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Dried fish as health food

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Ágrip á íslensku:

Eitt meginmarkmið verkefnisins var að afla grunnupplýsinga um eiginleika íslensks harðfisks og að upplýsingarnar yrðu opnar og þannig öllum harðfiskframleiðendum á Íslandi til hagsbóta.

Megin niðurstaða verkefnisins er að harðfiskur er mjög ríkulegur próteingjafi með 80-85% próteininnihald. Amínósýrurnar voru mældar og bornar saman við amínósýrur í eggjum. Niðurstaðan er að harðfiskprótein eru af miklum gæðum. Þessar niðurstöður styðja við markaðssetningu á harðfiski sem bæði heilsusamlegum mat og þjóðlegum mat. Mikilvægt er að skoða saltinnihald í harðfiski betur og reyna að minnka það til að auka hollustu harðfisks sérstaklega í inni-heitþurrkuðum harðfiski þar sem það var mun hærra en í öðrum harðfiski.

Mælingar á snefilefnum leiddu í ljós að magn þeirra í harðfiski er vel innan marka miðað við ráðlagðan dagskammt (RDS) nema í selen. Magn þess í 100 g er á við þrefaldan ráðlagðan dagskammt. Það er þó ekki talið skaðlegt á nokkurn hátt.

Lykilorð á íslensku: *Harðfiskur,inniþurrkun, útiþurrkun, prótein, örverur, snefilefni*

Summary in English:

The main object of this project was to provide information of the quality in Icelandic dried fish to be of benefit for all producers in Iceland.

The main results showed that dried fish was a very rich source of proteins, containing 80-85% protein. Amino acids were measured and compared to the amino acids in eggs. It was concluded that the proteins in the dried fish were of high quality. This supports the marketing of dried fish in the health foods and traditional food markets. It is important to analyse better the salt content in dried fish, and reduced it to improve balanced diet in dried fish, especially for indoor produced dried fish, which salt content is rather high.

The trace elements in dried fish showed minimal content, except for selen where the content was threefold the recommended daily allowance (RDA). This is not hazardous for people in any way.

English keywords: *Dried fish, indoor drying, outdoor drying, protein, microorganism, trace elements*

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1. INTRODUCTION

Dried fish has been a staple food of the Icelanders for centuries. Little information is available about its functionality and processing but it is mentioned frequently in Icelandic tales.

In the old days dried fish was the main food in Iceland and was eaten with butter and sometimes dulse. There is a tradition for eating dried fish during the month of Þorri, along with other traditional foods. Popularity of dried fish has increased substantially over the last years and it is widely consumed as a snack in homes and during holidays. The annual production of dried fish and sales is 200-250 tons, which is produced from 2.800 – 3.000 tons of gutted fish.

Dried fish is also used as a supplemental food for pets, which is an increasing industry. The requirement for quality for such production is very strict, especially with regard to export. Marketing of dried fish abroad has not been very successful.

Dried fish production

Dried fish are miscellaneous products and are produced from catfish, haddock, cod, pollock, blue whiting and halibut. The most common species are haddock, catfish and cod. Whole fillet, pieces, blocks and minced fish are used in the production. Over the past few years there has been great development in the production of dried fish from minced fish, though the production has decreased in the last year especially because of increased production costs.

Treatment and production at sea

The raw material for the production of dried fish is always fresh and it is always catched by line. Such a fishing method is gererally considered as one of the best with regard to the quality of the raw material and also fullfils the requirements of environmentally friendly fisheries. The haddock is fished by line using sandlaunce, herring, and saury as a bait. The haddock is put in slurry ice on board and stored there until filleting the day after.

During landing the temperature of the fish is measured and registered. By securing the best possible hygiene and good manufacturing practices, the original quality of the raw material is secured.

There are three different processing methods used for the production of dried fish.

Outdoor drying

Before outdoor drying, the fish is filleted by hand, the fillets are trimmed and cleaned and visible bones and bloodstaines are removed. The fish is prepared by cutting a hole in the tail before hanging on outdoor stock racks. The fillets are washed in 3,5% brine. The fillets are hanged on bars (2m*0,5m*0,5m) in the drying station. If the fillets are too closely adjoined on the bars, the ventilation will not be suffeciently between them.

The Huts (drying houses) are usually situated near the ocean or other windy places, to ensure the quickest drying. The prevailing dry climate in the West Fjord region of Iceland is particularly suitable for outdoor drying.

Fig. 1. Hut for outdoor drying.

In outdoor drying in flakes the wooden racks with the fishes are ordered on tubs. The tubs are wheeled to the flakes and the racks are ordered in the flakes.

The fish is only dried in the flakes from September until early May. Outdoor drying depends on the weather condition and the best temperature for drying is around 0°C. If the weather condition is unsuitable for outdoor drying, such as rain, snow or high temperatures, the fish is stored in a freezing compartment until the weather becomes suitable for drying.

