80% of dogs have experienced some form of periodontal disease already by age 2. The disease develops as a result of plaque accumulation. Plaque starts to develop when salivary glycoprotein and extracellular polysaccharides form a membrane on the tooth surface. This is a good matrix for bacterial colonization and eventually the dental plaque starts to take off (36). The products targeting oral health claim to prevent plaque, keep gums healthy, keep the breath fresh and similar. One of the most known products targeting oral health are the dental sticks – extruded sticks with strong elastic texture.
- Products for **skin health and shiny fur** – several products market treats for enhancing the shininess of the fur and/or ease the itchiness or redness of the skin. In fact, skin disorders are very common in dogs and cats. Most often, skin problems are caused by allergies or diseases such as atopic dermatitis (37). While some products target the itchy skin, others are targeting just the shininess. These products are mostly rich in oils, especially in omega 3. Peer-reviewed research papers on this topic are limited, however, the veterinary centers recommend omega-3, omega-6, biotin, zinc, vitamin E and copper for keeping the skin healthy and the fur shiny (38; 39). Some brands have taken a step further and target products for a specific fur color.
- Products for cats with **kidney problems** – treats specific to cats often contain taurine and cranberries that should ease the urinary issues, common among cats. Taurine is one of the 11 essential amino acids for cats. It is needed for healthy reproduction, eyesight and hearing. It also serves as a precursor for the synthesis of complex fats that support the skin's barrier function (39). Urinary system infections that can develop into kidney failure are common in cats. It is widely believed that as cranberries might help prevent urinary tract infection in humans, it could also have the same effect in cats, although the scientific evidence is limited and inconsistent (40).
- **Hairball** prevention – these products target cats. Cats groom themselves often and eventually ingest the loose hairs as they do so. Over time, a hairball develops in the stomach and as the cat

wants to vomit it out, it may bring along gagging and coughing – a horrific scene for the cat owner to watch. Large hairballs can also cause health problems for cats, especially those with long hair. It is recommended to provide sufficient water for the cat and to make sure that the diet is rich in fibers to prevent large hairballs (41).

The leading trend in the pet food market is humanization that was highlighted in the Pet Food Summit 2024 by the panelists from leading pet food companies (42). The trend in Europe goes hand in hand with the changes in traditional family model, the ageing population and the decrease in birth rate. In fact, in 2014, a study by Mintel showed that 50% of Europeans treat their pets with as much care as they would their children (43). In social media, terms like 'pet-parents' and 'furry babies' are becoming more frequent when referring to pet owners and their pets respectively.

The high priority given to pets in modern families also reflects purchasing decisions. The consumers are looking for mildly processed (such as raw food) products (44), as well as products with human-grade ingredients. In an online survey that was distributed in USA, it was found that when buying food, 46% of 1926 pet owners are giving more priority to buying healthy food for their pets compared with themselves, 53% reported giving equal priority and only 3% of the pet owners give more priority to themselves (45).

A survey with pet owners also revealed that although pet owners want to feed their pets the best and most nutritious food, then the labeling and marketing strategies have made it difficult for the pet owner to determine the best. Some trends, such as gluten-free or raw food diets, have not been scientifically proven to offer any more health benefits than traditional diets. As many as 63% of 1993 pet-owners find information on pet food labels misleading and 47% did not find information on pet food labels easy to understand (45). In fact, 52% of 900 dog owners in the US, answering an online survey, have stated that their dog's nutrition is more confusing than their own (46).

## Pet snack processing methods

Dry kibble is the most popular form of pet food, created through extrusion — a high-pressure cooking process. Ingredients like meat, grains, and vitamins are mixed into a dough, cooked, and shaped into pellets. After drying, these pellets are coated with fats and flavorings for taste. Kibble is valued for its affordability, convenience, and long shelf-life. However, producing high-meat formulations can require advanced techniques, such as pre-drying or specialized equipment.

Baking is a lower-temperature alternative to extrusion, often used for premium pet foods or treats. This method results in denser, biscuit-like foods that may retain more nutrients due to the gentler cooking process. Baking is considered a natural option for pets with dietary sensitivities, though it is less common on a commercial scale.

Freeze-drying preserves food by freezing it and removing moisture via sublimation. This process is frequently used for raw diets or high-meat products, maintaining the nutritional and textural qualities of fresh food. Freeze-dried foods are lightweight, shelf-stable, and easy to rehydrate, making them a premium choice for health-conscious pet owners.

Canned food involves cooking ingredients and sealing them in vacuum-packed cans, followed by sterilization under high heat. This method provides a high-moisture diet, ideal for pets needing hydration or those with dental issues. Wet food is palatable and nutritious but must be refrigerated after opening to prevent spoilage.

Dehydrated foods are made by slowly removing moisture through air-drying or heating. This method is commonly used for treats or as a base for rehydrated meals. Dehydration retains many nutrients while making the food lightweight and shelf-stable, but it may require rehydration before feeding.

Raw diets aim to replicate ancestral eating habits by using uncooked meats, organs, and sometimes vegetables. Homemade versions require precise balancing to ensure nutritional adequacy. Commercial raw diets are often frozen or freeze-dried for safety. High-Pressure Processing (HPP) is sometimes applied to raw foods to reduce pathogen risks without cooking.

HPP is a non-thermal technique used to inactivate pathogens while preserving raw food qualities. By applying high pressure, this method enhances safety and extends shelf life without altering the nutritional profile, making it ideal for high-quality raw diets

Emerging technologies, such as ultrasound and pulsed electric fields, are being explored to improve food safety and nutrient retention. These techniques reduce energy use compared to traditional thermal processes, aligning with sustainability goals. An overview of the most traditional processing methods is given in Table 10.

*Table 10 Type of pet food and their respective processing technology.*

| Type | Process | Moisture (%) | Technology |
|---|---|---|---|
| **Dry (Kibble)** | Extrusion | 10-12 | Extruders, dryers, coaters |
| **Wet/Canned** | Retorting | 70-80 | Mixing tankers, retorts, sealing machines |
| **Semi-moist** | Low-temp extrusion | 15-30 | Low-temp extruders, preservative systems |
| **Freeze-dried** | Freeze-drying | 2-5 | Freeze-dryers |
| **Dehydrated** | Dehydration | ~ 10 | Air/oven dryers |
| **Raw (Homemade)** | Manual preparation | ~ 70 | Kitchen tools (blender, grinder) |

| | | | |
|---|---|---|---|
| **Raw (Industrial)** | Either freezing raw meat or treated at low temperature (around 40°C) | ~ 10 | Industrial freezer, oven |
| **Baked** | Baking | ~ 10 | Industrial ovens |

## Highlights from Part II

- By large, the pet food market in BSR countries is similar and no specific differences between the products sold in BSR countries were identified. Among the studied BSR countries, Germany and Poland are among the leading exporters of pet food in the world.
- The aging population and changes in the modern family model serve as great tailwinds for the pet food market that is projected to grow significantly in coming years with an annual growth rate (CAGR) of 7.4% through 2029.
- Article 13 of the Regulation (EC) 767/2009 sets a framework for using the claims on feed. The regulation prohibits claims regarding prevention, treatment or cure of a disease. Claims about the optimization of nutrition and support of physiological conditions are permitted and thus common functionalities attributed to pet food are having positive effects for oral health, skin health, urinary problems, and hairballs. The two last are mostly cats' problems.

# Part III Sensory Tests

Part III presents the results from all sensory assessments included in the GoA 1.2, these are:

- Session with expert assessors evaluating the human food products made of round goby
- Consumer study with round goby products for human consumption
- Session with expert assessors evaluating the pet treats made of fish
- Consumer study with pet snacks made of fish.

## Sensory analysis of round goby products for human consumption

### Purpose and Samples

The purpose of the sensory analysis by an expert panel was to map the sensory properties of 6 different Goby products and choose the samples for the consumer study with the aim to get deeper insight into consumer perception of the products.

*Table 11 Assessed samples and their characteristics*

| Sample # | Sample name | Sample origin | Sample code | Tests ordered |
|---|---|---|---|---|
| 1 | RG in tomato sauce | Riga Gold – commercial product found in Estonia and Latvia. Purchased in Estonia, produced in Ukraine | TOM-EST | Sensory and consumer study |
| 2 | Goby in tomato sauce | Commercial product purchased from Poland, produced in Poland | TOM-PLN | Sensory |
| 3 | RG chips (dried) | Commercial product purchased from Estonia, produced in Estonia | DRY-EST | Sensory and consumer study |
| 4 | Whole dried RG | Commercial product purchased from Poland | DRY-PLN | Sensory |
| 5 | Fried RG | Prepared the fresh fish by coating it with breadcrumbs and frying on a pan | FRY-LAB | Sensory and consumer study |
| 6 | Smoked RG | Prepared the fresh fish by smoking it in smoke oven | SMK-LAB | Sensory and consumer study |

A total of six different goby products were assessed at descriptive sensory analysis by a trained panel, as described in Table 11. Two of the samples were found from Estonian market, two of them were found from Polish market and the last two were prepared from raw round goby by the project team.

To clean the palate between the samples, the assessors were served water and unflavored crackers on the side at the time of assessment.

## Description of the methodology – sensory panel

The sensory evaluation of the products was carried out by 7 assessors with previous training and experience in evaluating similar types of samples. The final assessment method was based on relevant scientific sources, developed in-house protocols and discussion with the assessors.

Samples (Figure 3) were kept cool at 4 °C and served at room temperature (22 °C). The evaluation was carried out in the form of a consensus discussion and the samples were coded with a random three-digit code. The evaluation was carried out in a dedicated sensory room where any external factors that could interfere with the evaluation were eliminated, in accordance with ISO 8589:2007.


*Figure 3 Products analyzed*

The Descriptive Sensory Analysis (Quantitative Descriptive Analysis) used a 10-point scale, where 0 - "none", 1 - "very weak", 5 - "moderate" and 9 - "very strong". The evaluation started with appearance modality, followed by odor, taste and finally texture. For appearance, fish integrity was evaluated. For odor and taste, overall intensity, fish, sour, sweet and additive intensity were the parameters to be evaluated. In addition, saltiness, umami and bitterness were also assessed for taste. In texture, crumbliness, meat hardness, bone hardness, dryness and oiliness were evaluated. During the evaluation, additional comments on all modalities could be added if desired.

Data collection was carried out using RedJade sensory software (RedJade Sensory Solutions LLC, Martinez CA, USA). Data was analyzed and visualized MS Excel (Microsoft, Redmond WA, USA). Attribute modalities are indicated with following abbreviations: “A.” – appearance, “O.” – odor, “T.” – taste, and “X.” – texture.

