Report nr. Å0509

Underutilised fish species

Raw material properties of muscle fraction from Greater Argentine, Northern Wolffish and Polar Cod

Part of the project *Consumerproducts* in the EU-project SEAFOOD*plus*

June 2005

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REPORT

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Author: Ann Helen Hellevik, Marianne Synnes and Iren Stoknes	**Signature:**
Signed by: Iren S. Stoknes	**Signature:**

Summary:
The objective of this study was to find the raw material properties for Northern Wolfish (*Anarhichas denticulate)*, Greater Argentine (*Argentina silus*) and Polar cod (*Boreogadus saida)* by analysis of technological suitability (chemical and physical examination).

The examined species are characterised by having a white and lean flesh. The fat content of the muscle fraction varied between 0,9 and 1,6 %. Norhern Wolffish had a low protein content (9,9 %) and a corresponding high water content (89 %). Greater Argentine had a high protein content (18,7 %) and low water content (79,1 %). Greater Argentine had a very good water holding capacity of frozen and thawed material compared to the other species tested, including the reference species Cod (*Gadus morhua*). Correspondingly Greater Argentine had clearly the lowest loss of weight during cooking. Both Polar Cod and Northern Wolffish had lower water holding capacity and higher cook loss than the reference species.

This study has confirmed that the muscle from Greater Argenine had good technological properties and would possible be suitable as raw material for minced fish products and seafood product development in general.

Keywords: Greater Argentine, Norhern Wolffish, Polar Cod, water content, water holding capacity, protein content, fat content, raw material properties.

Distribution:

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1. Introduction

This report is part of the deliverables from the project Consumerproducts (project 4.4). This project is one of four projects in the RTD pillar 4, Seafood from source to consumer product, in the overall project SEAFOODplus (FOOD-CT-2004-506359 SEAFOODPLUS (IP)).

In work package 4.4.4. Møreforsking (Moere Research/MOERE) should examine technological suitability of selected underutilised species as possible raw materiel sources for consumer-driven development of functional seafood products.

In the preliminary work (Synnes and Stoknes, 2004) a selection of underutilised fish species of possible interest for further product development was presented. It started with an overview of 22 underutilised fish species. The overview was limited to 15 fish species based on comments from some of the project participants. From the 15 underutilised fish species a suggestion of 3 relevant species for further investigation was made. The decision was based on factors like: FAO catches, proposed suitability for restructured products and availability.

The objective of the study was to find the raw material properties for Northern Wolffish *(Anarhichas denticulatus)*, Greater Argentine *(Argentina silus)* and Polar cod *(Boreogadus saida)* by analysis of technological suitability (chemical and physical examination).

2. Materials and methods

2.1 Materials

The 3 underutilised fish species selected for chemical characterisation and determination of raw materiel properties were Northern Wolffish *(Anarhichas denticulatus)*, Greater Argentine *(Argentina silus)* and Polar cod *(Boreogadus saida)*. Cod *(Gadus morhua)* was chosen as a well known reference species.

1. Northern wolffish (*Anarhichas denticulatus*)

Family: Anarhichadidae (Wolffishes)
Order: Perciformes (perch-likes)
Class: Actinopterygii (ray-finned fishes)
Max. size: 180 cm TL (male/unsexed;); max. published weight: 20.0 kg
Environment: benthopelagic; oceanodromous; marine; depth range 60 - 900 m
Climate: polar; 80°N - 43°N, 65°W - 61°E
Distribution: North Atlantic: Spitsbergen, Novaya Zemlya, Barents and Norwegian seas, the Shetlands, the Faeroes, Iceland and south-eastern coasts of Greenland; also known occasionally in northern North Sea and Skaggerak. Western Atlantic: Arctic to Sable Island off Nova Scotia and Grand Banks in Canada. In contrast to the other wolffish species, northern wolffish can be caught by pelagic trawl, and is a usual by-catch during cod fishing in the Barents Sea.
Morphology: Coloration bluish-black with indistinct spots on the sides. Flesh is soft and watery.
Biology: Inhabits offshore waters in midwater; adults also near bottom from 60-970 m, mainly 100-900 m. Feeds on sea gooseberries, medusas, small fishes, also echinoderms, crustaceans and mollusks (not so hard-shelled). Northern wolffish spawns at great depths.

The flesh of Northern wolfish is soft and watery, but tender white colour makes it attractive. The outcome is quite low since it looses much water upon handling. However, the properties of the flesh have previously been evaluated by Møre Research, and the results revealed that it has potential when prepared right (Margareth Kjerstad, personal communication). The total catch reported for Anarhichas spp. to FAO for 2001 was 15 117 t; all of it reported to be the species *A.lupus* and *A. minor.*

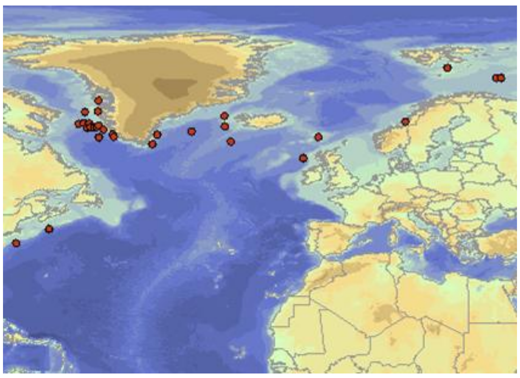


Figure 1: Occurrence of Northern wolffish (source: www.fishbase.org)

2. Greater argentine (*Argentina silus*)

Family: Argentinidae (Argentines or herring smelts)
Order: Osmeriformes (smelts)
Class: Actinopterygii (ray-finned fishes)
Max. size: 70.0 cm SL (male/unsexed); max. reported age: 35 years
Environment: bathydemersal; oceanodromous; marine; depth range 140 - 1440 m
Climate: deep-water; 75°N - 40°N, 69°W - 31°E
Resilience: Low, minimum population doubling time 4.5 - 14 years (K=0.12-0.14; tm=5-9)
Distribution: Eastern Atlantic: Svalbard to west coasts of Scotland and Ireland, deeper parts of North Sea and across the Wyville Thomson ridge to Denmark Strait. Western Atlantic: Davis Strait to George's Bank in Canada. Greater Argentine is often obtained as by-catch during shrimp fisheries, and the stock is believed to be good.
Morphology: Dorsal soft rays (total): 11-13; Anal soft rays: 11-17. Scales with tiny spines on exposed parts. Dorsal fin begins above or nearly above tip of pectoral fin. Swim bladder is elongated and silvery. Body is slender to robust.
Biology: Probably form schools close to the bottom. Feeds on planktonic invertebrates including euphausiids, amphipods, chaetognaths, squids and ctenophores, also small fishes. Spawns from April to July. Growth is slow. Eggs and young are pelagic at depths of 400-500m.