The time of drying in the huts is 4-6 weeks, but the drying time depends on the size of the fish and weather conditions. If the wind is calm, electrical fans are used to move the air. A wire gauge is stringed over the fish to protect it from vermin, and sailcloth is tentered over the flake, to prevent snow, sand, rain and sun from getting in. Weather conditions in the West fjords region is particularly suitable for outdoor drying of fish, because of the dry and cold weather during the winter.

Secondary drying:

The dried fish is moved indoors only if the weather is dry, and the moisture content is then estimated. If the fish is not sufficiently dried, the wooden racks are ordered on tubs, which are located in the drying station at 10-15 °C., until the right moisture content is reached and the fish is fully dried. Fans are used to blow the moisture out of the station.

Fig. 2.Dried fish taken from racks

Then the dried fish is put in a special container and stored at -20°C in a freezer.

Packing

The dried fish is then semimilled or hammered in special equipment. In the old days, the fish was hammered manually, which was onerous work.

The dried fish is examined in order to exclude all defectives like damages and bones, which does not regularize the demand of the consumers and the company about quality. The fish is then packed.

The packing material is specially made for storing dried fish. After packing the fish is stored in a freezing compartment.

Fig. 3. Wrapped dried fish **.**

Indoor drying, warm:

The treatment of the raw material is the same for indoor drying as for the outdoor drying. The strength of the brine is 5%, and at the end of the process the fish is frozen and cut into small pieces and put on racks in a drying cabinet. The warm air heats up the fish and the remaining water in the fish evaporates causing moisture in the air. Part of the air is

recycled. Indoor drying is carried out at 18-20°C for four days. The fish pieces are dried at 20-30°C for 36-48 hours. The air velocity in the cabinet is about 3-4 m/sec.
After drying, the fish is packed and stored in a freezing compartment.

Indoor drying, cool:

The treatment of the raw material is the same for indoor drying as for the outdoor drying.
A third method is drying with cool air about -5 – 0°C in the beginning, but the heat is gradually increased when the moisture content have reached a certain level. The fish is dried in a controlled cabinet, where the temperature, moisture and air velocity is controlled in a closed system, as in a warm indoor drying.
Before drying, the fish is put in a 2% brine for 30 minutes or until the salt strength in the final product reaches 2,5%. After drying, the dried fish is packed and stored in a freezing compartment.

Health food

Diet greatly affects human health and this has influenced and created for a vast market of functional foods. The concept “functional foods” originated in Japan and spread from there to the West 15 years ago. The increased interest in functional foods is due to the increased expenses in the health services and because the average life span has increased.
Improved knowledge in nutrition has showed how diet can influence human health [(24)]. Today, there exist many different definitions of functional foods, but it always means food that have special attribution to increase health. [(20, 10)]. In a report from the European Commission Concerted Action on Functional Food Science in Europe functional food have to meet the following criteria: ”Functional food or medicinal food is any fresh or processed food claimed to have a health-promoting and/or disease-preventing property beyond the basic nutritional function of supplying nutrients. Functional foods are sometimes called nutraceuticals, a blend of the words *nutrition* and *pharmaceutical*, and can include food that has been genetically modified ” [(8)].
A food supplement is, typically, a nutrient added to a foodstuff which would otherwise not contain that nutrient. In general, the term is restricted to those additives which are deemed to be positive for health, growth or well-being [(6, 11)].

Fish and health

Numerous researches have shown that fish is good for the health. Based on health results for the last 40 years, a group of American scientists have concluded that consumption of fish minimizes the risk of stroke. The group pointed out that it is not enough to look at the omega-3 fatty acids alone in fish to improve health, one should also consider other components in fish, such as fish proteins. Proteins are long chains of aminoacids which form different proteins. At digestion and breakdown of proteins, smaller bioactive substances are formed, called peptides. They have good effects on the health. [(12)]. Protein content in fish is 16-20% of the total weight. According to the regulations protein content in fresh haddock is about 17-19% but in dried haddock the protein content is about 75-80% [(25)].

Seafood contains peptides. Peptides are involved in releasing hormones, controlling the level of the blood sugar and the metabolism in bones and nerves. By breaking down protein with fermentation or hydrolysis a peptide is formed [(26)].

Seafood contains long chains of omega 3 fatty acids. Many articles have been published about the importance of omega-3 fatty acids on health, especially on the cardiovascular system. [(27)]. The Food and Drug Administration has licenced so-called "Qualified health claim´s" for traditional food and food supplements which contain omega-3 fatty acids [(10)].

In 2001 the Consumers' Association of Iceland carried out a quality study on dried fish from different producers. The results indicated that there was a difference in the quality of the dried fish between different producers [(23)].