## Results of sensory panel analysis

The odor profiles of round goby products are visualized in Figure 4. The two canned fish products in tomato sauce (TOM-EST; TOM-PLN) had similar odor profiles, but the product found from Estonian market (TOM-EST), was a bit more sour and less sweet in odor than the product from Polish market (TOM-PLN). In the case of these two products, the intensity of tomato was scored under additive intensity and scored a point higher in TOM-PLN sample.

Also, two commercial dried fish products were assessed, the one found from Estonian market (DRY-EST) had the mildest odor profile of all the assessed products. Polish dried fish product (DRY-PLN) had quite intense overall odor, which mostly composed of fishiness.

Lastly there were two products made in house by the project team: fried round goby (FRY-LAB) and smoked round goby (SMK-LAB). The fried product was milder, but for additive intensity, the combined oiliness and roastiness were assessed and scored higher than the fish odor. The SMK-LAB had its smokiness dominating the odor profile (scored under additive intensity), but there was no sourness, and sweetness was scored the lowest of all the samples.

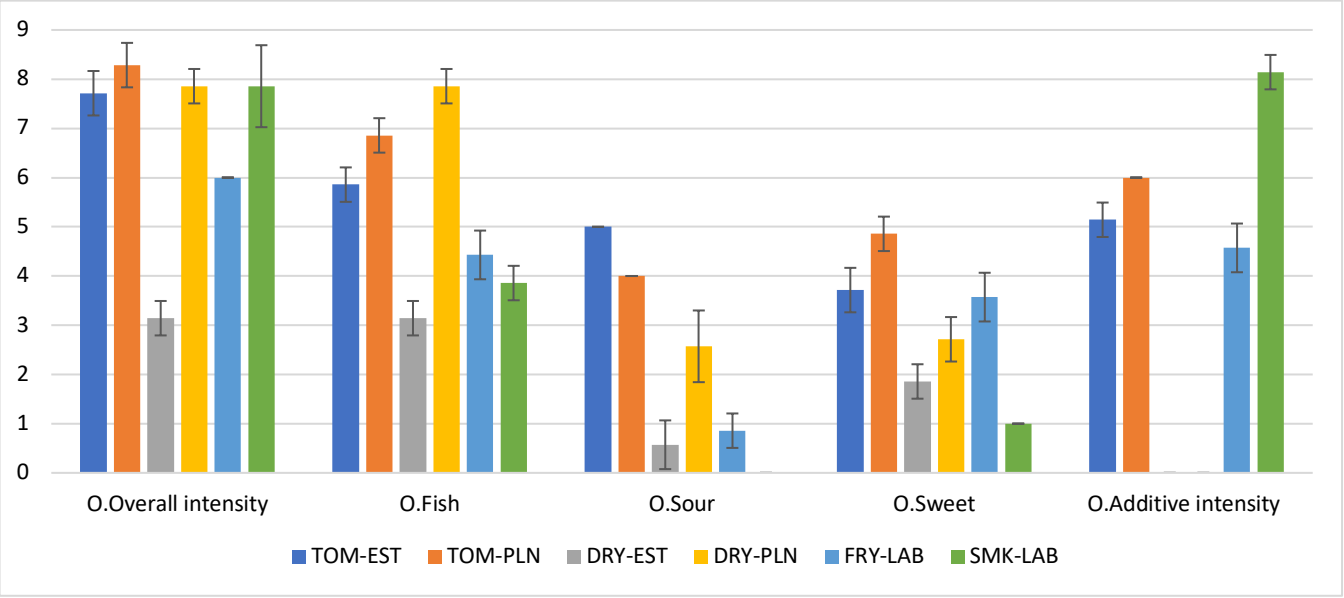


*Figure 4 Odor profiles of assessed samples*

In Figure 5, there are visualized the taste profiles of assessed samples. The two tomato sauce canned products were the sweetest and at the same time the sourest from assessed samples. Their tomato taste

intensity is assessed under additive intensity and was in similar level for both products. Bitterness was a bit higher for the TOM-EST sample. The most noticeable difference between these two products for taste, was the off-taste in TOM-PLN product. The intense off-taste was described as moldy and muddy, this was the only sample, where the raw material was goby, not round goby (RG).

The dried fish products had the highest saltiness and umami taste from all the assessed samples. The DRY-PLN had a slightly higher intensity of fish taste than the DRY-EST, along with some sourness and bitterness in taste that the other product lacked.

Fried and smoked RG products scored the least intense in overall taste and fishy taste. The SMK-LAB had the highest additive intensity (smokiness) and was sweeter than the fried product but did not reach the sweetness of tomato fish products. The FRY-LAB did not have any sourness to it. The taste of breading and oiliness were scored under additive intensity.

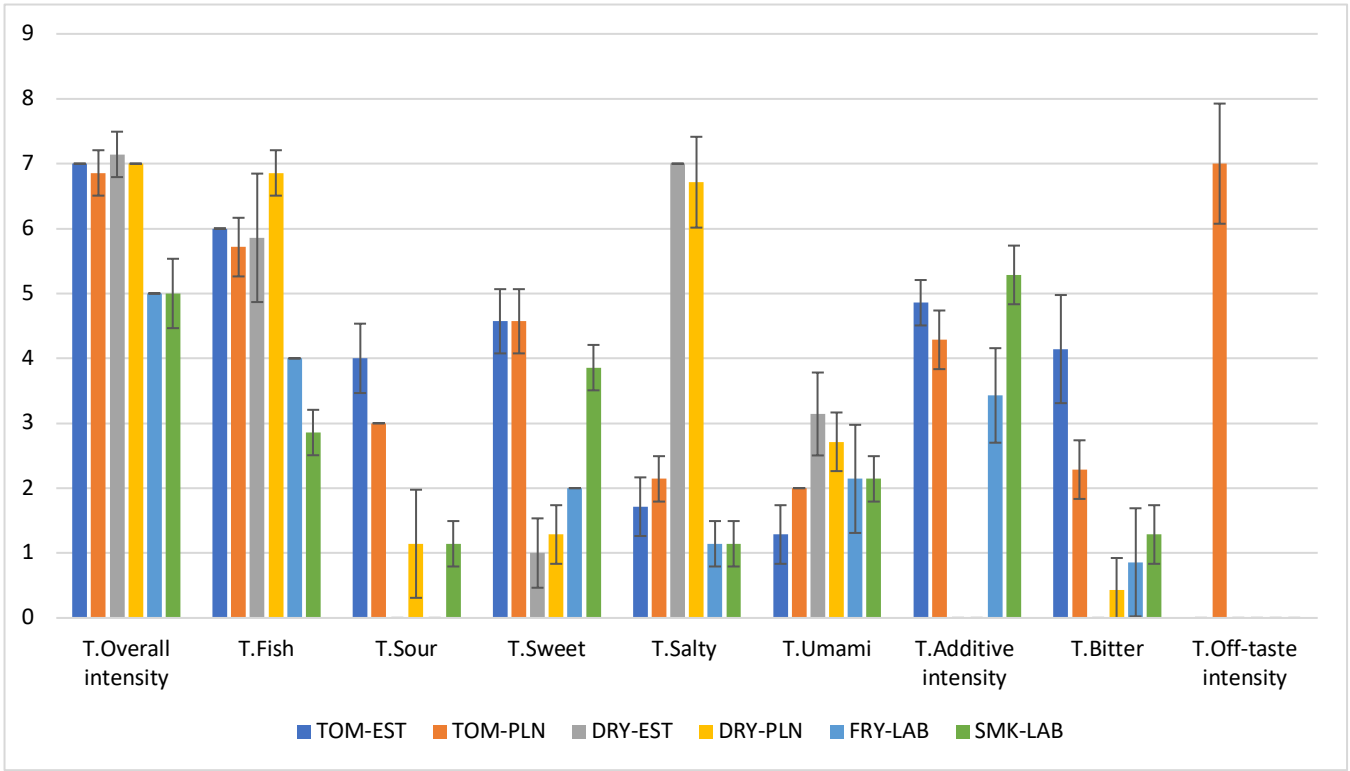


*Figure 5 Taste profiles of assessed samples*

The scores given for the one appearance attribute and the texture attributes are visualized in Figure 6. Only the canned products in tomato sauce (TOM-EST, TOM-PLN) had lost some of their integrity. The Goby

product from Poland (TOM-PLN) had still visible fish pieces in it and stayed together also when using fork, but the TOM-EST had chopped and very soft fish pieces in it, that broke when using fork. TOM-EST was scored with "1" in this attribute. The same kind of trend can be seen for the crumbliness of tomato products, the TOM-EST was scored the highest in this attribute for its little pieces and the TOM-PLN product still could hold its structure a bit more and was scored in the middle of this scale. The canned products were scored on the lower scale side for meat and bone hardness but had some oiliness to themselves that most of the samples did not have.

The dried fish products had the highest scores for meat hardness and dryness, but the DRY-EST was scored in both attributes 2 points lower than DRY-PLN. DRY-PLN had some bone hardness to it that was not seen in DRY-EST.

The fried (FRY-LAB) and smoked (SMK-LAB) RG products had the highest bone hardness. However, as assessors noted, the perceptions of bone hardness can vary depending on the part assessed. The FRY-LAB sample had also the highest oiliness, likely resulting from the pan-frying process.