The Greater Argentine is used fresh or in fish meal production. Can be utilised in the production of restructured products because of a good water holding capacity. Previous work on *A. silus* demonstrated that this bland white-fleshed fish was useful for a range of products including enrobed nuggets, fingers and fishcakes; and also produced good gels (Gormley et al., 1992; Gormley, 1993). The fisheries of this species are commercial in some of the European countries, but in some countries it is hardly used at all. The total catch reported for *Argentina spp.* to FAO for 2001 was 49 036 t.

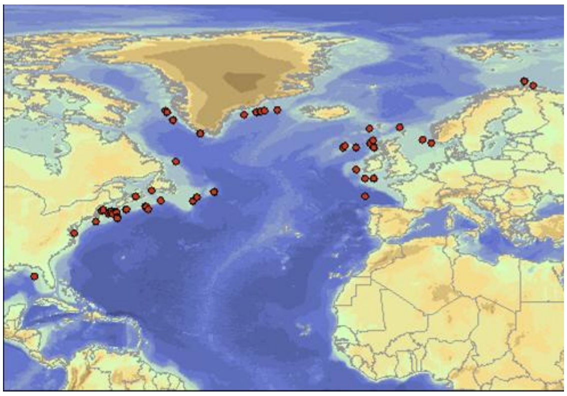
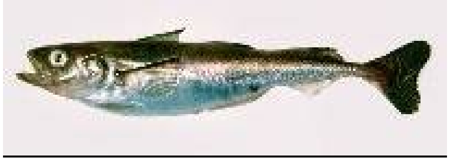


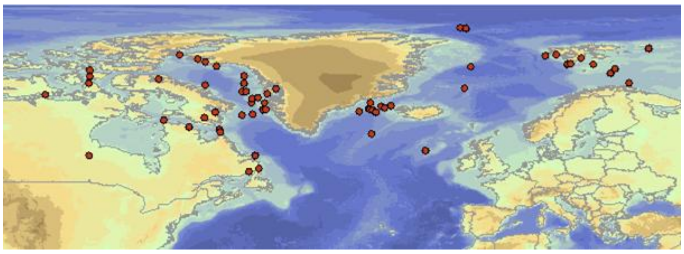
Figure 2: Occurrence of Greater Argentine (source: www.fishbase.org)

3. Polar cod (*Boreogadus saida*)



Family: Gadidae (Cods and haddocks)
Order: Gadiformes (cods)
Class: Actinopterygii (ray-finned fishes)
Max. size: 40.0 cm TL (male/unsexed); max. reported age: 7 years
Environment: demersal; oceanodromous; brackish; marine ; depth range 0 - 731 m. Pelagic, but can often be found close to the bottom at temperatures around 0°C.
Climate: polar; 85°N - 54°N, 180°W - 180°E
Resilience: Medium, minimum population doubling time 1.4 - 4.4 years (K=0.22; tm=2-5; Fec=30,000)
Distribution: Circumpolar in the Arctic. North Atlantic: White Sea, Iceland, and southern Greenland into the Miramichi River, New Brunswick in Canada. North Pacific: Bering Sea to Cape Olyutorski, the Pribilof Islands, and Bristol Bay. The polar cod might be difficult to catch, it can be found mostly in Russian zone in the Barents Sea.
Morphology: Dorsal spines (total): 0; Dorsal soft rays (total): 42-57; Anal spines: 0; Anal soft rays: 33-44; Vertebrae: 49-57. Caudal fin deeply concave. Lower jaw slightly longer than upper jaw. Chin barbel very small. No lateral line pores on head. Scales small and embedded, not overlapping. Brownish along the back with many fine points; the sides and belly silvery; the fins dusky with pale margins.
Biology: Occurs in coastal habitats during summer and winter. In the Beaufort Sea, it may also be found in brackish lagoons and in almost fresh water in river mouths. Although associated with the occurrence of ice (White Sea), it is present in ice-free near-shore waters (Alaska). Onshore-offshore movements are associated with spawning and movements of the ice. Feeds mostly on epibenthic mysids, also amphipods, copepods and fishes. Also caught with mid-water trawls. Euryhaline and eurythermic.

The fat content of polar cod is highest in the autumn; therefore the flesh is most suitable for production this season (Fiskeribladet, 2001). It is utilized as fishmeal and source of oil; in Russia it is used as fried or boiled fish, or canned in oil or tomato sauce. Salting of polar cod has been tried in Norway, with limited success. The total catch reported for this species to FAO for 2001 was 39 445 t; all caught by the Russian Federation.



Figur 3: Occurrence of Polar cod (source: www.fishbase.org)

It was decided to take samples for analysis from 10 individuals of each species. Several fishing vessels were contacted in order to collect species to the project. It was difficult to get big enough individuals from polar cod and greater argentine for doing all planned analysis on the same muscle sample. Both polar cod and greater argentine were collected on surveys with the Institute of marine research, Norway. Northern wolffish was collected from Norwegian commercial long liners.

Table 1: Species used in the present study. Number of fishes, date of fishery, position and depth.