To estimate the blood pressure reducing effects it is possible to measure the inhibition of a substance on angiotensin-I converting enzyme (ACE). In 1986, ACE inhibitor from peptides (Val-Tyr) from sardines in Japan was analysed [(29)]. Two years later inhibitor in tuna fish was analysed [(19)]. ACE inhibition substances were also found in water-soluble proteins in sardines [(18)]. The viscera silage from tuna fish increased the content of ACE inhibition 16 times. It also decreased the blood pressure in rats [(9)]. ACE inhibition in enzymes in krill has also been analyzed [(17)].

2. RESULTS ON DRIED FISH 1997

In 1997, the Icelandic Fisheries Laboratoies performed out microbial analyses and water activity measurements on indoor and outdoor dried fish. The fish was measured with and without the skin.

Microbial analysis

The method used for microbial analysis was according to APHA (1992). Total count was performed by method using Plate Count Agar (PCA) with 0.5% NaCl and incubated at 22°C for three days. Counting of lactic acid bacteria was done on MRS-S agar with surface plate method [13], and incubated at 22°C for three days. Counting of yeasts was done on Potato Dextrose agar with surface plating, and incubated at 22°C for five days. Counting of coliform bacteria was done according to MPN method. Preenrichment was done in LST broth and a confirmation test for total coliforms was done in a BGLB broth at 35°C and for feacal bacteria in EC broth at 44.5°C. Method for Listeria +/- test was according to USDA (FSIS) where preenrichment was done in UVM enrichment broth, then in Fraser broth and stroked on a Modified Oxford Agar (MOX). Counting of *Staphylococcus aureus* was done with a streak plate method on a Staphylococcus medium no.110 at 35°C for three days. Butterfield´s buffer was used in all dilutions.

Measurements on water activity

Water activity is defined as the vapour pressure of water divided by that of pure water at the same temperature, therefore, pure distilled water has a water activity of exactly one. Water activity was measured by Novasina AW-Center (AWC503 RS-C, Axair AG, Switzerland) equipment at standard temperature.

Results of measurements of microorganism and water activity

Results from the microbial analyses and water activity measurements in dried fish are shown in Fig. 4 and 5. Total samples analysed were 65. There was a great difference in the total average number of bacteria between outdoor and indoor dried fish. Outdoor and

indoor dried fish showed values of 4 and 7 log cfu/g, respectively. The average number of lactic acid bacteria, in outdoor- and indoor dried fish showed values of 0.4 and 5.4 log cfu/g, respectively. Number of yeasts in outdoor dried fish was five times more, compared to indoor fish. Coliforms were detected in three samples out of 34 in outdoor dried fish and in 27 samples out of 31 in indoor dried fish. No faecal bacterias were found in the samples. *Listeria* was found in one sample out of 65, in outdoor dried haddock fillets with skin. *Staphylococcus aureus* was found in sample of indoor dried fillets of catfish with skin.

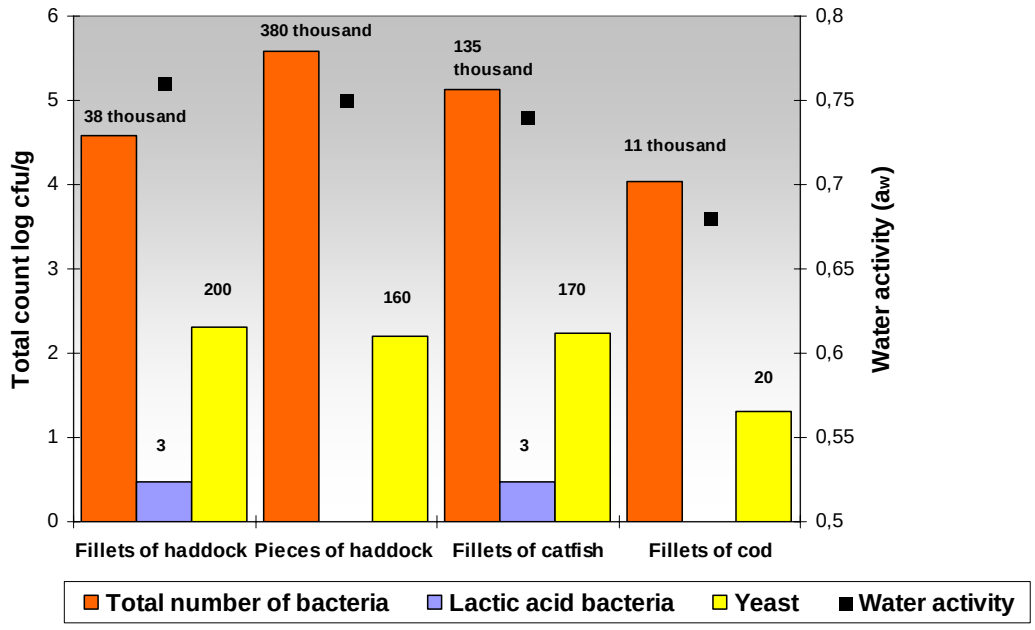

Fig. 4 Number of bacteria and water activity in outdoor dried fish.