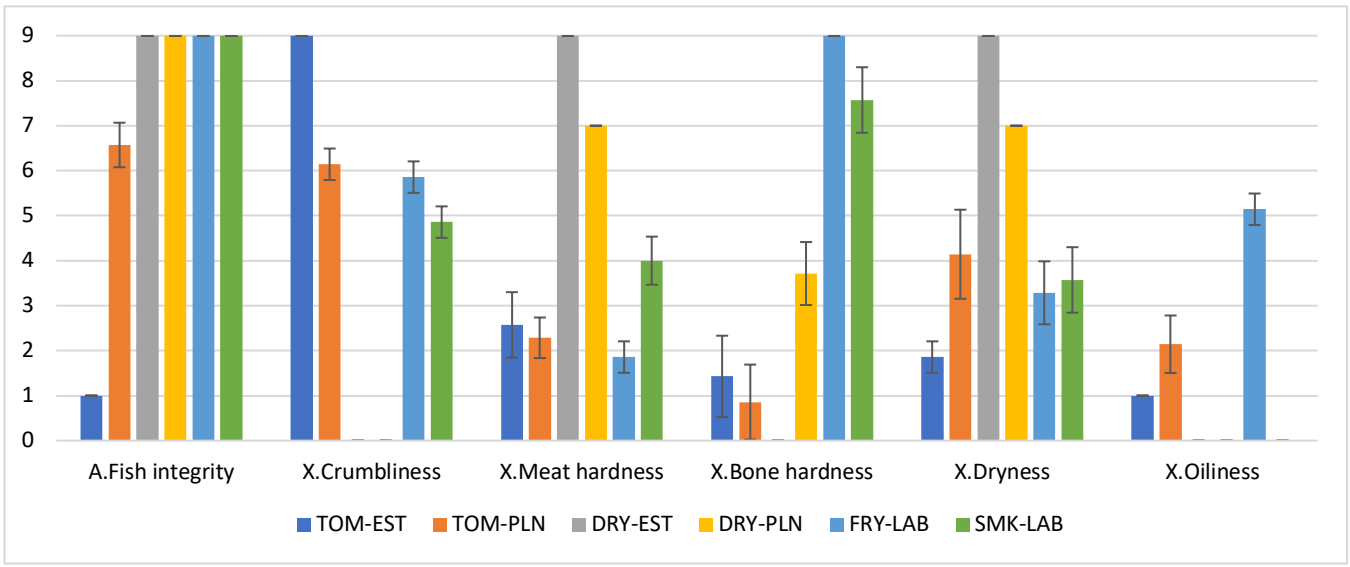


*Figure 6 Fish integrity scores and texture profiles of assessed samples*

### Highlights from the sensory panel analysis

The sensory panel analysis was conducted for six goby products. The purpose of the study was to map the sensory profiles of four commercial and two products made by the project team and then choose the samples for the consumer study.

- The canned tomato products had the sweetest odor and taste of the assessed samples. In texture, they were crumbly, and it was visually seen that the fish integrity was not the highest. These all are characteristic for this type of fish product as being in a sauce or marinade can soften the tissue. For the consumer study, TOM-PLN was excluded because of the intense moldy and muddy off-taste that it had.
- The dried RG products had the saltiest and the highest umami taste of all the assessed products. Their texture was rated the driest and hardest in meat. For the consumer study, DRY-PLN was excluded because it was challenging to serve – removing the meat from skin and bones was time-consuming, and the assessors commented that the skin was inedible. If the cleaning process had been done before serving, the consumers would not have gotten the full experience of this product.
- Fried RG and smoked RG were assessed in the texture with the hardest bones and in the taste as the lowest in overall intensity of assessed samples. They were both included in the consumer study. Even though they are not commercially available products, they were included as an example of what could be made from round goby.

### Description of the methodology – consumer study

The consumer study was conducted on 04.10.2024 at TFTAK AS. Recruited participants were all adult fish product consumers, who consented to data collection and had no related allergies. Participants were served four round goby products, with detailed descriptions provided in Table 1: 1) FRY-LAB; 2) SMK-LAB; 3) DRY-EST); and 4) TOM-EST. These samples were selected based on the preliminary sensory analysis conducted with a trained panel (refer to “Summary of sensory panel analysis”). The evaluation order of samples was randomized by Williams Latin Square. To clean the palate between the samples, the consumers were served water and unflavored crackers on the side at the time of assessment.

### Results of consumer study

Participants were asked additional questions about themselves, their consumption habits and interests after evaluating the samples. Out of 31 participants, 5 were males and 26 females. The distribution of participants by age groups is visualized in figure 7. Figure 8 shows the frequency of participants consuming

fish products. Less than 10% of them consume fish products less than 2-3 times a month, and over half of them eat fish products at least once a week.

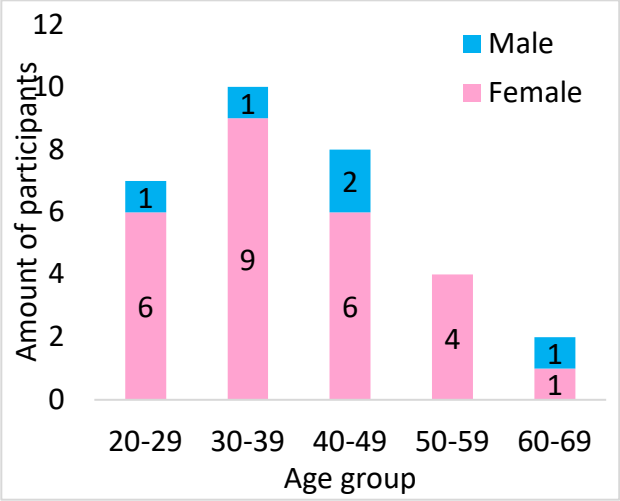


*Figure 7 Participants demographics*

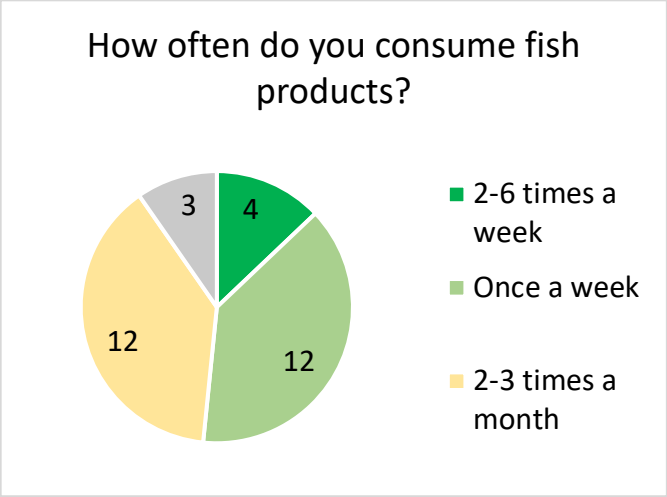


*Figure 8 Participants frequency of eating fish products*

Participants were asked about their interest in various local white fish species. The results are visualized in Figure 9. The round goby, highlighted in the figure got an average score of 3, indicating that participants had a neutral interest in this fish overall.

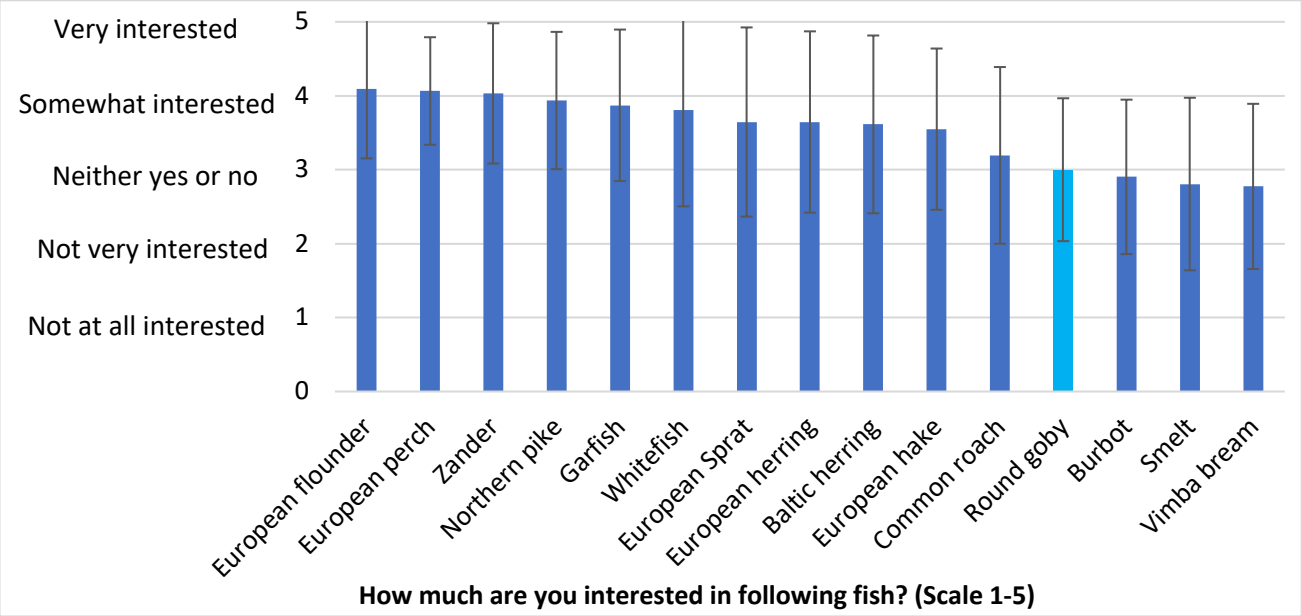


*Figure 9 Participants interest in different local fish*

Additionally, participants were asked about their interest in different types of fish products. The results can be seen in Figure 10. Participants were interested in most types of fish products, scoring above 3; the only exception was dried fish, which participants were less interested in.