Species	**Number**	**Date of fisheries**	**Position**	**Depth**
Northern wolffish (N73˚)	5	08.02.2005	N73˚14.0’ E14˚50.0’	517- 603 m
Northern wolffish (N72˚)	4	05.03.2005	N72˚20.0’ E16˚22.0’	480 m
Polar cod	*	20.08.2004	N78˚58.9’ E11˚37.5’	194-322 m
Greater Argentine	10	09.11.2004	N63˚33.0’ E10˚50.2’ and N63˚43.4’ E10˚57.7’	54-59 m
Cod	5	08.02.2005	N73˚14.0’ E14˚50.0’	518-602 m

* There is no exact number of individuals. The largest individuals were chosen for further analysis.

The species were frozen whole onboard and stored at -30˚C. The species were thawed over night in flowing cold fresh water.

2.2 Methods

2.2.1 Fillet yield

The fillets were weighed with skin on. Fillet yield was calculated from round fish weight.

Greater argentine:

The collected samples were small (29-42 cm, 270-980 g) and difficult to de-skin. The 10 largest individuals were taken out and weighed, length-measured, the gender was determined and weight of fillets was registered. Because of small sized fish, total outcome of raw materiel (flesh) was limited.

Northern wolffish:
The colleted species were rather big (64-113 cm, 3,1-13,9 kg) and difficult to de-skin. The fishes were weighed, the length was measured, weights of fillets were registered and determination of gender was performed for 9 individuals sampled from two different catches (se table 1). The fish meat from this species lost a considerable amount of water during production. In order to collect water being lost from the flesh, each fillet were placed in plastic bags. Because the size of the fillets, only the thickest part of dorsal muscle was taken out for homogenisation and further analysis (300 to 500 grams of each sample).

Polar cod:
This species was of small size (16,5-21 cm, 32-78 g), and it was not possible to sample enough flesh-material from each individual. Therefore, one sample from 17 of the biggest fishes was gathered. The 17 fishes were weight and length measured. The determination of gender and fillet weight was not registered because of the small size of the fish.

Atlantic cod:
Atlantic cod were selected as a reference species, since cod has been well characterised regarding raw material properties. The fishes were weighed, length measured, weight of fillets was registered and determination of gender was done on 5 fishes.

2.2.2 Sample preparation

Whole fillets from left side (or part of dorsal muscle, northern wolffish) of the fish were homogenised by a food processor (Braun Combimax 600) to a homogenous mass. Whole fillet from right side (or part of dorsal muscle, northern wolffish) of the fish was put in plastic bags and frozen. Also part of homogenised samples were put in plastic containers and frozen. Frozen samples were sent to other project partners for additional analysis (content of selenium and specific amino acids).

The analyses described below were performed at Møre Research's laboratory, if not otherwise mentioned.

2.2.3 Water content

The water content was determined according to a modified version of the method described by Børresen (1980), homogenised by a food processor (Braun Combimax 600), and moisture content of 5 g of homogenised sample was determined by drying the sample in an oven at 105˚C in 22 hours. The water content was determined as the weight loss after drying. It was conducted three parallels for each individual and the mean value was calculated.

2.2.4 Water holding capacity

Water holding capacity was determined according to a modified version of the method described by Børresen (1980). Homogenised sample from each individual (2 g) was centrifuged at 4500 rpm for 15 min, through a filter that allowed the water to be removed from the muscle. After centrifugation, the fillets were weighed again, and the difference before and after centrifugation was calculated. The water content was determined (method is described in chapter 2.2.3), and used to calculate the water holding capacity. Water holding capacity is presented as % remaining sample after centrifugation. The analysis was performed 3 times for each individual and mean value was calculated.

2.2.5 Cook loss

Cook loss was determined according to a modified version of the method described by Børresen (1980). Homogenised sample (2 g) from each individual were put in container with a filter that allowed the water to be removed from the sample, and incubated at 80˚C for 15 minutes. Then the containers were weighed. The water content was determined (method is described in chapter 2.2.3), and used to calculate the cook loss. Cook loss is presented as % lost sample. The analysis was performed 3 times for each individual and mean value was calculated.

2.2.6 Fat content

The total fat content was analysed according to the etylacetate method, Norwegian Standard No. 9402. The analysis was conducted at the Local food control authority in Ålesund.

2.2.7 Protein content

The total protein content was determined by Kjeldahl's method, in which acid digestion is used to convert nitrogen to ammonium ion (Ritzman and Daniels, 1975, NMKL-method nr. 6). The concentration of ammonia nitrogen is then evaluated by titration, a correction is made for nitrogen contributed by non-protein compounds, and the ammonia nitrogen value is multiplied by a factor of 6.25 to express protein nitrogen as total protein. The analysis was conducted at the Local food control authority in Ålesund.

2.2.8 Colour measurement

The colour of the raw muscle was measured with a Minolta Chromameter CR20. The measurement describes the whiteness (L=100 is white, L=0 is black), green-red (a*= -60 is green, a*= 60 is red) and yellow-blue (b* = -60 is blue, b*= 60 is yellow) colours of the sample. Ten measurements were conducted on each fillet from each individual (except polar cod, was not measured), and mean value was calculated.

3. Results

The results shown below are the average measurements from:

- 9 individuals of Northern wolffish from two different catches (Table 1)
- 10 individuals of Greater Argentine
- 5 individuals of Cod
- collected sample from 17 individuals of Polar cod

The results from measurements of weight, length, fillet yield and gender for each individual in this study are presented in appendix 1.

3.1 Fillet yield

The fillet yield was determined based on fillets with skin on, and was calculated from round fish, not gutted. The results are shown in figure 4.