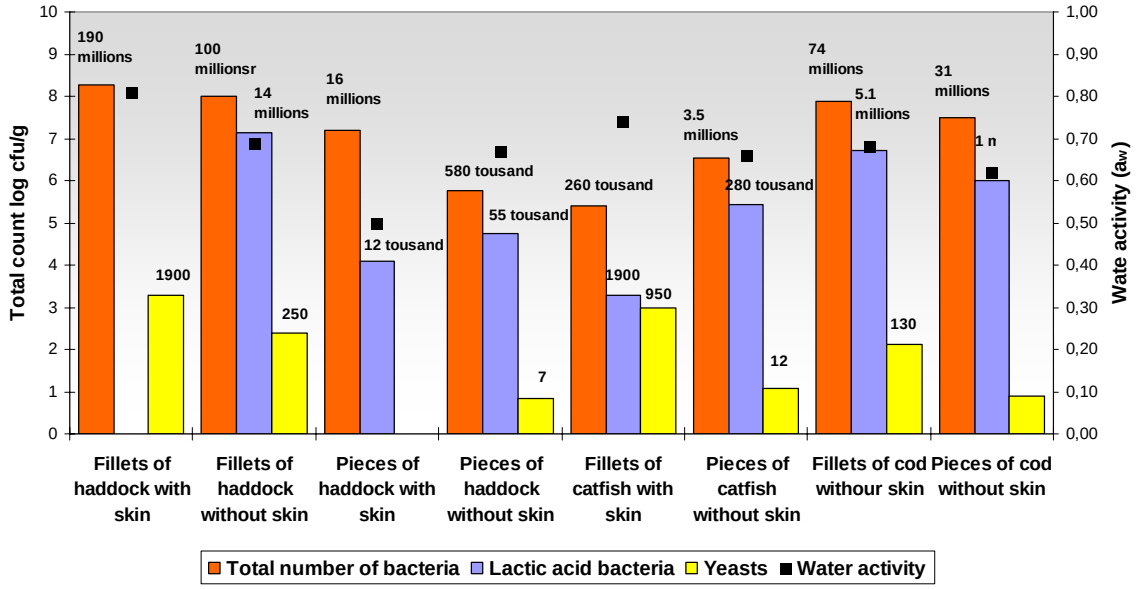

Fig. 5. Number of bacteria and water activity in indoor dried fish.

Despite high number of microorganisms in dried fish, it is not hazardous for people´s health.

There could be many reasons for the great difference in number of total bacteria between outdoor and indoor dried fish. Drying conditions could explain the difference. At outdoor drying conditions concerning temperature, moisture and air velocity are variable. Conditions for indoor drying are more stable. Temperature at outdoor drying is much lower and bacteria growth is much slower. In outdoor dried fish, existence of true psychrophiles should not be considered, because they don't grow at 22°C. Psychrophiles have optimum growth temperature of 12-15°C. It should have been preferable to grow the bacteria in outdoor dried fish at 12-15°C, to compare with growth 22°C.

Average water activity (a_w) in outdoor- and indoor dried fish had a value of 0,75 and 0,65, respectively. Generally, there is no microbial growth or toxic formation in food when the water activity is lower than 0,85. Dried fish products should have water activity around 0,6. According to rules from FDA from 2001 (http://www-seafood.ucdavis.edu/haccp/compendium/Chapt04.htm) water activity should be lower than 0.85 in food that are not stored in a refrigerator.

3. OBJECTIVE OF THE PROJECT „DRIED FISH AS HEALTH FOOD”

The main objective of this project was to increase the sale and consumption of dried fish as a health food, both abroad and in Iceland and will focus on:

- ✓ Define and measure primary nutrition- and health factors.
- ✓ Information with regard to the production, characteristics, quality and wholesomeness of dried fish.

4. MATERIALS AND METHODS

Dried fish samples from different producers were used in this study. The outdoor dried fish samples were dried for 4 to 6 weeks, and the indoor dried fish samples were dried at 18-22°C or at -1-+2°C for 12 to 20 hours and then at 18-22°C for 20 hours.

The following measurements were performed on the samples:

- ✓ Protein according to Kjeldahl method [16].
- ✓ Fat content according to Soxhlet method [4].
- ✓ Salt content, NaCl [3].
- ✓ Ash [16].
- ✓ TMA [2].
- ✓ TVN [22].
- ✓ Water content [14].
- ✓ Trace elements (copper, zinc, arsenic, selen, mercury and lead) were measured with IPMS after acid treatment. Quantity of the elements were then determined with ICPMS (Agilent 7500ce, Waldbronn, Germany) and ^{45}Sc, ^{72}Ge, ^{115}In og ^{205}Tl was used as an internal standard.
- ✓ Amino acids composition [7].
- ✓ Total count of bacteria cultured at 22°C [1].
- ✓ Number of Lactic acid bacteria [13].