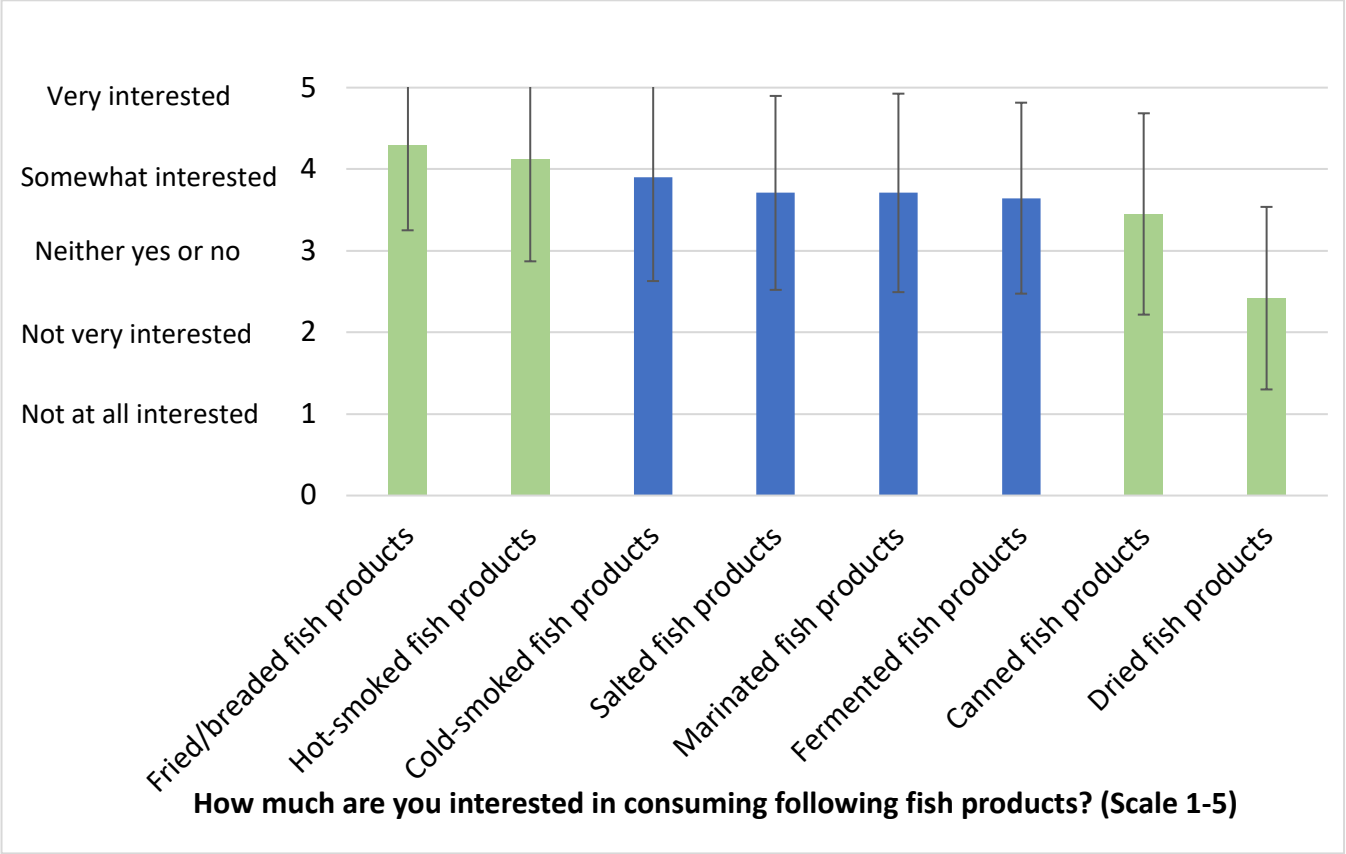


*Figure 10 Participants interest in different types of fish products. (Green – fish product types that were offered also in the consumer study. Blue – other types of fish products for comparison)*

The pleasantness scores for different modalities are visualized in Figure 8. The fried round goby (FRY-LAB) got the highest scores in all categories. The opposite could be seen for the DRY-EST product, that scored the lowest in all the modalities, especially distinctive in lower texture scores. However, all the scores were equal or over "5" which was the middle point for the scale, meaning the products were still acceptable for consumers. If individual consumers rated any of these modalities as unpleasant (score under 5) they were also asked to explain it in some words. The summary of the comments is in Appendix 1.

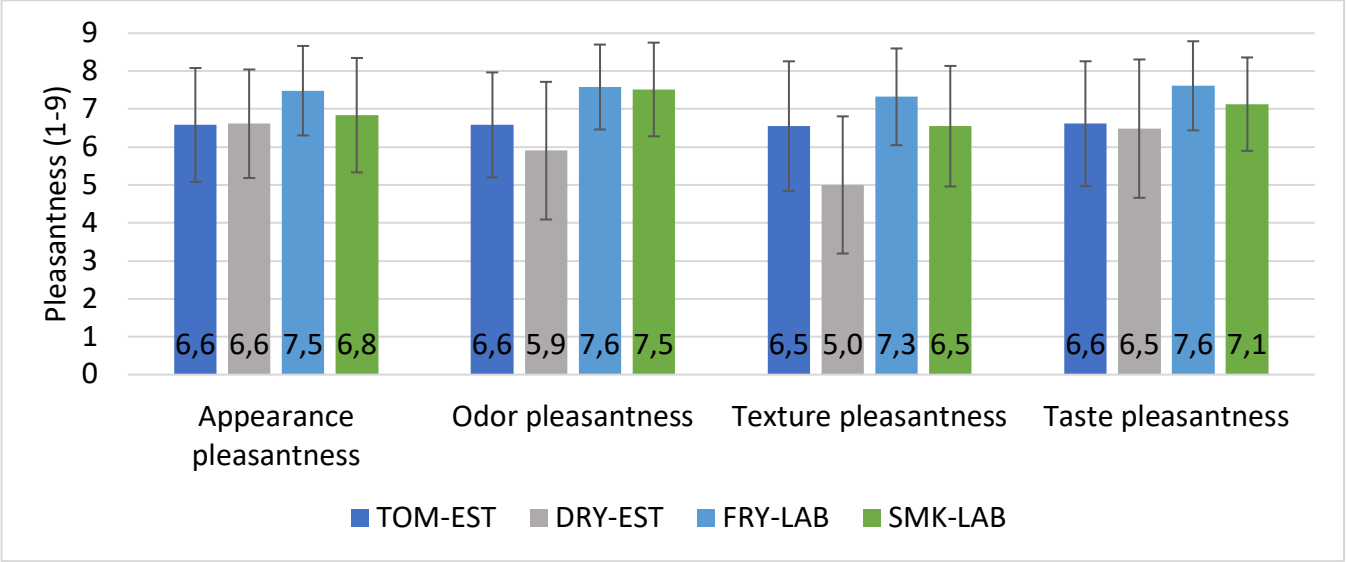


*Figure 11 Pleasantness by modalities*

Figure 12 visualizes the products eating comfortability and overall pleasantness. The canned product (TOM-EST) is the most comfortable to consume and the fried product (FRY-LAB) is overall the most pleasant product for the consumers. DRY-EST was scored the lowest, thus it seems that the overall pleasantness was influenced not only by lower sensory perception (Fig 11) but also its comfortability in easting (Fig 12).

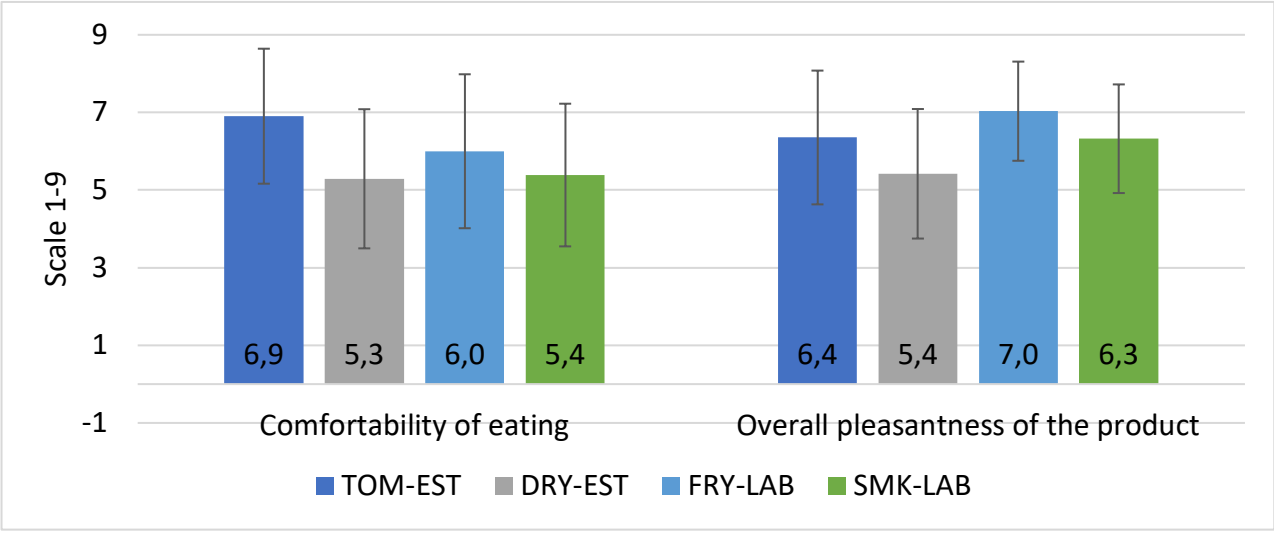


*Figure 12 Average scores given for products comfortability of eating and overall pleasantness*

Consumers were asked also about their purchase decision for every product. These results are visualized in Figure 13. The most "yes, definitely" answers got fried product (FRY-LAB) and the least dried product

(DRY-EST), which seems to be in accordance with the pleasantness scores. Based on the comments from participants who responded “maybe” and “no, definitely no”, the main reason for their hesitation to purchase the smoked RG was the presence of sharp bones, which were numerous. For the dried product (DRY-EST), consumers commented that they were not the consumers of this specific type of fish product, or the product had too hard texture.

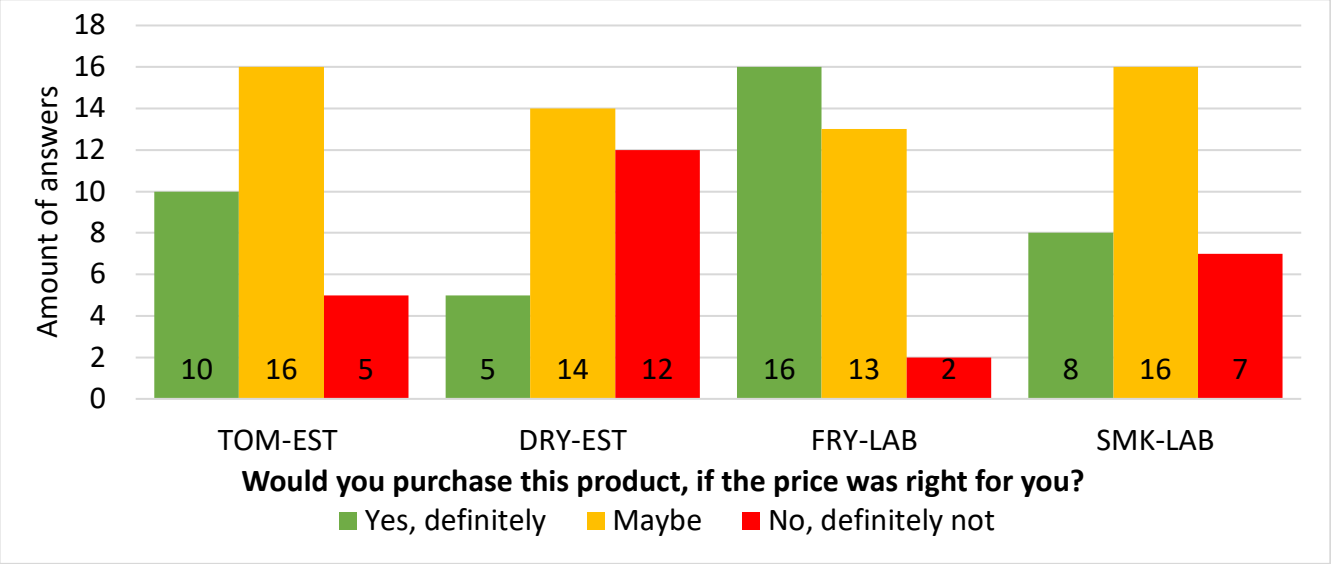


*Figure 13 Purchase decision*

After assessing all the samples by themselves, consumers were asked to rank the assessed samples by their preference. The results are visualized in the Figure 14. The fried RG sample (FRY-LAB) received the most first-place rankings, being selected as the top choice by 50% of the participants. The second preferred sample appears to be smoked RG (SMK-LAB), as it received more first and second places in total than the canned RG in tomato sauce (TOM-EST). Although TOM-EST was clearly ranked most frequently in second place, it still falls behind SMK-LAB. Dried RG chips (DRY-EST) got the last place by consumers, with nearly half of them rated this product at the fourth place.