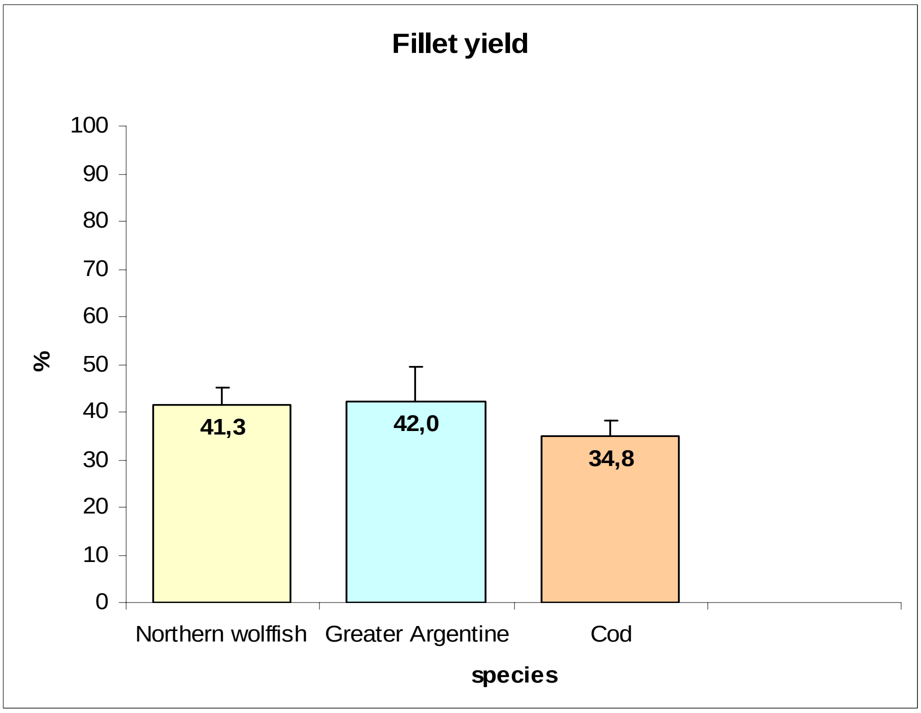
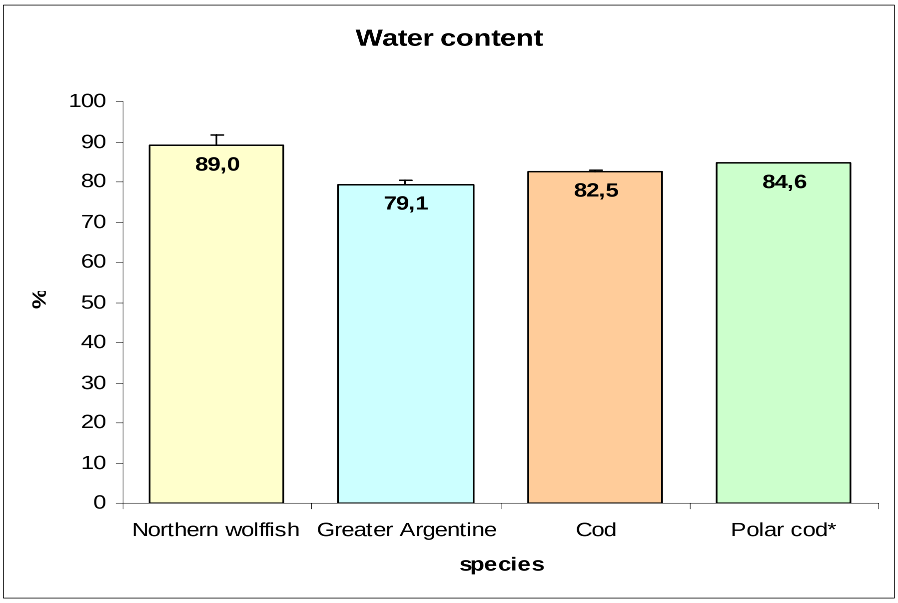


Figure 4: Average fillet yield based on fillets with skin on (as a percentage of whole "ungutted" weight) of northern wolffish, greater argentine and cod.

The figure shows that the best fillet yield was obtained from greater argentine (42 %). The reference species, cod, had the lowest yield (34,8 %) and northern wolffish with a fillet yield of 41,3 %

3.2 Water content

The results from water content analyses are presented in figure 5.



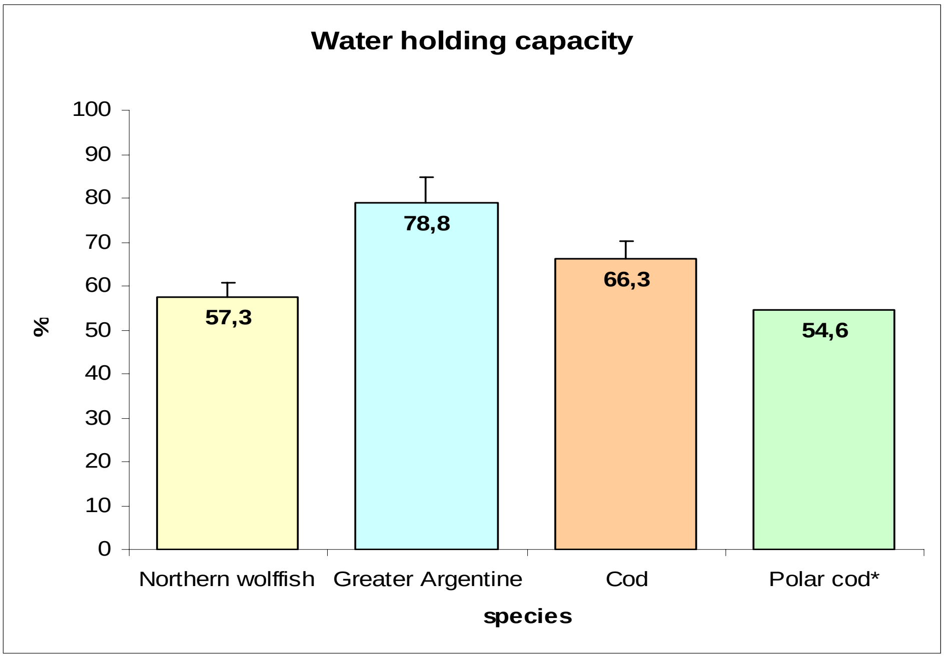
*Polar cod result is from a collected sample from 17 individuals.

Figure 5: Average water content in muscle fraction from northern wolffish, greater argentine, cod and polar cod.