5. RESULTS

Following are the results from the measurements of amino acid analyses, chemical- and trace elements, together with microbial analyses in outdoor and indoor dried fish, 2006. The results from the measurements of the number of bacteria from 1997 were compared with the results from 2006.

Protein and amino acid analysis

The results from the amino acids measurements in dried fish are shown in Table 1. The results were compared with amino acids in eggs (Livsmedelsverket 1996), and the results showed that dried fish was very rich in amino acids. High quantity of amino acids in dried fish reflects the high quantity of proteins (77-87 g/100g fish). The quantity of protein is variable and depends on the drying time of the fish. To enable the comparison of the samples the quantity of amino acids is calculated as a proportion of nitrogen in protein (mg/g nitrogen). The results are shown in Table 2.

The quality of protein depends on the amino acids essential in human nutrition in amounts adequate for human use. Quality wise, an egg nearly fullfils the amount of proteins needed for human body, second are proteins from milk, fish and meat. Proteins from plants are poorer. Limiting amino acid is an essential amino acid found in the shortest supply relative to the amount needed for protein synthesis in the body. Lysine, methionine, tryptophan or threonine are limiting amino acids in food.

Amino acid scoring evaluates the quality of food proteins by determining its amino acid composition and comparing it with that of a reference protein. The amino acid composition of a test protein can be compared with the composition of egg protein, and amino acid score can be derived to express the theoretical value of the test protein.

Limiting amino acid is found and the amino acid value calculated as a ratio of the amino acid in a reference protein. In Table 3 the amount of amino acids in dried fish were calculated as a proportion of amino acids in eggs. The calculation is based on values in Table 2. One can see that valine is a limiting amino acid, but the proportion is always above 60 % of the amount of the amino acid in eggs. It can be concluded that protein in dried fish is of high quality. One can consider that the value of amino acids does not reflect the efficiency of amino acids in the body, and no information of digestibility of

dried fish proteins is available. An excess of one amino acid can create such a demand for a carrier that it prevents the absorption of another amino acid, leading to a deficiency [30]. Overconsumption of proteins offers no benefits and may pose health risks.

Recommended intakes of proteins for adults is 0,+75 grams per kilogram of healthy body weight per day. For example, a 70 kg male needs 53 g of proteins per day. To fulfill this need he has to consume 66 g of dried fish. A 55 kg female needs 41 g of proteins per day, or 51 g of dried fish.

Generally, there is enough protein in the diet for humans. Some people are looking for additional protein and others are looking for protein-rich food supplements. Dried fish could fall in that category, and the results of amino acids in dried fish could help people to choose a protein-rich food. It is clear that small portions of dried fish can provide the need of proteins in the body.

Table 1. Amino acids in dried fish and egg.

	Eggs g/100g	Haddock fillet Indoor-cold g/100g	Haddock pieces Indoor-cold g/100g	Haddock fillet Indoor-hot g/100g	Haddock pieces Indoor-hot g/100g	Haddock fillet Outdoor g/100g	Catfish fillet Outdoor. g/100g
Essential amino acids							
Phenylalanine	0,71	3,52	3,613	3,36	3,457	3,44	3,25
Histidine	0,32	2,3	2,419	2,26	2,036	2,65	2,14
Isoleucine	0,73	4,04	4,129	3,87	4,032	3,94	3,77
Leucine	1,15	8,04	8,841	7,85	7,704	7,97	7,48
Lysine	0,99	8,97	9,864	8,86	8,593	9,2	7,82
Methionine	0,44	2,4	2,521	2,34	2,569	2,66	1,96
Tryptophan *)	0,18						
Valine	0,95	4,16	4,119	3,96	4,034	4,02	3,82
Threonine	0,61	3,56	3,61	3,36	3,497	3,5	3,48
Total	6,08	36,99	39,12	35,86	35,92	37,38	33,72
Other amino acids							
Alanine	0,77	4,94	5,462	4,73	4,531	4,93	4,68
Arginine	0,83	5,42	5,55	5,24	5,318	5,37	5,26
Aspartine acid	1,35	8,32	9,292	8,21	7,998	8,62	8,04
Glutamine acid	1,54	12,31	13,523	12,11	11,78	12,81	11,93
Glycine	0,46	3,68	4,073	3,6	3,384	3,76	3,66
Proline	0,51	2,5	2,772	2,64	2,671	2,76	2,65
Serine	0,99	3,59	3,625	3,39	3,534	3,56	3,45
Taurine **)		0,49	0,414	0,31	0,346	0,47	0,67
Tyrosine	0,56	3,35	3,409	3,22	3,304	3,25	2,98
Total	7,01	44,6	48,12	43,45	42,87	45,53	43,32
Both groups	13,09	81,59	87,236	79,31	78,79	82,91	77,04
Protein	12,6	81,4	84,8	81,1	80,7	81,0	82,7

*) Not analysed.