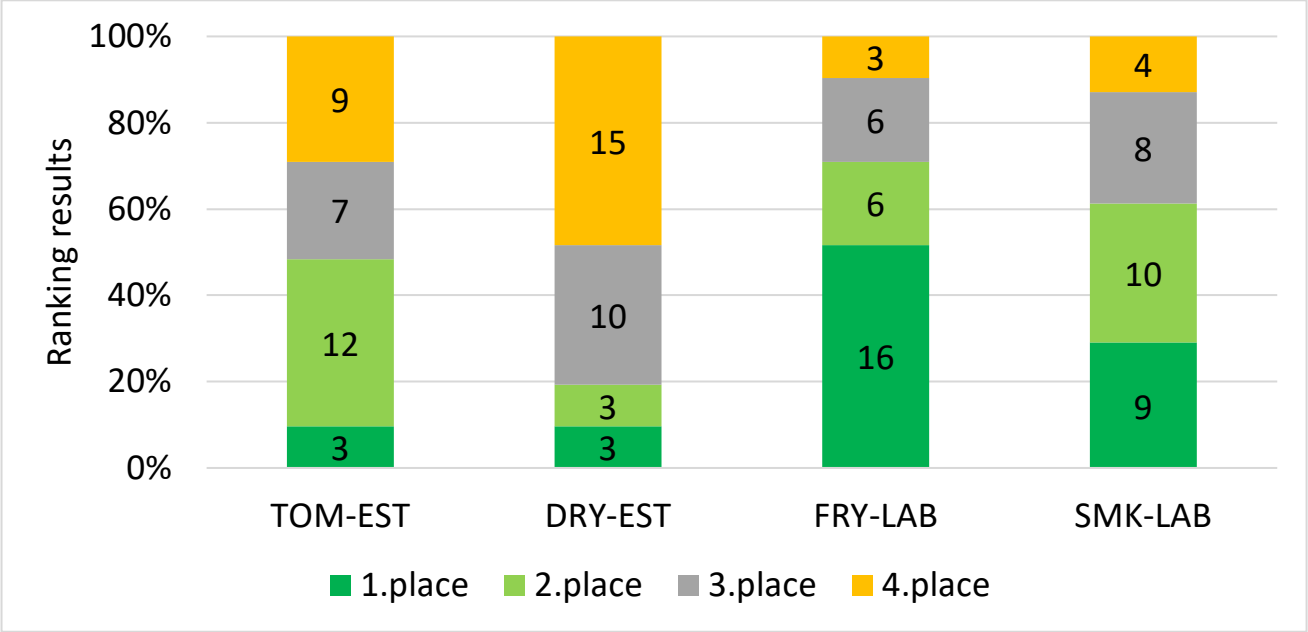


*Figure 14 Ranking of the assessed products*

### Highlights from the consumer study

- In this consumer study, participants assessed 4 different round goby products.
- When participants were asked about their interest in different fish, round goby scored a neutral "neither yes or no", but looking into the pleasantness scores of assessed products, all the products were evaluated with an average score over "5", meaning the products were pleasant for participants overall.
- Starting from the least preferred to most preferred, the lowest in the overall pleasantness was scored the dried RG chip (DRY-EST). This product got the last places in the ranking and only 16% of participants said that they would purchase this product. However, the pleasantness scores were still equal or over "5" for all the modalities assessed.
- When looking at the interest in different fish product types, the dried fish product scored the lowest – people who participated in this study were not very interested in dried fish – that may have influenced their assessment and scores given. The improvement for this product could be made in the texture, the product was commented to be too dry and hard to consume.
- The smoked RG (SMK-LAB) and canned RG in tomato sauce (TOM-EST) had very similar scores for overall pleasantness, but a bit different in comfortability of eating. The TOM-EST sample was rated as the most comfortable to eat out of all the assessed products. This may be the reason for it to be at the second place when asking about purchase decision. But the SMK-LAB product had higher

rated odor and taste pleasantness, and therefore when looking at the ranking results, this got the second place. Overall, these two products were at the middle for all different questions and modifying somehow the SMK-LAB product that it would be more comfortable for consumers consumption, could make the consumers purchase it. For TOM-EST, improvement could be made with appearance, odor and taste, but it seems that the eating comfortability would make people purchase it.

- The highest rated sample was the fried RG (FRY-LAB). Looking at the results, it should be kept in mind, that when the participants were asked about their interest in different fish products, the highest score was for the "Fried/breaded fish products" in what category this FRY-LAB was at. It is possible that consumers' expectations of good fish products influenced their sensory perceptions, including pleasantness. This product was rated the highest in appearance, odor, texture, taste and overall pleasantness. It was rated first in the ranking by over 50% of participants.
- In conclusion, although some improvements could be made for all the samples assessed in this consumer study, it is evident that round goby, which initially brought only neutral interest from consumers, was made into products that consumer found pleasant and were willing to purchase.

## Sensory analysis of fish products for pets

### Purpose and samples

The purpose of the sensory analysis with expert assessors was to map the odor profile of different types of fish-based pet snacks available on BSR market. The following consumer study was conducted with the aim of understanding how the products are perceived by the pets and pet owners and supporting the product development activities in the RoundGoby project. A total of four different pet snacks were assessed, as described in Table 12 and shown in Figure 15.

*Table 12 Assessed samples and their characteristics*

| Sample nr | Sample name | Serving size in consumer study | Sample composition | Tests ordered |
|---|---|---|---|---|
| 1 | Dr Stern raw snack | 2 raw snacks | European sprat, round goby, trout, pea flour, water | Sensory and Consumer study |
| 2 | Petbit fish cookies | 3 cookies | Perch, pea protein | Sensory and Consumer study |
| 3 | Danish dried fish | 1 fish | Round goby | Sensory and Consumer study |
| 4 | Island of Pets cookies | 2 raw snacks | Sprat, oat, pumpkin, oils and fats, collagen | Sensory and Consumer study |


*Figure 15 Assessed samples (Island of Pets cookies, Danish dried fish, Petbit fish cookies and Dr Stern raw snack)*

## Description of the methodology

The sensory evaluation of the products was carried out by ten assessors with previous training and experience in evaluating similar types of products. The final assessment method was based on relevant scientific sources, developed in-house protocols and discussion with the assessors. The evaluation was carried out in the form of a discussion and the samples were coded with a random three-digit code. The evaluation was carried out in a dedicated sensory room where any external factors that could interfere with the evaluation were eliminated, in accordance with ISO 8589:2007.

The descriptive sensory analysis (quantitative descriptive analysis) used a 10-point scale, where 0 - "none", 1 - "very weak", 5 - "moderate" and 9 - "very strong". For odor, overall intensity, fishy, vegetable, sour, sweet, roasty, cheesy, rancid (painty, cardboard, hay-like, chemical etc.) were the parameters to be evaluated. During the evaluation, additional comments could be added if desired and the intensity of any additional odor that occurred could be marked under the parameter “Other odors”.

Data collection was carried out using RedJade sensory software (RedJade Sensory Solutions LLC, Martinez CA, USA). Data was analyzed and visualized with MS Excel (Microsoft, Redmond WA, USA).

## Results – sensory assessment with the expert assessors

Figure 16 shows the odor profile of pet snacks. Additional comments by assessors are shown in Appendix 2. **Dr Stern raw snack** was the least fishy sample and was mostly characterized by sourness and various non-characteristic odors to fish such as cocoa and coconut fat (evaluated as “other odors”). In addition,

Dr Stern was the most rancid sample, possessing sharp, fecal and hay-like notes (although scored on the lower end of scale). **Petbit fish cookie** stood out as the fishiest sample, with distinct roastiness, sourness and sweetness. **Denmark dried fish** had the least intense odor, which was characterized by fishiness and sourness. However, the sample was mildly rancid having chemical and card-board-like nuances. **Island of Pets** was sweet, roasty and fishy, yet had distinct additional odors like herbs, spices, licorice and alcohol (evaluated as "other odors"). Cheesy and vegetable-like odors were not perceived in any of the samples; therefore, those parameters have been excluded from the figure.