The water content of the greater argentine was the lowest with 79,1 %, and northern wolffish highest with 89 %. Cod had a water content of 82,5 % and polar cod 84,6 %.

3.3 Water holding capacity

The results from water holding capacity analyses are presented in figure 6.



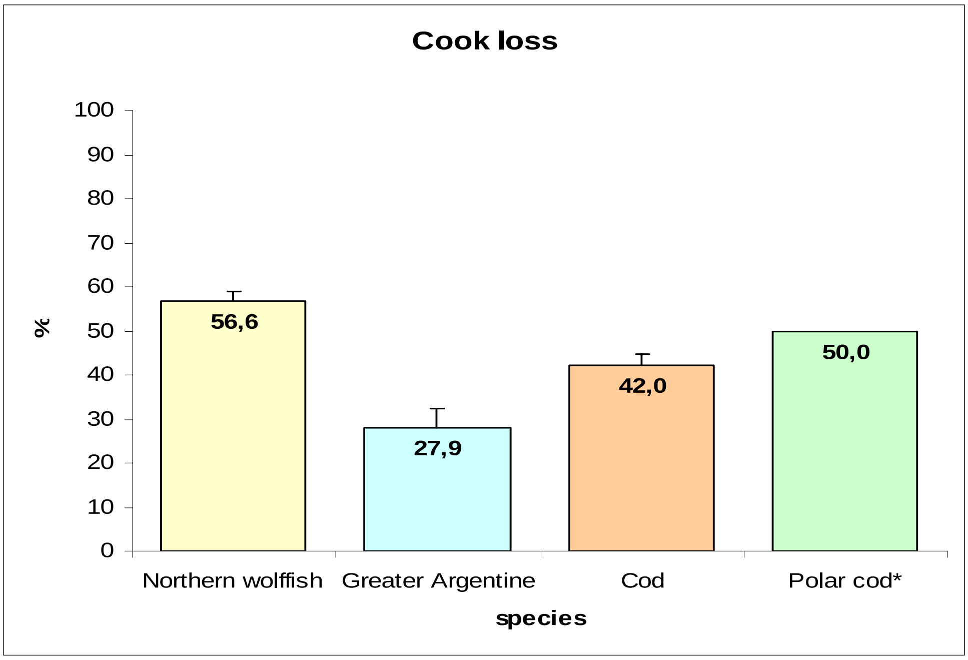
*Polar cod result is from a collected sample from 17 individuals.

Figure 6: Average water holding capacity in muscle fraction from northern wolffish, greater argentine, cod and polar cod.

The greater argentine had clearly the highest water holding capacity (78,8 %), and polar cod had the lowest (54,6 %). Cod had a water holding capacity at 66,3 % and northern wolffish 57,3 %.

3.4 Cook loss

The results from cook loss of the different species are presented in figure 7.



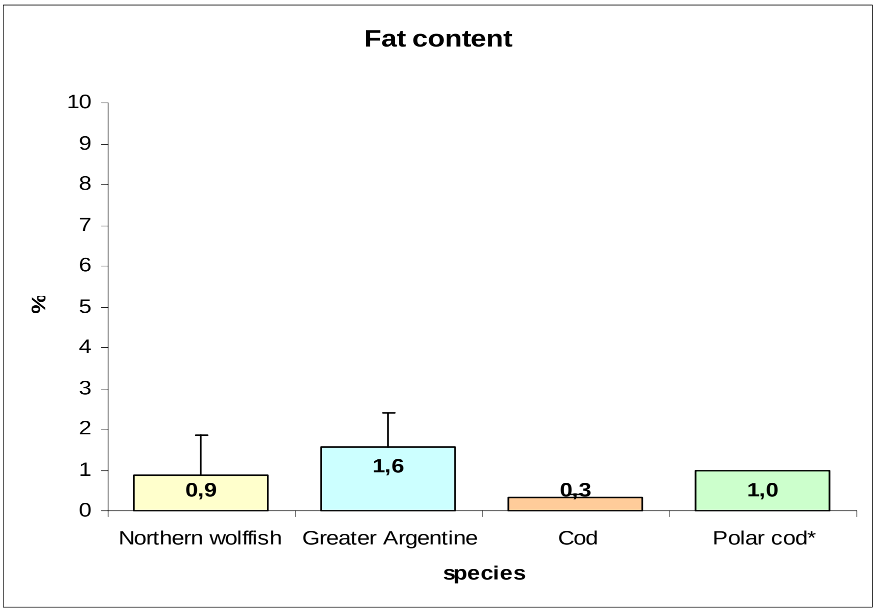
*Polar cod result is from a collected sample from 17 individuals

Figure 7: Average cook loss of muscle fraction from northern wolffish, greater argentine, cod and polar cod.

The measurements shows that northern wolffish had the highest cook loss, 56,6 %, the greater argentine had the lowest cook loss (27,9 %). Cod had a cook loss of 42,0 % and polar cod 50 %.

3.5 Fat content

The fat content of the different species are presented in figure 8.



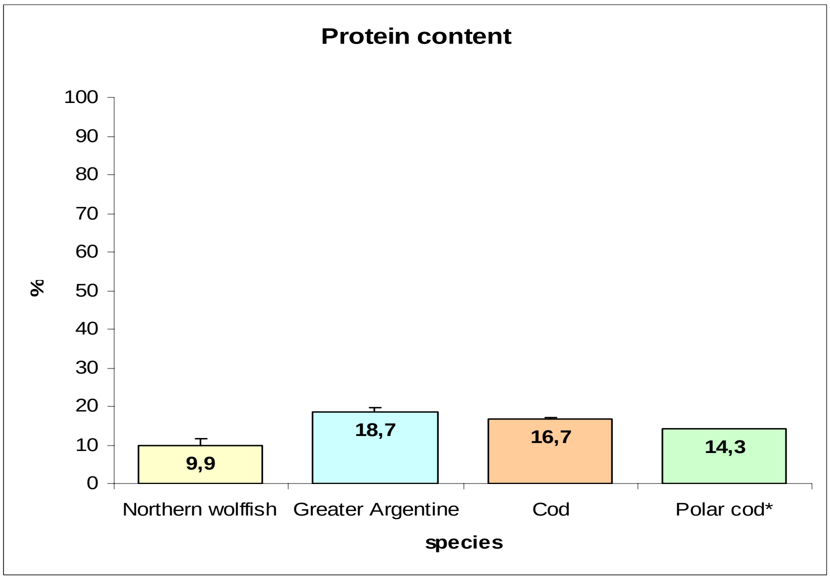
*Polar cod result is from a collected sample from 17 individuals.