**) In special circumstances Taurine can be placed as essential amino acid.

Table 2. Amino acids in dried fish and egg as a proportion of nitrogen (N).

	Eggs	Haddock fillets Indoor-cold	Haddock pieces Indoor-cold	Haddock fillets Indoor-hot	Haddock pieces Indoor-hot	Haddock fillets	Catfish fillets
						Outdoor	Outdoor
	mg/g N	mg/g N	mg/g N	mg/g N	mg/g N	mg/g N	mg/g N
Essential amino acids							
Phenylalanine	352	270	266	259	268	265	246
Histidine	159	177	178	174	158	204	162
Isoleucine	362	310	304	298	312	304	285
Leucine	570	617	652	605	597	615	565
Lysine	491	689	727	683	666	710	591
Methionine	218	184	186	180	199	205	148
Tryptophan *)							
Valine	471	319	304	305	312	310	289
Threonine	303	273	266	259	271	270	263
Total	2927	2840	2883	2764	2782	2884	2548
Other amino acids							
Alanine	382	379	403	365	351	380	354
Argenine	412	416	409	404	412	414	398
Aspartine acid	670	639	685	633	619	665	608
Glutamine acid	764	945	997	933	912	988	902
Glycine	228	283	300	277	262	290	277
Proline	253	192	204	203	207	213	200
Serine	491	276	267	261	274	275	261
Taurine **)	-	38	31	24	27	36	51
Tyrosine	278	257	251	248	256	251	225
Total	3477	3424	3547	3348	3320	3513	3274
Both groups	6404	6265	6430	6112	6102	6397	5822

*) Not analysed.

**) In special circumstances Taurine can be placed as essential amino acid.

Tafla 3. Amount of amino acids in dried fish as a proportion of amount of amino acids in egg (amount of amino acids per gram of nitrogen).

	Eggs	Haddock fillet Indoor-cold	Haddock pieces Indoor-cold	Haddock fillets Indoor-hot	Haddock pieces Indoor-hot	Haddock fillet Outdoor	Catfish-fillet Outdoor
Essential							
Amino acids							
Phenylalanine	100	77	76	74	76	75	70
Histidine	100	111	112	110	99	129	102
Isoleucine	100	86	84	82	86	84	79
Leucine	100	108	114	106	105	108	99
Lysine	100	140	148	139	136	145	120
Meþíonín	100	84	85	83	91	94	68
Tryptophan *)							
Valine	100	68	64	65	66	66	61
Threonine	100	90	88	86	90	89	87
Other amino acids							
Alanine	100	99	105	95	92	100	93
Arginine	100	101	99	98	100	101	97
Aspartine acid	100	95	102	94	93	99	91
Glutamine acid	100	124	130	122	119	129	118
Glycine	100	124	132	122	115	127	121
Proline	100	76	81	80	82	84	79
Serine	100	56	54	53	56	56	53
Taurine)**							
Tyrosine	100	93	90	89	92	90	81

*) Not analysed.

**) In special circumstances Taurine can be placed as essential amino acid.

Chemical analysis

Results from the chemical analyses of indoor and outdoor dried fish are shown in table 4.

Table 4. Chemical analysis on indoor and outdoor dried fish.

	Fat	Salt (NaCl)	Ash	TMA	TVN	Water
Sample	(%)	(%)	(%)	mg N/100g	mg N/100g	(%)
Haddock fillets, ind.-cold	0,6	1,6	5,9	18,9	89	14,8
Haddock pieces,ind.-cold	0,8	2,0	6,0	18,4	87	11,3
Haddock fillets, ind.-hot	0,8	3,9	7,1	70,8	150	15,0
Haddock piece, ind.-hot	0,75	4,2	7,5	18,8	81,5	11,3
Haddock fillets, outdoor	0,6	1,2	5,6	22,8	102	15,9

The amount of trimethylamine oxide (TMAO) in seafood is 40-120 mg/kg. After death special microorganisms reoxidate TMAO to trimethylamine (TMA). Total volatile nitrogen (TVN) contains total amount of volatile nitrogen bases (TMA), together with nitrogen groups which is synthesised by reaction from proteins. Table 4 shows that total amount of volatile bases is by far the highest in dried fish from haddock fillets, which have been dried in hot air indoors. The reason is that by indoor drying at 18-22°C the drying process takes about 96 hours, and more of volatile nitrogen compounds are formed than at lower temperature and shorter time. TVN content in indoor dried haddock pieces is lower, since they are frozen and then dried. Breakdown of nitrogen compounds is less because of shorter processing time and lower temperature. Generally, salt content for dried fishproducts is 1,5-2,0%. In indoor hot dried haddock products the salt content is rather high.