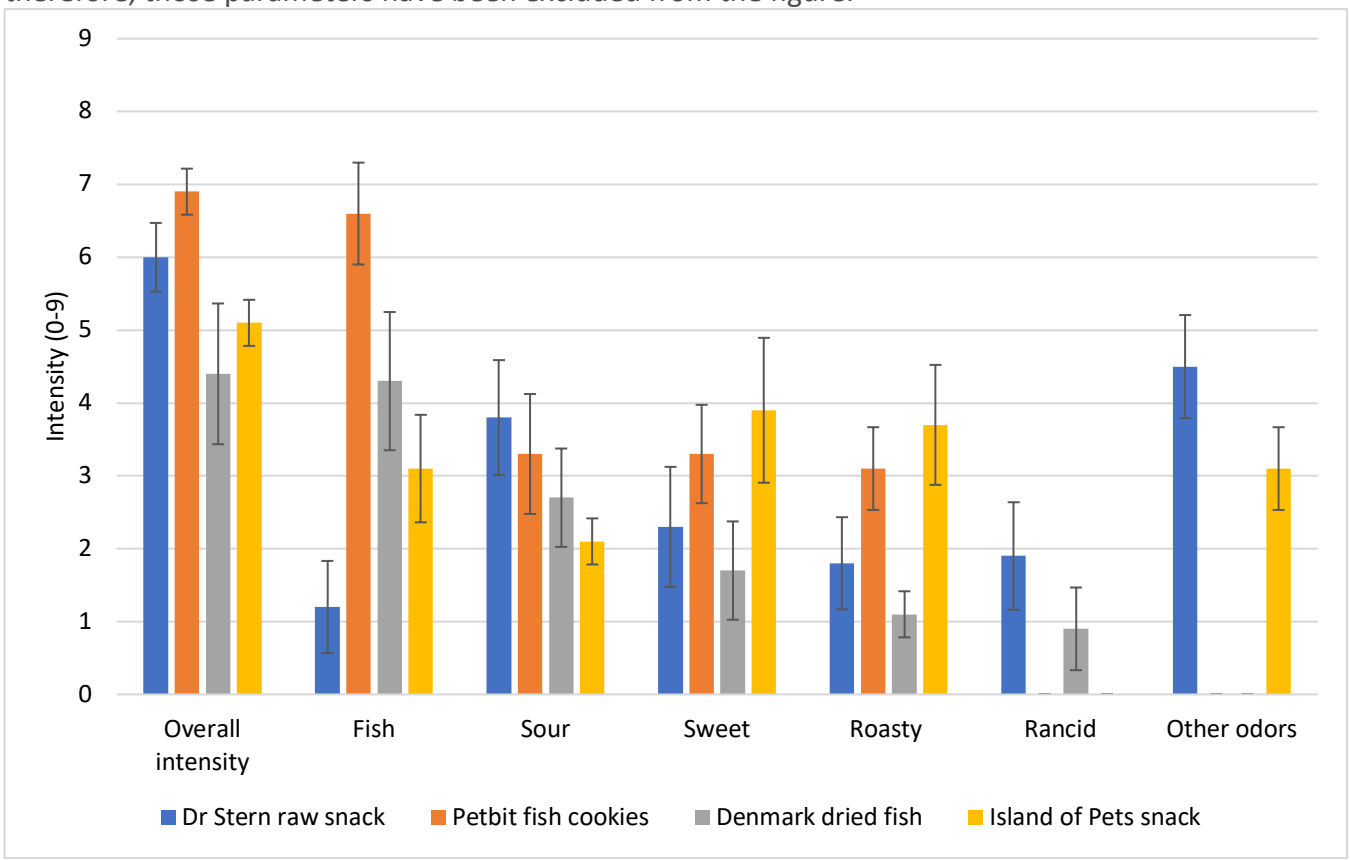


*Figure 16 Odor profile of pet snacks*

## Highlights from the sensory assessment of pet snacks with expert assessors

- In this sensory assessment session, four different pet snacks were evaluated by trained assessors
- Pet snacks on BSR market have highly variable odor profiles. Out of four products, Dr Stern raw snack and Denmark dried fish had rancid nuances
- Dr Stern and Island of Pets had very specific additional odor nuances, that were not fish-like, and these products were less fishy in general. In contrast, Petbit cookies and Danish dried fish were more fish-like and did not have other specific odor nuances.

## Description of the methodology – consumer study

The samples were repackaged into plastic bags and coded with three-digit codes for a blind evaluation, so the packaging and brand would not influence consumers' assessment. The owners were instructed to serve their pets one snack a day, to avoid overwhelming their pets. Evaluation order of samples was chosen by consumers themselves.

The questionnaire was divided into 3 parts, firstly to get the owners perspective of the snack, then the snack was served to the pet and the pet's reaction was observed and finally the suitability for training and willingness to purchase the product were rated.

When serving the sample for the pet, the owners were instructed to put the serving size of the snack into the feeding bowl of the animal. It was supposed to be done in the usual and natural time for the pet to get the treat or their food. If the pet would not consume the snack right away, the owners were instructed to leave the snack available for the animal for 1 hour.

Data collection was carried out using RedJade sensory software (RedJade Sensory Solutions LLC, Martinez CA, USA). Data was analysed and visualised with MS Excel (Microsoft, Redmond WA, USA).

## Participants

A consumer study was conducted with a total of 40 pet owners and their pets. Participants were recruited as a convenience sample, the only aim was to get equal amount of cats and dogs, which was fulfilled.

## Results of the pet snack consumer study

### Demographics and habits of pets

Consumers were asked to rate their pet's appetite and choose the best answer out of pre given list, to describe their pets' eating habits, these results are shown in Figure 18. The scale was developed by the research team, with 3 of the answers describing more of a picky eaters and 3 answers describing pets who consume all kinds of foods and seem to be with a good appetite. When looking at the results in Figure 18 it is seen that most of the dogs are with good appetite and eating everything that is offered (and wanting more), while biggest proportion of cats are rather on the picky eater side, 65% of participating cats were picky about their everyday food.

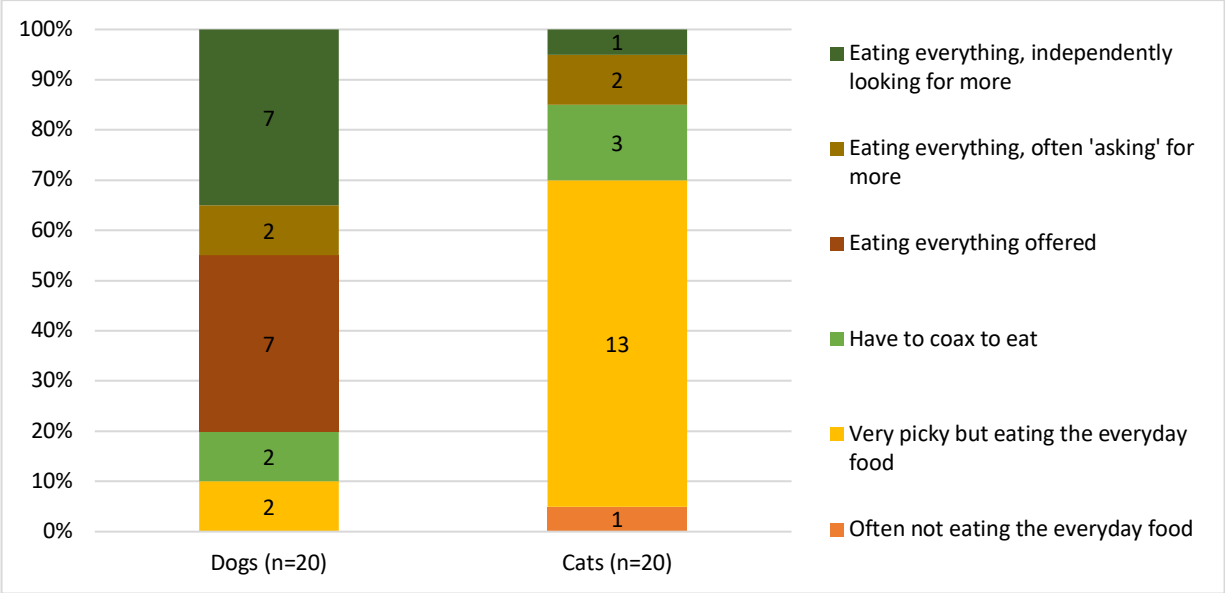


*Figure 17 Eating habits of pets*

Additionally, to pets eating habits, eating regularity was asked, to see if pets have fixed eating times or have the availability to craze their food all the time. From Figure 19, it is seen, that most of the participating dogs have set eating times, while for cats the most popular response was to having set eating times, but in addition having access to food at any time.

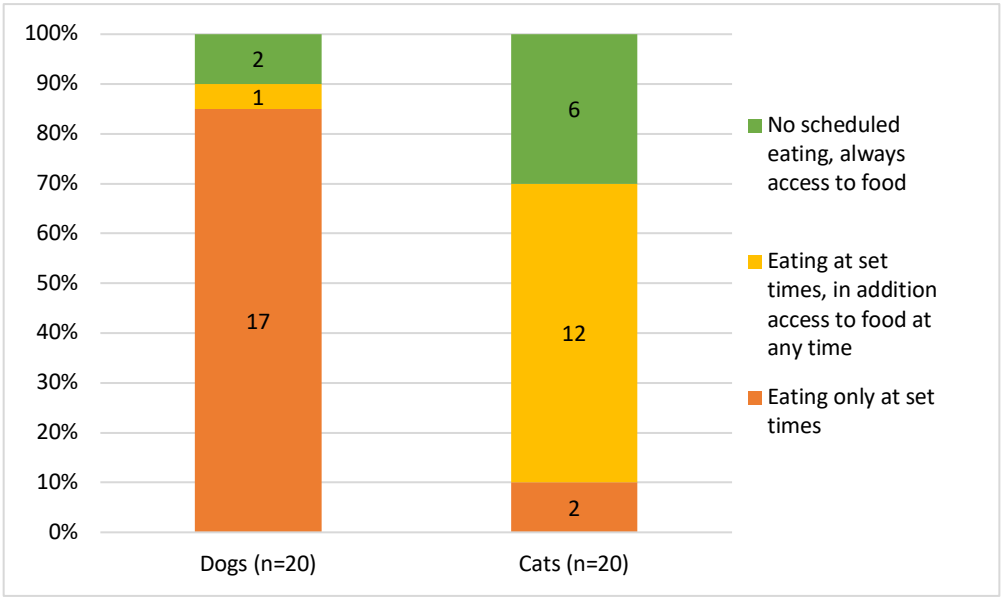


*Figure 18 Eating frequecy of pets*

As can be seen from Figure 20, all cats consume fish in their food or treats. Most dogs also consume fish products, with only 20% not consuming anything made from fish. 90% of all the participants serve their pets fish based snacks and/or food – there is a market for fish based pet snacks and food.

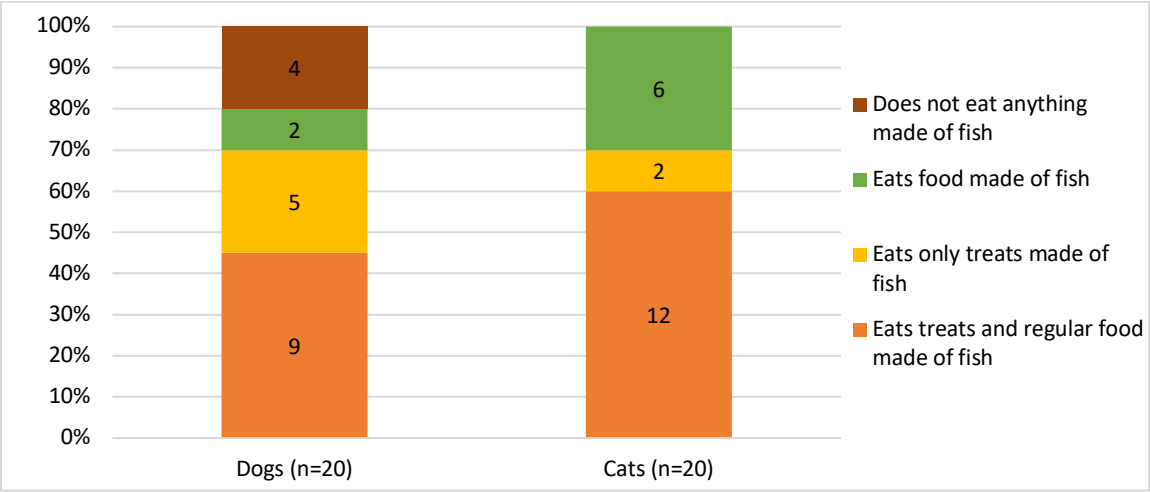


*Figure 19 Pets' consumption habits of fish-based food and snacks*

In Figure 21, the types of food that pets consume are visualized by dogs and cats. It seems that almost all participants eat kibble, with an exemption of 1 cat. 80% of cats eat wet food as well, but this is shown only for 30% of dogs. Raw food consumption is not that popular, but the proportions of dogs and cats in this field are similar. A total of 11 pets are consuming raw food made from raw meat and organs and only 3 of participants are eating food that is processed at low temperature meaning it still counts as raw food.