Figure 8: Average fat content in muscle fraction of northern wolffish, greater argentine, cod and polar cod.

The greater argentine had the highest content with 1,6 % and cod the lowest with 0,3 %. Polar cod had a fat content of 1 % and northern wolffish 0,9 %.

3.6 Protein content

The protein content of the different species are presented in figure 9.



*Polar cod result is from a collected sample from 17 individuals.

Figure 9: Average fat content in muscle fraction of northern wolffish, greater argentine, cod and polar cod.

The figure shows that greater argentine had the highest content with 18,7 % and northern wolffish the lowest protein content with 9,9 %. Cod had a protein content of 16,7 % and polar cod of 14,3 %.

3.7 Colour measurement

The results from the colour measurements from the different species are presented in figure 10.

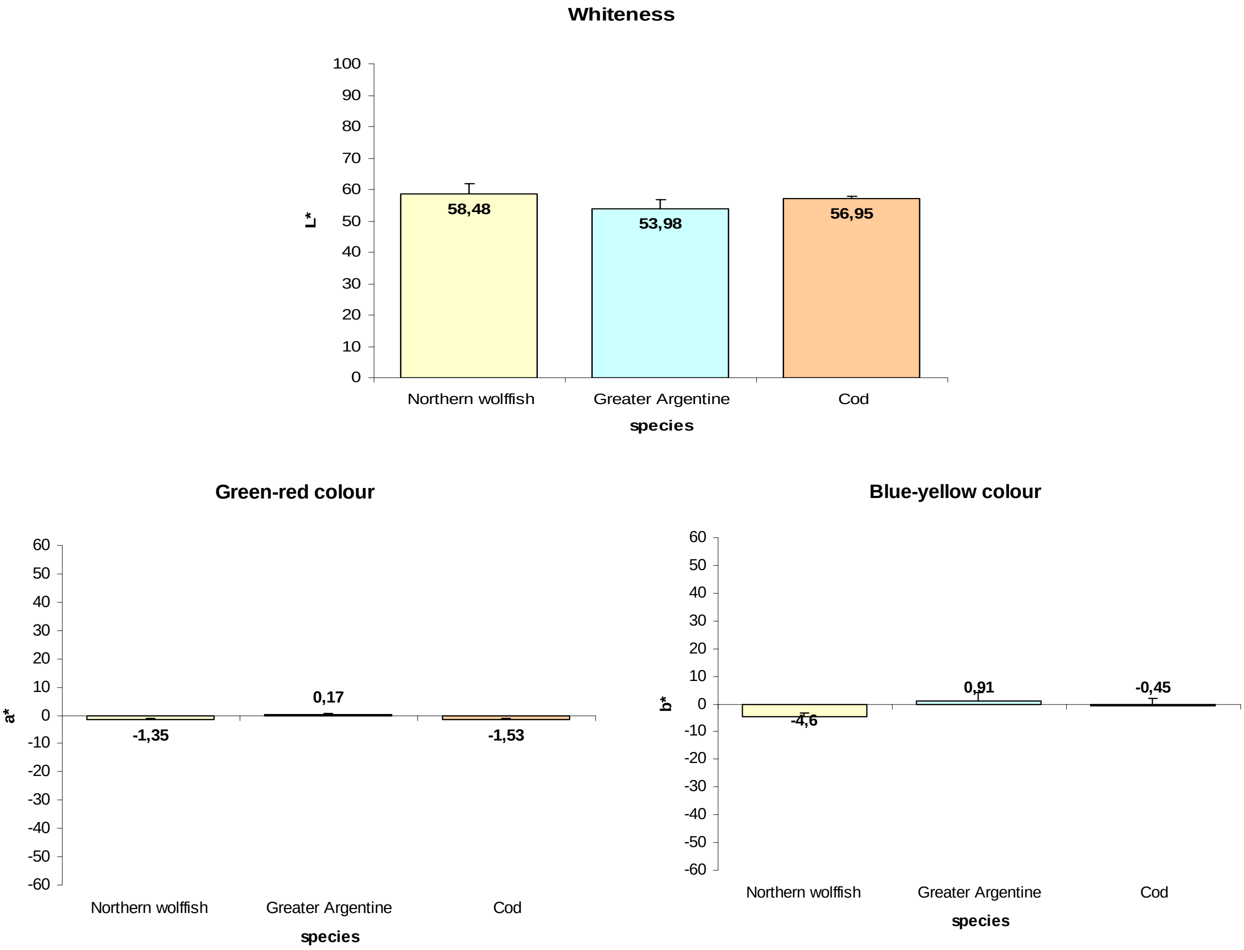


Figure 10: Average results of the colour measurements of northern wolffish, greater argentine and cod. L gives the relationship between black (0) and white (100), a* gives the relationship between green (-60) and red (60) and b* gives the relationship between blue (-60) and yellow (60).*

The measurements show that for whiteness there are differences between the species. The greater argentine has the lowest values (L*=53,98) and the northern wolffish the highest (L*=58,48). The instrumental measurements for whiteness could also be confirmed by the human eye (subjective observations). Green-red (a*) and blue-yellow (b*) measurements also show that the greater argentine has a bit more red and yellow colour compared to the other species tested.