Mineral analyses

Minerals may be devided into three categories, according to functionality or importance for the human body.

- ✓ **Elements which are essential for human body**. In this category are elements like iron, copper, zinc, chromium, selenium, calcium, magnesium, lithium, cobalt, molybdenum, iodine, and fluor.
- ✓ **Elements which are nonessential (their function is not fully known).** In this category are elements like tin, nickel, vanadium and manganese.
- ✓ **Elements which are toxic in overdose** are e.g**.** cadmium, molybdenum, lead, mercury, arsenic, borium and tin.

Some of the minerals are essential in small doses, but toxic for the body in overdoses. Sometimes its function is not known, only that they are essential, e.g. the element selenium. Prior to 1957 selenium was considered toxic, when its biological function was discovered. Today there exist biological reactions, where selenium plays important rule in the process [(28)].

Table 5. Mineral analysis on indoor and outdoor dried fish (mg/kg).

Samples	Copper	Zinc	Arsenic	Selenium	Cadmium	Mercury	Lead
Haddock fillets,ind.-cold	1,58	14,69	23,03	1,51	0,05	0,12	0,04
Haddock piece, ind.-cold	1,05	15,58	31,34	1,93	0,05	0,22	0,02
Hoddack fillets, outdoor	1,05	12,99	21,36	1,98	0,05	0,16	0,03
Haddock fillet ind..hot	1,05	15,84	21,78	1,80	0,05	0,19	0,07
Haddock pieces 1kl	1,05	16,24	18,44	1,64	0,05	0,24	0,04
Catfish fillets-outdoor	1,80	46,28	8,52	1,09	0,06	0,36	0,09

It is useful to calculate how large part of RDA comes from 100 grams of dried fish products. The results are shown in Table 6.

Table 6. Mineral in 100 grams of dried fish as a ratio (%) of recommended dietary allowance (RDA).

Tegund sýnis	Kopar % af RDS	Sínk % af RDS	Selen % af RDS
Haddock fillets, ind.-cold	17 %	16 %	3*RDS
Haddock pieces, ind.-cold	12 %	17 %	3*RDS
Haddock fillets, outdoor	12 %	14 %	3*RDS
Haddock fillets, ind.-hot	12 %	18 %	3*RDS
Haddock pieces, ind.-hot	12 %	18 %	3*RDS
Catfish fillets,outdoor	20 %	51 %	3*RDS

Selenium is an essential component of the enzyme glutathione peroxidase, which can be found in the catalyst glutathione peroxidase, which can be found in red blood cells. Selenium prevents formation of free radicals which cause ageing, but free radicals are harmful excreta from cells. Selenium plays the same role as vitamin E, i.e. as an antioxidant, and minimise the effects of mercury in mammals. RDA for adults varies between different countries, e.g. in Iceland RDA is 40-50 µgrams per day, but in Finland the RDA is 110 µgrams per day [(5)]. In dried fish (Table 6) the amount of selenium is tripled compared to RDA. Since most of selenium compounds from food are water-soluble, they secrete fast from the body but absorption of selenium in the body is small [(5)]. Because of that there should be no harmful effects from selenium.

Zinc supports the work of numerous proteins in the body. Zinc stabilizes cells membranes, helping to strengthen their defense against free radical attack. Zinc also assists in the function of the immune system and in growth and development. It also participates in the synthesis, storage and release of the hormone insulin in the pancreas, although it does not appear to play a direct role in insulins action. RDA for adults are 7-9 milligrams per day. The amount of zinc in outdoor dried catfish is higher than in dried haddock products, or 46 milligrams per kilogram compared to 14-16 milligrams per kilogram. Thus 100 grams of dried catfish contains half of RDA for zinc.

Arsenic is one of the heavy metals and can be carcinogenic in humans. The amount of arsenic is three times higher in dried haddock products, than in dried catfish (Table 5), but still far below dangerous levels.

Cadmium and mercury are also heavy metals and are related to zinc. Unlike zinc they are not nutrients and they are harmful. They can react with sulfuric compounds, e.g. in enzymes and inactivate them and, furthermore they can form toxic organic compounds. Amount of mercury in dried catfish is higher than in dried haddock, but far below dangerous level.

Lead was one of the first metals known to be toxic. Children are sensitive towards lead poisoning. The symtoms are fretfulness, but if the poisoning is serious it can cause anemia and brain damage. Only nominal amount of cadmium and lead is found in dried fish, and results show that the amount is far beneth the level of analysis (Table 5). Also, it can be seen that the amount of mercury is far below the levels that the European Union have authorised, or 0,5 milligrams per kilogram of fish.