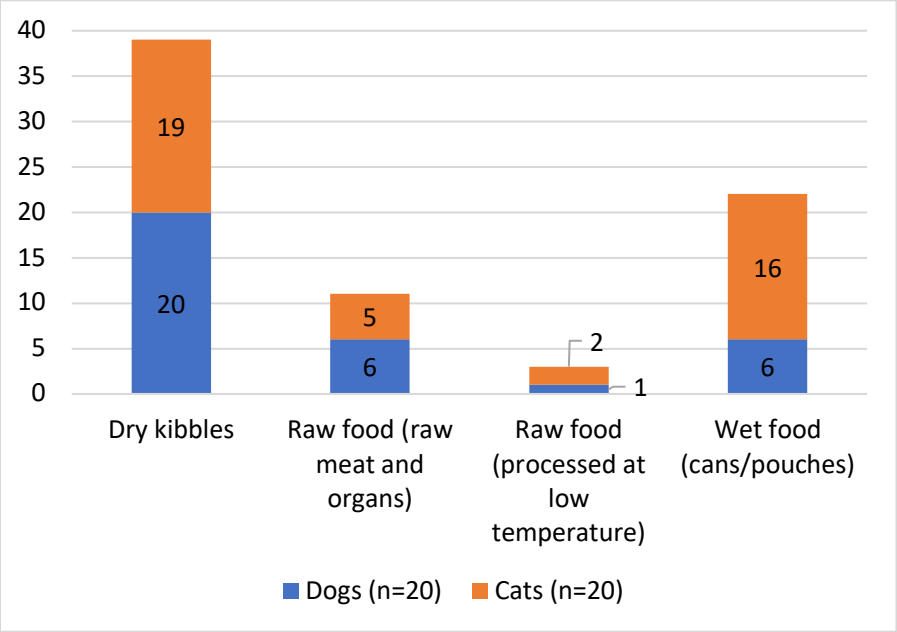


*Figure 20 Consumption of different types of food*

All dogs get treats at least once a week, with 70% getting them daily as can be seen from Figure 22. In the case of cats, daily treats are given only to 30% of participants, another 30% of participating cats get snacks less than once a week and three participating cats never receive snacks.

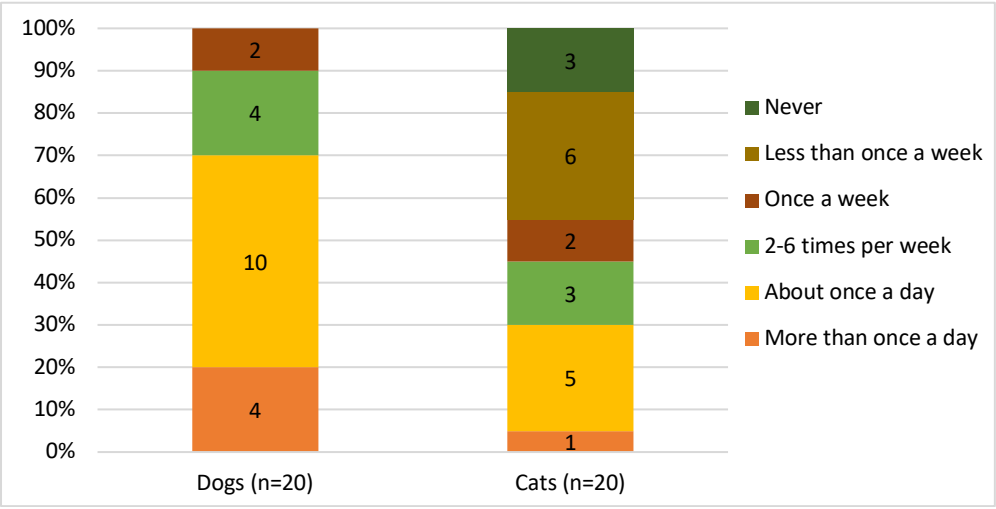


*Figure 21 Frequency of getting treats by pet type*

## Evaluation of samples

Pet owners were asked to rate the acceptability of snacks appearance, odor and texture on a scale of 1 to 7, where “1” stood for “Not acceptable at all” and “7” for “Very acceptable”. The results are visualized in figure 23. In all the modalities the highest rated product was the cookie.

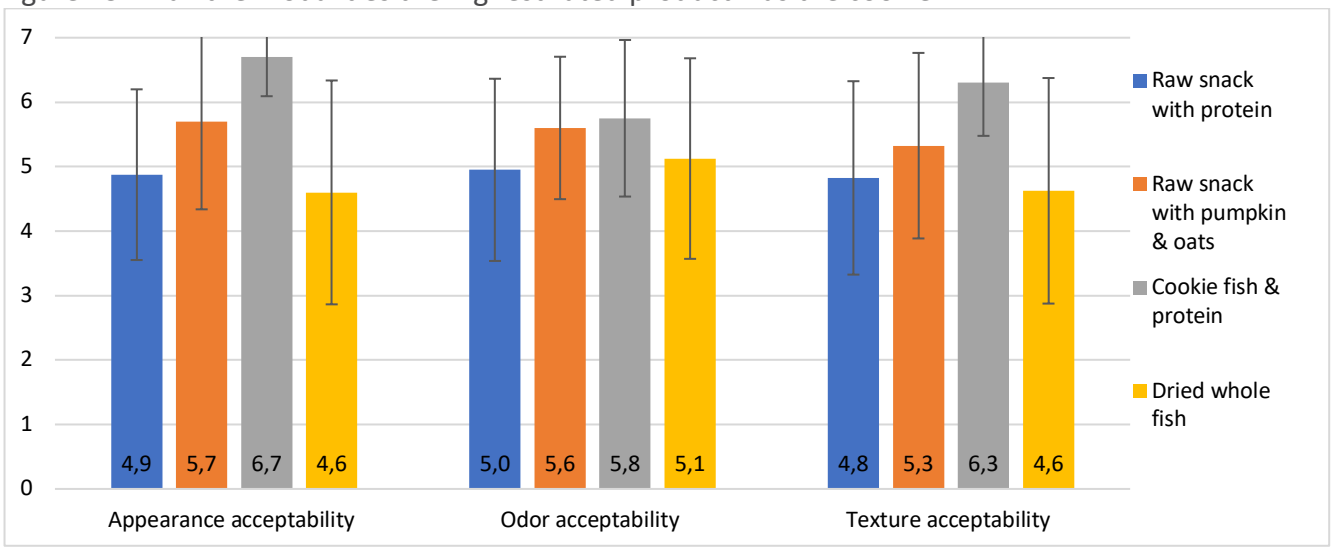


*Figure 22 Owners’ acceptability of product modalities*

Looking at sample consumption by pet type (Figure 24), it seems like most dogs eat all the snacks and some ask even for more. For cats most of the time, participants would not eat even half of the portion, the only exception was the cookie, where the number of eaters was the highest (15 out of 20).

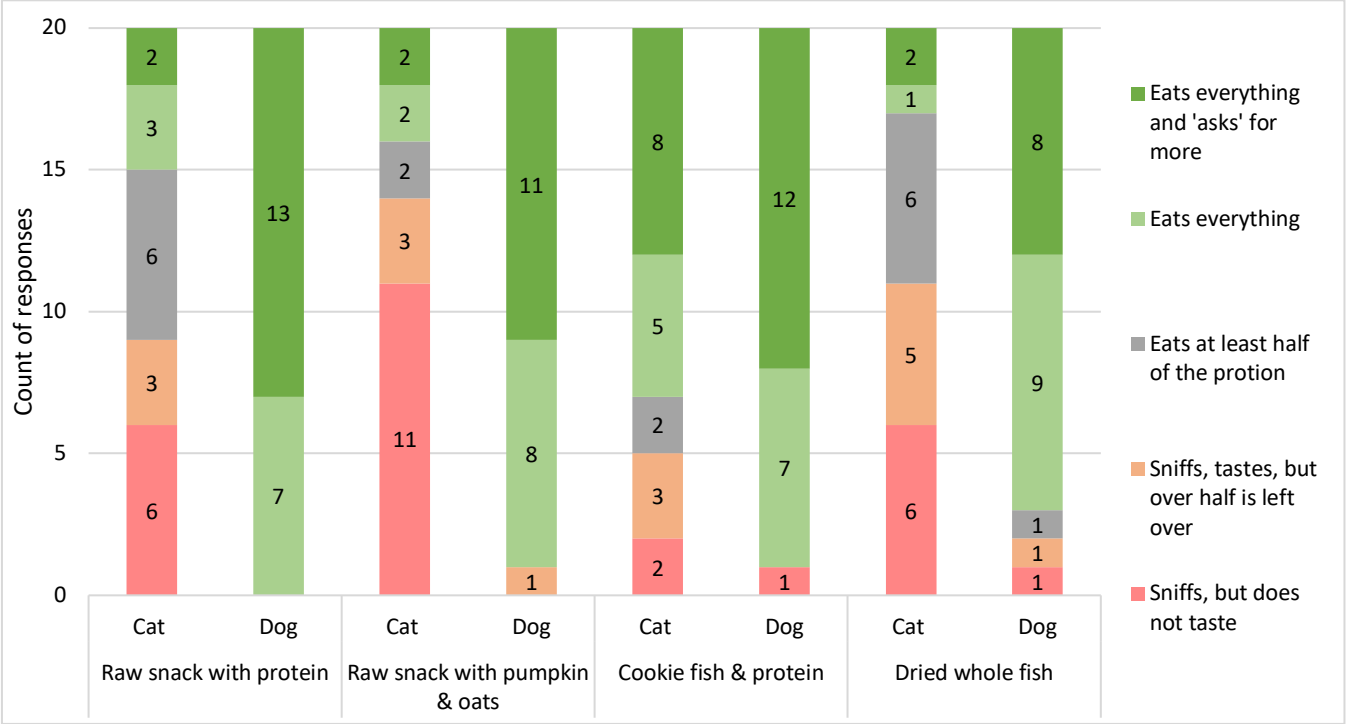


*Figure 23 Consumption of samples by pet type*

Pet snacks are used for additional motivation during the training of the pet, therefore one of their selling points could be a suitability for training. Visualized in figure 25 are all the answers of the pet owners who train their pets, 14 cats and 1 dog who are not being trained are excluded from this graph. It can be seen that smaller samples: raw snack with pumpkin and oats and the cookie are suitable for training. For raw snacks with protein, the pet owners are split with the decision, with almost half of them saying “yes” and half of them “no”. Dried fish would not be used for training by most of the responders.