4. Discussion

Filleting
Because of the small size of polar cod, scalpel and tweezers were used to cut out fillets. This was a “fiddling” and time-consuming work. In an industrial scale there have to be used other methods of course, to separate the meat from the fish. The greater argentine was easy to fillet but difficult to de-skin. The same was the case with northern wolfish. Today there are several machines that probably can be used. Machines that use centrifugal force, others are mechanical filleting and skinning machines. Some examples are types of Baader machines for producing mince of fish flesh. The machines have flexible squeezing belts that transport fillets to a perforated drum and gently squeeze the fish meat trough a perforation. Hard particles such as bones, fins and skin remain on the outside of the drum. The properties of raw material and the hole diameter of the drum determine the texture of the final product (www.baader.com/Fish_Baadering.325.0.html).

Water content
The analyses show that the water content was highest in flesh from northern wolffish, 89 %. This is in accordance with previous measurements (Willemsen, 2001), which reports a water content in northern wolffish of 87 %. Compared with measurements of flesh from cod (82,5 %), this is rather high. The flesh of greater argentine has the lowest water content (79,1 %) in this study. This is also in accordance with previous studies (Bykov, 1983), reporting a water content in flesh from greater argentine from 75,4 to 81,1 %.

Water holding capacity
Flesh from northern wolfish had a water holding capacity of 57,3 %. The lowest among the species investigated in the present study. This was expected based on the observation that a considerable amount of water was lost from the flesh during thawing and filleting. Water was pouring out from the flesh during storing and handling of fillets. The measurements shows that it was flesh from polar cod that had the lowest water holding capacity (55,6 %). The water holding capacity of greater argentine was highest among the studied species (78,8 %), while flesh from cod had a water holding capacity of 66,3 %. Previous measurements (Willemsen, 2001) have shown a water holding capacity of 60,8 % for northern wolffish a bit higher than what was found in this study.

Cook loss
The flesh from northern wolffish seems to have the highest cook loss (56,6 %) for the species tested in this study. Although flesh from polar cod had the lowest water holding capacity, the results indicate that the polar cod do not have the highest cook loss. Flesh from cod had a cook loss at 42,0 %. That is in accordance with previous tests (Willemsen, 2001) that show a cook loss of 40,6 %. Flesh from greater argentine had the lowest cook loss (27,9 %). The results from this study indicate that increasing water holding capacity gives a lower cook loss, which is in accordance with previous results (Synnes, et.al. unpublished data; Sarma et al, 2000).

Fat content
Flesh from greater argentine had the highest fat content in this study (1,6 %). Earlier studies (Bykov, 1983) reported a fat content for greater argentine between 0,4 and 4 % because of seasonal variation. Flesh from polar cod had a fat content of 1,0 %. That is a bit higher than what

was previously reported (Bykov, 1983; 0,4-0,8 %). Flesh from northern wolffish had a fat content of 0,9 %. That is 1,2 % lower than Willemsen (2001) found. Cod had a fat content of 0,3. This is in accordance with previous measurements (anon, 2002) which reports a fat content of 0,3 %.

Protein content
Flesh from greater argentine had the highest protein content of the species examined in this study (18,7 %). Earlier studies (Bykov, 1983) reported a protein content in greater argentine from 17,2 to 18,5 %, slightly less than what was found in our study. Flesh from cod had the second highest protein content, 16,7 %, nearly 2 % lower than earlier reported (anon, 2002). Flesh from polar cod had a protein content of 14,3 %. That is approximate 2 % lower than reported by Bykov (1983) were a content between 16,3 and 19,1 % was found. Flesh from northern wolffish had the lowest protein content in this study, 9,9 %. That is slightly lower than the results reported from Willemsen (2001) which was 10,5 %.

Colour measurements
The colour measurements show that northern wolffish had the whitest and the “bluest” colour, probably because of the high water content in the flesh. The flesh from greater argentine was less white and more yellow, probably because of low water content and higher content of protein and fat.

Applications for raw materials
Greater argentine is used as a fresh/frozen raw material in fish meal production. Minced muscle flesh from greater argentine is used in production of restructured fish products because of its good water holding capacity. Previous work demonstrate that this lean white-fleshed fish might be good raw material for use in a range of products including enrobed nuggets, fingers and fishcakes. In Norway there are some producers of minced fish from greater argentine. There have been attempts to start minced production onboard one boat in Norway. The yield for minced fish was 28-29 % from whole fish. Mince from greater argentine has a very good binding power, even after freezing. But the TAC (total allowable catch) was reduced, the prices were low, the profitability went down and the production was closed (Roaldnes, personal communication). Our results indicate that greater argentine is the most suitable species, in this study, as raw materiel for minced fish products.

Northern wolffish have been characterized as “uneatable” and not suitable for human consumption. However, other studies reports that it is most suitable as salted fish and as smoked fish (Willemsen, 2001). Further marketing tests report that fried natural fillets and fried smoked fillets are good products for consuming. The best processed product is smoked loins (Kjerstad and Emblem, 2004). Northern wolffish may also be suitable for certain seafood products, even though it has a high water content and quite low protein content.

Polar cod is utilized as fishmeal and as a source for fish oil. In Russia it is used as fried or boiled fish, or canned in oil or tomato sauce. Individuals of this species are seldom found at sizes over 30 cm (E. Hermansen, Institute of marine research, personal communication). The total catch reported for this species to FAO for 2001 was 39 445 t; all caught by the Russian Federation.

5. Conclusion

In this study three different underutilised species have been analysed with emphasis on their raw material properties. It can be concluded that Greater Argentine has the best potential for being a suitable raw material for further product development.

The chemical composition of flesh from Greater Argenine is favourable because of high protein, acceptable fat-content (1,6 %) and quite low water content. The physical properties of flesh from Greater Argentine are very good. The water holding capacity is high and water- and cook loss low. The colour of the flesh is also white and acceptable.

We will therefore recommend that the species Greater Argentine can be considered as a possible raw material in minced, formed or other new innovative fish products in the future.

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7. References

Anon. (2002). In *Facts about fish.* The national Institute of Nutrition and Seafood Research, Norway

Bykov, V.P. (1983). Marine fishes: chemical composition and processing properties. Amerind Publishing Co. Pvt. Ltd., New Delhi. 333 p. (FishBase).