Microbial analyses

Results of microbial analyses in indoor and outdoor dried fish are shown in figure 6. The number of microorganism is shown on a logarithm scale. There was a great difference in total number of microorganism in indoor dried (hot air), compared with outdoor dried fish. The average number of total bacteria in indoor dried fish was 5,4 log cfu/gram and in outdoor dried fish 3,6 log cfu/gram. The same trend was found in the number of lactic acid bacteria in indoor dried fish, wheras the number was between 5-6 log cfu/gram, and beneath 2 log cfu/gram in outdoor dried fish. Both the number of total bacteria and the number of lactic acid bacteria in indoor dried fish was smaller than in indoor dried products dried at hotter condition. These results are in correspondence with the results from 1997. Therefore, number of true phsycrophiles could be higher in outdoor dried fish, compared to indoor dried fish, but these bacterias do not grow at 22°C .

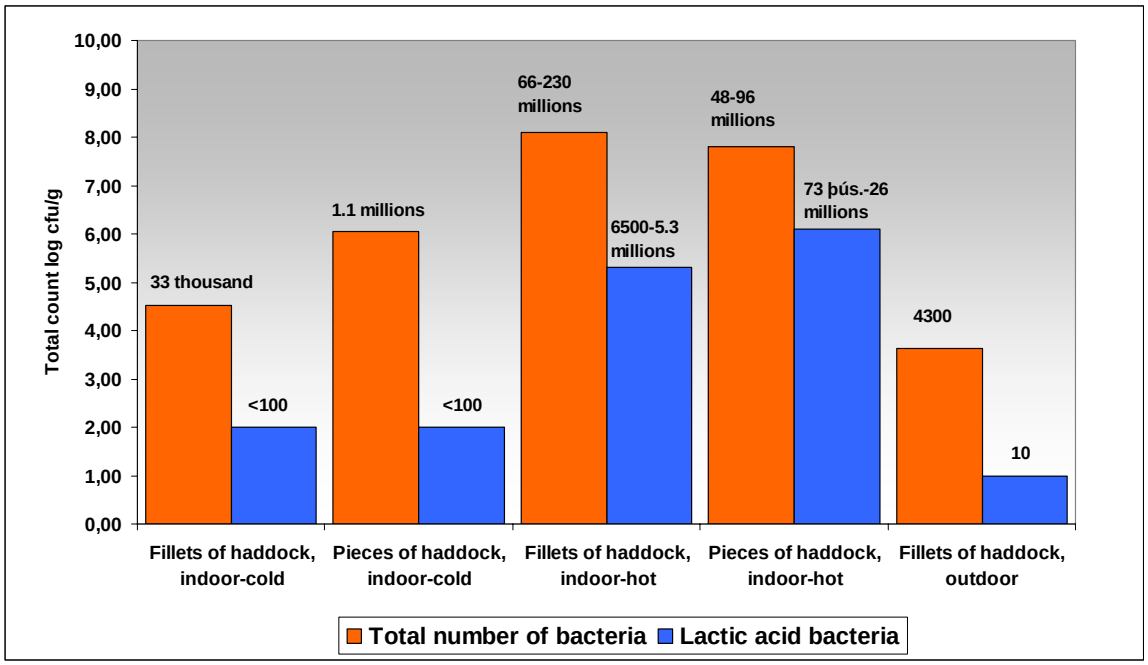

Figure 6. Average number of microorganism (in one gram) in indoor and outdoor dried fish. The number of microorganism is shown above the columns.

6. DISCUSSION AND CONCLUSION

The results indicated that dried fish is a good source of quality protein and also contains minimal amount of heavy metals, except for selenium.

The results from the project will be useful for all the producers of dried fish in Iceland, and the restults will be published officially. These results will help the producers of dried fish to market their products, as the discussion of dried fish will be more positive, and likely that these products will be more visable in the supermarket.

Export of dried fish considering the popularity of the product domestically. The price of dried fish is rather high compared with other food products, but not if one considers the health effects of the food, and that he is dried and only 10% of the original raw material is commercialized.

The results will give the producers opportunity to increase the marketing abroad, which could lead to more development in the buisness, especially if one can promote dried fish as a health food. Furthermore, these results will be available for progressive research on dried fish and development on this area. It can be meantioned that people at the Tourism department in Hólaskóli University are interested in carrying out a marketing research

and introduce dried fish in relation with tourism and traditional food and are confident that they can use these results in their research.

The main market for dried fish is domestic, and its sale is highest around Þorri and during summer holidays. Results of this research may increase the domestic sale, and stabilze it over the whole year. Incresing knowledge of dried fish as a health food will, hopefully open up foreign markets and lead to increasing development to adjust this traditional food product to those markets. People from Asia and many western countries which traditionally eat dried seafood products could be very interesting target market for Icelandic producers of dried fish products.

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