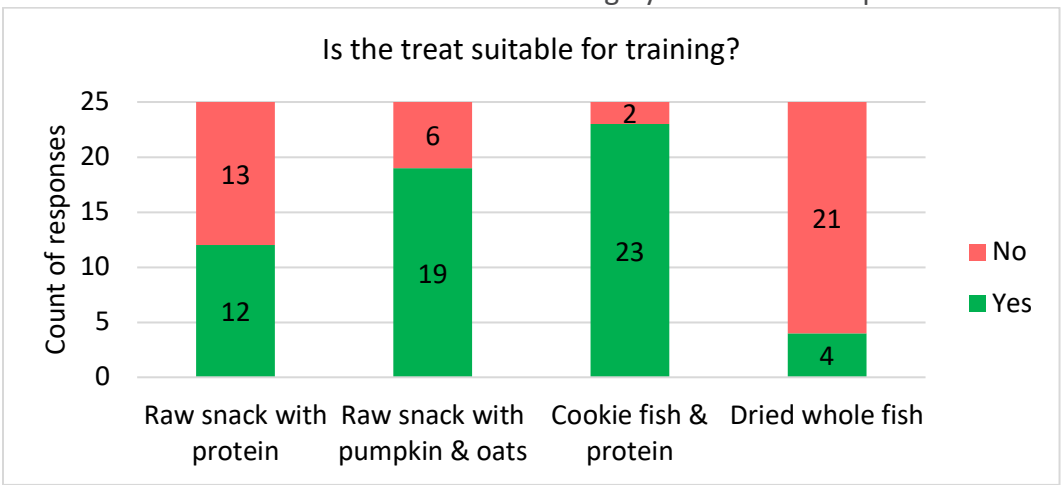


*Figure 24 Treats’ suitability for training. Only answers from pet owners training their pet are included.*

The purchase decision of the samples is visualized in Figure 26.

- When looking at overall results by all the participants, it is seen that the most answers of “yes, definitely would purchase” got the cookie.
- Consumers distributed equally in all categories for raw snack with protein.
- While most of the dog owners would purchase the raw snack with pumpkin and oats, the trend is not seen looking at cat owners, who are hesitant to purchase this product.
- Pet owners are hesitant to purchase the dried whole fish, while dog owners distributed equally to all three categories, cat owners chose the most frequently the answer of “No, definitely would not purchase”.

Explanation for “Maybe” and “No, definitely not” answers was asked and the results are presented in Table 14. The most common reason for refusing to purchase the product was that the pet did not eat it. Other reasons often mentioned include unfavorable size and too crumbly texture.

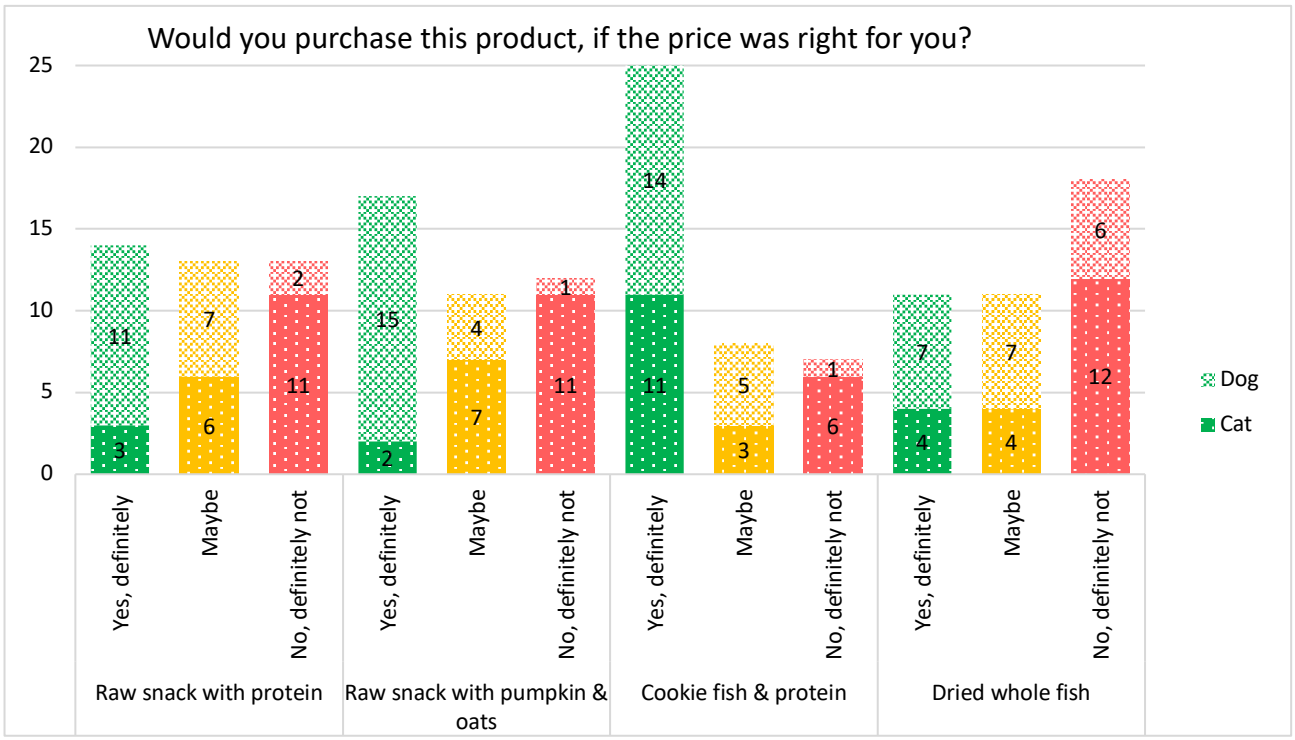


*Figure 25 Purchase decision of samples by pets*

*Table 13 Purchase decision comments*

| | "Maybe" | "No, definitely not" |
|---|---|---|
| Raw snack with protein | Bad odor (2), too big and crumbly (4), unappealing (1), does not suit for training (2) | Pet does not eat (8), too crumbly (3), does not differ from other products on the market (2) |
| Raw snack with pumpkin & oats | Too big and dry (4), pet does not eat (2) | Pet did not eat (9), too dry (1) |
| Cookie fish & protein | Too small (2), does not differ from other products on market (3), pet did not eat (1), owner does not like the odor (1), does not purchase snacks (1) | Pet did not eat (6), the owner does not like the odor (1) |
| Dried whole fish | Owner does not find it appealing (3), too big (2), too crumbly (2) | Pet did not eat (7), too big (3), owner did not find appealing (2), crumbly (2), too hard bones that get stuck in throat (2) |

### Highlights from the pet snacks consumer study

A consumer study was conducted with 40 pets (20 cats and 20 dogs). They were served 4 different types of fish-based snacks.

Consumption habits:

- Dogs have mostly good appetite and eat everything that is offered (and want more), while the biggest proportion of cats are rather on the picky eater side of the scale - 65% of participating cats were picky about their everyday food.
- Most dogs have fixed eating times when they get their food, but for cats, it was seen that the most common answer was, that the cat has always access to food.
- When looking at the consumption of fish-based pet snacks and food, it was seen that 90% of participants serve their pets regularly fish based food and/or snacks. Therefore, there seems to be a market for fish based petfood and -snacks.
- The consumption of food types is different for cats and dogs. Though almost all participants serve their pets kibble, 80% of cats get additionally wet food, but for dogs the wet food consumption is only 30%. Raw food seems to be hidden trend, that only 15% of pets consume weekly.
- Owners were asked about the frequency of giving snacks to their pets and this revealed that all participating dogs get treats weekly, with 70% of them getting treats at least daily. For cats daily treats were served only by 30% of participants and 25% of cats get treats less frequently than once a week. This seems to suggest that when developing snacks, dogs snacks seem to have a bigger

market than cat snacks. This may have been influenced also by the training of pets, because snacks are often used in training as an additional motivator. 14/20 participating cats did not train at all, for dogs only 1/20 participant was not trained.

Evaluation of samples:

- Looking at sample consumption by pet type, it seems like most dogs eat all of the served snacks and some ask even for more. For cats most of the time, participants would not eat even half of the portion, the only exception was the cookie.
- The highest score in all the modalities got the cookie, which also got most of “yes definitely would purchase” answers. Although raw snack with pumpkin & oats got most would purchase answers from dog owners, cat owners are hesitant and would not probably purchase this snack, as its texture did not seem to be appealing to cats.
- Regarding the purchase decision, it seems that the first thing owners think about is if pet eats the treat or not. Additionally, it was confirmed that suitability for training is important for dog owners, but other than that, consumers look for unique snacks, that would be different from the choices already on the market.
- Dried whole fish was the lowest scoring sample in appearance and texture acceptability for owners and received highest number of answers “definitely would not purchase”. This sample was too big, crumbly and unappealing to owners. Additionally, because it was a whole dried round goby, it included bones, which were hard to eat for cats and in some cats the product induced a choking problems.

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# Appendix 1. Comments from the consumer study with round goby products for human consumption

| Product | Modality | If score under "5" - comments |
|---|---|---|
| TOM-EST | Appearance | Looks raw, broken fish |
| | Odor | - |
| | Texture | Bones are disturbing |
| | Taste | Too sweet, bitter aftertaste |
| | Comfortability of eating | Bones are disturbing |
| DRY-EST | Appearance | - |
| | Odor | Raw fish, marine odor |
| | Texture | Too hard, could break teeth |
| | Taste | - |
| | Comfortability of eating | Too hard to bite, sharp edges |
| FRY-LAB | Appearance | - |
| | Odor | - |
| | Texture | - |
| | Taste | - |
| | Comfortability of eating | Small and sharp bones that are disturbing |
| SMK-LAB | Appearance | - |
| | Odor | - |
| | Texture | Dry, skin texture is not pleasant, too many small bones |
| | Taste | - |
| | Comfortability of eating | Too many small, sharp bones |

# Appendix 2. Additional comments about the pet snacks by the sensory panel

| Sample | Odor |
|---|---|
| Dr Stern raw snack | Hay, fecal, sharp (rancidity); Cocoa, coconut fat (other) |
| Petbit fish cookies | - |
| Denmark dried fish | Chemical, cardboard (rancidity) |
| Island of Pets snack | Herbs, spices, liqorice, alcohol (other odors) |