Børresen, T. (1980). New methods for determination of liquid holding capacity, Salt water holding capacity and cook loss in fish muscle (in Norwegian). FTFI Report 663, 1-7-2, Tromsø, Norway

Froese, R. and Pauly, D. Editors. 2004. FishBase. World Wide Web electronic publication. www.fishbase.org, version (07/2004).

Fiskeribladet, Norway, January 26., 2001, pp.18-19.

Gormley, T.R (1992). A note on consumer preference of smoked salmon colour. Irish Journal of Agricultural and Food Research, 31, 199-202.

Gormley, T.R. (1993). Food Centre finds uses for smelts. Seafood News, 4, 19.

Kjerstad, M. and Emblem, W. (2004). Production and marketing test of smoked Northern Wolffish (*Anarhicas denticulatus*) Møre Research report No. Å0401 (In Norwegian).

Pedersen T., 1989. Numbers from processes and products in Norwegian fish industry. Universitetsforlaget 2.ed. 1989 volume 1 (In Norwegian).

Ritzmann, S.E. and Daniels, J.C. (1975). Introduction In: *Serum protein abnormalities: Diagnostic and Clinical aspects*. Ritzmann, S.E. and Daniels, J.C., Eds. Boston, Little, Brown and Company.

Sarma, J., Reddy, G.V.S. and Srikar, L. N. (2000). Effect of frozen storage on lipids and functional properties of proteins of dressed Indian oil sardine (*Sardinella longiceps*), *Food Research International, Volume 3. (10) 815-820.*

Synnes, M., Emblem, W. and Kjerstad, M., unpublished data; Møre Research, Norway.

Synnes M. and Stoknes I. (2004). Underutilised fish species. A selection of underutilised fish species as possible raw materiel for product development in the project *Consumerporducts* which is part of the EU-project SEAFOODplus. Møre research working document.

Willemsen, H.M. (2001). Characterisation and trial production of northern wolffish (*Anarhicas denticulatus*) Møre Research report No. Å0122 (In Norwegian).

(www. baader.com/Fish_Baadering.325.0.html).

8. Appendix

Table 1: Results from each individual fish species in this study.

Species	Individual nr.	Length cm	Weight kg	Gender*	Fillet yield %	Water content %	Water binding capacity %	Cook loss %	Fat content g/100g	Protein content g/100g
Northern	1	113	13,875	2	46,4	89,2	56,4	59,7	1,2	9,9
wolffish	2	98	10,365	2	40,0	85,6	53,4	54,9	1,9	12
(N72˚)	3	84	5,496	1	45,4	90,9	62,2	59,1	0,2	8,7
	4	64	3,088	1	42,6	92,2	60,9	57,7	0,1	7,4
	average	**89,75**	**8,206**		**43,58**	**89,49**	**58,20**	**57,85**	**0,85**	**9,50**
	Standard deviation				**2,9**	**2,9**	**4,1**	**2,2**	**0,9**	**2,0**
Northern	1	82	5,946	1	41,7	88,2	60,5	57,2	0,7	11,2
Wolffish	2	69	3,91	1	44,7	91,3	57,9	51,4	0,2	8,1
(N73˚)	3	97	9,775	2	38,9	84,6	55,4	56,6	3	12
	4	81	5,134	2	37,8	89,5	53,2	55,7	0,3	9,4
	5	79	5,002	1	34,1	89,1	56,1	57,3	0,3	10,1
	average	**81,6**	**5,9534**		**39,4**	**88,6**	**56,6**	**55,6**	**0,9**	**10,16**
	Standard deviation				**4,0**	**2,5**	**2,8**	**2,4**	**1,2**	**1,5**
Greater	1	42	0,976	1	48,2	77,1	79,5	31,56	3,2	18,8
argentine	2	32	0,316	1	25,3	78,6	80,7		1,6	18,8
	3	42	0,8	1	39,0	80,3	63,6	22,36	2,7	16,7
	4	30	0,258	2	49,6	77,8	85,7	25,94	1,7	19,9
	5	33,5	0,402	1	37,8	79,8	78,0	33,86	1,5	17,9
	6	30	0,256	1	40,6	79,0	83,7	30,20	1,4	18,8
	7	34,5	0,343	1	46,1	79,0	78,5	33,59	1,2	19,1
	8	32	0,284	1	39,4	80,6	80,3	33,10	0,6	18,1
	9	32,5	0,27	1	45,9	79,6	77,3	36,53	0,9	19,1
	10	29	0,266	1	48,1	79,7	80,7	31,90	0,8	19,4
	average	**33,75**	**0,4171**		**42,0**	**79,1**	**78,8**	**27,9**	**1,6**	**18,7**
	Standard deviation				**7,3**	**1,1**	**5,9**	**4,4**	**0,8**	**0,9**
Atlantic	1	68	2,802	1	35,0	82,7	67,4	43,21	0,4	16,7
Cod	2	64	2,138	1	35,0	82,8	67,4	39,53	0,3	16,5
	3	61	2,37	1	35,1	82,1	62,1	42,96	0,3	17,2
	4	61	2,026	1	39,2	82,7	72,0	39,02	0,2	16,2
	5	73	3,096	1	29,6	82,2	62,7	45,52	0,4	16,9
	average	**65,4**	**2,486**		**34,8**	**82,5**	**66,3**	**42,0**	**0,3**	**16,7**
	Standard deviation				**3,4**	**0,3**	**4,0**	**2,7**	**0,1**	**0,4**
Polar	1	18,5	0,06		29,6	84,6	54,6	50,0	1	14,3
cod	2	19	0,054							
	3	19,5	0,058							
	4	19	0,062							
	5	20,5	0,066							
	6	20	0,07							
	7	21	0,078							
	8	20,5	0,07							
	9	18,5	0,062							
	10	21	0,058							
	11	19	0,048							
	12	19	0,054							
	13	18	0,052							
	14	16,5	0,032							
	15	17,5	0,04							
	16	18,5	0,062							
	17	16,5	0,04							
	average	**19,0**	**0,1**							

* 1: female
* 2: male